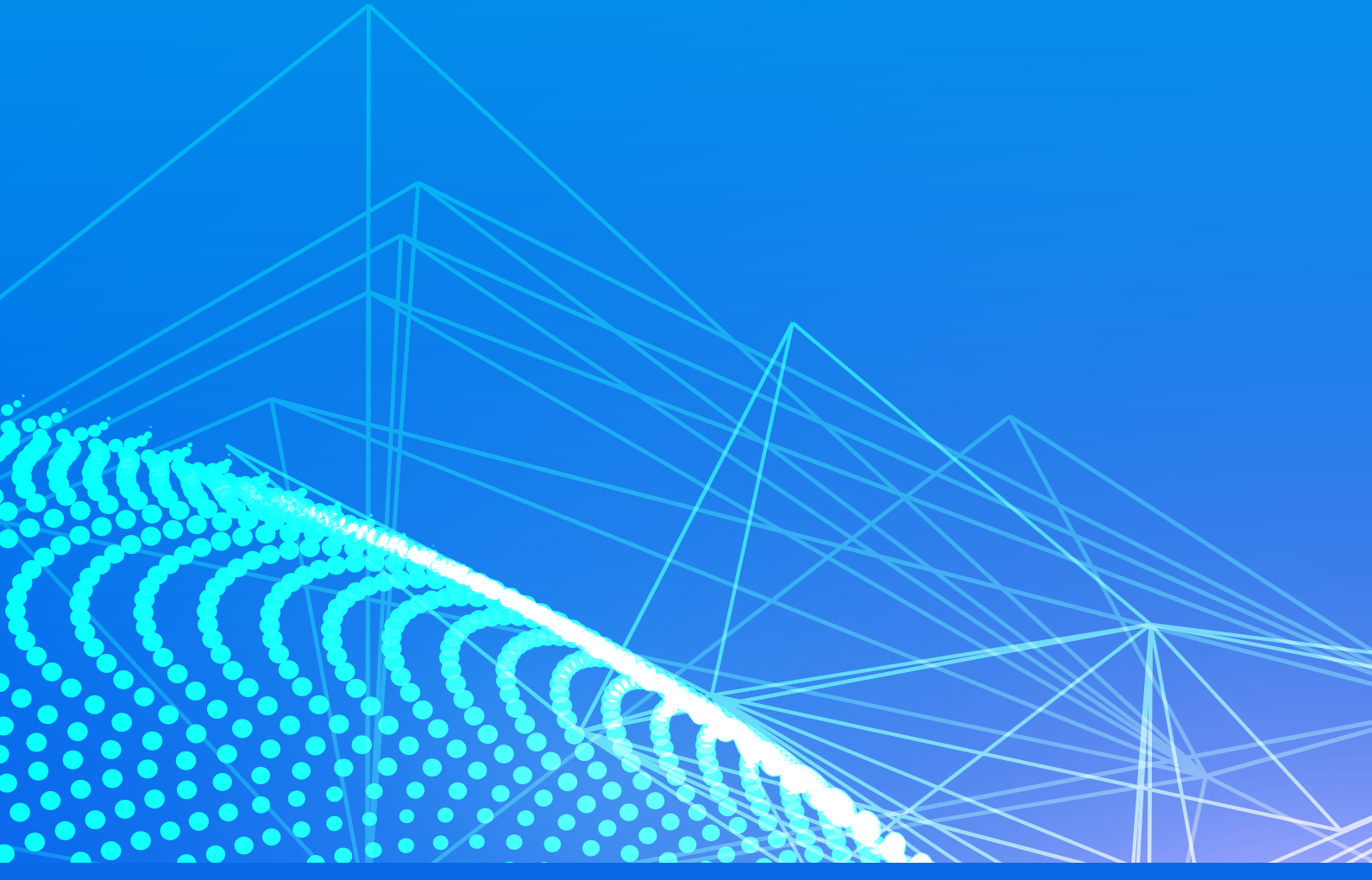
ISJET

INTERNATIONAL SCIENTIFIC JOURNAL OF ENGINEERING AND TECHNOLOGY

Volume 3 No. 2 July-December 2019



ISSN 2586-8527 (Online)

Panyapiwat Institute of Management

Indexed in the Thai-Journal Citation Index (TCI 2)

INTERNATIONAL SCIENTIFIC JOURNAL OF ENGINEERING AND TECHNOLOGY (ISJET)

Volume 3 No. 2 July-December 2019

ISSN 2586-8527

PANYAPIWAT INSTITUTE OF MANAGEMENT

INTERNATIONAL SCIENTIFIC JOURNAL OF ENGINEERING AND TECHNOLOGY (ISJET)
Volume 3 No. 2 July-December 2019
ISSN 2586-8527

Copyright
Panyapiwat Institute of Management
85/1 Moo 2, Chaengwattana Rd.,
Bang Talad, Pakkred,
Nonthaburi 11120, Thailand
Tel. +66(0) 2855 1560
Fax. +66(0) 2855 0392
https://www.tci-thaijo.org/index.php/isjet/index
https://isjet.pim.ac.th
Email: isjet@pim.ac.th

Published by
Chulalongkorn University Press
Bangkok, Thailand
Tel. +66(0) 2218 3549-50
Fax. +66(0) 2215 3621
http://www.cupress.chula.ac.th
E-mail: cuprint@hotmail.com

Copyright©2017, Panyapiwat Institute of Management

INTERNATIONAL SCIENTIFIC JOURNAL OF ENGINEERING AND TECHNOLOGY (ISJET)

Volume 3 No. 2 July-December 2019 ISSN 2586-8527

Objective:
International Scientific Journal of Engineering and Technology will be dedicated to serving as a forum to share knowledge on research advances in all fields of sciences: Engineering, Technology, Innovation, Information Technology, Management Information System, Logistics and Transportation, Agricultural Science and Technology, Animal Science and Aquaculture, Food Science, and other areas in Sciences and technology. Submissions are welcomed from both PIM as well as other Thai and foreign institutions.

Scope:
Engineering, Technology, Innovation Technology, Management Information System, Logistics and Transportation, Agricultural Science and Technology, Animal Science and Aquaculture, Food Science, and other areas in Sciences and Technology

Type of Article:
• Research article
• Academic article
• Book review
• Review article

Languages of academic work:
Article written either English languages are accepted for publication.

Reviewing Policy:
1. Any manuscript to be accepted for publication must have been reviewed and approved by at least two peer reviewers in that particular field or related fields.
2. The submitted manuscript must have never been published in any other periodical, and must not be in the approving process for publication by any other periodical. Also, the author must not plagiarize the work of other people.
3. The article, expression, illustrations, and tables that are published in the Journal are the sole responsibility of the author, and definitely not that of Panyapiwat Institute of Management.
4. The Editorial Board of Panyapiwat Journal reserves right for decision making on publishing any article in the Journal.

Frequency of Publication:
Twice a year
• The first issue: January-June
• The second issue: July-December

Publication and Access Charges:
There are no charges to submit and publish all types of articles. Full articles in pdf format can be downloaded freely from the journal website.

ISJET Journal Editorial Board
The office of Research and Development
Panyapiwat Institute of Management
85/1 Moo 2, Chaengwattana Rd.,
Bang Talad Pakkred, Nonthaburi 11120, Thailand
Tel. +66(0) 2855 1560
Fax. +66(0) 2855 0392
E-mail: isjet@pim.ac.th
Website https://www.tci-thaijo.org/index.php/isjet/index

INTERNATIONAL SCIENTIFIC JOURNAL OF ENGINEERING AND TENCNOLOGY
Volume 3 No. 2 July-December 2019
ISSN 2586-8527 (Online)

Advisory Board

Assoc. Prof. Dr. Somrote Komolavanij	Panyapiwat Institute of Management, Thailand
Prof. Dr. Mitsuhiro Kagami	Panyapiwat Institute of Management, Thailand
Assoc. Prof. Dr. Pisit Charnkeitkong	Panyapiwat Institute of Management, Thailand
Assoc. Prof. Dr. Chom Kimpan	Panyapiwat Institute of Management, Thailand
Assoc. Prof. Dr. Paritud Bhadhubanyong	Panyapiwat Institute of Management, Thailand
Assoc. Prof. Dr. Tippaporn Mahasinpaisarn	Panyapiwat Institute of Management, Thailand

Editor-in-chief

Assoc. Prof. Dr. Parinya Sanguansat	Panyapiwat Institute of Management, Thailand

Associate Editor of Engineering

Asst. Prof. Dr. Phannachet Na Lamphun	Panyapiwat Institute of Management, Thailand

Associate Editor of Information Technology

Dr. Nattakarn Phaphoom	Panyapiwat Institute of Management, Thailand

Associate Editor of Science

Dr. Wirin Sonsrettee	Panyapiwat Institute of Management, Thailand

Associate Editor of Logistics and transportation

Dr. Tantikorn Pichpibul	Panyapiwat Institute of Management, Thailand

Associate Editor of Agricultural Science and Technology

Asst. Prof. Dr. Korawit Chaisu	Panyapiwat Institute of Management, Thailand

Editorial Board

Prof. Dr. Chidchanok Lursinsap	Chulalongkorn University, Thailand
Prof. Dr. Parames Chutima	Chulalongkorn University, Thailand
Prof. Dr. Phadungsak Rattanadecho	Thammasat University, Thailand
Prof. Dr. Thanaruk Theeramungkong	Sirindhon International Institute of Technology, Thammasat University, Thailand
Prof. Prasanta Kumar Dey	Aston Business School, Aston University, UK
Assoc. Prof. Dr. Chawalit Jeenanunta	Sirindhorn International Institute of Technology, Thammasat University, Thailand
Assoc. Prof. Dr. Panich Intra	Rajamangala University of Technology Lanna, Thailand
Assoc. Prof. Dr. Ruengsak Kawtummachai	Panyapiwat Institute of Management, Thailand
Assoc. Prof. Dr. Wilaiporn Lee	King Mongkut's University of Technology North Bangkok, Thailand
Asst. Prof. Dr. Adisak Joomwong	Maejo University, Thailand
Asst. Prof. Dr. Nattapon Chantarapanich	Kasetsat University, Sriracha Campus, Thailand
Dr. Nattaporn Chotyakul	Panyapiwat Institute of Management, Thailand
Dr. Pravel Albors	Aston Business School, Aston University, UK
Dr. Rangsima Chanphana	Chulalongkorn University, Thailand
Dr. Thongchai Kaewkiriya	Panyapiwat Institute of Management, Thailand

Journal Secretary

Ms. Suchinda Chaluai	Panyapiwat Institute of Management, Thailand

Peer Reviewers

Prof. Dr. Parames Chutima	Chulalongkorn University, Thailand
Assoc. Prof. Dr. Chanboon Sathitwiriyawong	King Mongkut's Institute of Technology ladkrabang
Assoc. Prof. Dr. Montalee Sasananan	Thammasat University, Thailand
Assoc. Prof. Dr. Porpan Vachajitpan	Burapha University, Thailand
Assoc. Prof. Dr. Ruengsak Kawtummachai	Panyapiwat Institute of Management, Thailand
Assoc. Prof. Dr. Somrote Komolavanij	Panyapiwat Institute of Management, Thailand
Assoc. Prof. Dr. Suthep Butdee	King Mongkut's University of Technology North Bangkok, Thailand
Assoc. Prof. Dr. Thananya Wasusri	King Mongkut's University of Technology Thonburi, Thailand
Asst. Prof. Dr. Adisak Joomwong	Maejo University, Thailand
Asst. Prof. Dr. Sopark Sonwai	Silpakorn University, Thailand
Dr. Sumeth Yuenyong	Mahidol University, Thailand
Dr. Thawatchai Suwanapong	Prince of Songkla University, Thailand

INTERNATIONAL SCIENTIFIC JOURNAL OF ENGINEERING AND TECHNOLOGY (ISJET)
Volume 3 No. 2 July-December 2019
ISSN 2586-8527 (online)
Panyapiwat Institute of Management
85/1 Moo 2, Chaengwattana Rd.,
Bang Talad, Pakkred, Nothaburi 11120
Thailand

Dear Contributors,

It is with great joy to celebrate the new issue of International Scientific Journal of Engineering and Technology (ISJET). ISJET provides an exciting opportunity for researchers to share their recent achievements and discoveries with communities of learners and practitioners across science and engineering fields. We are committed to publish up-to-date, original research articles, accessible openly through our official site https://isjet.pim.ac.th, or https://www.tci-thaijo.org/index.php/isjet/index. Our team have been working hard in this issue to sort for high-quality pieces of work. Efforts of authors, the Editorial Boards, and our contributors are much appreciated.

Needless to say that the technological landscape is advancing very rapidly. Our goal is to always ensure the flexibility of shifting perspectives across multidisciplinary approaches, while maintaining rigorous and academic standards and research ethics. Suggestions, thoughts, and submissions for future issues of the journal are always welcome.

Finally, on behalf of the Editorial Board, I would like to take this opportunity to thank everyone who has contributed to the ISJET, and to urge you to continue submit your research to publish in the journal. Your cooperation will be highly appreciated. If you have any questions or suggestions, please directly contact me or the journal coordinator at: isjet@pim.ac.th or https://www.tci-thaijo.org/index.php/isjet/index. I look forward to hearing from you.

With kind regards,

Dr. Nattakarn Phaphoom
Associate Editor of Information Technology

CONTENTS

- **Alternative Design for Salad Spinner-Sallatë** 1
  Suchada Rianmora, Dulyawat Padnoi, Tanapoom Rattanopas, and Boonyanuch Yantabutr

- **Development of an RFID System for Fixed Asset Monitoring in a University: A Case Study** 15
  Salamat Begmanov and Pisal Yenradee

- **Modified Coral Reef Optimization Algorithm for Motorcycle Routing of Food Delivery Service in Thailand** 26
  Tantikorn Pichpibul

- **Simple Online and Real-time Tracking with Feature Matching Enhancement for Re-identification after Occlusion** 34
  Koksal Chou, Natsuda Kaothanthong, Chawalit Jeenanunta

- **Thai Celebrity Information Extraction Based on Association Rule Measures** 42
  Chinorot Wangtragulsang, Nattakarn Phaphoom, Phannachet Na Lamphun, Pisit Charnkietkong, Jian Qu

- **The Comparison's Food Nutrition of Roasting of Cocoa Bean from some Private Company in Thailand and Taiwan** 51
  Korawit Chaisu

PIM
PANYAPIWAT
INSTITUTE OF MANAGEMENT
สถาบันการจัดการปัญญาภิวัฒน์


PIM
PANYAPIWAT
INSTITUTE OF MANAGEMENT
สถาบันการจัดการปัญญาภิวัฒน์

Alternative Design for Salad Spinner-*Sallatë*

Suchada Rianmora, Dulyawat Padnoi, Tanapoom Rattanopas and Boonyanuch Yantabutr

School of Manufacturing Systems and Mechanical Engineering
Sirindhorn International Institute of Technology, Thammasat University
Pathumthani, Thailand
E-mail: suchada@siit.tu.ac.th, boss.dulyawat@gmail.com, tanapoomerz@gmail.com, yantabutr.b@gmail.com

Received: April 22, 2019 / Revised: June 11, 2019 / Accepted: June 26, 2019

***Abstract*—In order to develop and improve the salad spinner for everyday use with the least amount of time and skills required, and for a limited storage space, product design and development (PDD), rapid prototyping (RP) concepts have been applied for creating the guideline of the conceptual model, *Sallatë* salad spinner. Three alternative designs are suggested based on Kansei Engineer method with questionnaire. Dimensions and physical characteristics of the salad spinner have been created by applying the concept of ergonomics to fit the people who use it. Using this proposed design can help the users to minimize their time spent preparing ingredients with no skills required.**

***Index Terms*—Product design and development (PDD), Rapid prototyping (RP), Salad spinner, and Ergonomics Design.**

I. Introduction

Nowadays, an increasing amount of people is becoming aware of the importance of taking care of their body and eating healthy. As the newer generation are more concerned about their health and are attentive towards clean food and salads. With 25.5% [1] of the target customer, aging between eighteen to thirty-five years old, living in the metropolitan area, living space and time is limited. With no space and time, preparing their own meal can take a considerable amount of time according to individual skills.

Therefore, most people tend to buy meals, instead of preparing for their own. However, the price of salads for instance, is more expensive than most of the common recipe menus, and is more expensive comparing to the original cost of the ingredients. In addition, with chemicals and dirt on vegetables, improper cleaning method can cause illness. In response to this problem, the study will be proposing to investigate several options for making the meal preparation faster and require lesser skills with kitchen tools.

Before starting to design the salad spinner, a questionnaire was raised, with the area of interest being the metropolitan region. The questionnaire focused on how the target customer thinks towards a new kitchen gadget appliance that can shortens time preparing and cooking regarding limited storage spaces.

II. Research Background

Present in this section are the background of the research for identifying the customer's behavior, requirement and perceptions towards the salad spinner. These people will be accounted as the target group of the new salad spinner design. Four phases of *Product Design and Development* (PDD) have been described in the following subsection.

Before getting into phase 1, we reviewed some of the related researches and the existing salad spinner products in the market. After the questionnaires have been completed, a combination of both the base model and the questionnaire results will be taken into consideration towards the primary model. The number of respondents was 112 and all respondents live in the Bangkok metropolitan region and surrounding provinces. The questions were emphasized on the analysis of traditional kitchenware on new generation consumer behavior.

• *Customer Requirement*

Due to a hasty lifestyle in the city, people need proper equipment to keep up with their pace. With new generations trying to maintain a healthy lifestyle, an appliance that could prepare food and shortens time spent preparing food would be a solution.

• *Customer Perception*

Referring to the normal method, washing vegetables rinsed with water in a bucket is a common thing that every household does. However, with chemicals and dirt on vegetables, improper cleaning method can cause illness. Rinsing and washing with pure water helps reduce both normal and chemical residue around 25% [2]. For vinegar or baking soda mixed with water helps reduce left over residues approximately, 60% and 90% [2] respectively, compared to pure water. This infers that a new design should be able to withstand these chemicals.

• *Existing Products*

As being said, there are many existing appliances in the market already, but mostly all of them are basic gadgets or has only a few functions. Therefore, comparing the existing products in the market has been done to see its flaws and strengths, so it could be used as a reference for further use.

As there are many online market sources, the samples have been analyzed wholly and narrowed it down to four main sites, which are *Amazon*, *Alibaba*, *E-bay*, and *Lazada*.

After we explored the market, as shown in the four tables above, we compare all of the best models in the market together to find the most suitable reference model, as shown in Table V and from comparing the best seven models, the fifth model, "*Kitchen Master All-in-One Salad Maker*" is selected to be the primary model because of its versatility

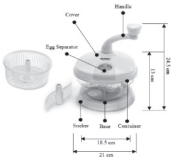
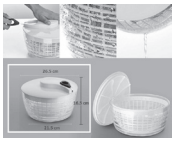
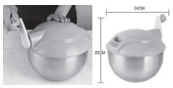
1. Products from Amazon

TABLE I
PRODUCTS FROM AMAZON

No.	Product and Components	Picture
1	**Salad Spinner LOVKITCHEN [3]** The dimension of the spinner is 25.4 × 25.4 × 15.24 cm. The material of this product is Hard Plastic. Retails at $18, around 592 THB [4].	
2	**Nopro Mini Salad Spinner [5]** The dimension of the spinner is 13 cm height × 20 cm diameter. Retails at $13, around 427 THB [4].	
3	**Prepworks by Progressive [6]** The dimension of the spinner is 20 × 20 × 8 cm. Retails at $21, around 691 THB [4].	

2. Products from Alibaba

TABLE II
PRODUCTS FROM ALIBABA

No.	Product and Components	Picture
1	**Hand-Powered Food Chopper Salad Spinner Vegetable Mixer [7]** The dimension of the spinner is 13 cm height × 21 cm diameter. The material of this product is plastic (PP+PS). Retails at $8.2 around 270 THB [4].	
2	**Vegetable Dehydrator [8]** The dimension of the spinner is 16.5 cm height × 26.5 cm diameter. The material of this product is plastic (PP+PS). Retails at $8, around 265 THB [4].	
3	**WT Stainless Steel Vegetable Salad Spinner [9]** The dimension of the spinner is 22 cm height × 24 cm diameter. The material of this product is stainless steel. Retails at $8, around 265 THB [4].	
4	**Green and White Manual Rotate Vegetable Salad Spinner [10]** The dimension of the spinner is 20.2 cm x 20.2 cm x 19 cm. The material of this product is plastic (PP+PS). Retails at $6.53, around 216 THB [4].	
5	**Eco-Friendly Salad Spinners with bowl [11]** The dimension of the spinner is 19.5 cm height x 26 cm diameter. The material of this product is plastic (PS+PP). Retails at $6.59, around 218 THB [4].	

3. Products from Lazada

TABLE III
PRODUCTS FROM LAZADA

No.	Product and Components	Picture
1	**Micronware Salad Spinner [12]** The dimension of the spinner is 20 cm height × 25 cm diameter. The material of this product is hard plastic. Retails at 255 THB.	
2	**GEFU Salad Spinner ROTARE [13]** The dimension of the spinner is 17 cm height × 25 cm diameter. The materials of this product are plastic (ABS/PS) and stainless steel. Retails at 1,790 THB.	
3	**ZTS Kitchen Cook Fruit Vegetable Salad Spinner Dryer Colander Strainer Sifter Tool [14]** The dimension of the spinner is (L) × (W) × (H) 19 × 16 × 16.5 cm. The material of this product is plastic (PS+PP). Retails at 666 THB.	
4	**Multifunction JUMBO 4.5 QUART [15]** The dimension of the spinner is 22 cm height × 24.5 cm width. The material of this product is plastic (PS+PP). Retails at 999 THB.	
5	**GEFU Salad Spinner SPEED WING [16]** The dimension of the spinner is 15 cm height × 27 cm width. The material of this product is stainless steel. Retails at 3490 THB.	

4. Products from E-Bay

TABLE IV
PRODUCTS FROM E-BAY

No.	Product and Components	Picture
1	**Kitchen Master All-in-One Salad Maker [17]** With a transparent glass, this salad spinner retails at $30, around 986 THB [4].	
2	**Press Salad Spinner [18]** The dimension of the spinner is 26 × 26 × 15 cm. Retails at $40, around 1315 THB [4].	

TABLE V
SALAD SPINNER – COMPARISONS

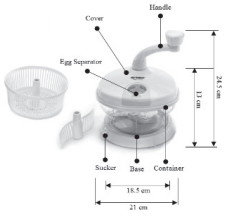
Product	Functions
 LovKitchen Large [3]	• Cutter : N/A • Hand Pump : N/A • Hand Spin : Yes • Die Change : N/A • Drainer : Yes • Brake : N/A • Side Lock : Yes • Water Hole : N/A • Collapsible : N/A
 Nopro Mini Salad Spinner [5]	• Cutter : N/A • Hand Pump : N/A • Hand Spin : Yes • Die Change : N/A • Drainer: Yes • Brake : N/A • Side Lock : Yes • Water Hole : Yes • Collapsible : N/A
 Prepworks [6]	• Cutter : N/A • Hand Pump : N/A • Hand Spin : Yes • Die Change : N/A • Drainer : N/A • Brake : N/A • Side Lock : N/A • Water Hole : N/A • Collapsible : Yes
 Hand-Powered Food Chopper Salad Spinner Vegetable Mixer [7]	• Cutter : Yes • Hand Pump : N/A • Hand Spin : Yes • Die Change : N/A • Drainer : N/A • Brake : N/A • Side Lock : N/A • Water Hole : Yes • Collapsible : N/A

TABLE V
SALAD SPINNER – COMPARISONS

Product	Functions
 Micronware Salad Spinner [12]	• Cutter : N/A • Hand Pump : N/A • Hand Spin : Yes • Die Change : N/A • Drainer : N/A • Brake : N/A • Side Lock : N/A • Water Hole : N/A • Collapsible : N/A
 Kitchen Master All-in-One Salad Maker [17]	• Cutter : Yes • Hand Pump : N/A • Hand Spin : Yes • Die Change : Yes • Drainer : N/A • Brake : Yes • Side Lock : N/A • Water Hole : N/A • Collapsible : N/A
 Presse Salad Spinner [18]	• Cutter : N/A • Hand Pump : Yes • Hand Spin : N/A • Die Change : N/A • Drainer : Yes • Brake : N/A • Side Lock : N/A • Water Hole : N/A • Collapsible : N/A

A. Phase 1: Customer's behavior towards clean food (salad spinner)

After collecting some ideas about customer's behaviors towards clean food (salad spinner), to construct the drafted design of the spinner, three main activities were established; *data collection process*, *data analysis*, *discussion results and conclusion.*

1. Data collection

In order to construct the salad spinner, market survey has been conducted by using data collection method. Questionnaire was selected as the method for data collection process. Questions were created and distributed in three parts, in order to determine the importance parameters such as how often do they cook, kitchenware storage size, most suitable space to be stored in the cupboard, how people response to a new gadget that can shorten the amount of food preparation time and most importantly the expected price that customer's are eager to pay for the salad spinner.

Illustrated in Fig. 1 is the sample questions of the self-administered questionnaires used for finding the customer's opinions and requirements on the existing kitchenware, some answers could be used for interpreting the words to be design directly and effectively.

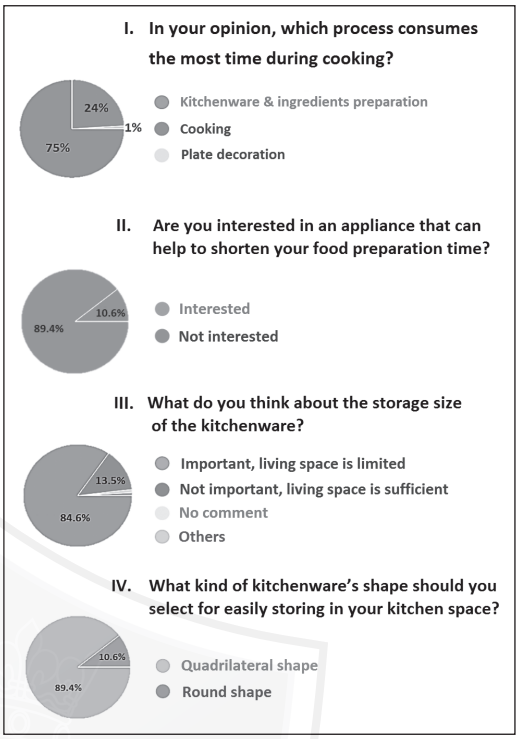


Fig. 1. The sample questions of the self-administered questionnaires raised for identifying the customer's requirements.

2. Data analysis

There were 112 questionnaire participants who took part answering via Google form. The first part of the questionnaire contains basic questions about the participant. From the questionnaire results 64 participants were female, 46 were male and two not specified. With 57.1% aging between 18 – 25 years old, 20.5% aging between 26 – 35 years old, and the rest is 36 years old and above. Most of the participants' answers live in a household with 3 – 5 family members, and their income per month, 33% being more than 35,000 THB (1100 USD), 22.3% ranging from 15,000 – 25,000 THB (470 – 780 USD) and so on. The second part of the questionnaire was base on "Problems you have encounter." Most participants, 37.5% spends around half an hour to an hour cooking, 27.7% spend less than half an hour, 16.1% spends more than an hour cooking, despite 18.8% does not have any spare time to cook. Along with 28.6% of participants cooking once or twice per month, 26.8% cook more than 4 times per month and 23.3% cook 3 – 4 times per month. With more than 76% of the participants saying they spend most of their time preparing kitchenware and ingredients, more than 84% thinks that space for storing kitchenware is important.

The results obtained from the questionnaire indicate that participants are interested in an appliance that can help shorten food preparation time, and they preferred to have a quadrilateral shape for the appliance and most response expecting the product to cost around 400 – 700 THB (12–22 USD).

3. Discussion of questionnaire results and conclusion

After obtaining the results from the questionnaire, our group will continue the design with a quadrilateral shape. The majority of the response said they want the salad spinner to be push by hand. However, our group discussed that we will continue with the salad spinner using rotating mechanism by hand, due to the standard ergonomic height of the kitchen countertop [19] is 36 inches, roughly 91 cm above floor, because of that, hand spin mechanism is used due to less effort used for operating. In addition to the questionnaire results, our group decided to add some functions to the primary model to create a new design that will be more convenient to the user.

B. Phase 2: Translating requirements to be the design

In order to translate the requirements of the target customers to be the salad spinner design, factors affecting the salad spinner are considered and classified into three groups; *the dimension of appliance, mechanism, and material for each part.*

• *Dimension of Appliance*

According to the research objective, where storage space of the appliance is to be reduced. The design of the kitchenware appliance has to be compact, in the mean time providing sufficient amount of serves that customers desired, while being able to conveniently fitting in the corners of the customer's cupboards as well.

• *Mechanism*

To shorten meal preparation time, the movement of kitchenware appliance must lessen the user's effort and is easier to operate than common appliances.

• *Material for each part*

This research applies that knowledge about materials for selecting the suitable material for individual part, with lowest cost possible.

III. The Salad Spinner, SALLATË

After translating the customer's behaviors and requirements from the self-administered questionnaires, the drafted design was constructed. The key theme of this developed design was raised by seeking a gap in the market where there is no salad spinner as functional just yet, with the metropolitan area's life style and this generation's devotion towards clean and healthy foods, customers will be able to prepare food/ingredients for themselves, despite individual cooking skills within a short amount of time. These have led to our research for creating an alternative design for salad spinner, which is called *Sallatë*, and the overall phases required for accomplishing this new design, 5 phases are expressed as shown in Fig. 2.

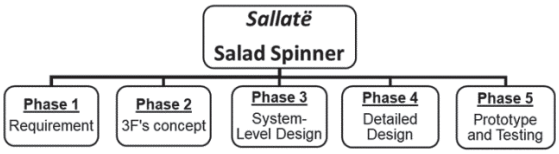


Fig. 2. Five phases for creating new design of salad spinner.

A. Phase 1: Expected design and Requirement from the questionnaires and the reference models.

From the questionnaire results combined with the reference model, a new prototype design that is more innovative than the existing products could be developed. Compare and adapt the good things from the existing product, with additional functions that could be added to the primary model, with a proper engineering point of view.

As the dimension of these products are roughly 20 × 20 × 20 cm, the expected design can be inferred that it should be roughly around this size as well. Since material used for these product references are all plastic, the expected design would likely use food-grade plastic. The expected design would likely be kept flat when left idle, and is able to fit into the corners inside cupboards. Additional functions will be included for a multipurpose used. The product characteristics, customer emotional requirements, and their definitions are presented in Table VI and VII.

TABLE VI
Product Characteristics and Their Definitions

Product Characteristics	Definitions
Quadrilateral	Salad spinner has a quadrilateral shape.
Round	Salad spinner has a round shape.
Rotating *(Spin)*	Applying force in circular motions to the handle.
Pushing	Applying force vertically downwards to the cap/topmost area of the equipment.
Multifunctional	Salad spinner can perform numerous operations.
Simple	Salad spinner can perform only specific operations.
Normal *(Plastic)*	The quality of the material is ordinary.
Excellent *(Steel)*	The quality of the material is exemplary.

TABLE VII
CUSTOMER EMOTIONAL REQUIREMENTS AND THEIR DEFINITIONS

Customer Emotional Requirements	Definitions
Affordable (Cheap)	Salad spinner should be sold with low price.
Unaffordable (Expensive)	Salad spinner should be sold with high price.
Modern	Salad spinner has a new, up-to-date appearance.
Classic	Salad spinner has a typical appearance.
Light	Salad spinner contains light weight
Heavy	Salad spinner contains high weight
Luxurious	An upscale design engages customer to buy the product
Average	A common design engages customer to buy the product

B. Adjective words with 7-points semantic differential scale

The answer of the 46 participants were analyzed from SPSS program. Three main factors are concerned as the following.

• *Kaiser-Meyer-Olkin Measure of Sampling Adequacy*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy uses to check the data validity for *Factor Analysis*. The value should be more than 0.5 for the reliability of the data obtained and make sure that the data is suitable for *Factor Analysis*. The result obtained from this step is presented in Fig. 3.

• *Barlett's Test of Sphericity*

The result is applied to deal with the hypothesis test. For this test the hypothesis is shown as:

H_0: Correlation Matrix = 1

H_1: Correlation Matrix ≠ 1

When the significance value is less than 0.05, H_0 is rejected. This can be concluded that the Correlation Matrix ≠ 1. The result of this test obtained is shown in Fig. 3.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.523
Bartlett's Test of Sphericity	Approx. Chi-Square	53.533
	df	28
	Sig.	.003

Fig. 3. Kaiser-Meyer-Olkin Measure of Sampling Adequacy result.

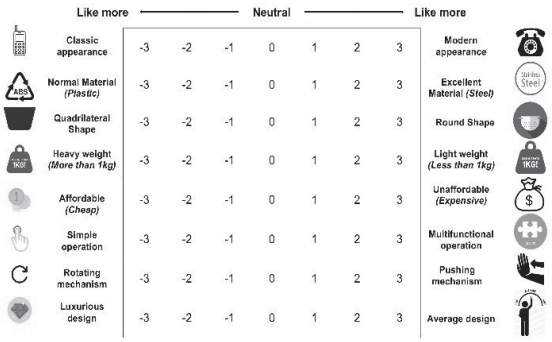


Fig. 4. Adjective words with 7-points semantic differential scale.

• *Rotated Component Matrix*

Rotated Component Matrix is used for identifying which factor should be arranged in which group. This can be considered by factor loading of each factor. Which factor loading is the greatest one, it is considered to be in that group. The scree plot shows the *Eigenvalue* on y-axis and the *component number* is on x-axis (Fig. 5). When the *Eigenvalue* is more than 1, the consideration of component number was emphasized and recorded.

A scree plot always displays a downward curve. The point where the slope of the curve is clearly leveling off indicates the number of factors that should be generated by the analysis. Both criteria sometimes yield an unreasonably high number of factors. And the scree plot suggests either three or five factors due to the way the slope levels off twice.

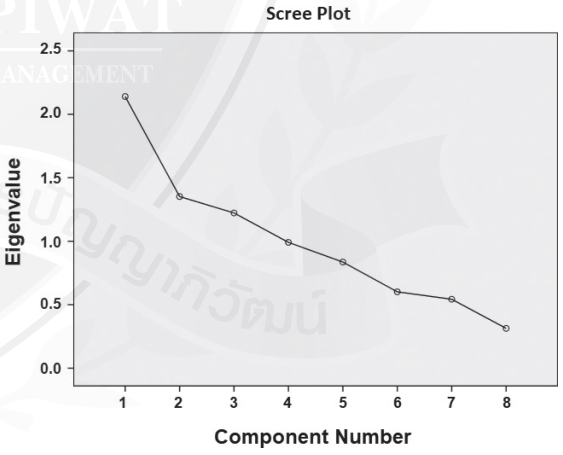


Fig. 5. The Scree Plot.

For running a factor analysis is to reduce a large number of variables that describe a complex concept such as economic status to a few interpretable latent factors. In other words, we would like to find a smaller number of interpretable factors that explain the maximum amount of variability in the data. The design of salad spinner (Sallatë) can be separated into 3 groups (Fig. 6).

Rotated Component Matrix[a]

Kansei words		Component		
Positive	**Negative**	**1**	**2**	**3**
Modern	Classic	0.825		
Plastic	Stainless Steel	0.692	0.441	-0.289
Quadrilateral	Round	-0.535	-0.428	-0.375
Light	Heavy		0.742	
Affordable	Unaffordable		0.707	
Multifunctional	Simple		-0.212	0.718
Spin	Push			0.651
Luxurious	Average	-0.5		0.547

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Fig. 6. Rotated Component Matrix.

Presented in Table VIII are the adjective words recommended for creating new design of salad spinner where the conceptual ideas were grouped according to the results from "*Rotated Component Matrix*" (Table IX).

TABLE VIII
THE ADJECTIVE WORDS RECOMMENDED FOR CREATING THE NEW DESIGN OF SALAD SPINNER

Customer's Requirement	Product Specification
1. *Price:* Expensive/Cheap 2. *Appearance:* Modern/Standard 3. *Weight:* Light/Heavy 4. *Design:* Simple/Luxurious 5. *Size:* Compact/Big	1. *Mechanism:* Push/Spin 2. *Material:* Plastic/Steel 3. *Function:* Multi-functional/ Simple 4. *Shape:* Quadrilateral/Round

TABLE IX
THE CONCEPTUAL IDEAS OBTAINED FOR THE NEW DESIGN

Model No.	Idea of salad spinner	Customer's Requirement	Product Specification
1		"Modern"	"Plastic" "Round"
2		"Light" "Affordable"	"Plastic"
3		"Luxurious"	"Multi-functional" "Spinning"

The researchers started to sketch the spinning design with various platforms and functions to fit the customer's requirements and product specifications listed in the previous phase (Table IX). The water draining part and the spinning system were the key components of this approach. Illustrated in Fig. 6 to 8 are the drafted designs (freehand drawings) of the salad spinning bowl.

For *model A*, the lid was designed as round-shaped cover with push-to-spin function. The drainer, extra die/cutter socket, and brake system were provided on the lid area around the cylinder-shaped spinner. Bowl and basket were created in the same direction with the tapered cylinder design. The draining sockets were formed in pattern with uniform layout.

For *design B*, the overall functions of this model were quite similar to the first one; however, the topmost and bottommost areas were changed. The round-shaped design (i.e., tapered cylinder bowl with round lid) provided the waste spaces; when it was located on the table or cooking area, since it could not be fitted easily to the other corner-designed cookware/kitchen products (e.g., microwave).

During spinning activity, the user might lose control since there were no references or handles to help the user to fix the bowl in place. Redesigning the salad spinner as a four-sided shape with every angle around ninety degrees and anti-slip buttons underneath the bowl could help to reduce the accidents. However, to remove the basket in and out easily, a taper design is required for creating bowl. The proper sketch of this model is shown in Fig. 8.

Sudden, extreme fatigue occurs for a variety of reasons, one of those is applying force on the push button (spinning mechanism) several times (i.e., up and down directions). Doing this may cause the fatigue around the fingers and hand, in order to reduce muscle strain and pain, the alternative spinning mechanism should be introduced. Normally, using the push-to-spin function presents the disadvantage during spinning attempt; pushing stroke is quite short. It may need a speed-increaser gear to increase the rotating stroke; however, the speed-increaser gear reduces the output torque which may result in insufficient spinning torque for certain vegetable.

For *model C*, the cone-shaped spinning handle was created to connect with the gear for turning the basket in 360 degrees. Comparing to the previous design, the way to drain the water out of the basket was quite easy and less human labour required. However, the shape of the lid and basket presented in this design (Fig. 9) were not recommended. The corner/edge design was required.

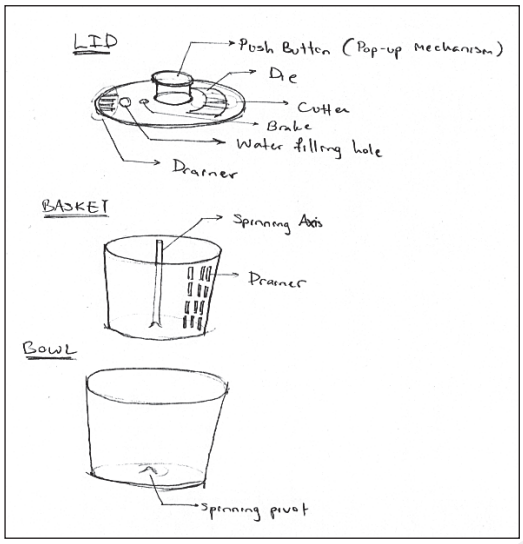


Fig. 7. Drafted model A: Push-to-spin design with round lid.

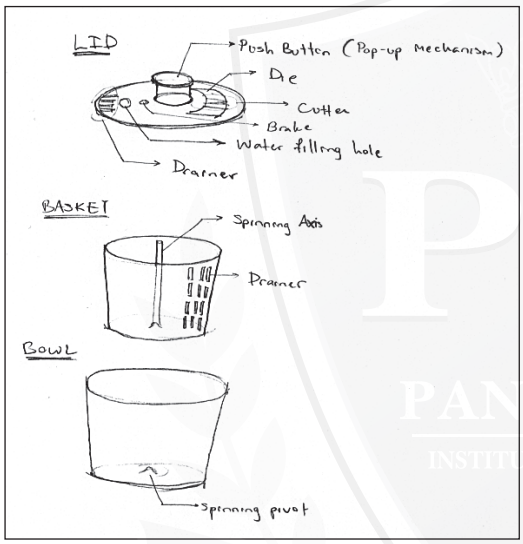


Fig. 8. Drafted model B: Push-to-spin design with square lid.

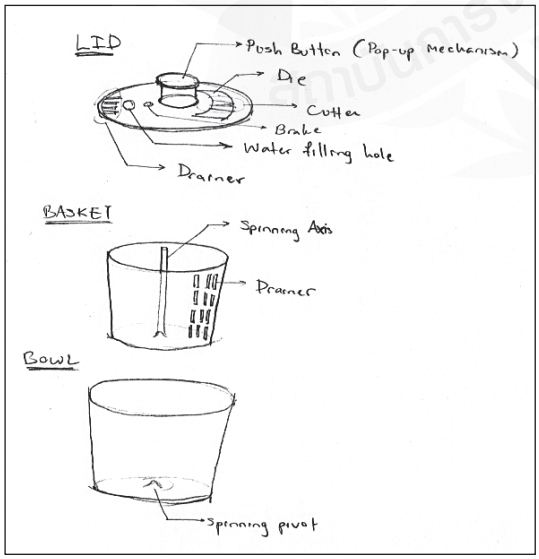


Fig. 9. Drafted model C: Spinner (Handle) with round bowl.

The advantages of the existing products which are available in the market (as presented in the related works), and the sketched models (A, B, and C) were applied as the guidelines for creating the alternative salad spinner.

The following issues were used as the key components:

- spinner with cone-shaped handle
- a four-sided shape (i.e., corner/edge lid and bowl)
- tapered cylinder basket
- anti-slip buttons underneath the bowl
- organized draining sockets around the basket and the lid
- brake system
- extra die/cutter on the lid

C. Phase 2: Concept of "3F's approach" for the salad spinner

The research of interest for this salad spinner prototype is the functional use of the salad spinner. As the aforementioned of the ideas for salad spinner, the "*Affordable*" issue was the critical point for the new design to be survived in the competitive market. To emphasize its functional use, the three main components details and functions will be mentioned in this chapter. The salad spinner embodies the 3F approach, form, fit and function as shown below.

I. Form

As mentioned earlier, the salad spinner dimension will be roughly 20 × 20 × 20 centimeters, respectively. The design of the salad spinner will be in a quadrilateral shape. This is so that the salad spinner can fit neatly in the corners of the storage cupboard (Fig. 10: a comparison between quadrilateral and rounded shape kitchenware), according to limited kitchen space in the metropolitan area.



Fig. 10. Quadrilateral and round shaped kitchenware [20].

II. Fit

The salad spinner consists of three main parts, which are *lid, basket*, and *bowl*, the drafted configurations of this proposed model are shown in Fig. 11. The details of each component will be presented in the sub-section below.

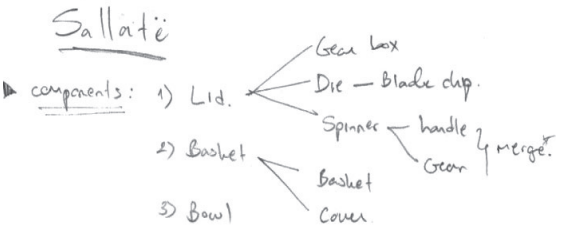


Fig. 11. Drafted configurations of the proposed model.

1) Lid

For the lid component contains the gearbox, die, and the spinner. Shown in Fig. 12, is the lid of the expected design, the brake, water filler and drainer has been added for draining and washing conveniently. The die slot contains blade chip storage whereas the blade is kept and the blade chip slot is where the user will be able to change depending on the die the user chose, chopping die, slicing die, for instance.

The blade chip contains a knife, like a mandolin slicer, whereas the user can slice vegetables or fruits along the die slot according to the blade type die the user chose, an example is shown below in Fig. 13. To attach the lid neatly with the bowl, rubber stripes will be attached on the side.

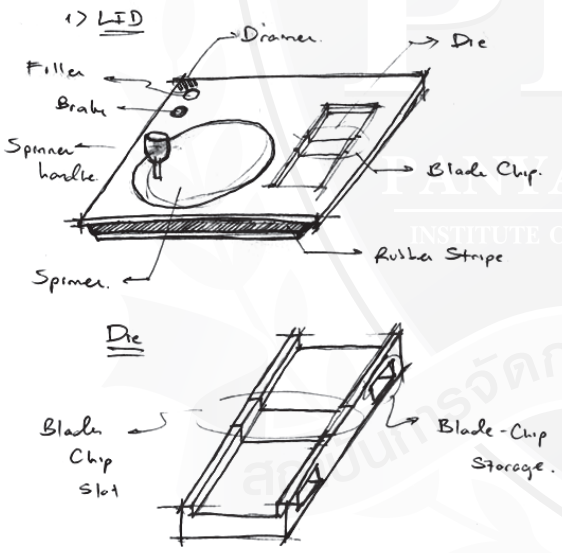


Fig. 12. Conceptual model of *Lid* and *Die slot*.



Fig. 13. Example of the die slicer (Mandolin Slicer) [21].

2) Basket

Presented in Fig. 14 is the basket of the expected design, the main component of the basket is the cover and basket. The cover is inserted with gear set and is locked with the basket.

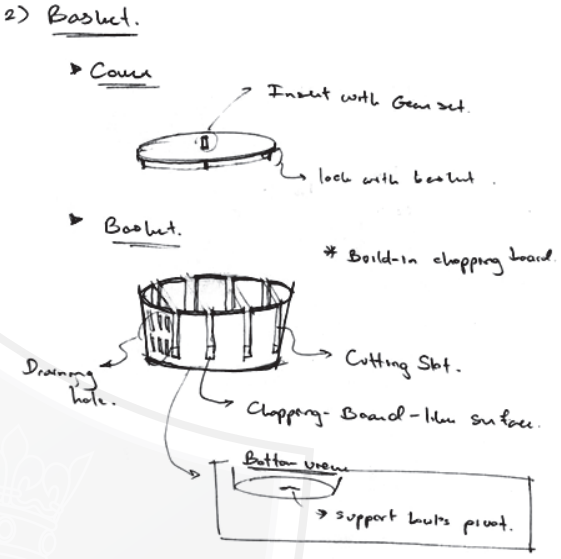


Fig. 14. Conceptual model of Basket.

The basket has a build-in chopping board like surface, with the basket designed to have cutting slot so that the user can cut vegetables externally by inserting a knife through the cutting slot for precise cutting, basket has small draining holes for the water to be drained out, and underneath the basket there will be a pivot hole to support the bowl's pivot.

3) Bowl

Referring to Fig. 15 is the bowl of the expected design, with a pivot point for the spinning axis and an anti-slip surface to hold the bowl while spinning in place.

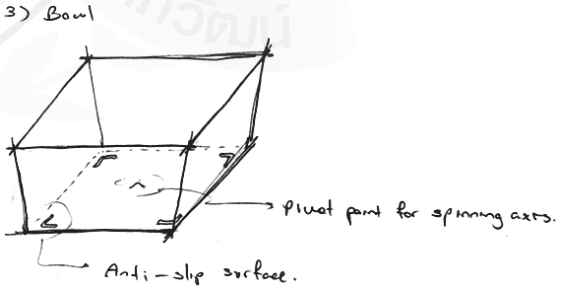


Fig. 15. Conceptual model of Bowl.

III. Function

The function of the salad spinner is to minimize time preparing ingredients, clearly cut vegetables and fruits precisely, and drain/wash water out leaving vegetables/fruits/food nice and clean.

For cutting vegetables and fruits precisely, there will be blade chip slots that allow the user to choose what type of cut they would like to mince their food. The die slot contains blade chip storage where the blades are kept and the blade chip slot is where the user will be able to change the type of knife, depending on the die the user chosen, the user will be able to cut the vegetables, fruits, etc, precisely by sliding back and forth. As for the basket, the user will also be able to cut vegetables externally via the cutting slot by inserting a knife through the gaps of the basket.

D. Phase 3: System-level design

In order to identify the physical characteristics of the salad spinner, all components are classified and operational stage conditions. These data can help the designer to minimize some mistakes that might be occurred during the design stage. Fig. 16 illustrates the main frame of the developed prototype.

For the lid mechanism, six items are required: *blade clip, handle, gear set, die/die slot, brake and spinner.* These six items build up the lid, and the mechanism to chop, spin and wash vegetables/fruits/food inside. At the bottom of the bowl, we will attach the anti-slip pad on the corners to hold the bowl while spinning in place.

Lastly, the basket set, two items are required which are *basket cover and the basket.* The basket cover is attached to the bottom of the lid and the basket has a pivot hole underneath which will be put on top of the bowl.

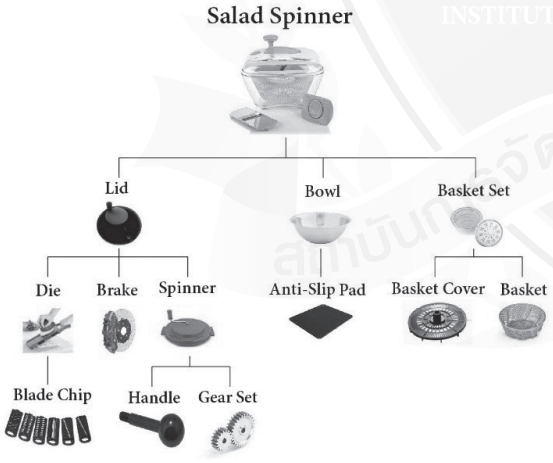


Fig. 16. The mainframe of the salad spinner.

E. Material considerations

From the mainframe diagram, different parts of the salad spinner will use different materials. For the salad spinner to be set at the lowest price possible, two plastic materials will be used to make the salad spinner, *Polypropylene (PP) and Acrylonitrile Butadiene Styrene (ABS).*

1) Polypropylene (PP)

The main property of PP [22] is that it is semi-rigid, translucent, has good chemical resistance, and good heat resistance [23]. The properties of PP are shown below in Table X.

TABLE X
PROPERTIES OF PROPYLENE

Physical Properties:	Value:
Tensile Strength:	0.95-1.30 N/mm^2
Notched Impact Strength:	3.0-30.0 Kj/m^2
Thermal Coefficient of Expansion:	100-150 $\times 10^{-6}$
Max. Continued Use Temperature:	80°C (176°F)
Melting Point:	160°C (320°F)
Glass Transition Temp. (Atactic):	-20°C (-4°F)
Glass Transition Temp. (Isotactic):	100°C (212°F)
Density:	0.905 g/cm^3

2) Acrylonitrile Butadiene Styrene (ABS)

ABS is an ideal material of choice for various structural applications. Some advantages of ABS [24] is that it has a good impact resistance, even at low temperatures, is a good insulating properties and is mechanically strong and stable over time. The properties of ABS is shown below in Table VI.

TABLE XI
PROPERTIES OF ABS

Physical Properties:	Value:
Elongation at Break	10-50%
Elongation at Yield	1.7-6%
Flexibility (Flexural Modulus)	1.6-2.4 GPa
Hardness Shore D	100
Stiffness (Flexural Modulus)	1.6-2.4 GPa
Strength at Break (Tensile)	29.8-43 MPa
Strength at Yield (Tensile)	29.6-48 MPa
Toughness (Notched Izod Impact at Room Temperature)	200-215 J/m

Therefore, PP and ABS will be use for the following parts, shown below in Table XII. The part that is in contact with food will use Polypropylene and for parts that are not in contact with food will use ABS to minimize the price as possible.

TABLE XII
MATERIALS USED FOR EACH PART

Function Part:	Material Used:
Spinner	ABS
Spinner Handle	ABS
Spinner Brake	ABS
Lid	Polypropylene
Bowl	Polypropylene
Die Slot	Polypropylene
Basket	Polypropylene
Spinner	ABS

F. Phase 4: Detailed Design

In order to create and develop the new design of the salad spinner, the characteristics of the key components which are *handle attached on the lid* (applying the concepts of ergonomic and detachable), *blade die located on the lid*, *basket* (cutting board inspired), and *quadrilateral shape of the basket and bowl* (storage utilization) are taken into considerations. Illustrated in Figs. 17-20 are the 3D CAD models of the lid, basket, and bowl designs.

I. Lid

As the lid is designed to be multifunctional, there are several functions that will be included, these functions are as follows.

1) Hand Spinner

The hand spinner will be designed to be able to fold/remove during storage and able to pull up/re attach during in use.

2) Brake

The brake will allow the user to stop the spinning basket without forcing at the handle to extend the product's life span.

3) Filling hole

The filling hole is designed to allow the user to fill up the water without taking the lid off to reduce time loss in meal preparation.

4) Drainer

The drainer is designed to allow the user to drain water without taking the lid off to reduce time loss in meal preparation.

5) Die slot

The die slot is designed for the user to be able to insert their desired type of cut by inserting a cutting die of their choice. The die slot is also designed to be able to stack up to obtain maximum utilization of space. The die for inserting the die slot will be designed based on basic cuts.

6) Die cover

The die cover will be the cover part of die section, to keep the die clean and make the appliance surface flat to optimize storage space.

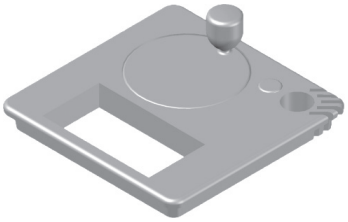


Fig. 17. CAD model of conceptual lid design.

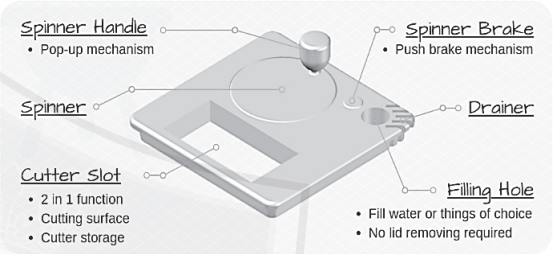


Fig. 18. Functions of the conceptual lid design.

II. Basket

The basket is designed to be able to cut the food on its base, with the blade slot designed to guide the blade while cutting. The drainage slot will be designed to have angle outwards, to provide the optimal drainage of the water after food washing.

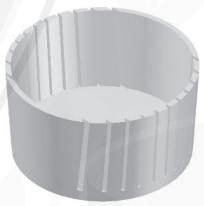


Fig. 19. CAD model of conceptual basket design.

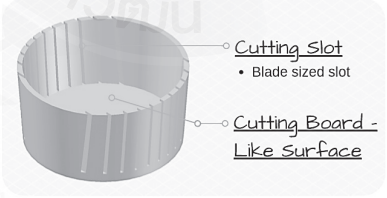


Fig. 20. Functions of the conceptual basket design.

III. Bowl

The bowl is designed to be microwavable and dishwasher safe, an anti-slip will be attached underneath to keep the bowl in place. Moreover, the bowl can be separated from the lid and basket to be used as a salad bowl itself. The dimension of the bowl will be compatible with the living space our target customer has.

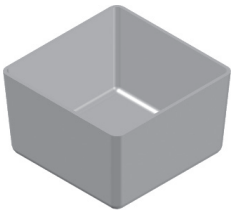


Fig. 21. CAD model of conceptual bowl design.

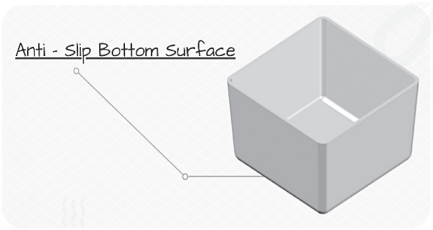


Fig. 22. Functions of the conceptual bowl design.

After combining all components, the 3D virtual model was established (Fig. 20) and this model was ready for fabricating in rapid prototyping (RP) process explained in the next section.

Presented in Fig. 24 is the overall details of the "*Sallatë*" salad spinner where the dimension and brief description of each component will be mentioned and expressed.

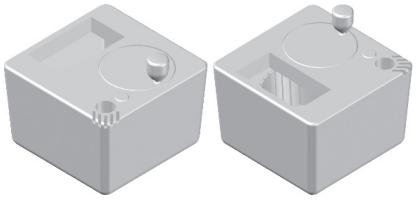


Fig. 23. 3D virtual model of the "Sallatë" salad spinner.

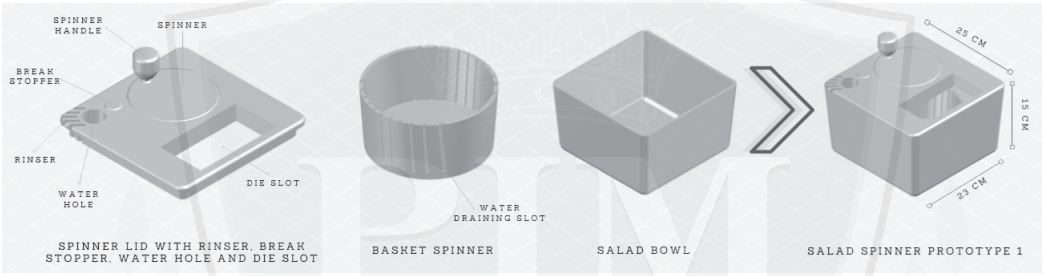


Fig. 24. The overall details of the proposed salad spinner model.

G. Phase 5: Testing and Refinement

After 3D model has been made by using SolidWorks, Rapid prototyping (RP) method has been used to create a prototype by using 3D printer. *XYZ da vinci 1.0A 3D printer* operated by using fused filament fabrication (FFF) technique. The material used is ABS plastic, which gives high strength and durability, as mentioned earlier in Table VII the material can be formed into different layer of the workpiece. The 3D printing is used for the salad spinner prototype model, the 3D printer layers the ABS plastic layer by layers into a salad spinner geometry shape. Fig. 25 is the prototype of the salad spinner printed by the 3D printer using ABS plastic.

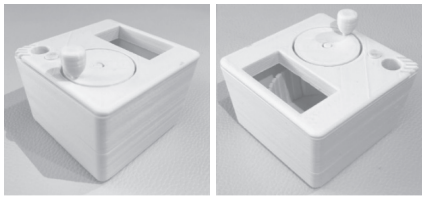


Fig. 25. Real picture of RP (Scale 1:3).

IV. Discussion and Conclusion

From the results above, the concept design of this product were occurred from the survey of customer's demand. Integrating between design and function is applied into the design of the product in order to satisfy demand of customer. The guidelines/criteria for creating the proper salad spinner are as follows.

- *Spinner:* cone-shaped handle, and 360-degree rotating system
- *Lid:* a four-sided shape with tapered design, organized layout for small draining sockets, brake system, and extra die/cutter
- *Basket:* tapered cylinder basket with organized draining sockets
- *Bowl:* a four-sided shape with anti-slip buttons underneath the bowl

After the core idea is acquired, mechanic and material parts are considered. From the results acquired earlier, 3D CAD model is constructed to show the design and rough function of the product. Next, material part is considered. Then, a prototype is created to show the appearances of the first phase

of product design. For further design, the mechanism part will involve the concept design with 3D CAD model to demonstrate how concept product will work. To produce and inject a new plastic mold, the mold costs 70,000 THB each. The price for polypropylene plastic is 79 THB [4] per kilogram, and for ABS plastic the price is 57 THB [4] per kilogram, for a minimum order of 1000 kilograms. To produce one complete product of the salad spinner, 'Sallatë', 0.165 kilograms (with a safety factor of 10%) of ABS plastic will be used for three parts; lid, gear, and cutting die. As for polypropylene plastic, 0.275 kilograms (with a safety factor of 10%) will be use for three parts; bowl, basket, and basket lid. To achieve this unit price, corresponding with the minimum order, the amount of ABS plastic required is 1000 kilograms in order to produce 6060 pieces, and 1665 kilograms of polypropylene is required in order to produce 6054 pieces for this unit cost price. The processing cost for the "*Sallatë"* includes 1,000,000 molding cycles with 160 THB for the price per cycle, amount to a cost of 350,000 THB for the price of mold (five molds are selected), which is 457 THB for processing cost per unit. For a total of 6000 units, 546 THB will be the cost of material and processing cost per unit, and plus a 30% profit 710 THB will be the selling price of the "*Sallatë"*. Nevertheless, in case of injecting a new plastic mold, the cost might be quite high for a university research project; our group has another alternative way to direct this know-how as well. We can also do a flow analysis of how the water flows in and out of the basket. Also, the prototype design refinement will take place in upcoming events as we rendered material 3D model and animate the salad spinner demonstration.

References

[1] Urban Population of Thailand, (2018, Oct.) The World Fact-book. [Online]. Available: https://bit.ly/1nk5eRW

[2] Maharusee Yamee (2015, May). Journal of Public Health Nursing. Insecticides Near Disaster. [Online]. 29(2). [Online]. Available: https://bit.ly/2CN442j

[3] Salad Spinner LOVKITCHEN. (2018, Oct.). [Online]. Available: https://amzn.to/2AdqjfC.

[4] Bank of Thailand, (2018, Oct.). Daily Foreign Exchange Rates. [Online]. Available: https://bit.ly/2OpnRv0

[5] Norpro Mini Salad Spinner. (2018, Oct.). [Online]. Available: https://amzn.to/2CQnseQ

[6] Prepworks by Progressive Collapsible Salad Spinner. (2018, Oct.). [Online]. Available: https://amzn.to/2EooeBr

[7] Hand-Powered Food Chopper Salad Spinner Vegetable Mixer. (2018, Oct.). [Online]. Available: https://bit.ly/2NKfLrF

[8] Vegetable Dehydrator. (2019, Feb.). [Online]. Available: https://bit.ly/2GuWxam

[9] WT Stainless Steel Vegetable Salad Spinner. (2019, Feb.) [Online]. Available: https://bit.ly/2trtmg0

[10] Green and White Manual Rotate Vegetable Salad Spinner. (2019, Feb.). [Online]. Available: https://bit.ly/2TOezrb

[11] Eco-Friendly Salad Spinner with bowl. (2019, Feb.). [Online]. Available: https://bit.ly/2GO28b5

[12] Micronware Salad Spinner. Available: https://bit.ly/2Cml0Mo (2018, Oct.). [Online].

[13] GEFU Salad Spinner ROTARE. (2019, Feb.). [Online]. Available: https://bit.ly/2S8UM45

[14] ZTS Kitchen Cook Fruit Vegetable Salad Spinner Dryer Colander Strainer Sifter Tool. (2019, Feb.). [Online]. Available: https://bit.ly/2EfLkbo

[15] Multifunction JUMBO 4.5 QUART. (2018, Oct.). [Online]. Available: https://bit.ly/2GKdlto

[16] GEFU Salad Spinner Speed Wing. (2018, Oct.). [Online]. Available: https://bit.ly/2EeD77c

[17] Kitchen Master All-in-One Salad Maker. (2018, Sep.). [Online]. Available: https://bit.ly/2PGaVxH

[18] Presses Salad Spinner. (2018, Oct.). [Online]. Available: https://ebay.to/2Ox3jRC

[19] Chris Adams (2018, July). Height Standards for Kitchen Countertops. ThoughtCo. [Online]. Available: https://bit.ly/2A1KtYb

[20] Quadrilateral and round shape kitchenware. (2019, Jan.). Available: https://bit.ly/2H54sur

[21] Mandolin Slicer. (2019, Jan.). [Online]. Available: https://bit.ly/2SJzjUu

[22] Properties of Polypropylene. (2018, Nov.). [Online]. Available: https://bit.ly/2z9P0aX

[23] Advantage of Polypropylene. (2018, Nov.). [Online]. Available: https://bit.ly/2PyIFjL

[24] Properties of ABS. (2018, Nov.). [Online]. Available: https://bit.ly/2Pp59U6



Suchada Rianmora is a lecturer in School of Manufacturing Systems and Mechanical Engineering (MSME), Sirindhorn International Institute of Technology, Thammasat University, Thailand.

She received her D.Eng from Asian Institute of Technology, Thailand. Her research interests are reverse engineering, rapid prototyping, design and development, and manufacturing processes.



Tanapoom Rattanopas is a senior student in Industrial Engineering Program from School of Manufacturing Systems and Mechanical Engineering (MSME), Sirindhorn International Institute of Technology, Thammasat University, Thailand. His research interests are Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), reverse engineering, product design and development, and finite element analysis.



Dulyawat Padnoi is a senior student in Industrial Engineering Program from School of Manufacturing Systems and Mechanical Engineering (MSME), Sirindhorn International Institute of Technology, Thammasat University, Thailand. His research interests are the product design and development, manufacturing process design, and rapid prototyping.



Boonyanuch Yantabutr is a senior student in Industrial Engineering Program from School of Manufacturing Systems and Mechanical Engineering (MSME), Sirindhorn International Institute of Technology, Thammasat University, Thailand. Her research interests are reverse engineering, instrument process control, and product design and development.

PIM
PANYAPIWAT
INSTITUTE OF MANAGEMENT
สถาบันการจัดการปัญญาภิวัฒน์

Development of an RFID System for Fixed Asset Monitoring in a University: A Case Study

Salamat Begmanov and Pisal Yenradee

Logistics and Supply Chain Systems Engineering Program, Sirindhorn International Institute of Technology, Thammasat University, Pathum Thani, Thailand
Industrial Engineering Program, Sirindhorn International Institute of Technology, Thammasat University, Pathum Thani, Thailand
E-mail: sbegmanov@gmail.com, pisal@siit.tu.ac.th

Received: June 20, 2019/ Revised: August 4, 2019/ Accepted: August 21, 2019

***Abstract*—This paper aims to develop a radio frequency identification (RFID) system for fixed asset monitoring and control in a University. It includes selection of hardware, design and development of software, identification of suitable position and how to attach RFID tags to the fixed assets to obtain 100% readability, conducting experiments to determine the accuracy and time required to read the RFID tags, and performing economic analysis of the RFID system. A case study with real implementation in three selected rooms of Sirindhorn International Institute of Technology, Thammasat University, was performed. Experimental results show that the developed RFID system can achieve 100% accuracy, significantly reduce total time for fixed asset check when compared with the manual system, and economically justified when the number of fixed asset items is relatively high.**

***Index Terms*—RFID system, fixed asset monitoring, sequential algorithms, intranet of things, economic analysis**

I. Introduction

A manual system of fixed asset monitoring and checking in Thai Universities is time consuming, tedious, inaccurate, and stressful. Fixed asset data are generally stored in an accounting system database. All fixed asset items must be checked regularly at least once a year or once a semester. Some fixed asset items have an information of its location such as a room number. During fixed asset checking period, staffs of each department will receive a hard copy of check sheet listing all items to be checked within their control. Each fixed asset item has 15 digits number ID, description, number of units (one or more than one), and its location (room number which is optional).

The manual system is time consuming since the staffs must read the description of the asset with 15 digits number ID and try to manually find the asset item in the room. It is inaccurate because the asset items in the room are mixed between the items that need to be checked and other items. It is often found that some items are actually in the room but the staffs cannot find it at the first time of checking. If someone moved the asset out of the rooms that the staffs are not responsible, those items may not be found and may be considered as "Lost" items. It is stressful since responsible persons may need to pay for the "Lost" items, therefore, the check must be done carefully with high concentration. The process is much more time consuming when the "Lost" items are expensive and they need to be checked for the second or third times.

An RFID (radio frequency identification) system is expected to be suitable for monitoring and checking fixed assets in Universities because when the staff brings the RFID reader not too far away from the RFID tags, the tag IDs will be automatically read although the staffs may not see the tags. This characteristic of RFID reduces a chance that the fixed asset item exists but the staff cannot find it.

A. Objectives

The paper has specific objectives as follows.

1. To develop the RFID system for fixed assets checking, which is fast and accurate, to be used at Sirindhorn International Institute of Technology (SIIT), Thammasat University (TU).
2. To evaluate the time and accuracy of fixed asset checking process.
3. To evaluate whether the RFID system is economically justified to be used in practice at SIIT, TU.

B. Scopes

This paper has limited scopes as follows.

1. The RFID reader used in this research is a model of handheld reader that is currently available at SIIT.
2. RFID tags are passive type, which is inexpensive. They have various models with various sizes, which are currently available at SIIT.
3. The application software to be developed is only a prototype that has limited functionalities.
4. Implementation of the RFID system will be performed in only three rooms with different environments, which are a department office, a meeting room, and a graduate research room.

II. Literature Review

This section provides a review of RFID system and its application in various aspects including advantages, system design, database, RFID tags, fixed assets control, intranet of things, RFID standardization, and benefits and costs analysis. The purpose of this review is to explain the characteristics of developed RFID system when compared with those in literature.

A. RFID systems advantages

Advantages of RFID technology is automatic data recording (retrieving, updating), high data accuracy, high durability, reusability and uniqueness of RFID tags [1]. If the RFID system (handheld reader, database storage, IoT) is integrated with an external system (e.g. SAP ERP, etc.), the system would require additional communication protocols, special antenna, internet of things, modified architectural design, tag encoding scheme, etc. This paper focuses on the RFID system without any external system integration but the conclusion section recommends some possible ways of integration.

B. RFID system development

Some RFID systems are all-in-one complete system, which may not require further development before use. However, most systems available in the market are non-complete system, which require further development before it is functional. This paper uses the non-complete RFID system where further developments are needed to make it possible to check fixed assets in Universities. Some literatures on RFID applications state perfect reading performance of RFID devices, however, in practice, this assumption does not hold true [2]. Various experiments are needed to reach 100% of tag readability according to a selected environment.

C. Database storage

Increasing demand for RFID systems is giving initiative to develop the "RFID smart shelf" applications using full capacity of RFID tags [3]. But the study targets on using only TID memory RFID tag capacity (see section D. Types of tags and readability) as unique unalterable code and using SQL server database to store additional information on fixed assets.

The Application Level Event (ALE) standard of EPCglobal organization [4] allows writing own business logic for RFID tag data manipulation. The ALE does not require a special structured language. For instance, ALE and data stream system for RFID data processing are demonstrated using SQL-based stream query language structure for event-detection organization [5-6]. This paper also utilizes the modern SQL functions for event-detection (data duplicate prevention, registration, retrieve, update, input) within developed software and creates own database schema.

D. Types of RFID tags and readability

RFID tags are classified into five classes and the purpose of classification is to reach cheapest versions of various tags [4]. The EPCglobal [7] classifies tags as follows: Class 0/1: passive, 0-factory programmed (TID), 1-user data input, Class 2: passive, read-write memory, Class 3: non-active with battery, longer range and broadband, Class 4: active with additional sensing, Class 5: activator, classified as reader.

Reference [8] explains a 4-month observation on readability and retention rate between passive tags (low frequency (LF) 30-500 kHz, high frequency (HF) 13.56 MHz) showing no difference between LF and HF passive tags at distance 7-10 cm and 10-15cm, respectively.

The study uses UHF (Ultra High frequency, 850-950 MHz) passive tags of Classes 1 and 2 which last long, approximately 10 years [6] and are readable from the default command called "Read" [2]. The typical passive tags consist of four memories called EPC (electronic product code), user, password, and TID (tag identifier). This paper utilizes the TID memory capability which is unalterable, pre-programmed by the manufacturer.

Reference [7] suggests experimenting every selected tag position to avoid the interference of electromagnetic environments on tag readability. Reference [9] conducted experiments with active RFID tags in metallic environments to increase human effort which are comparatively costly. An experiment with active RFID tag and antenna for hidden tag positions yielded 96% of readability [10]. Another deep experiment with passive tags and RFID antenna reached 99% of tag readability but the paper comments if the environment becomes sensitive, the readability decreases accordingly [11]. This paper will conduct experiments with stationary objects (fixed assets) arranged in less electromagnetic environments and expects to reach 100% of tag readability with passive tags and increase the visibility with single and continuous functions of handheld reader.

E. Fixed assets

Fixed assets, known as 'tangible asset", is a term used in accounting for assets and property that cannot easily be converted into cash and are meant for use for many years. Fixed asset depreciates in value year-over-year. Growth rate of fixed assets can be increased by employing more investment [12]. The fixed assets of SIIT are made of both metallic and non-metallic materials of several types, for example, chairs, arm-chair, tables, shelves, air conditioners, wall partitions, personal computers, and electrical appliances.

F. Intranet of things

Internet of Things (IoT) is a global a network infrastructure, linking any RFID systems together through network connectivity [7] or material objects connected to the wide network [13]. This paper does not assume global connectivity but utilizes the local network, hence, the network connectivity is called "intranet of things."

G. RFID system standardization

Developing countries and global companies face challenges in adoption of the RFID technologies as there is less global standards harmonizing EPC Gen 2 into ISO standards [4] and obstacles in sharing "valuable RFID data" [14].

This paper utilizes ultra-high frequency (UHF) passive tags of Classes 1 and 2, EPC Gen2 compliant which follows the RFID air interface protocol for communication between 840 and 960 MHz bandwidth. The EPC Gen2 compliant, by ISO/IEC 1800-6C protocol, enables operations across frequencies in Asia, including Thailand. The handheld reader follows working mode–China Standard 920-925 MHz, output power–between 5 and 30 dBm.

H. Cost-benefit analysis

Reference [1] explains a citation of reference for identification of three inventory discrepancies: inventory shrinkage from thefts, process errors, and misplacement of assets. Identification of such discrepancies, especially asset theft, has great impact to the project investment. Every identification system holding above mentioned costs may be beneficial in terms of company size, but the loss may be huge with traditional monitoring systems.

Typical approach to economic design is to reduce device and labor costs and increase social or environmental positive impacts. But the detailed project investment analysis would involve technical (project planning, design, construction, maintenance) aspects, financial (project budget and other expenses) aspects, and economic (balance between the technical and financial aspects) aspects [15-17]. In this paper, the financial aspect includes the acquirement of RFID hardware and software, development of prototype software, etc., the technical aspects include the environment learning, RFID system design, etc., the economic aspect includes the labor cost saving and investments.

III. Methodology

The research methodology follows the block diagram (presented in Fig. 1) which explains the main four development steps for the RFID based fixed asset monitoring system. The gathering data step collects specific information for the project by studying the current manual system and the fixed assets, their environments, and the current RFID systems available in the market. The software deployment activities involve the development of the RFID system and the infrastructure. The implementation activities consist of installation of the RFID system and conducting experiments with the passive tags for suitable positions, data accuracy, data visibility and readability rate. The final system performance step involves the economic evaluation of the RFID system.

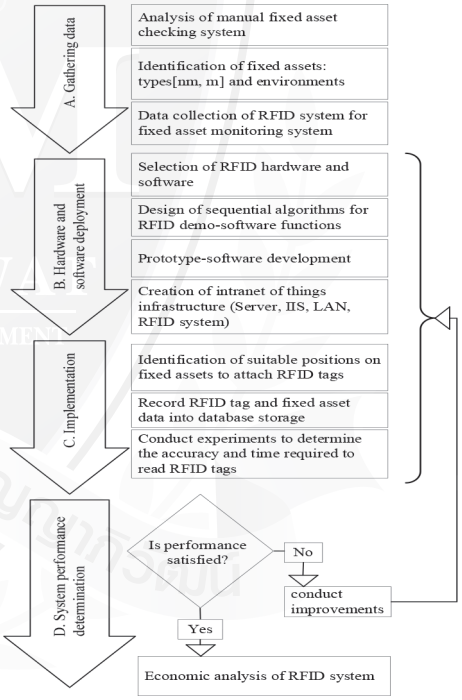


Fig. 1. Block diagram of methodological steps.

A. Gathering data

In this step, the current manual fixed asset checking system, characteristics of the fixed assets and their environments are thoroughly studied. Then components of the RFID system are identified for further developments.

1) Analysis of manual fixed asset checking system

The manual fixed asset checking system has 6 steps as follows.

1. Two staffs (a staff of responsible department and a witness from other department) go together **into a room** to check each item on the check sheet, which should be in that room. If the item is "**Found**", a **check mark** will be made on the check sheet, otherwise noted as "**Not found**". Please note that some fixed asset items not listed on the check sheet may be available in that room.
2. The two staffs go into the **next room** to check remaining items on the check sheet, which should be in that room and also to find the "Not found" items from previous rooms. The "Not found" items may be changed to a check mark if it is found in this room.
3. Step 2 is repeated until all rooms under their responsibility are completely checked.
4. All fixed asset items without the check mark will be reported as "Not found" items.
5. All "Not found" items will be considered by a management team to be classified as "**Lost**" items **or not**.
6. For the "Lost items", responsible persons may need to **pay for them** based on the remaining book value.

2) Identification of fixed assets and environments

This research selects three rooms of SIIT with different functions and different types of materials of fixed assets to test the performances of the RFID system. Rooms 1-310, 1-415, and 1-416 are meeting, office, and graduate student rooms, respectively. They have 74, 51, and 19 items of fixed assets, respectively. Layouts of fixed assets in each room are presented in Figs. 2 to 4. Note that the legends: m, and nm in the layouts mean metallic, and non-metallic materials of the fixed assets.

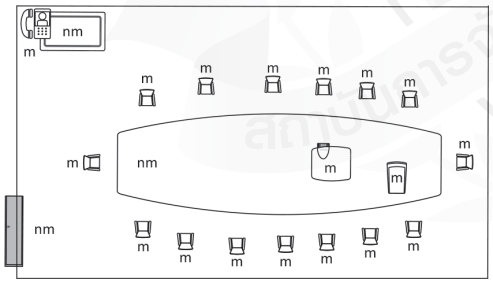


Fig. 2. Layout of Room 1-416.

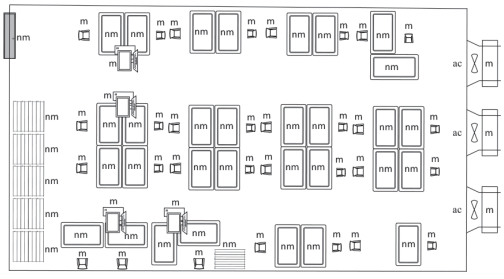


Fig. 3. Layout of Room 1-310.



Fig. 4. Layout of Room 1-415.

3) Main hardware components of RFID system for fixed asset checking system

The RFID hardware components are RFID tags (serial data transponder), RFID reader (serial data receiver), and data storage as shown in Fig. 5. The handheld RFID reader ensures that the serial (TID) and text data are safely recorded, updated and scanned. The RFID reader is synchronized with the server database storage through the wireless LAN.

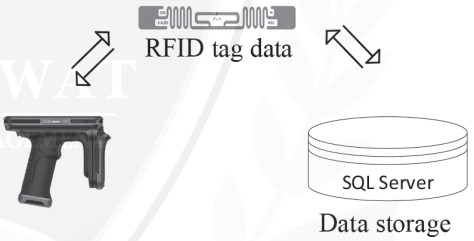


Fig. 5. Components of RFID system.

B. Hardware and software deployment

1) Selection of RFID system and software

As stated in the scope of this research that the RFID reader and RFID tags must be the current models available at SIIT. Additional hardware and software include Wi-Fi router, MS SQL Server and SQL express for database creation, and Intranet of Things infrastructure.

2) Design of sequential algorithms

Sequential algorithms are flexible and are created according to the project design requirements. For example, a sequential algorithm verifies RFID tags by group with the RFID antenna in an offline environment [18]. Another algorithm is created for coordination of the Received Signal Strength Indicator (RSSI) to detect RFID tags stored in digital floor plan and Building Information Modeling (BIM)

database [19]. In this research, the algorithms are basically created for single and continuous scan functions of the RFID Prototype-software and for synchronization with the SQL Server database at real time.

The single scan function means that an RFID tag will be read only one time when the user presses the trigger of the RFID reader. The continuous scan function is operated when the user presses a start button on the reader and the reader automatically reads all tags located within operational range until the user press stop button. The user can walk to different locations in a room and also change directions of the reader to allow it to read continuously all RFID tags available in the same room. The single scan function is suitable for registering new data of an RFID tag for a new fixed asset item or for finding a fixed asset item (when it is already registered). The continuous scan function is suitable for checking all fixed asset items available in the room.

Single scan function

There are two single scan functions for room and fixed asset related data. Room related algorithm is designed to register information of a new room into the database, or to retrieve information of all fixed asset items belong to that room (see Fig. 6). Fixed asset related algorithm (see Fig. 7) is to a) register information of a new fixed asset item into the database, b) retrieve, or update information of the fixed asset item (if the RFID tag attached to the fixed asset item is already registered).

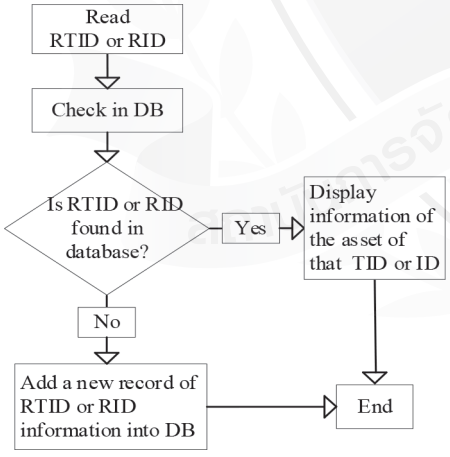


Fig. 6. Room related algorithm.

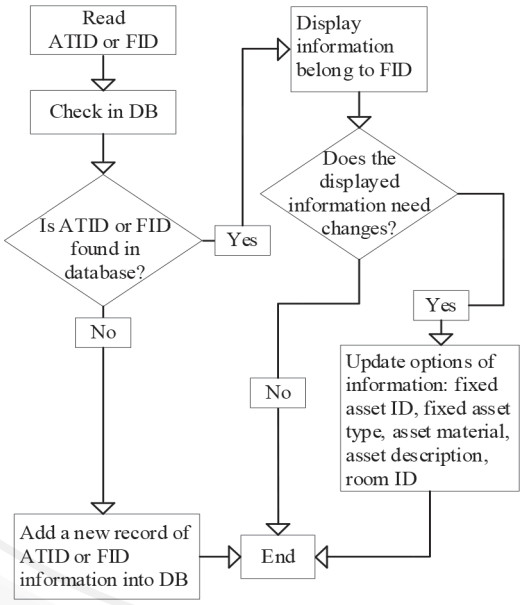


Fig. 7. Fixed asset related algorithm (Single scan).

Continuous scan function

The continuous scan function has only one algorithm to continuously read all RFID tags attached to fixed asset items in the room (see Fig. 8). After the user brings the RFID reader to scan all tags, some tags may be detected more than one time. If the tag is detected for at least one time, we consider that the fixed asset item is found. During continuous scan process, we may detect some unknown RFID tags that come with some equipment, which were not registered in the database for fixed asset checking purpose. These unknown RFID tags will be automatically reported. The user has an option to let the database remember them and not report them again. Note that when the RFID reader power is set at a high level, it may detect some RFID tags attached with the fixed assets located in an adjacent room. If these tags were registered in the database, they are not the unknown tags and no action should be taken.

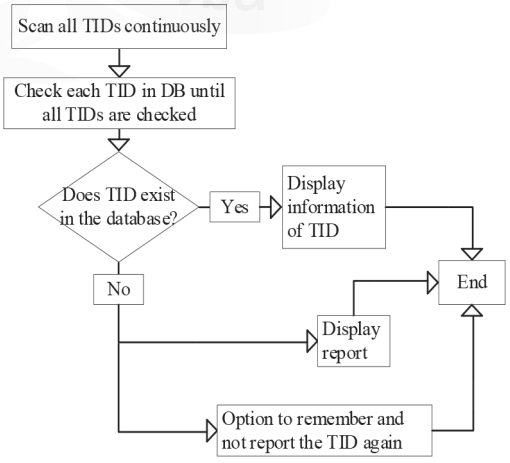


Fig. 8. Fixed asset related algorithm (continuous scan).

3) Prototype-software development

The Prototype-software is developed using c-sharp language based on the sequential algorithms for single and continuous scan functions presented in Figs. 6 to 8.

4) Creation of Intranet of Things (IoT)

The IoT infrastructure consists of SQL Server, Internet information services manager (IIS), Wireless LAN, and RFID reader as shown in Fig. 9.

The SQL Server is the database storage management system where the database is developed using SQL language to response to the data stream requests from the handheld reader. The tag IDs and additional meaningful data are recorded into the database. The database tables consist of:

1. Room table has two columns of RID (room number) and RTID (tag ID of RFID tag attached to room door).
2. Fixed asset table has 5 columns of ATID (tag ID of RFID tag attached to fixed asset), FID (fixed asset code), asset type, asset material, and asset description.

The IIS, an extensible web server supporting the HTTP protocol, supports the network requests between the handheld reader and SQL Server.

Wireless LAN consists of a Wi-Fi router and a local network that supports the connection between the server and handheld reader using the IIS HTTP protocol.

RFID reader is the data transponder and receiver into/from the server.

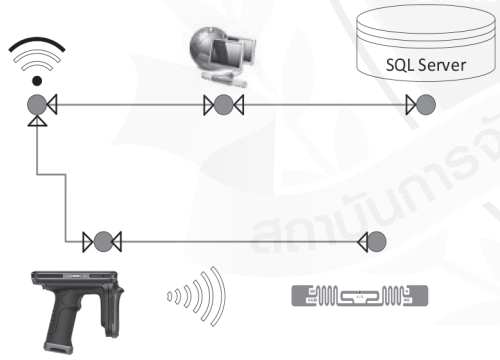


Fig. 9. Intranet of Things structure.

C. Implementation

After the RFID hardware components are selected and prototype software is completely developed, the RFID system is ready to be implemented in a real situation of three selected rooms at SIIT, TU. There are three important implementation activities, namely, identification of suitable positions to attach RFID tags on fixed asset items, registration of RFID tags and information of fixed asset items into the database, and conducting experiments to determine the accuracy and time required to read RFID tags.

1) Identification of a suitable position to attach an RFID tag to each fixed asset item

Six models of passive RFID tags will be attached to all fixed asset items in three selected rooms. There are some guidelines to identify the suitable position as follows:

1. The suitable position should be at the front side of the fixed asset so that everyone can clearly see the tag whether it is attached or lost.
2. The tags should be attached in the way that the plane of the tag is approximately perpendicular to the direction of wave transmitted from the handheld reader. Based on the layout of the room, it is known that the staff carrying the handheld reader will walk along which route to scan all tags, and what will be the natural direction of wave transmitted from the reader.
3. If it is possible, the tags should be attached at the level between hip and shoulder of a staff to reduce muscle stress of the staff to scan the tag.
4. When the tag is attached to the fixed asset item, trial readings by the reader will be performed to ensure that the tag can be detected by the reader. If the materials of the asset are metallic or mixed between metallic and non-metallic materials, it may interfere the wave transmitted from the reader, hence the tag cannot be effectively read. In this case, a high density (durable) foam material with a thickness of not less than 10 mm is recommended to support the tags to be away from the surface of the fixed asset. Note that a two-sided adhesive tape will be used to fix the foam material directly to the fixed asset, and the tags will be attached to the foam material using its self-adhesive.

2) Record RFID tags and fixed asset data into database

The single scan function is used to register RFID tags of rooms and fixed asset items together with descriptions of the fixed asset items into the database. We conduct an experiment to measure the required time to register the rooms and all fixed asset items in the rooms into the database. The results will be reported in the next section.

3) Conduct experiments to determine the accuracy and time required to read RFID tags

One of the objectives of this paper is to analyze the accuracy and time required to check all fixed asset items in three selected rooms using the developed RFID system. Note that experiments conducted by references [11] and [21] reported 79-96% readability rate for moving objects but this research conducts experiments with stationary objects, which requires the accuracy target of 100%.

The experiments in terms of data accuracy and time basically consist of continuously identifying the suitable positions until the tag readability rate is

satisfied. Other experiments include the changing of power levels of handheld reader to find out a readable distance of RFID tag, and application of the foam material to avoid the electromagnetic interference at the selected positions. The above-mentioned experiments are repeatedly conducted until the system readability rate of 100% is obtained.

D. System performance determination

The most important system performance of this research is the accuracy level of fixed asset checking by RFID system. The target of accuracy level is 100%. When the accuracy level from experiments is lower than 100%, causes of error will be identified and solved until 100% is achieved. When the system performance is satisfied, experiments will be conducted to measure the time required using continuous scan function to continuously check all fixed asset items. Finally, an economic analysis of the RFID system and the manual system when it is used for a large-scale checking of all fixed asset items available in SIIT will be performed.

IV. Results and Discussions

In this section, the results of performance analysis of manual fixed asset checking system, the conducted experiments on suitable tag position, tag readability rate, fixed asset visibility, data accuracy based on analysis of time and RFID system output power are discussed. The economic justification of the developed RFID system will be performed using net present value (NPV) technique.

A. Performance analysis of manual fixed asset checking system

An experiment is mainly conducted by the author and partly by fourth year industrial engineering students. They manually check all fixed asset items in three selected rooms where the RFID system is installed. The experiment is repeated by 9 times in each room.

The feeling of stress, discomfort is often experienced, especially when missed assets are occurred and then rechecked. The missed items are more frequently occurred in Rooms 1- 415 and Room 1-310 where the layouts are more complicated and crowded by many fixed asset items than Room 1-416.

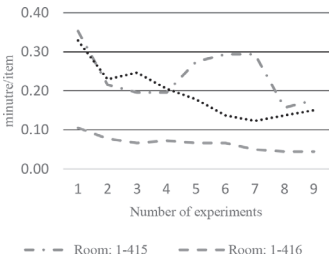


Fig. 10. Average time per item of manual checking in each room based on chronological order.

Fig. 10 shows the average time per item of manual checking in each room based on chorological order of checking. The graphs of Rooms 1-415 and 1-310 show a decreasing trend which indicates that when the same person gains experience in manual checking the average time per item time can be reduced due to learning effect. Note that the replication numbers 5 to 7 of Room 1-415 were performed for the first time by fourth year students. Thus, the average time per item is relatively high when compared with the author that has experiences. The graph of Room 1-416 does not show clear learning effect since the layout of fixed assets in the room is simple and the manual check is an easy task.

TABLE I
Average Time Per Item of All Replications for Manual Checking

Room:	Complexity of layout	Average time per item
1-415	Complex	0.24
1-416	Simple	0.067
1-310	Complex	0.194

Table I shows the average manual checking time per item of all replications in each room. It is found that the average checking time per item is highly influenced by the easiness of checking which is dependent on the complexity of fixed asset layout or arrangement.

A one-way analysis of variance (ANOVA) technique is used to determine whether the room has significant effect on the average time per item of manual fixed asset checking at the confidence level of 95%. It is found that the effect of the room is significant. When the Fisher's multiple mean comparison technique is used, it is found that the average time per item of Rooms 1-415 and 1-310 are not significantly different. However, the average time per item of Room 1-416 is significantly lower than that of Rooms 1-415 and 1-310.

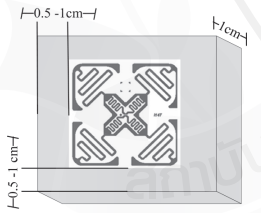
B. How to attach RFID tags to the fixed asset items to achieve 100% readability

Based on the developed RFID system and real experiments in three selected rooms, it is found that the suitable positions to attach RFID tags should be carefully determined to achieve 100% readability. There are recommendations to achieve 100% readability as follows.

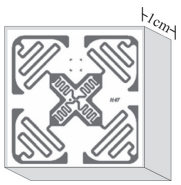
1. If the materials of the fixed asset at the position to attach the RFID tag are non-metallic, (e.g., wood, plastic, foam, fabric, and leather,) the RFID tag can be attached directly on the surface of the fixed assets. The output power of the handheld RFID reader should be set at 5 dBm, and the distance

between the reader and the RFID tag should be about 25 cm.

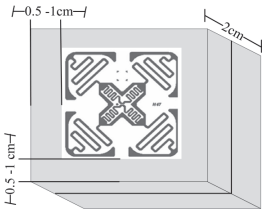
2. If the materials of the fixed asset at the position to attach the RFID tag are metallic or semi-metallic, (e.g., steel, aluminum, plastic or rubber body on steel structure,) they may interfere the RFID tag and the RFID tag should be supported by a hard foam material with a thickness of at least 1 cm. Note that the size of the foam should be bigger than the size of RFID tag (as shown in Fig. 11 (a)) to prevent the interference around the edges of the RFID tag. Fig. 11 (a) shows that when the tag is attached on the foam material, it has top, bottom, left, and right margins of 5 to 10 mm. Fig. 11 (b) shows that there is no margin left at each side of the RFID tag. In this case the readability is not good since it cannot avoid interference around the edges of the RFID tag. Fig. 11 (c) is similar to Fig. 11 (a) but the thickness of the foam is 20 mm instead of 10 mm. This case is recommended when the fixed asset materials are metallic and semi-metallic materials and it has additional interferences from electrical or electronics components, e.g., the air conditioners, printers, and motors. The output power of the handheld RFID reader should be set at 5 dBm, and the distance between the reader and the RFID tag should be about 25 cm.
3. Not all metallic and semi-metallic fixed asset items will interfere the RFIG tag, and need the foam material to support the RFID tag. Therefore, we may try to attach RFID tag directly without the foam material, if the tag cannot be read, the foam materials with thickness of 10 and 20 mm. will be used to support the tag, respectively.



(a) Good



(b) Bad



(c) Excellent

Fig. 11. Tag interference prevention using foam support.

C. Analysis of time to identify suitable position and attach RFID tag to the fixed asset

The time to identify suitable position and attach an RFID tag to the non-metallic fixed asset is 1-2 minutes. However, when the fixed asset material is metallic or semi-metallic, the time is 5-7 minutes, which is longer since the tag may need to be supported by a foam material. Additionally, a trial reading by the reader should be done.

Based on the three selected rooms, the suitable position for RFID tag is near the position of the fixed asset code written on the fixed asset for 97% of all asset items. There are 3% of all fixed asset items that the current position of the fixed asset code cannot be easily seen when the staff is walking along the aisles. Therefore, the fixed asset code is rewritten at the suitable position near to the suitable position of the RFID tag.

D. Analysis of time of RFID system

To register new data and update data of the fixed asset, the single scan function is used. The function with output power between 5-14 dBm at the distance about 25 cm. is applied. The time to register RFID tag and enter new fixed asset data is 2.3 minutes on average. The time to update data of the fixed asset is 1.3 minutes on average.

An experiment is conducted by using continuous scan function to check all fixed asset items in each room. The output power of the reader is set at 5-14 dBm at the distance about 25 cm. The number of items in each room and the average time per item to check all asset items are recorded. Note that three industrial engineering students performed replication numbers 9 to 20 of Room 1-415 while other experiments were done by the author.

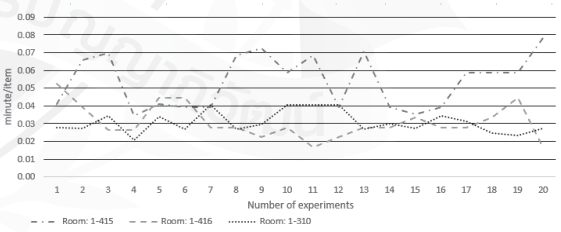


Fig. 12. Average time per item of continuous scan by RFID in each room based on chronological order.

Fig. 12 shows graphs of average time per item of continuous scan function using RFID system in three rooms. Each graph has random fluctuations but the trend is not clearly seen which means that the use of RFID system is very simple and does not require experience of users or the learning effect is not clearly seen. Note that the manual fixed asset checking required experiences to reduce the checking time (see Fig. 10).

The average time per item of all replications of continuous scan function using RFID system is

presented in Table II. The one-way ANOVA technique is used to determine whether the room has significant effect on the average time per item of continuous scan function using RFID at the confidence level of 95%. It is found that the effect of the room is significant. When the Fisher's multiple mean comparison technique is used, it is found that the average time per item of Room 1-415 is significantly different from that of Rooms 1-416 and 1-310.

To facilitate comparison between the manual and RFID systems, bar graphs of average time per item in each room of manual and RFID systems are presented in Fig. 13. It can be clearly seen that the RFID system can reduce the average fixed asset checking time per item greatly. When the two samples t-test is used, it is found that the average time per item of the RFID system is significantly lower than that of the manual check system of all rooms at confident level of 95%.

TABLE II
AVERAGE TIME PER ITEM FOR CONTINUOUS SCAN BY RFID

Room:	Complexity of layout	Average time per item
1-415	Complex	0.055
1-416	Simple	0.031
1-310	Complex	0.031

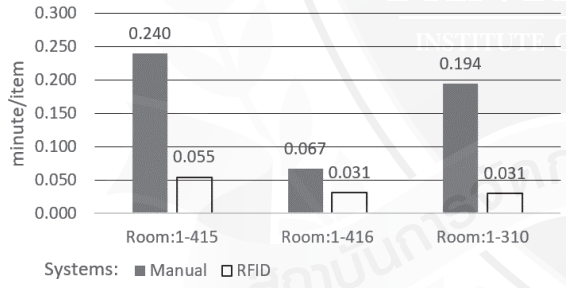


Fig. 13. Comparison of average time per item of manual and RFID systems.

E. Economic analysis

This paper focuses on net present value (NPV) technique for economic justification of the RFID system. The NPV technique requires an estimation of investment, operation and maintenance (O&M) cost, labor cost savings, useful life, and minimum attractive rate of return (MARR). The investment includes RFID handheld reader cost of 35,000 Baht, software development cost of 100,000 Baht, and RFID tag cost of 5 Baht per unit. The annual O&M cost is estimated by 5% of RFID and software development cost, plus 1% of RFID tag cost, which is assumed to occur at the end of years 2 to 10. The labor cost saving is assumed to be occurred at the end of years 1 to 10. The useful life of the RFID system is 10 years and the MARR is 5% based on the accounting system of SIIT, TU. The selected three rooms are good representatives of all rooms in SIIT. The average time saving per item is estimated from ((0.240-0.055) + (0.067-0.031) + (0.194-0.031))/3, which is 0.128 minutes. The labor cost of staffs that check the fixed asset is estimated at 200 Baht per hour (35,000 Baht per month). We need two staffs to check the fixed asset (checker and witness). The fixed asset is checked 2 times a year (once a semester).

Let I, O_t, S_t, i represent the investment, O&M cost at the end of year t, labor cost saving at the end of year t, and MARR, respectively. Equation (1) is used to calculate the NPV.

$$NPV = -I + \sum_{t=1}^{10} (S_t - O_t)(1 + \frac{i}{100})^{-t} \quad (1)$$

where

$I = 35{,}000 + 100{,}000 + 5X$

$O_t = 0.05(35{,}000+100{,}000) + 0.01(5)\,X$, $t = 2, 3, \ldots, 10$

S_t (0.128/60) (200) (2)(2) X, $t = 1, 2, ..., 10$

Note that the NPV is dependent on the variable X, which is the total number of fixed asset items that need to be checked. Table III shows the NPV at different values of X. It is found that the RFID system is economically justified when the total number of fixed asset items is at least 23,048 items and the fixed assets are checked twice a year.

TABLE III
NPV AFFECTED BY TOTAL NUMBER OF FIXED ASSET ITEMS

Number of items	NPV (Baht)
10,000	-102,294
15,000	-63,094
20,000	-23,894
23,048	0
25,000	15,306
30,000	54,506

F. Recommendation on designing and implementing the RFID system

The RFID tags are attached to the fixed asset item using self-adhesive tape supplied with the tags. It is possible that the RFID tag is accidentally removed or detached from the fixed asset item. If the RFID tag is lost, but the fixed asset item is available in the room. The scanning result will indicate that the fixed asset item is not found in the room, which is wrong. On contrary, when the RFID tag is detached form the fixed asset item but the tag is still in the room while the fixed asset item is already lost. The scanning result may indicate that the fixed asset item is found in the room, which is also wrong. Therefore, a discipline should be set to ensure that each fixed asset item to

be checked must have an attached RFID tag, and there is no RFID tag which is free or dropped on the floor.

The developed RFID system for fixed asset checking is economically justified when the total number of fixed asset items is about 23,000 units based on assumptions that all fixed asset items will be checked only twice a year, the benefit is only direct benefit of labor cost saving without considering indirect benefit of more accurate inventory record, the labor cost will not be increased in the next 10 years, and cost of RFID tags will not be reduced in the next 10 years. However, when the indirect benefit, labor cost increasing, and RFID tag cost reduction are considered, the number of fixed asset items to economically justify RFID system investment will be significantly reduced from 23,000 units.

V. Conclusions

A. Conclusions

This research was conducted to satisfy 4 objectives. First, the prototype of RFID system for fixed asset checking is successfully developed. Second, the time and accuracy of fixed asset checking are evaluated and it is found that the RFID system is significantly faster and more accurate than the manual system. Third, an economic analysis using the NPV method is performed and found that the RFID system is economically justified if the number of fixed asset items of SIIT is at least 23,000 units. At the moment, it is not economically justified considering only the direct benefit of labor cost saving. Finally, the last objective is to recommend further research and development of the RFID system for fixed asset monitoring and control in Universities. This objective will be satisfied in the next section.

B. Limitations and recommendations for further development

The developed RFID system has some limitations as follows. First it is only a prototype system with limited functions. Second, it is currently a standalone system, which is not integrated with the accounting system. Real benefits will be obtained when it is integrated with the current accounting system.

There are some recommendations for further development as follows.

1. The developed system is flexible and can be improved with additional modifications. Because of the research time limitation, the author could not finish, for instance, the continuous scan function for scanned TIDs match-checking directly from database storage then save into csv file which would reduce data analysis time. Another example, the database storage can be synchronized by Microsoft Azure Cloud Services where the asset status, reports, etc. can be created directly from web service.
2. The RFID system and technology can be further developed to include full capability of passive tag memories (EPC, write-read, password, user memories) and the algorithms can be modified on continuous scan function to get a more meaningful information.
3. The prototype software and database storage can be improved for saving meaningful image, video, or voice information of expensive fixed assets.
4. The RFID system can be extended for other applications which has more benefits than the fixed asset monitoring and control purpose. It can be integrated with an ERP system. The allocation of codes "from one system to another" [21] should be performed. Standardization of fixed asset IDs would prevent incorrect inputs. Regularity of student attendance check [22-23] with modification of algorithms and a compact handheld reader can be developed. Storage of huge asset data at several university departments integrated with IoT for data security may be done to improve economic justification of the RFID system. IoT with RFID system would collect the asset data from university buildings: an increased complex data visibility for central financial department. Complicated exam scheduling at universities [24] can be developed using RFID. RFID system with IoT can improve "university power consumption" management [25].

Acknowledgment

The first author would like to express special thanks to SIIT, Thammasat University, and the ADB-JSP Scholarship Program for their precious support to complete his Master of Engineering degree.

References

[1] K. O. Roper, A. Sedehi, and B. Ashuri. (2015). A cost-benefit case for RFID implementation in hospitals: adapting to industry reform. *Emerald Insight.* [Online]. *33(5-6),* pp. 367-388. Available: https://doi.org/10.1108/F-05-2013-0041

[2] J. S. L. Ting and A. H. C. Tsang. (2012, Jan.). Design of an RFID-based Inventory Control and Management System: A Case Study. *The West Indian Journal of Engineering*. [Online]. *34(1-2)*, pp. 70-79. Available: https://sta.uwi.edu/eng/wije/vol3401-02_jan2012/documents/Abstract-Inventory-ControlandManagementSystem.pdf

[3] X. Qing, Z. N. Chen, and A. Cai, "Multi-loop antenna for high frequency RFID smart shelf application", *2007 IEEE Antennas and Propagation Society International Symposium*, 2007, pp. 5467-5470.

[4] N. Adhiarna and J. Rho, "Standardization and Global Adoption of Radio Frequency Identification (RFID): Strategic Issues for Developing Countries," *2009 Fourth International Conference on Computer Sciences and Convergence Information Technology*, 2009, pp. 1461-1468.

[5] Y. Bai, F. Wang, P. Liu, C. Zaniolo, and S. Liue, "RFID Data Processing with a Data Stream Query Language," in *Proc. 2007 IEEE 23rd International Conference on Data Engineering,* 2007, pp. 1184-1193.

[6] S. A. Joseph and N. J. Joby, "Analyzing RFID tags in a distributed environment," in *Procedia Technology-24-ICETEST*, 2015, pp. 1483-1490.

[7] X. Jia, Q. Feng, T. Fan, and Q. Lei, "RFID technology and its applications in Internet of Things (IoT*),"* in *proc. 2012 2nd International Conference on Consumer Electronics, Communications and Networks (CECNet),* 2012, pp. 1282-1285.

[8] A. Suriyasomboon and V. Chavananikul, "Electronic identification of pigs in Thailand," in *proc*. *IAALD AFTA WCCA*, 2008, pp. 1059-1062.

[9] K. V. Raju, D. Sachan, and S. Biswas. (2013, Feb.). Application of RFID based inventory management system in power project sites. *International Journal of Innovative Research and Development.* [Online]. *2(2),* pp. 313-327. Available: http://www.ijird.com/index.php/ijird/article/download/35002/28199

[10] M. Dhanalakshmi and U. Mamatha, "RFID based management system", in *Proc. of ASCNT*, 2009, pp. 227-234.

[11] H. Vogt, "Efficient Object Identification with Passive RFID Tags," in Mattern F., Naghshineh M. (eds) *Pervasive Computing, Pervasive 2002. Lecture Notes in Computer Science*, vol. 2414, 2002, pp. 98-113.

[12] I. Satyanarayana, N. B. C. Sidhu, and A. Naresh. (2015, Mar.). Evaluation of fixed assets management. *International Journal of scientific research and management.* [Online]. *3(3).* pp. 2500-2504. Available: https://www.ijsrm.in/index.php/ijsrm/article/download/503/445/

[13] C. Sun, "Application of RFID technology for logistics on Internet of Things," *AASRI Procedia*, vol. 1, pp. 106-111, 2012.

[14] K. Micheal and L. McCathie, "The pros and cons of RFID in supply chain management," in *Proc. 4th Annual International Conference on Mobile Business, ICMB* 2005, pp. 623-629.

[15] F. Tsai and C. Huang, "Cost-benefit analysis of implementing RFID system in port of Kaohsiung," *Procedia-Social and Behavioral Sciences*, vol. 57, pp. 40-46, 2012.

[16] A. K. Masum, F. Bhuiyan, and M. A. K. Azad. (2013). Impact of Radio Frequency Identification (RFID) technology on supply chain efficiency: An extensive study. *Global Journals.* [Online]. *13(4)*, pp. 9-15. Available: https://globaljournals.org/GJRE_Volume13/3-Impact-of-Radio-Frequency-Identification.pdf

[17] A. Dukyil, A. Mohammed, and M. Darwish. (2018, Jan.). Design and optimization of an RFID-enabled passport tracking system. *Journal of Computational Design and Engineering*, *5(1)*, pp. 94-103. Available: https://www.sciencedirect.com/science/article/pii/S2288430017300301?via%3Dihub

[18] J. S. Choi, H. Lee, D. W. Engels, and R. Elmasri. (2012, Mar.). Passive UHF RFID-Based Localization Using Detection of Tag Interference on Smart Shelf. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*. [Online]. *42(2),* pp. 268-275. Availible: https://ieeexplore.ieee.org/document/5751704

[19] A. Motamedi, M. M. Soltani, and A. Hammad. (2013, Oct.). Localization of RFID-equipped assets during the operation phase of facilities. *Advanced Engineering Informatics*. [Online]. *27(4)*, pp. 566-579. Available: https://dl.acm.org/citation.cfm?id=2561199

[20] J. Royo, P. Lamban, J. Valencia, M. Olivera, and M. Monreal, "Study to determinate the feasibility of RFID to facilitate traceability in a logistic operator," *Procedia Engineering*, vol. 63, pp. 829-834, 2013.

[21] F. Costa, M. S. Carvalho, J.M. Fernandes, A.C. Alves, and P. Silva, "Improving visibility using RFID – the case of a company in the automotive sector," *Procedia Manufacturing,* vol.13, pp. 1261-1268, 2017.

[22] U. A. Patel and S. Priya. (2014, Aug.). Development of a student attendance management system using RFID and face recognition: A Review. *International Journal of Advance Research in Computer Science and Management Studies*. [Online]. *2(8),* pp. 109–119. Available: www.ijarcsms.com

[23] O. T. Arulogun, A. Olatunbosun, O. A. Fakoluji, and O. M. Olaniyi. (2013, Feb.). RFID based students attendance*, IJSER*. [Online]. *4(2)*, pp. 1-9. Available: https://www.ijser.org/paper/RFID-Based-Students-Attendance-Management-System.html

[24] A. Akbulut and G. Yilmaz. (2013, Feb.). University exam scheduling system using graph coloring algorithm and RFID technology. *IJIMT*. [Online]. *4(1)*, pp. 66-72. Available: http://www.ijimt.org/show-41-570-1.html

[25] K. Sharma and T. Suryakanthi, "Smart System: IoT for university," in *Proc. of ICGCIoT*, 2015, pp. 1586-1593.



Salamat Begmanov received B.A. in Business Management from the National University of Uzbekistan in 2009. Then, he worked in local and international companies in Uzbekistan in different positions until 2016. Currently, he is pursuing his master of engineering in logistics and supply chain system engineering at SIIT, Thammasat University, Thailand and is expected to get degree in July, 2019. His research interests include RFID system development, fixed asset monitoring, sequential algorithms, intranet of things, and economic analysis.



Pisal Yenradee is an Associate Professor in Industrial Engineering Program at Sirindhorn International Institute of Technology (SIIT), Thammasat University. He holds a B.Eng. in Production Engineering from King Mongkut's Institute of Technology, North Bangkok and M.Eng. and D.Eng. in Industrial Engineering and Management from Asian Institute of Technology. His research interests focus on production planning and inventory control systems, JIT, ERP, TOC, finite capacity scheduling systems, aggregate production planning, master production scheduling, supply chain, and applied operations research. He has published papers in and served as a reviewer for many international journals.

Modified Coral Reef Optimization Algorithm for Motorcycle Routing of Food Delivery Service in Thailand

Tantikorn Pichpibul

Panyapiwat Institute of Management, Faculty of Logistics and Transportation Management, Nonthaburi, Thailand
E-mail: pichpibul@gmail.com

Received: September 9, 2019/ Revised: October 31, 2019 / Accepted: November 18, 2019

***Abstract*—This paper investigates a case of a restaurant which provides the delivery of Thai barbecue (BBQ) food to customers around Nonthaburi Province, Thailand. Currently, the delivery planning is done by using personal experience which is inefficient. In order to solve this case study which was identified as a vehicle routing problem, with backhauls, a coral reef optimization algorithm is modified and compared to the real decisions of the planner who has motivated this problem. The results show that the proposed algorithm is competitive with the planner decision. The total delivery distances are also decreased by 17.97%. These results suggest that coral reef optimization algorithms may be useful to many different restaurant delivery services.**

***Index Terms*—vehicle routing, backhauls, transportation, coral-reef optimization algorithm.**

I. Introduction

This paper focuses on a vehicle routing problem which is motivated by a real case study. The main activities as shown in Fig. 1 in this case study are purchasing food including pork, chicken, other meats, and vegetables entering into restaurant for the preparation of products as shown in Fig. 2. After that, restaurant handles the distribution of the products and electric stove burners loaded by motorcycle to customers located around Nonthaburi Province, Thailand.

Two groups of customers must be served. First group is the customers who order the products today, and need to receive products and electric stove burners loaded from the restaurant in order to cook themselves. Second group is the customers who ordered the products yesterday, and need to get used electric stove burners loaded back to the restaurant as shown in Fig. 3. Generally, both of the customer groups must be visited by only one motorcycle.

Fig. 4 shows a daily operation. In every evening, the restaurant receives the products from the kitchen and performs the routing by the only one planner who spends hours focusing on the route planning by using her own experience. After that, the products and electric stove burners are packed into baskets and delivered to the customers. When the delivery is done, the motorcycles will assign to pick up used electric stove burners from the customers, and will return to the restaurant.

The planning of each route must be performed within one hour. As mentioned earlier, the current route planning is not effective due to using personal experience of the planner. Therefore, the restaurant must improve the delivery efficiency in order to minimize the total delivery distances of the motorcycle routes by using a modified coral-reef optimization algorithm developed in this paper. It is a tool which will help the planner to assign the route of delivery to suitable motorcycles.

II. Literature Review

The case study in this paper was identified as vehicle routing problem with backhauls (VRPB) that a motorcycle delivers products from restaurant to customers in linehaul, and picks up used electric stove burners from customers to restaurant in backhaul as shown in Fig. 5. The VRPB problem was first found in the publication of the article [1]. It is known to be an NP-hard problem [2-3]. The constraints of the VRPB are as follows.

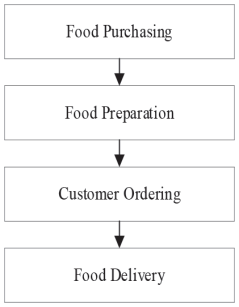


Fig. 1. Flowchart of main activities.



Fig. 2. Products.

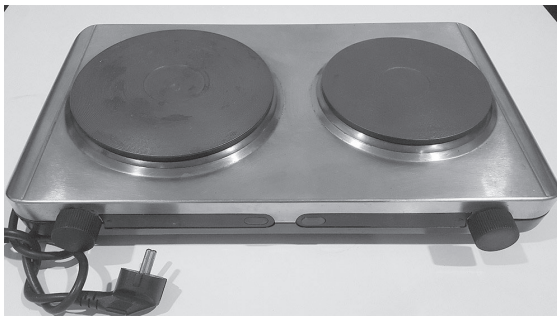


Fig. 3. Electric stove burner.

• Each customer is visited and left with the same motorcycle, and must be visited once by one motorcycle.
• Each motorcycle starts and ends at the restaurant.
• Each motorcycle contains at least one delivery customer (linehaul). Motorcycles servicing only pick-up customers (backhaul) are not allowed.
• All products and electric stove burners are loaded at the restaurant. All used electric stove burners are unloaded at the restaurant.
• The total delivery demand in each motorcycle (linehaul) cannot exceed the motorcycle capacity.
• The total pick-up demand in each motorcycle (backhaul) cannot exceed the motorcycle capacity.
• All motorcycles have the same capacity.
• Split demand is not permitted.
• The number of motorcycles used in each day cannot exceed the number of available motorcycles.

The study of the VRPB has attracted many researchers since the problem was proposed [2], [4-6]. Some well-known algorithms were proposed including exact algorithm [7-9], cluster-first route-second algorithm [10-11], Tabu search algorithm [12-13]. In this paper, we propose a modified coral reef optimization (CRO) algorithm [14] to solve the case study which scales well to real-world problem that are encountered in one of the food delivery business in Thailand. Moreover, the survey on literature reveals that there is no previously published research that presents CRO algorithm to solve the VRPB. This is our contribution to develop CRO algorithm introducing a new procedure which attempt to capture the nature of VRPB.

III. Coral-Reef Optimization Algorithm

The coral-reef optimization (CRO) algorithm is one of optimization algorithms based on an artificial simulation of the mechanism of coral reefs' formation and reproduction. In order to solve the VRPB by using the CRO algorithm, we therefore modify the structures of the CRO algorithm that the flowchart is given in Fig. 6.

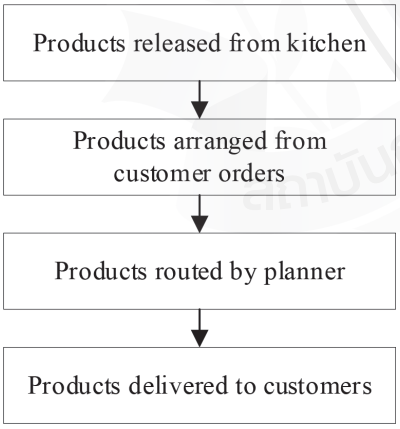


Fig. 4. Flowchart of daily operation.

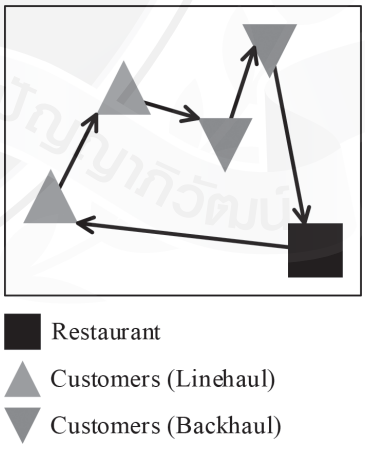


Fig. 5. Example of motorcycle route.

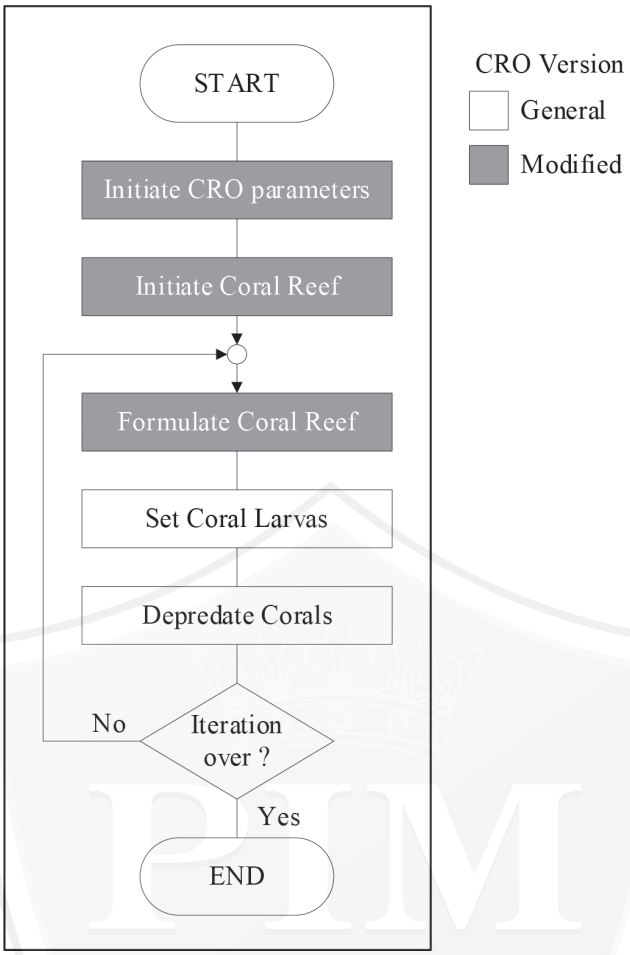


Fig. 6. Flowchart of modified CRO algorithm.

A. Initiate CRO parameters

The CRO algorithm includes some parameters which are described as follows:

• Coral reef is a set of corals consisting of a $N \times M$ square grid assuming that each square (i, j) is able to allocate each coral.

• Coral represents a VRPB solution which is encoded as a string of the same nomenclature, consisting of a customer set identifier (including L = Linehaul, B = Backhaul) followed by n which represents the customer node number. For the customers in set L, they require delivery of products and electric stove burners from the restaurant. Set B is the customers who require pick up of used electric stove burners to the restaurant. The example of VRPB solution from coral encoding is shown in Fig. 7. It represents two routes as customer node. For the first motorcycle, it departs from the restaurant 0, delivers products and electric stove burners to customers L1 and L3, and picks up used electric stove burners from customers B1 and B2, and return to the same restaurant. For the second motorcycle, it departs from the restaurant 0, delivers products and electric stove burner to customers L2, and picks up used electric stove burner from customers B3, and return to the same restaurant.

• Coral larva represents the new solution produced by broadcast spawning procedure (when the egg and sperm from two corals meet together), brooding procedure (in case of self-fertilization in each coral), and budding or fragmentation procedure (when the coral has grown enough to produce budding or it is caused by storms and boats' grounding).

• Coral health represents the total delivery distances in each coral.

B. Initiate Coral Reef

In general, the CRO algorithm always randomly produces each coral to occupy in the reef. It assigns the corals to some squares in the grid and other squares to be empty which is represented by the holes in the reef where new corals can freely settle and grow in the future. In addition, we produce an extra coral by using the Clarke-Wright savings (CW) algorithm [15] in order to make a better chance to reach the best coral. After all corals are produced, the CRO algorithm will calculate the coral health of every coral. The example of a coral reef is shown in Fig. 8.

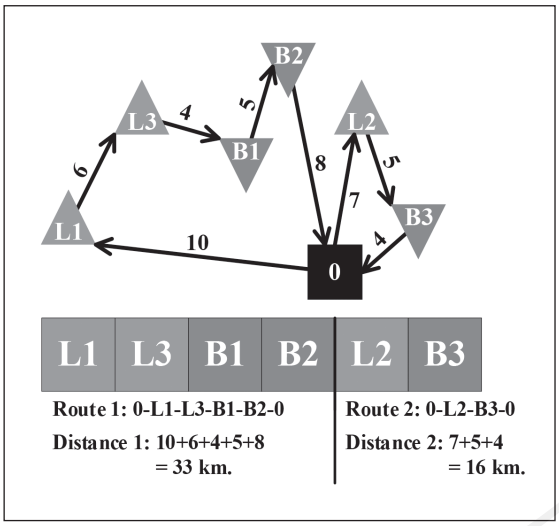


Fig. 7. Example of VRPB solution from coral encoding.

C. Formulate Coral Reef

A coral larva is produced by using broadcast spawning and brooding procedures which are described as follows:

1) Broadcast spawning

The existing corals in the reef are chosen at random to be broadcast spawners. Note that, the corals that are not chosen to be broadcast spawners will reproduce by brooding procedure. In the next step, couples out of the pool of broadcast spawner corals are randomly chosen. Each couple will form a coral larva by using inter-move operators [16] including shift moves and swap moves. The shift moves remove customers from the first coral and insert them in another place of the second coral. The swap moves select customers from both corals and exchange them. After that, the coral larva is released out to the water. Note that, the chosen corals are parents only once.

2) Brooding

As previously mentioned, each coral that is not chosen from the broadcast spawning procedure is reproduced to be a coral larva by using intra-move operators [16] including shift moves and swap moves. The shift moves remove customers from the chosen coral and insert them in another place of the same coral. The swap moves select customers from the chosen coral and exchange them. After that, the coral larva is released out to the water similar to the broadcast spawning procedure. After all coral larvas are produced, the CRO algorithm will calculate the coral health of every coral larva.

3) Budding or fragmentation

All corals are sorted by their health in ascending order. From these corals, the one is randomly chosen, and then duplicates itself to be the new coral larva.
Set Coral Larvas

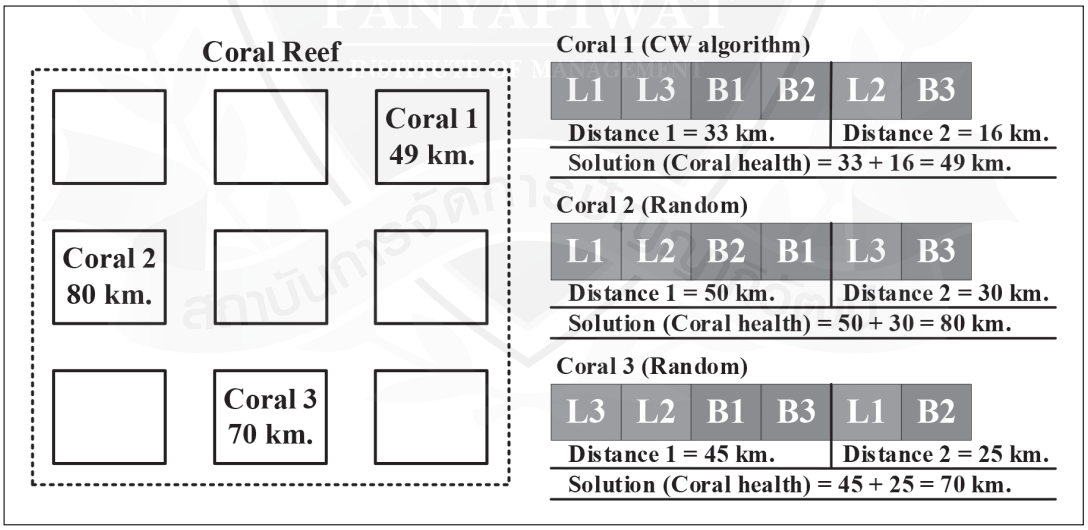


Fig. 8. Example of a coral reef.

D. Set Coral Larvas

When all coral larvas are formed through the procedures, they will try to set and grow in the coral reef one by one. First, each coral larva will randomly try to set in a square (i, j) of the coral reef. If the square is empty (hole in the coral reef), the chosen coral larva will grow to be the new coral in the coral reef. On the other hand, if this square is already occupied by a previous coral, the chosen coral larva will grow only if its health is better than the existing coral's health. Otherwise, it will be depredated by animals in the coral reef.

E. Depredate Corals

The corals may die when all squares in the coral reef are full in order to free space in the coral reef for next coral generation. The coral which has the worst health is chosen to be discarded from the coral reef.

F. Stopping Condition

The process of the CRO algorithm is continued until the stopping condition represented by the number of iterations is satisfied. It will stop and select the best coral in terms of total delivery distances as the final solution of the VRPB.

IV. Computational Results

The proposed algorithm was coded in Visual BASIC 6.0 on an Intel® Core™ i7-5500U CPU 2.40 GHz with 8.00 GB of RAM under Windows 7 64-bit platform. For CRO algorithm, we have set the coral reef to be 3 × 3 square grid and the total number of iterations equal to 1000.

The real-world problem from the restaurant in Nonthaburi Province, Thailand was tested. The numerical experiment used real data provided by the restaurant. In this experiment, the case study depends on three days of delivery in September, 2019. Each day is separated by considering a number of customers (including low, medium, high).

We discuss the case study that the percentage deviation between the solutions obtained from the proposed algorithm (*cro*) and the planner's experience (exp) is calculated as follows:

$$\text{Percentage deviation} = \left(\frac{cro - \exp}{\exp} \right) \times 100 \qquad (1)$$

From the results in Table I, we found the new solutions for all days. The total delivery distances are decreased by 17.97%. It can be shown that the motorcycle route planning obtained by the proposed algorithm is better than the planner's experience in all directions. Moreover, we provide the example of motorcycle route planning in day 1 by the planner's experience and the proposed algorithm which are illustrated in Figs. 11 and 14. Figs. 9 and 12 show the delivery routes in linehaul, and Figs. 10 and 13 show the pick-up routes in backhaul by the planner's experience and the proposed algorithm.

V. Conclusion

In this paper, we have presented a modified coral-reef optimization algorithm to solve the vehicle routing problem with backhauls and the real-world problem which concerns with the route planning of the motorcycles to deliver the products and electric stove burners from the restaurant to the customers, and pick up used electric stove burners to the restaurant. The numerical experiment has been done by using the real data provided by the restaurant comparing with the planner's experience. From the numerical test, the proposed algorithm is competitive in terms of the quality of the solutions found, and shows better performance for the real-world problem. It is shown that the proposed algorithm can be used to solve this kind of problem.

TABLE I
Computational Results

Day	Number of customers	Number of motorcycle routes	Solution (km.)	
			Planner's experience	Proposed algorithm
1	21	2	52.36	41.37
2	32	2	87.22	76.81
3	50	3	80.26	62.15

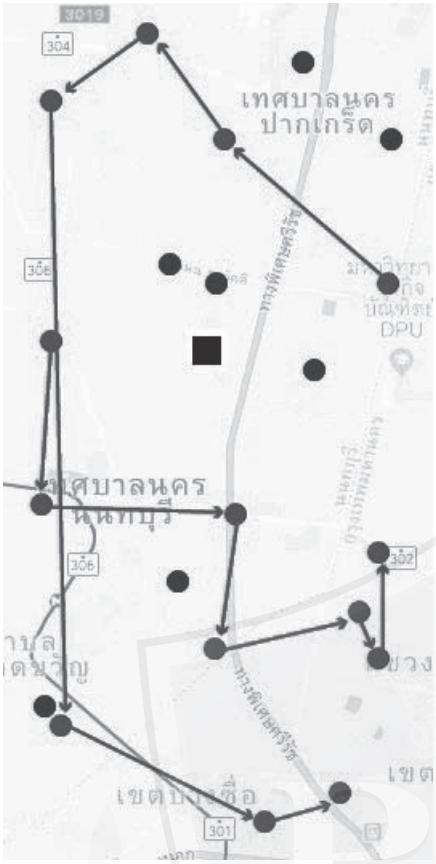


Fig. 9. Delivery route (linehaul) by planner's experience.



Fig. 10. Pick-up route (backhaul) by planner's experience.

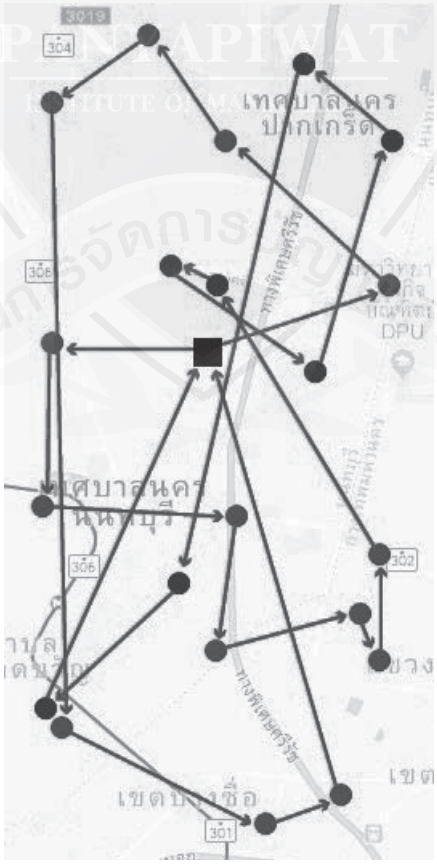


Fig. 11. Motorcycle route by planner's experience.

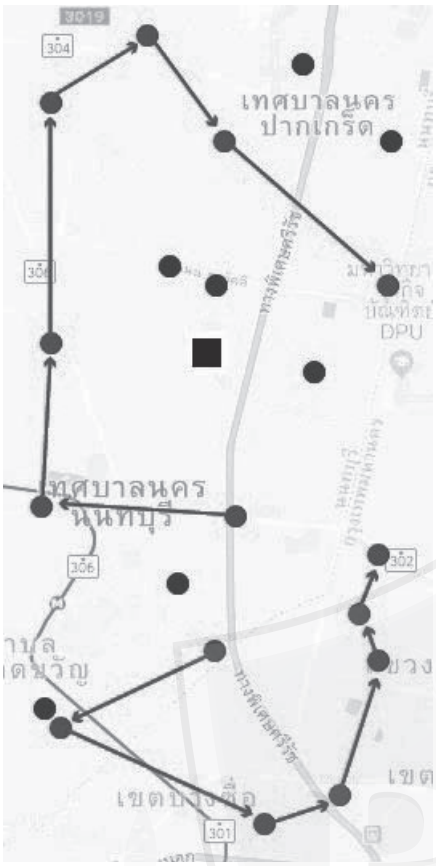


Fig. 12. Delivery route (linehaul) by proposed algorithm.

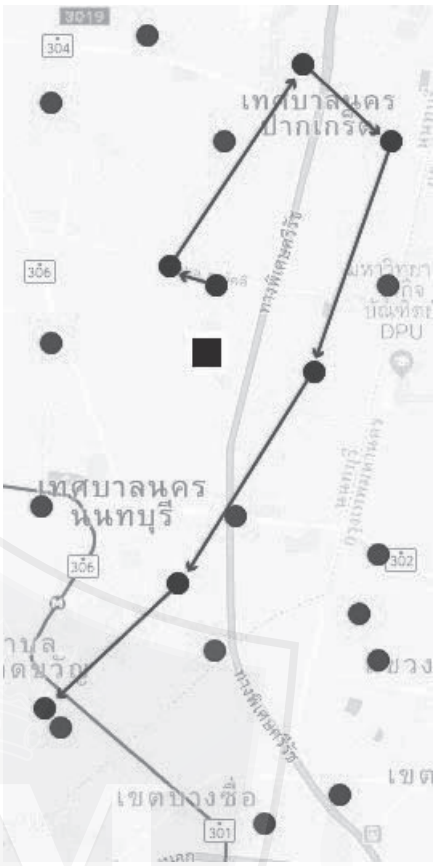


Fig. 13. Pick-up route (backhaul) by proposed algorithm.

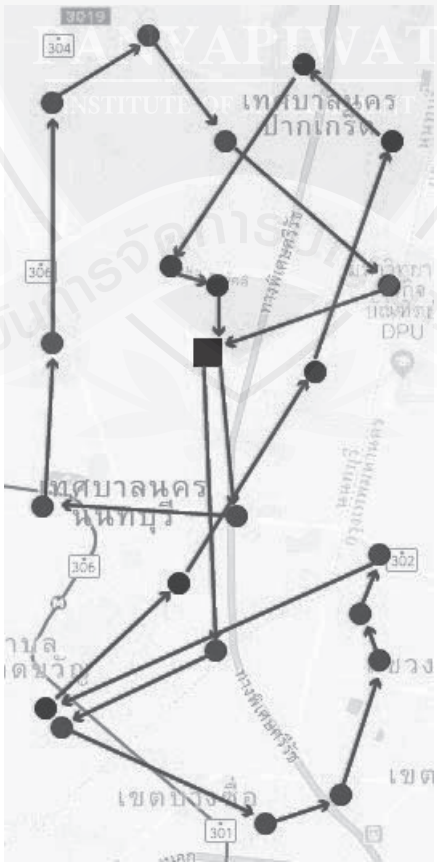


Fig. 14. Motorcycle route by proposed algorithm.

References

[1] M. Goetschalckx and C. Jacobs-Blecha, "The vehicle routing problem with backhauls," Eur. J. Oper. Res., vol. 42, no. 1, pp. 39-51, Sep. 1989.

[2] E. E. Zachariadis and C. T. Kiranoudis, "An effective local search approach for the Vehicle Routing Problem with Backhauls," Expert. Syst. Appl., vol. 39, no. 3, pp. 3174-3184, Feb. 2012.

[3] D. P. Cuervo, P. Goos, K. Sörensen, and E. Arráiz, "An iterated local search algorithm for the vehicle routing problem with backhauls," Eur. J. Oper. Res., vol. 237, no. 2, pp. 454-464, Sep. 2014.

[4] G. Nagy and S. Salhi, "Heuristic Algorithms for Single and Multiple Depot Vehicle Routing Problems with Pickups and Deliveries," Eur. J. Oper. Res., vol. 162, no. 1, pp. 126-141, Apr. 2005.

[5] Y. Gajpal and P. L. Abad, "Multi-ant colony system (MACS) for a vehicle routing problem with backhauls," Eur. J. Oper. Res., vol. 196, no. 1, pp. 102-117, Jul. 2009.

[6] G. Y. Tütüncü, C. A. C. Carreto, and B. M. Baker, "A visual interactive approach to classical and mixed vehicle routing problems with backhauls," Omega, vol. 37, no. 1, pp. 138-154, Feb. 2009.

[7] C. Yano, T. Chan, L. Richter, T. Cutler, K. Murty, and D. McGettigan, "Vehicle routing at quality stores," Interfaces, vol. 17, no. 2, pp. 52-63, Mar-Apr. 1987.

[8] P. Toth and D. Vigo, "An exact algorithm for the vehicle routing problem with backhauls," Transport. Sci., vol. 31, no. 4, pp. 372-385, Nov. 1997.

[9] A. Mingozzi, S. Giorgi, and R. Baldacci, "An exact method for the vehicle routing problem with backhauls," Transport. Sci., vol. 33, no. 3, pp. 315-329, 1999.

[10] M. Goetschalckx and C. Jacobs-Blecha, "The vehicle routing problem with backhauls: properties and solution algorithms," Georgia Institute of Technology. Technical Report MHRC-TR-88-13, 1993.

[11] P. Toth and D. Vigo, "A heuristic algorithm for the symmetric and asymmetric vehicle routing problem with backhauls," Eur. J. Oper. Res., vol. 113, no. 3, pp. 528-543, Mar. 1999.

[12] I. H. Osman and N. A. Wassan, "A reactive tabu search meta-heuristic for the vehicle routing problem with back-hauls," J. Sched., vol. 5, no. 4. pp. 263-285, Aug. 2002.

[13] J. Brandão, "A new tabu search algorithm for the vehicle routing problem with backhauls," Eur. J. Oper. Res., vol. 173, no. 2, pp. 540-555, Sep. 2006.

[14] S. Salcedo-Sanz, D. Gallo-Marazuela, A. Pastor-Sánchez, L. Carro-Calvo, A. Portilla-Figueras, and L. Prieto, "Offshore wind farm design with the Coral Reefs Optimization algorithm", Renew. Energ., vol. 63, pp. 109-115, Mar. 2014.

[15] G. Clarke and J. W. Wright, "Scheduling of vehicles from a central depot to a number of delivery points," Oper. Res., vol. 12, no. 4, pp. 568-581, Jul-Aug. 1964.

[16] C. Groër, B. Golden, and E. Wasil, "A library of local search heuristics for the vehicle routing problem," Math. Program Comput., vol. 2, no. 2. pp. 79-101, Jun. 2010.



Tantikorn Pichpibul is currently a faculty member at Faculty of Logistics and Transportation Management, Panyapiwat Institute of Management, Thailand. He received the the Ph.D. degree in Engineering from Sirindhorn International Institute of Technology, Thammasat University, Thailand and his M.Sc. in Internet and Information Technology from Naresuan University, Thailand. His research area interest includes operational research, decision support system, and logistics and supply chain management.

PANYAPIWAT INSTITUTE OF MANAGEMENT

Simple Online and Real-time Tracking with Feature Matching Enhancement for Re-identification after Occlusion

Koksal Chou, Natsuda Kaothanthong, Chawalit Jeenanunta

School of Management Technology, Sirindhorn International Institute of Technology,
Thammasat University, Pathumthani, Thailand
E-mail: m6022040353@g.siit.tu.ac.th, natsuda@siit.tu.ac.th, chawalit@siit.tu.ac.th

Received: May 13, 2019/ Revised: August 6, 2019 / Accepted: August 20, 2019

***Abstract*—Occlusion in people tracking in computer vision is the problem that affects the tracking continuity as the information of the object is lost when the tracked object is behind another object. This study proposes a tracking algorithm that is robust to occlusion. The algorithm is designed based on the algorithm called Simple Online and Real-time Tracking (SORT) which utilizes deep neural network detector, Kalman Filter, and Hungarian algorithm. The feature extraction method is used to capture the information of objects before and after occlusion to solve the problem of multi-object tracking in the presence of occlusion. This method can improve the lack of memory bottleneck of SORT which is a crucial requirement for robust multi-object tracking. The experiment is performed on 13 testing videos which contain multi-people walking pass each other with and without background noise. The result from the experiment shows that the proposed method can increase multi-object tracking accuracy of SORT. The algorithm can correctly re-identify the object after the occlusion event.**

***Index Terms*—Convolutional neural network, feature extraction, multiple object tracking.**

I. Introduction

Multi-object tracking is an application in computer vision that is used to track multiple moving objects in the video file or real-time video stream. It gives an ability for a computer to understand the context of the image by using an algorithm to process and analyze each image stream. The algorithm should be designed to keep tracking the identity and location of the same object throughout the duration that the object appears in a different frame within a video. At first, the algorithm must be able to detect the objects, their types, and locations when they appear in a certain frame in the video. Then the algorithm must be able to detect, associate, and differentiate objects in the following frames. For natural video, there exist noises in several forms that make tracking multiple objecnnts difficult. The problem such as occlusion makes it hard to differentiate multiple objects. In order to design a state-of-the-art algorithm, researchers must take these noises into consideration. Multi-object tracking can be used in various applications such as surveillance, robotic, industrial, self-driving car, shopping, etc.

The main purpose of this study is to develop a method that can effectively keep track of multiple objects in real time in the presence of partial and total occlusion.

This paper is organized as follow: Review on previous works and related literature are presented in section 2. Section 3 describes the proposed method, experiment setting, and key performance indicator. The result and comparison are demonstrated in section 4. Finally, section 5 discusses the conclusion of outcomes and future work.

II. Literature Review

A. Object Comparison and Detection

Multiple objects tracking is a two-stage problem. The first stage is the detection problem which tries to locate the coordinate of the object within one frame. The second stage is the tracking problem that is required to associate the same object between frames.

The early form of object detection is template matching. It compares the feature of source image, and the template image. In Image Correlation Matching, each pixel value is the feature of both source and template image [1]. Cross-correlation is used to calculate the image correlation which is the sum of pairwise multiplication for each corresponding pixel of the two images. Both images are supposed to have the same dimension. However, this method is not robust in the presence of changing in the

global brightness of the images being compared [2]. Extended from Correlation Matching, S.-q. Chen [3] used a more advanced template matching algorithm. This algorithm used classic pyramid search by transform template image into different angles and different scales and then thoroughly compared to the source image. This algorithm returns both the position and orientation of the matched template. Similar approach enhanced the performance of Grayscale-based matching by limiting computation to the object edge areas. It is based on the assumption that the shape of an object is defined by the shape of its edge. This technique can, therefore, reduce some unnecessary computation.

Another method used for detection by comparing the object feature is called local feature extraction. It extracted key-point from an image in the pixel level. Key-points from the template are used to compare with key-point from different sources to find the matched pair of images. The well-known key-point descriptors are Scale Invariant Feature Transform (SHIF) [4] and Speeded-up Robust Features (SURF) [5]. However, both algorithms are patented. Oriented Features from Accelerated and Segments Test and Rotated Binary Robust Independent Elementary Features (ORB) is proposed by E. Rublee et al. [6] as an alternative to SHIF and SURF with superior performance. Viswanathan [7] use FAST (Features from Accelerated and Segments Test) to compare the brightness of a certain pixel in the picture to another 16 surrounding pixels. Then those 16 pixels are divided into three groups: brighter than, darker than or similar to the pixel in the middle. If more than half of those surrounding pixels are brighter or darker than the middle pixels, then that middle pixel is selected as key-point. Then Calonder, Lepetit, Strecha and Fua [8] used BRIEF (Binary Robust Independent Elementary Features) to convert all the key-point, found by FAST into a binary feature vector. Together, FAST and BRIEF can represent an object. BRIEF descriptor only contains 1 and 0. Each key-point is described by a feature vector of 256 bits string. By using a multiscale image pyramid over FAST and Rotation with BRIEF, ORB can archive scale and rotation invariant.

Convolutional Neural Network (CNN) is a Deep Learning algorithm designed to process image file, assign weights and biases to various features in the image, and then differentiate one image from another. For the learning process, the convolutional neural network observes the pattern of the group of pixels from the input image. Then find the common feature among the set of images from the same category. In the next step, CNN used the newly found feature to compare with a set of test images in the same and different categories. It then updated weight and biases based on the result of the comparison. This process happened for hundreds or thousands of iterations until the test accuracy is satisfied. After the final stage of learning, CNN can classify an image into different categories. This neural network can perform image matching better than traditional image matching such as template matching. There is one drawback that limits its performance to use as object detection. CNN can only tell if there is an object of interest inside the image, but it could not tell the specific location of that object.

To add the localization ability to CNN, Ren, He, Girshick and Sun [9] proposed the algorithm called Faster R-CNN. The algorithm composed of two modules, region proposal module and Fast R-CNN [10]. R-CNN used a selective search algorithm to identify the region proposal in order to detect the feature. This method can find the object of interest and the location in which it resides. Though, searching and comparing through all the sub-region inside the image would be too slow and time-consuming which will affect the performance of the detection network. Instead, a separate deep neural network is used to predict the region proposal. By applying detector inside a new proposed region, Faster R-CNN can outperform its predecessors and work in real-time at speed up to 5 frames per second.

B. Video Tracking

In the second stage of multi-object tracking, Video tracking is an assignment problem that is used to assign moving objects with unique IDs.

D. Comaniciu et al. [11] proposed a method to use a mean shift for tracking objects. Mean shift has been used to solve the clustering problem. In computer vision, Mean shift used image feature as the probability density function. Color histograms of the object in the first image are used to create a confident map of the next image. Then mean shift found the mean of a confident map around the old position of the object. Calculating iteration over iteration until it found the peak of a confident map. Mean shift gave the probability of the pixel color that occurs in the object in the previous image to each pixel of a new image. It outputted the new location that the object resides in the new video frame. This algorithm failed when two similar objects make a full occlusion or object is moving too fast.

Chirag I. Patel et al. [12] proposed another method that uses object contour for tracking. The algorithm uses centroid coordinates of the contour to define the state of the object along with its velocity and acceleration. Then the motion model is used to predict the next state of the object. This method is computationally inexpensive and can even track an object in the presence of partial occlusion. The limitation of this approach is that the color of the object must be different from the background.

Bewley, Ge, Ott, Ramos and Upcroft [13] proposed an algorithm called Simple Online and Real-time

Tracking (SORT) to solve a multi-object tracking problem. This algorithm extended the advantage of the efficiency of Deep Neural Network. Detection from CNN is represented as a state of the object. Then Bewley, Ge, Ott, Ramos and Upcroft [13] used SORT to apply linear motion model to the object state such that they can predict its new state in the next frame. This method can keep track of individual person accurately. Although this algorithm is robust with a distinguishable appearance of people, when there is full occlusion between multiple people, the algorithm tended to fail by switching ID or assign a new ID to the object after the occlusion. It happened because SORT lack of memory represents the property of the object.

Addressing the weakness of Convolutional Neural Network, Sadeghian, Alahi and Savarese [14], Xiang, Zhang and Hou [15], Fang, Xiang, Li and Savarese [16] and Fan and Ling [17] apply Recurrent Neural Network (RNN) to assist tracking process. CNN network performed best for interclass classification problem. But in multi-people tracking, people belonged to the same class that shares similar features. These similarities acted as distractors to the network. Fan and Ling [17] introduced Structure-aware network for visual tracking (SANet), which used object's own structure information to differentiate it from distractors. RNN is utilized to represent object structure and integrate with CNN to distinguish similar feature of different people. The method trained features of the object in real time in different stages using RNN which give the memory to the network. In the presence of noise such as full occlusion, SANet used learned features to re-identify the object. Benchmark result shows that this algorithm is robust to full occlusion and can effectively keep track of multiple people. However, RNN is computational expensive which make online training very slow. The whole algorithm can run less than 1 frame per second. This fact prevented the usage of SANet and another RNN based network in real-time object tracking.

III. Methodology

The objective of this study is to propose the Multi-object tracking algorithm that is robust to full occlusion. The study extends the method of SORT by incorporating the feature extraction algorithm to give instant memories of objects appearances right before the occlusion happen. Those memories are then used to associate the IDs of lost tracked objects after occlusion to the existing objects. This method is called Simple Online and Real-time Tracking with Feature Matching Enhancement (SORT-FME). SORT-FME is developed based on three main steps. The first step is detection, the second step is tracking and the third step where this study mainly focuses on is feature matching enhancement. Fig. 1 shows all the steps for SORT-FME.

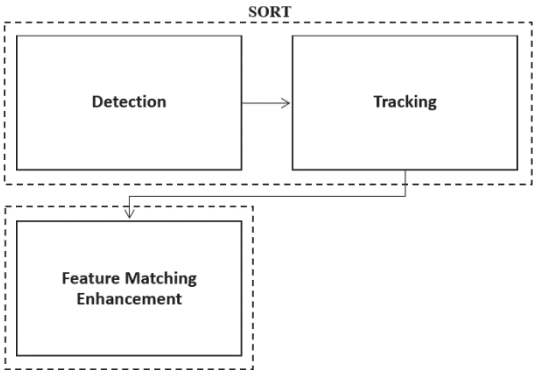


Fig. 1. SORT-FME Framework

A. Detection

For the detection problem, as utilized by SORT, Faster Region CNN (FrRCNN) detection framework is used with default parameter. Output probability of more than 50% is selected to determine if a certain person is detected. Video file (or real-time video stream) is input through a detection network. The output from this detection is a set of coordinates of the bounding box that person resides in and its confident probability. It is in the form of [startX, startY, endX, endY, confident] where startX, endX are the range of coordinate in the vertical axis and startY, endY are the range of coordinate in the horizontal axis.

B. Tracking

Simple Online and Real-time Tracking is select as tracking algorithm framework. This algorithm augments the four coordinates of the rectangle of the detected object to model a state of that object. The state is represented as 7 components in each video frame for each object as below:

$$stateX = \left[x,\ y, s, r,\ \dot{x}, \dot{y}, \dot{s}\right]^T \quad (1)$$

Where in frame T, x and y are the vertical and horizontal location of the center of the box. s is the area of the box and r is aspect ratio which is constant. $\dot{x}, \dot{y}, \dot{s}$ are velocity component. Kalman filter is used in SORT to estimate new object's state and data association method to match the estimated box to the detection box [18]. Parameters from SORT are set as their default with minimum detect before it registers new ID to detected object to 3 consecutive frames and maximum age of 1 frame of lost detection before SORT terminate tracking of old IDs. SORT will then output new coordinates of the objects to create bounding boxes around objects in the new frame along with their IDs.

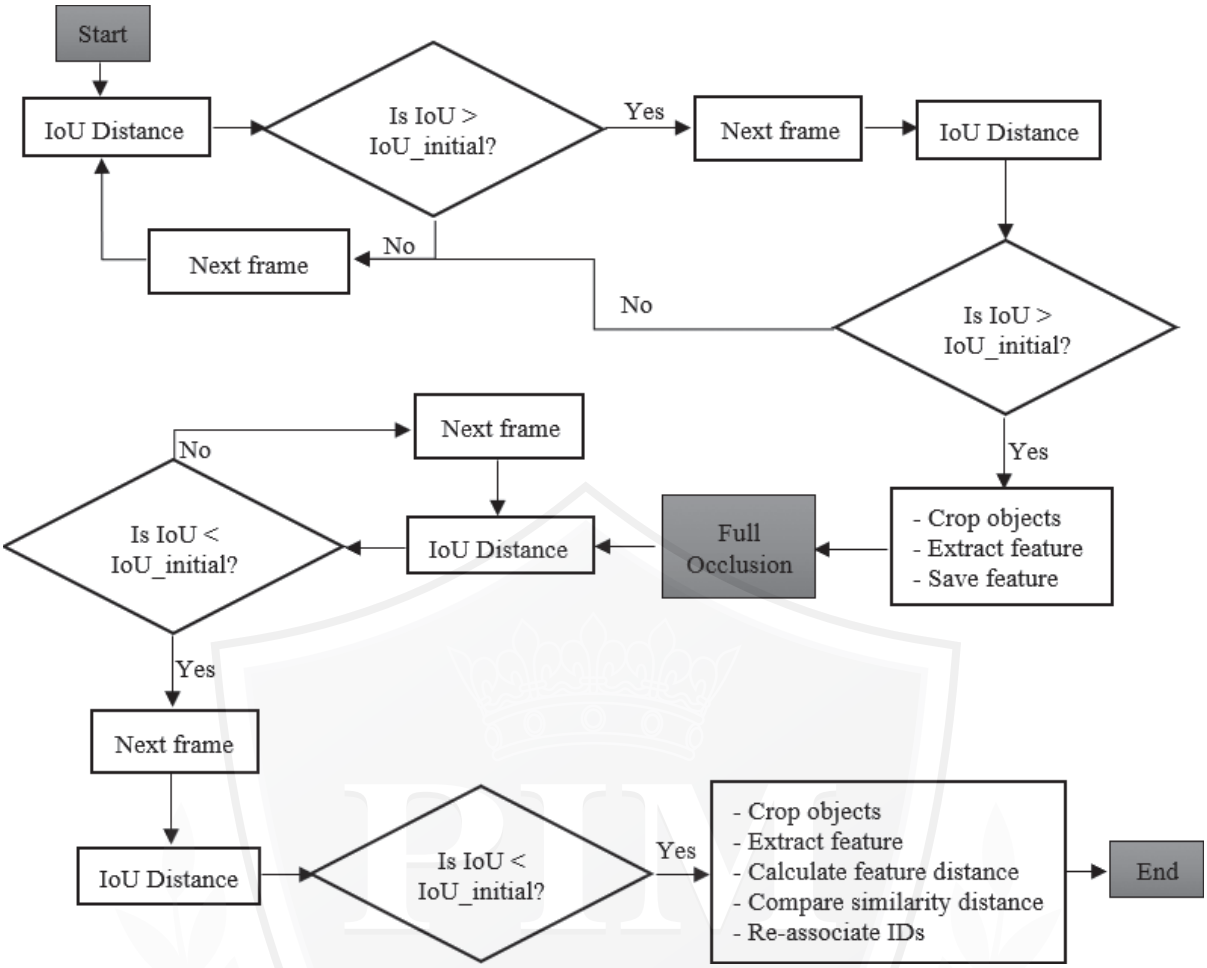


Fig. 2. Feature Matching Enhancement flow chart

C. Feature Matching Enhancement

For the third step, SORT-FME is proposed to re-identify the object after occlusion. In order to solve the total occlusion problem, the algorithm must be able to remember the structure of the objects before two or more objects occlude with each other. The structure of the objects must be captured right at the start of occlusion. If the structure is captured after a large part of the objects has occluded, feature information can be lost by the occluded part. If it is captured long before occlusion happens, there is more chance that occlusion will not happen, or the features will be more different from those of object after occlusion. To detect the instance for the beginning of occlusion, intersection-over-union (IoU) distance is used between bounding box of the object.

$$IoU = \frac{Area\ of\ \ Overlap}{Area\ of\ \ Union} \tag{2}$$

Given the bounding box coordinate of object1 and object2:

object1= [startX1, startY1, endX1, endY1]

object2= [startX2, startY2, endX2, endY2]

Area of overlap and union are calculated by:

$$startx = \max\left(startX1, startX2\right)$$
$$starty = \max\left(startY1, startY2\right)$$
$$endx = \min\left(endX1, endX2\right)$$
$$endy = \min\left(endY1, endY2\right)$$
$$Area\ Overlap = \max\left(0, endx - startx\right) * \max\left(0, endy - starty\right) \tag{3}$$
$$Area\ of\ \ Union = Area\ object1 + Area\ object2 - Area\ overlap \tag{4}$$

Where *startx, starty, endx, endy* are the rectangle coordinates of the overlapped section.

Based on the experiment, the optimal *IoU* distance is set to a maximum of 0.15 for each box to contain full enough shape of the object to extract the features. At the frame where *IoU* is more than 0, algorithm triggers waiting moment. In the next frame if *IoU* increases, which mean that both objects converge, the bounding box of each object are cropped out from the picture. After that, feature extraction algorithm called Oriented Features from Accelerated and Segments Test and Rotated Binary Robust Independent Elementary Features (ORB) is used to extract the features from cropped images and save to

memory with their respective ID. This algorithm uses a brightness at a pixel level to detect a key-point of the image. A group of key-points is representing the feature of an object. Feature extracted by ORB are the vectors of binary descriptors with the size of 256 bits.

During occlusion, only detection network and motion model are used. Feature extraction will not be applied as there is an incomplete structure of object in interest. End of occlusion is trigger by *IoU* distance smaller than 0.15. The proposed algorithm waits for another frame to see if *IoU* getting smaller than the previous frame which signifies that both objects are diverging. When the condition is true, it captures news images within the bounding boxes. Then features are extracted from those pair as vectors of binary descriptors. The next step, the feature of each object after the occlusion will be compared with the feature of each object before the occlusion. Since the feature of each object is represented by binary descriptor, brute force matching with Normalized Hamming distance is used for comparison. Normalized Hamming distance is the sum of XOR operation between 2 binary vectors.

$$Norm_{Hamming} = \sum_{i=1}^{n} V(i)\ XOR\ U(i) \tag{5}$$

Where *V(i)* and *U(i)* are binary vectors.

After finding the distance between each vector of each pair, the distance can be summed and divided by the total matching vector to get the average distance. The pair that has the least distance is the most similar one and could possibly be the same person. Hungarian algorithm will be used to optimally solve the assignment problem. So new IDs will be generated based on the IDs of the object before the occlusion happens. These IDs will replace false IDs provide by SORT. Fig. 2 gives the process flow chart of the algorithm.

D. Experiment

This study focuses on keep tracking of multiple people in the indoor environment where there is no lighting change. The room is set up with no clutter. A single camera is fixed overhead under the ceiling.

The experiment is done on videos recording with Lenovo workstation P320, OS Ubuntu 16.04 LTS, CPU Core i7-7700T, GPU Quadro P600, RAM 8GB, 1080p Webcam with autofocus.

Table I

Videos Experiment set 1 and 2

Test	Number of people	Re-Occlusion	Reverse Direction	Clothes	Background Noise
1	2	No	No	Different	No
2	2	No	No	Same	No
3	2	No	No	Same	No
4	2	No	Yes	Same	No
5	2	No	Yes	Different	No
6	3	No	Yes	Different	No
7	2	No	No	Different	Yes
8	2	Yes	No	Different	Yes
9	2	Yes	No	Same	Yes
10	2	Yes	No	Same	Yes
11	2	No	Yes	Different	Yes
12	3	No	No	Different	Yes
13	3	No	No	Different	Yes

The experiment is set to evaluate the performance of the proposed model against the visual similarity of the test subject and total occlusion. As shown in table I, the first set of videos (test 1 to test 6) contain plain background, the second set of videos (test 7 to test 13) contain some background noise.

E. Key Performance Indicator

Evaluation of Multi-Object Tracking proposed by Smith, Gatica-Perez, Odobez and Ba [19] consists of 3 measurements: recall, precision, and coverage test. The object that will be tracked is denoted by ground truth object (*GT*) with index *j*. The output from the tracking algorithm will be referred to as a tracker (*e*) and are indexed by *i*. Both *GT* and *e* are described by bounding boxes coordinates with respective index.

For *i* and *j* as an index of tracker and ground truth object, recall is defined as:

$$Recall_{i,j} = \frac{\left|e_i \cap GT_j\right|}{\left|GT_j\right|} \tag{6}$$

This value measures how much ground truth object (*j*) is covered by the respective tracker (*i*). It is within the range between 0 (no overlap) and 1 (fully overlap).

Precision is expressed as:

$$Precision_{i,j} = \frac{\left|e_i \cap GT_j\right|}{\left|e_i\right|} \tag{7}$$

Precision measure the coverage of tracker (*i*) over ground truth object (*j*). It also has a value between 0 (no overlap) and 1 (fully overlap).

Coverage Test will tell if *GT* is being tracked or not. The object being track required a high value of precision and recall. F-measure is used to formulate the coverage test.

$$F = \frac{2 * Recall * Precision}{Recall + Precision} \quad (8)$$

Coverage threshold (C_t) can be set so that if $F > C_t$, the object is correctly tracked. These KPI are calculated for each picture frame. For video tracking in this experiment:

$$Recall = \frac{number\ of\ correctly\ tracked}{number\ of\ ground\ truth} \quad (9)$$

$$Precision = \frac{number\ of\ correctly\ tracked}{number\ of\ tracked} \quad (10)$$

The Classification of Events, Activities, and Relationships (CLEAR) is proposed by Bernardin and Stiefelhagen [20] that applied accuracy and precision to define the performance of tracker. Multiple Object Tracking Precision shows the average dissimilarity between ground truth and all the correctly tracked object. It is computed as:

$$MOTP = \frac{\sum_{t,i} d_{t,i}}{\sum_t c_t} \quad (11)$$

Where c_t represents the total number of matches that generate by tracker and $d_{t,i}$ represent the correctly matched hypotheses to object *i* in frame *t*. It defines how precise the algorithm localizes objects. Another figure is called Multiple Object Tracking Accuracy. It is a combination of 3 mains errors.

$$MOTA = 1 - \frac{\sum_t (FN_t + FP_t + IDSW_t)}{\sum_t GT_t} \quad (12)$$

GT_t is the number of ground truth object in each frame *t*. FN_t is the number of missed assignments. For example, there is an object to track in the frame, but the algorithm failed to register the ID. FP_t is an error caused when tracker give object ID while there is no object to track. The last notation is $IDSW_t$ which stand for ID switch. During the tracking of objects, ID can change from one to another even the tracked object remains the same. It causes an error to the output and limits the performance of the tracking algorithm.

Wu and Nevatia [21] quantified multi-object tracking performance by introducing 5 quality measurements. Mostly Track (MT) count the number of objects that more than 80% of its trajectory is tracked. In contrast, mostly lost (MT) count the number of objects that more than 80% of its trajectory is lost or in other words, less than 20% of its trajectory is tracked. Fragments (Fgmt) counts the time that ground truth trajectory is interrupted. False alarm (FAT) as the name implies, count the number of tracking results that are not associated with any ground-truth object. The last one is ID switch (IDSW) which count the frequency of identity switch between a pair of an object.

SORT-FME focuses on re-associate the identification after the occlusion based on the object's structure before the occlusion happens. The performance evaluation is design in the way that it will reflect the ability of the proposed method to solve the occlusion problem. It is represented as multi-object tracking accuracy.

$$MOTA\% = 1 - \frac{\sum_v IDSG_v}{\sum_v GT_v} \quad (13)$$

Where *v* is the video file index and GT_v is the number of ground truth object in each video file. *IDSG* is the number of changing the ID in each video file.

IV. Performance Evaluation

The performance of SORT-FME is used to compare with the performance of SORT for the same video files by using MOTA% as a key performance indicator. Table II shows the comparison result of SORT and SORT-FME. The 2nd column shows the number of ground truth objects in each test scenario. The 3rd column represents the number of objects that are successfully tracked by SORT. The 4th column shows the successfully tracked results from SORT-FME. From the 5th column are the recall, precision, and F-measure of result from SORT and SORT-FME. Since the number of tracked objects are the same as the number of ground truth objects, the result of recall, precision, and F-measure are the same. The F-Measure of SORT-FME gives the value of 1 for most videos which indicate that the tracking algorithm has full coverage most of the objects. In contrast, F-measure of SORT gives value mostly between 0 and 0.5 which indicate that most of the tracking is lost after occlusion. These values show that the SORT-FME gives better result than SORT in correctly re-associating the ID after occlusion. Multi-object tracking accuracy (MOTA%) for all video experiments is also calculated based on tracking result from SORT and SORT-FME.

MOTA% for SORT is:

$$MOTA\%_{SORT} = 1 - \frac{18}{35} = 48.5\%$$

MOTA% for SORT-FME is:

$$MOTA\%_{SORT-FME} = 1 - \frac{11}{35} = 68.5\%$$

Looking at MOTA%, the proposed method can increase the accuracy of SORT up to 20%. In most case, SORT can keep track only one object in the event of occlusion. The object that is totally occluded by the foreground object will be lost. After occlusion, SORT will apply a new ID to the occluded object, hence the ID is inconsistency. By applying feature extraction and comparison to SORT, lost tracks ID of an object can be recovered and reassigned to that

object. Fig. 3 (a) and (b) shows the tracking before occlusion and the successful tracking after occlusion by SORT_FME, respectively. In a certain case; however, the algorithm fails to reassign ID because the object changes perspective appearance during occlusion. The feature comparison step can also be confused by the visual similarity among objects and give false ID to the output.

TABLE II
TRACKING RESULT OF VIDEO EXPERIMENTS

Test	Number of Ground Truth	Correctly Tracked		Recall		Precision		F-Measure	
		SORT	SORT-FME	SORT	SORT-FME	SORT	SORT-FME	SORT	SORT-FME
1	2	1	2	0.5	1	0.5	1	0.5	1
2	2	1	2	0.5	1	0.5	1	0.5	1
3	2	0	2	0	1	0	1	0	1
4	2	2	0	1	0	1	0	1	0
5	2	1	2	0.5	1	0.5	1	0.5	1
6	3	0	0	0	0	0	0	0	0
7	2	1	2	0.5	1	0.5	1	0.5	1
8	4	1	2	0.25	0.5	0.25	0.5	0.25	0.5
9	4	3	4	0.75	1	0.75	1	0.75	1
10	4	3	3	0.75	0.75	0.75	0.75	0.75	0.75
11	2	2	2	1	1	1	1	1	1
12	3	2	3	0.66	1	0.66	1	0.66	1
13	3	0	0	0	0	0	0	0	0

In test 6 and test 13, there are 3 people in the videos. The people occlude for a long period of time and multiple times. The occlusion of the second pair happens before the occlusion of first pair finish. People in the video are walking with non-linear motion. For SORT, the tracking is failed because there are long occlusion and non-linear movements. These problems are supposed to be solved by SORT-FME but because there are 2 occlusions happen within the same time frame, the algorithm cannot match the new pairs to several old pairs of the object. SORT-FME is designed to match only one new pair to one old pair.

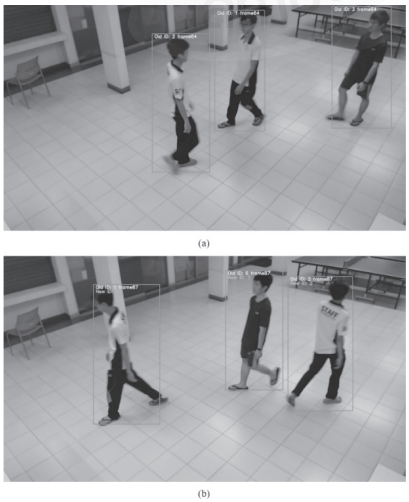


Fig. 3. Before occlusion (b) After occlusion

V. CONCLUSION AND FUTURE WORK

The goal of object tracking is to make the computer understand the spatial and temporal context of video sequences. Computer processes object's information then keeps associating the same object throughout the video. Occlusion is one of the problems that make the tracking algorithm failed as the information of the object being tracked is replaced by the overlapped object. SORT-FME solves this problem by introducing a feature matching method. It enhances the ability of SORT to remember the feature of the tracked object. This new method can improve multi-object tracking accuracy of SORT up to 20% to become the object tracking algorithm that is more robust to occlusion.

Since the baseline model consumes less computational power, this algorithm can work in real-time with a live stream camera such as CCTV. However, for the current state of the model, it can only keep track of 2 people and 3 people from simple occlusion. If all 3 or more people occlude at the same time and at the same place, the method can face assignment problem and tends to fail.

For future work, non-linear motion model such Particle filter [22] can be used to fill a gap of non-linear movement of the object. Also, combinatorial optimization can be added on to solve the matching problem for tracking 3 and more people which occlude at the same time. More and larger testing data can be added so that the tracking performance can be improved.

References

[1] A. Gruen, "Adaptive least squares correlation: a powerful image matching technique," *South African Journal of Photogrammetry, Remote Sensing and Cartography,* vol. 14, no. 3, pp. 175-187, 1985.

[2] A. Nakhmani and A. Tannenbaum, "A new distance measure based on generalized image normalized cross-correlation for robust video tracking and image recognition," *Pattern recognition letters,* vol. 34, no. 3, pp. 315-321, 2013.

[3] S.-Q. Chen, "A corner matching algorithm based on Harris operator," ICIECS 2010, Wuhan, 2010, pp. 1-2.

[4] D. G. Lowe, "Object recognition from local scale-invariant features," ICCV, Corfu, 1999, pp. 1150-1157.

[5] H. Bay, A. Ess, T. Tuytelaars, and L. Van Gool, "Speeded-up robust features (SURF)," *Computer vision and image understanding,* vol. 110, no. 3, pp. 346-359, 2008.

[6] E. Rublee, V. Rabaud, K. Konolige, and G. Bradski, "ORB: An efficient alternative to SIFT or SURF," ICCV, Barcelona, 2011, pp. 2564-2571.

[7] D. G. Viswanathan, "Features from accelerated segment test (fast)," in *Proc*. ICISA 2014.

[8] M. Calonder, V. Lepetit, C. Strecha, and P. Fua, "Brief: Binary robust independent elementary features," ECCV, Crete, 2010, pp. 778-792.

[9] S. Ren, K. He, R. Girshick, and J. Sun, "Faster r-cnn: Towards real-time object detection with region proposal networks," NIPS, Montreal, 2015, pp. 91-99.

[10] R. Girshick, "Fast r-cnn," Proc. IEEE-ICCV, Santiago, 2015, pp. 1440-1448.

[11] D. Comaniciu, V. Ramesh, and P. Meer, "Real-time tracking of non-rigid objects using mean shift," CVPR, South Carolina, 2000, pp. 142-149.

[12] C. I. Patel and R. Patel, "Contour based object tracking," *International Journal of Computer and Electrical Engineering,* vol. 4, no. 4, pp. 525, 2012.

[13] A. Bewley, Z. Ge, L. Ott, F. Ramos, and B. Upcroft, "Simple online and realtime tracking," ICIP, Phoenix, 2016, pp. 3464-3468.

[14] A. Sadeghian, A. Alahi, and S. Savarese, "Tracking the untrackable: Learning to track multiple cues with long-term dependencies," Proc. IEEE-ICCV, Venice, 2017, pp. 300-311.

[15] J. Xiang, G. Zhang, and J. Hou, "Online Multi-Object Tracking Based on Feature Representation and Bayesian Filtering within a Deep Learning Architecture," *IEEE Access,* vol. 7, pp. 27923-27935, Feb. 2019.

[16] K. Fang, Y. Xiang, X. Li, and S. Savarese, "Recurrent autoregressive networks for online multi-object tracking," WACV, California, 2018, pp. 466-475.

[17] H. Fan and H. Ling, "Sanet: Structure-aware network for visual tracking," CVPR, Hawaii, 2017, pp. 42-49.

[18] G. Bishop, and G. Welch, "An introduction to the kalman filter," *Proc of SIGGRAPH, Course,* vol. 8, no. 27599-23175.

[19] K. Smith, D. Gatica-Perez, J.-M. Odobez, and S. Ba, "Evaluating multi-object tracking," CVPR, San Diego, 2005, pp. 36-36.

[20] K. Bernardin and R. Stiefelhagen, "Evaluating multiple object tracking performance: the CLEAR MOT metrics," *Journal on Image and Video Processing,* vol. 2008, pp. 1, 2008.

[21] B. Wu and R. Nevatia, "Tracking of multiple, partially occluded humans based on static body part detection," CVPR, New York, 2006, pp. 951-958.

[22] R. Van Der Merwe, A. Doucet, N. De Freitas, and E. A. Wan, "The unscented particle filter," NIPS, Vancouver, 2001, pp. 584-590.



Chawalit Jeenanunta is an associate professor of School of Management Technology (MT), Sirindhorn International Institute of Technology, Thammasat University, Thailand. He received a B.S. degree in Mathematics and Computer Science, and M.Sc. in Management Science from University of Maryland and he received his Ph.D. in Industrial and Systems Engineering from Virginia Polytechnic Institute and State University. His Research interests are in area of applications of operations research, simulation, large-scaled optimization and supply chain management.



Natsuda Kaothanthong is a Lecturer of School of Management Technology (MT), Sirindhorn International Institute of Technology, Thammasat University, Thailand. She received a B.S. degree in Information Technology from Sirindhorn International Institute of Technology. She received her M.S and Ph.D. in Information Sciences from Graduate School of Information Sciences, Tohoku University, Japan. Her Research interests are Data Mining, Business Intelligence, Computer Vision, and Computational Geometry.



Koksal Chou is a Master Student in Management Technology at Sirindhorn International Institute of Technology (SIIT), Thammasat University. He received his Bachelor of Engineering (B.E) degree in Electrical and Electronic Engineering from Institute of Technology of Cambodia, Phnom Penh, Cambodia in 2017. In the same year he received the Excellent Foreign Student (EFS) scholarship award from Sirindhorn International Institute of Technology (SIIT), Thammasat University (TU), Thailand. His research interests are Computer Vision, Deep Learning, Optimization, and Supply Chain Management.

Thai Celebrity Information Extraction Based on Association Rule Measures

Chinorot Wangtragulsang, Nattakarn Phaphoom, Phannachet Na Lamphun, Pisit Charnkietkong, and Jian Qu

School of Engineering and Technology
Panyapiwat Institute of Management, Nonthaburi, Thailand
E-mail: chinorot_w@hotmail.com, nattakarnpha@pim.ac.th, phannachetnal@pim.ac.th, pisitcha@pim.ac.th, jianqu@pim.ac.th

Received: April 22, 2019 / Revised: August 21, 2019/ Accepted: August 29, 2019

***Abstract*— this study aims to develop a system to automatically extract and select celebrity information from websites, as traditionally celebrity information is gathered and selected by hand, which is rather time-consuming and often unable to stay updated due to large number of celebrities in Thailand, and potential ambiguity and conflict between information sources on the Internet. This study proposes a novel method that uses pattern matching and association rules to extract date of birth, height and weight of celebrities from websites. In addition, a weight estimation system based on height and BMI is developed. It is found that our system is able to obtain more celebrity information than many Thai websites such as MThai.com. Also, the weight estimation system is able to estimate celebrities' weights based on height and BMI index.**

***Index Terms*—Information extraction, personal information extraction, unstructured data, weight estimation**

I. Introduction

Personal information of celebrities, such as actors and singers, has been normally collected by hand or in some examples through crowd-sourcing (like Wikipedia), and then stored in database for further use. One notable example is the Internet Movie Database (IMDb), which allows registered members (including the celebrities themselves, their agents, or the production crew) to put in additional data as needed. Due to its long history, ownership by Amazon, and huge number of contributors, the IMDb is able to keep the large amount of information up-to-date.

In non-crowd-sourced websites however, usually the web administrator or staff must perform research, validation and import solely by hand, which although highly accurate, is fairly time-consuming and poorly-scalable against large amount of data. In this case, the computer's role in such data extraction is limited to being a vessel for the human-processed data. This can be partly attributed to lack of punctuation mark to separate words which makes information extraction by machine is a challenging task.

Although there are Thai websites that collect data on Thai celebrities such as Thaiza[1], MThai[2], Siamdara[3] and the Thai version of Wikipedia, such efforts are not centralized and as a result, information on celebrities were fragmented (present on one website but not others). In addition, due to large amount of Thai celebrities, smaller Thai websites have limited data management abilities. One notable example is the Siamdara website where few, if any, Thai celebrity has information post-2015, and MThai does not have as many celebrities as Siamdara.

Due to difficulties in updating large amount of Thai-language celebrity information, we propose a novel automated method to solve above problems. Our method uses novel rules to extract possible pieces of information (date of birth, height and weight) or "personal information candidates" from websites, and then association rule measures and statistical rules are used to select the most likely personal information candidate. In addition, weight information is relatively rare compared to information such as date of birth, especially for female actresses, possibly due to privacy reasons. Furthermore, in an effort to solve the missing weight information problem, we propose a modified BMI method to estimate weight for the celebrities.

The remaining parts of this paper are similar and related works, description of the method used in this paper, result of our method, discussions of issues

[1] https://entertainment.thaiza.com, accessed on 6 November 2019.
[2] https://people.mthai.com/starthai, accessed on 6 November 2019.
[3] http://www.siamdara.com/profile/thais, accessed on 6 November 2019.

encountered while we implement the method, and conclusion and future works.

II. Literature Review

Unstructured text is usually user-generated content that cannot be easily inserted into conventional databases.

Information Retrieval (IR) is query-based acquisition of a piece of information from a large collection of data. Using a search engine is basically an information retrieval. A main difference from IE is IR returns the result in natural language that humans can understand, while IE returns the result in a machine-understandable form for further processing.

Information Extraction (IE) serves as one of the core operations of text mining. The work of IE aims at recognizing specific types of information from objects of interests, events or relationships directly from text. Examples of the research attempts and techniques used are reviewed in this section. Reviewed works are grouped as lexicon-based works, free-text works, and personal information extraction works.

In this section we review lexicon-based works. Many information extraction systems and studies rely on a certain corpus and are in medical or biological fields. Liu et al. [1] developed AZDrugMiner to extract Adverse Drug-Event (ADE) from online patient forums as post-marketing drug surveillance is deemed a highly critical component of drug safety. AZDrugminer aimed to overcome inadequacies in existing system by extracting information from social media sites such as DailyStrength and PatientsLikeMe. Instead of lexicon-based extraction system like others, AZDrugMiner used machine learning to determine relationship, although many rule-based systems were also used. Likewise, Xu et al. [2] proposed a data-driven information extraction system for Chinese electronic medical records. This work used a Chinese medical term lexica and cross-domain dictionary to improve recall on named entities. The lexica were enriched further by pattern iteration. These systems had high precision but reliance on existing programs and infrastructure render this approach unsuitable for data that had little existing infrastructure.

Non-medical examples are work by Sasali et al. [3] who evaluated information extraction techniques using Malay documents such as magazines, novels, Quran, hadiths and other. The techniques used were lookup list, morphological rules (with noun affixes and verb/objective/noun affixes) and Rayner's Rule. It was found that morphological rules with verb/adjective/noun affixes was the most effective but further lexicon build-up was recommended.

In this section, Information extraction from open-text corpus include work by Sharma and De Choudhury [4] who developed a system that extracted nutritional information of food and ingestion content in Instagram. In this system, the researcher manually made a list of "canonical food names" or words that could query food-related Instagram posts. The USDA National Nutrient Database for Standard Reference database was used as a reference. The researcher processed the list of tags in each post and matched it with the list of canonical food. Also, there was a second method that compared the tag to the food descriptors in USDA. This method was reliable and accurate (89%) for food of moderate content. This work relied heavily on English language posts. On the other hand, Li et al. [5] created a web information retrieval system to extract news information from Baidu through analysis of URL of search results and the DOM structure of the web page. While it achieves high extraction and matching rate for open-text document, the search engine is limited to Baidu.

Works related with personal information extraction include that of Chen et al. [6] which proposed a hierarchical system that could extract personal information from resume PDF files. This work used conditional random fields and supporting vector machine to segment resumes into blocks and extract information. Li et al. [7] suggested a user profile extraction (Education, job and spouse) from Twitter. This approach requires only weak supervision but was limited to Twitter and job recall and precision were low as mentioning of job places in Twitter did not always mean that person was employed in such places.

Chen et al. [8] who introduced a robust web personal name information extraction system integrated with a heterogeneous attribute extraction and disambiguation system that extract features from multiple sources without supervision while achieving excellent precision. However, this approach has a relatively lower recall rate as each integrated AE approach covers only a percentage of the heterogeneous texts. Aboaoga and Ab Aziz [9] used rule-based approach for Arabic person name extraction. This approach used Introductory Words Person List and BAMA to recognize personal names. This study experimented on newspaper (sports, economy and politics) and found that named entity type, corpus size, number of keywords and rules, stop-words detection and morphological analyzer had impact on performance. It also found that this approached worked best on sports content.

There was one work that use statistical feature. Qu and Lu [10] investigated multi-translatable out-of-vocabulary terms which had received little attention and proposed a combined method that saw the use of statistical feature extraction, an artificial neural network combined with backward feature selection, and evolutionary parameter optimization.

Majority of the aforementioned works used corpus which was a finite, predictable set of data. Although there were some works on free-text acquired from a

search engine, those were primarily focused on other languages, which already had some infrastructure. The system proposed by this project mainly focuses on Thai-language free-text data extraction.

One study that described difficulties in Thai language named entity extraction is one by Imsombut and Sirikayon [11] on Thai tourism ontology, because agro attraction such as national parks had long word names, while shopping stores had larger variation of word names, in contrast with cultural attractions like temples and people's monuments.

The method proposed in this study uses a set of manually-made rules to automatically extract pieces of information related with date of birth, height and weight as "personal information candidates" from websites. Then, association rule measures and statistical rules which are co-occurrence, support, confidence, lift and conviction are used to select the most likely personal information candidate. Furthermore, weight of celebrities is estimated by using available height information and two sets of BMI values. Further details are specified in the following chapter.

III. Materials and Methods

This study aims to retrieve personal information birthday, height and weight from unstructured, Thai-language text such as website snippets. The experiment uses names of Thai celebrities as input. We also develop a weight estimation system for celebrities whose weight information is not obtained by the pattern-matching system, which estimate weight based on height and two sets of BMI values. The method consists of 4 parts: web crawling, rule-based pattern matching, selection by statistical method, and weight estimation using height and BMI index. The diagram is shown in Fig. 1 below:

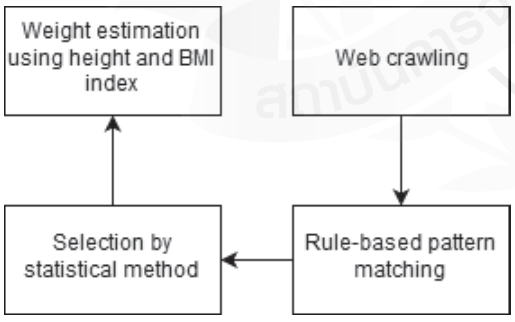


Fig. 1. Diagram of the information extraction process.

A. Web crawling

Web snippets related with Thai celebrities are the main source of information and acquired by using Google Custom Search API[4]. According to [10], the snippet limit should be 100 to ensure maximum coverage with acceptable noise. Example of the obtained snippets is shown in Fig. 2.



Fig. 2. Example of a web snippet from Google API.

A database is made to keep snippets for further use as shown in Fig. 3. In the table, title, URL, snippet, and the names of celebrities used to search for the snippet are stored. Each entry is given IDs.

SID	Title	Snippet	Web	Searcl
19...	บันเทิง - 'ลน' สวมวิญญาณ...	29 ก.ย. 2559 - เบรกความ...	www.naewna.com/enter...	รถบัส
19...	ข่าว'น้องรถบัส'ภูมิใจเป็นนัก...	14 ม.ค. 2560 - รถบัส : ส...	https://entertainment.ka...	รถบัส
19...	มาเรีย เข้าถึงอารมณ์เด็กเจ...	28 ก.ย. 2559 - กำลังเข้มข้...	https://www.siamzone.c...	รถบัส
19...	พูดคุยกับคู่ขี้ต่างวัย 'ฮัท จิร...	15 ม.ค. 2561 - 'ฮัท-จิรวิช...	www.trueplookpanya.co...	รถบัส
19...	Ladprao General Hospita...	... 2560" ณ ชั้นใต้ดิน ศูนย์...	www.ladpraohospital.co...	รถบัส
19...	Download รถบัส ด.ช.ภคพ...	Result for: รถบัส ด.ช.ภค...	www.aslady.de/video/รถ...	รถบัส
19...	chanyamcclory - Instagr...	เข้ากัน ที่สำคัญหน้าตาเหมื...	https://deskgram.org/ch...	รถบัส
19...	โป๊ป-มิว ชวนแฟนคลับผู้ใช...	18 ม.ค. 2561 - ... โป๊ป-ธ...	www.becmultimedia.com...	รถบัส
19...	'ลน-แยม'นำทีมนักแสดง'ดว...	11 ก.ย. 2559 - ทิพย์รดา ไ...	m.innnews.co.th/mobile/...	รถบัส
19...	บ้านเมือง - คุจิ้นต่างวัย 'อั...	20 ธ.ค. 2560 - นานมัน 1 ...	www.banmuang.co.th/ne...	รถบัส
19...	บันเทิง - 'ลน' อึ้ง! 'มาเรีย' เ...	29 พ.ย. 2559 - น้ำตามาเร็...	www.naewna.com/enter...	รถบัส
19...	ดูดวงใจพิสุทธิ์ (จด) วันที่ 1...	14 ต.ค. 2559 - ... ลูกหมี ...	lakorn.guchill.com ? ละคร...	รถบัส
19...	หวนคืนบัลลังก์คู่จิ้นในด่าน...	27 พ.ย. 2560 - ภคพล ต้...	https://www.tvpoolonline...	รถบัส

Fig. 3. Example of the snippet table.

B. Rule-based pattern matching

In this section, date of birth, height and weight of the celebrities are extracted using pattern matching approach, detail of each part shall be explained below. Regular expressions are used to extract "candidates" or possible words. Hand-crafted regular expression rules are used.

The pattern matching locates the input (celebrity names) in the snippet and then find a certain group of keywords that matches one of the rules. Then a personal information candidate is extracted based on such rules. If there is no matching, the next rule will be selected, and repeats until a match is found, or the rules are exhausted. Diagram of the pattern matching approach is shown in Fig. 4 below.

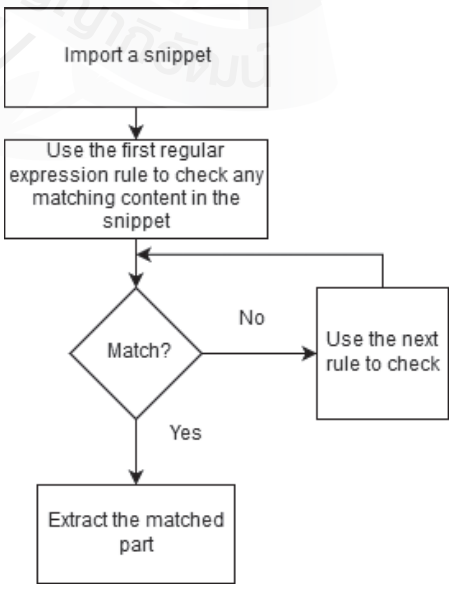


Fig. 4. Pattern matching diagram.

[4]https://developers.google.com/custom-search, accessed on 6 November 2019.

The first group of personal information candidates to be extracted is date of birth. Keywords such as "วันเกิด" or "เกิดวันที่" and "พ.ศ." (Buddhist Era) are used to locate and extract the candidate, as shown in Table I.

TABLE I
EXAMPLE OF EXTRACTED BIRTHDAY INFORMATION

Named entity	แอน อังคณา ทิมดี
Snippet	ประวัติ แอน อังคณา ทิมดี เกิดเมื่อวันที่ 9 กุมภาพันธ์ 2507 เป็นนักร้อง นักแสดง ผลงานละคร กุหลาบเหนือเมฆ และภาพยนต์ เรื่อง เขี้ยวอาฆาต.
Matching rules	%s.*?เกิด.*?([0-9]?[0-9]).?(\S+).*?([0-9][0-9][0-9][0-9])
Matched content	9 กุมภาพันธ์ 2507

As seen in Table I, birthday candidate of Angkana Timdee is 9 February 1964 as part of the snippet matches with one of the rules.

The second group of personal information candidates is height. In this part, the pattern matching approach would look for any 3-digit numbers near the keywords in the snippets, as it is improbable for an adult celebrity to have height less than 100cm unless they have medical issue (dwarfism etc.), before extracting it. Examples are shown in Table II.

TABLE II
EXAMPLE OF HEIGHT EXTRACTION

Named entity	นิศาชล ต้วมสูงเนิน เม
Snippet	3 ธ.ค. 2016 ... กลับมาพบกันอีกครั้ง กับ คอลัมน์ สวัสดีแคมปัส สัปดาห์พี่แคมปัส มีนางเอกช่อง 3 มาแนะนำ น่า รักสดใส สมวัย แถมดีกรีความสวยไม่ธรรมดา เราไปรู้จักเธอพร้อมๆ กัน. ชื่อ-นามสกุล : นิศาชล ต้วมสูงเนิน นิกเนม : เม วันเกิด : 24 เมษายน 2536 อายุ : 23 ปี พี่น้อง : มีน้องสาว 1 คน น้ำหนัก : 48 กิโลกรัม ส่วนสูง : 167 เซนติเมตร บ้านเกิด : อุดรธานี
Matching rules	ส่วนสูง.*:? (1\d{2})
Matched content	167

The third personal information candidate group is weight. The pattern matching approach looks for a keyword such as "น้ำหนัก" and then select any number behind it as shown in Table III.

TABLE III
EXAMPLE OF WEIGHT EXTRACTION

Title	รัศมีแข ฟ้าเกื้อล้น | GMM52 NEWFACE
Snippet	รัศมีแข ฟ้าเกื้อล้น. ชื่อเล่น. รัศมีแข. เพศ. ชาย. อายุ. 31 ปี 5 เดือน. น้ำหนัก. 89 กก. ส่วนสูง. 184 ซม. สัดส่วน. -. สีตา. ดำ. สีผม. ดำ. แบบผม. สั้น. ภาษา. ไทย/อังกฤษ/สวีเดน. รองเท้า. 9. ความสามารถพิเศษ.
URL	http://gmm.52com/newface/RDM8050
Matched content	89

In this section, 3 groups of personal information candidate groups are extracted. Due to the large number of candidates, statistical methods are used to select the correct personal information candidate which will be explained in the next section.

C. Selection by statistics

We use five statistical features for selecting the possibly correct personal information candidate, which are support, co-occurrence frequency, confidence, lift, and conviction. Each of the described statistical features is explained below.

1) Support

Support is the number of times a name of celebrity and a personal information candidate appear together divided by the total number of snippets. The formula is:

Where a is actor's name and b = information candidate $c_1 \ldots c_n$

$$Supp(a \to b) = \frac{f(a \cap b)}{N} \quad (1)$$

2) Co-occurrence frequency

Co-occurrence frequency is a number of times a celebrity name and a personal information candidate appears together.

Where a = actor's name and b = information candidate $c_1 \ldots c_n$

$$Co\text{-}occurrence\ (a \to b) = a \cap b \quad (2)$$

3) Confidence

Confidence is calculated by comparing the support of a celebrity name and a personal information candidate to support of the celebrity name.

Where a = actor's name and b = information candidate $c_1 \ldots c_n$

$$Conf(a \to b) = \frac{Support(a \cap b)}{Support(a)} \quad (3)$$

4) Lift

To get lift of a personal information candidate, divide the support of a celebrity name to the candidate by multiplication of individual support of celebrity and individual support of the candidate.

Where a = actor's name and b = information candidates $c_1 \ldots c_n$

$$lift(a \to b) = \frac{Support(a \cap b)}{Support(a)\,Support(b)} \quad (4)$$

5) Conviction

Conviction is division of support of the celebrity name by support of named entity that does not co-occur with candidate, and then support of candidate is compared against support of candidate without named entity.

Where a = actor's name and b = information candidates $c_1 \ldots c_n$

$$Conv(a \rightarrow b) = \frac{Support(a)}{Support(a \cap \neg b)} \quad (5)$$

D. Weight estimation using height and BMI index

Due to unavailability of weight information, an estimation method based on BMI index is proposed. BMI index is an indirect measurement of body fatness. The BMI index of less than 18.5 is considered underweight, and more than 24.9 is considered overweight. It is calculated by dividing the weight (in kilograms) with a squared height (in meters)

As celebrities tend to be fitter (male), or skinnier (female) than the average population, it is assumed that female BMI index should be slightly under average to maintain the slim body shape. On the other hand, muscular male celebrities should have BMI slightly over average due to muscle weight. According to Kate Stinchfield of Health.com[5], Angelina Jolie has an estimated BMI of only 17.9, while Arnold Schwarzenegger is estimated to have BMI of 30.8.

From our previous experiment, we establish 2 sets of BMI values for weight estimation. The first set of BMI values used numbers 18 and 22 (slightly underweight for female and near the upper healthy limit for male) as the BMI values for female and male celebrities. Then, the second BMI value for male and female celebrity weight estimation is calculated from average BMI of celebrities with known weight information, which are 16.7 and 20.2 respectively. Details of the BMI formula are as follows:

$$BMI_{(f,m)} = \frac{body\ weight(kg)}{body\ height(m)^2} \quad (6)$$

Where f = (18,16.7), m = (22,20.2)

In addition to our modified BMI formula, we also use a formula based on Martin Berkhan's ripped BMI (fat level at 5-6%) calculation per the following formula.

$$BMI_{ripped} = Height(cm) - 100 \quad (7)$$

Berkan's formula, however, is developed for athletes.

IV. Experiment and Result

A. Web crawling

We used 317 celebrity names presented on MThai.com/starthai, as input. Snippets were obtained by using Google Custom Search API, using the celebrity name as keywords for searching. In total we obtained 22,484 snippets, an average of 70.92 snippets per one celebrity. Some celebrities were relatively obscure and resulted in less than 100 snippets being attributed to them. Additionally, a master student was hired to manually collect personal information to make a baseline for comparison.

B. Pattern matching

The recall number of possible candidates for birthday extracted is 458, height is 98 and weight is 119.

C. Selection by statistical methods

This section includes 3 accuracy graphs for the 3 celebrity candidate groups, and one graph for BMI estimation. Fig. 5 Shows a graph for date of birth.

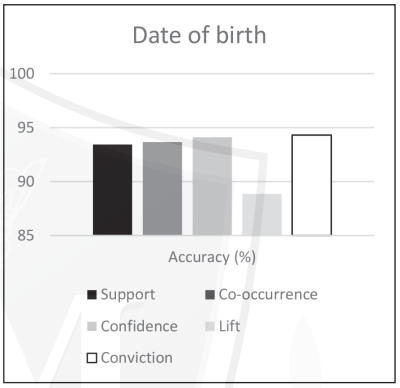


Fig. 5. Accuracy of date of birth features.

As seen in Fig. 5, conviction has the highest accuracy at 94.32%, followed by confidence, co-occurrence, support and lift respectively.

Most of the incorrect result were from misattribution as some celebrities did not have birthday information. Another problem was some snippets included a list of celebrities and their birthdays. As a result, the system happened to pick the birthday of someone other than the intended entity. Misspelling in words such as "พ.ศ." or "กรกฎาคม" also affected accuracy. Also from observation, candidates tend to be misattributed if multiple birthdays and actors are included in the same snippet.

If a snippet includes a list of celebrities and their birthdays, which still counts as co-occurrence despite misattribution. For this reason, some candidates have identical confidence. One Thai celebrity, Alice Tsoi, has relatively obscure birthday information and result in multiple contesting candidates (1 and 4 June 1991).

The next part is result from height candidate group. Fig. 6 below shows accuracy of height candidate features.

[5]https://www.health.com/health/gallery/0,,20460621,00.html, accessed on 6 November 2019.

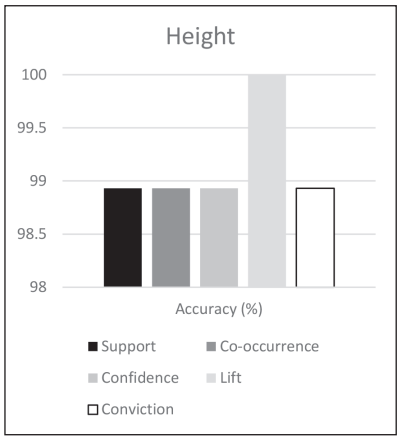


Fig. 6. Accuracy of height candidates.

According to Fig. 6, accuracy for most features are equal at 98.93% except lift, which each correct candidate has higher than all other candidates.

On height, assessment of candidates showed that out of 98 height candidates, 4 candidates do not have co-occurrence with the named entities. Gee-Thanyachon does not co-occur with her correct 170cm candidate because the candidate instead appears with her old name: Rattakorn. Similarly, Gale-Waethaka has height information under her old name Wipawee. Another is due to misspelling of the nickname in the snippet. The highest number of co-occurrence is 9, with the celebrity name Mak Parin.

Out of 94 celebrities with collected height candidates, only 4 celebrities have two height candidates as shown in Fig. 7 below.

Heightcan	ActorID	SupportCooc	Confidence	Lift	Conviction
160	137	0.0000444741	0.0238096	35.6905	1.02439
162	137	0.0000444741	0.0238096	89.2262	1.02439
165	189	0.0000444741	0.0140845	17.5939	1.01428
167	189	0	0	0	1
165	311	0.0000889482	0.0136054	16.9955	1.01379
167	311	0.0000444741	0.00680272	12.7466	1.00685
168	313	0.000266845	0.1	149.9	1.11111
174	313	0.0000889482	0.0333333	53.5357	1.03448

Fig. 7. Features of all ambiguous height candidates.

As seen on Fig. 7, the candidates for the celebrity no. 137 have similar values in all but Lift. For the celebrity no.189 (Gale-Waethaka), the 167 cm candidate does not have co-occurrence with the named entity due to name changes as mentioned. Named entities number 311 and 313 each has one candidate with more confidence, lift and conviction then the other, and is the correct candidate.

The next personal information candidate group to be evaluated is weight. Result is shown in the following Fig. 8.

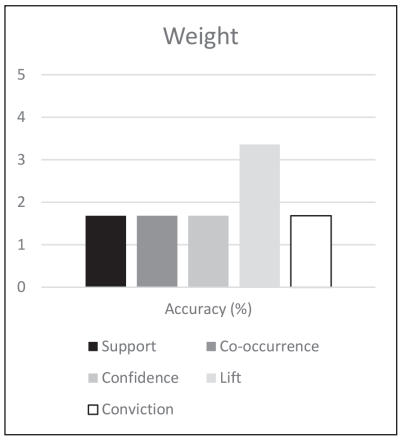


Fig. 8. Accuracy of weight candidates' features.

According to Fig. 8, accuracy is very low compared to date of birth and height, with maximum accuracy being only 3.36% for lift.

While 100 celebrities have weight attributed to them, only 44 attributed weight values are deemed plausible by manual inspection. The remaining 66 celebrities have attributed weight of less than 40 kilograms which is impossible for a well-looking actor/actress, except one who is a child actor).

The next part is weight estimation using height, 2 sets of BMIs (18 and 16.7 for female and 22 and 23.2 for male celebrities) and Berkan's fomula. As only 94 celebrities have height attributed, weight estimation is calculated only for them. Result of weight estimation is shown in Fig. 9.

FName	LName	NickNa...	Gender	Weight	BMIEst
รัศมีแข	ฟ้าเกื้อลัน	รัศมีแข	M	89	(NULL)
คณัสนันท์	นักตะเข่	มาร์ค	M	69	71.28
นราวิชญ์	จิตรบรรจง	เขม	M	68	68.9238
วัทธิกร	เพิ่มทรัพย์หิรัญ	เกี๊ยก	M	68	71.28
ธนวรรธน์	วรรธนะภูติ	โป่ป	M	65	67.375
อรรคพันธ์	นะมาตร์	อ่อม	M	73	72.0742
พิชญะ	นิธิไพศาลกุล	กอล์ฟ	M	53	63.58
กิจเกษม	แมคแฟดเดน	เจมส์	M	58	71.28
ศตวรรษ	เศรษฐกร	เต๊ะ	M	60	66.6072
ปกรณ์	ฉัตรบริรักษ์	บอย	M	63	71.28

Fig. 9. Complete weight information of male celebrities at BMI = 22 (gender, obtained weight, BMI estimation).

As visible in Fig. 9, the estimated weight is higher for most male celebrities except 3 male celebrities who weigh more than the BMI estimation, out of 20 male celebrities with attributed weight. One male celebrity does not have BMI calculation due to absence of height information.

An example of obtained and estimated weight of female celebrities is shown below:

FName	LName	NickName		Weight	BMIEst
ณปภา	ตันตระกูล	แพท	F	43	52.9891
ตฤณญา	มอร์สัน	แคท	F	51	56.2096
พิชชาภา	พันธุมจินดา	แพร์	F	49	54.91
ณัฐวรา	วงศ์วาสนา	มิ้นท์	F	45	51.7275
พรรัมภา	สุขใต้พึ่ง	แพร	F	49	56.8651
กัญจน์ณิช	กิตติพรภาณุวงศ์	แก้วใส	F	45	51.7275
คามิลล่า	กิตติวัฒน์	มิลลี่	F	48	51.1024
พีชญา	วัฒนามนตรี	มีน	F	47	51.7275
เดบาร่า	ซี	เด็บบี้	F	45	49.8636
แอน	ทองประสม	แอน	F	49	50.4811
เวธกา	ศิริมณีวัฒนา	เกล	F	47	51.7275
อัมราภัสร์	จุลกะเศียน	มิ้ม	F	51	56.8651

Fig. 10. Example of weight information of female celebrities at BMI = 18 (Obtained weight and BMI estimation).

On the other hand as seen in Fig. 10, female celebrities' obtained weight is generally lighter than the BMI estimation. It is notable that no female celebrity is heavier than the BMI estimation.

Then, the second set of BMI values (16.7 for female and 20.2 for male celebrities) is used. Fig. 11 below is a complete result of modified estimation for male celebrities.

FName	LName	NickName	...	Weight	BMIEstMod
คณัสนันท์	นักตะเข่	มาร์ค	M	69	65.448
นราวิชญ์	จิตรบรรจง	เขม	M	68	63.2846
วัทธิกร	เพิ่มทรัพย์หิรัญ	เกี๊ยก	M	68	65.448
ธนวรรธน์	วรรธนะภูติ	โป๊ป	M	65	61.8625
อรรคพันธ์	นะมาตร์	อ๋อม	M	73	66.1772
พิชญะ	นิธิไพศาลกุล	กอล์ฟ	M	53	58.378
กิจเกษม	แมคแฟดเดน	เจมส์	M	58	65.448
ศตวรรษ	เศรษฐกร	เต๊ะ	M	60	61.1575
ปกรณ์	ฉัตรบริรักษ์	บอย	M	63	65.448
เศรษฐพงศ์	เพียงพอ	เต่า	M	65	64.0017

Fig. 11. Example of modified (BMI = 20.2) weight estimation (the rightmost column) compared with the obtained weight for male celebrities.

As seen in Fig. 11, 2 male celebrities have BMI estimation being within 1 kilogram of the obtained weight.

The following part is the modified BMI estimation result for female celebrities.

FName	LName	NickN...	...	...	BMIEstMod
ณปภา	ตันตระกูล	แพท	F	43	46.5746
ตฤณญา	มอร์สัน	แคท	F	51	49.4053
พิชชาภา	พันธุมจินดา	แพร์	F	49	48.263
ณัฐวรา	วงศ์วาสนา	มิ้นท์	F	45	45.4658
พรรัมภา	สุขใต้พึ่ง	แพร	F	49	49.9814
กัญจน์ณิช	กิตติพรภาณุวงศ์	แก้วใส	F	45	45.4658
คามิลล่า	กิตติวัฒน์	มิลลี่	F	48	44.9163
พีชญา	วัฒนามนตรี	มีน	F	47	45.4658
เดบาร่า	ซี	เด็บบี้	F	45	43.8275
แอน	ทองประสม	แอน	F	49	44.3702
เวธกา	ศิริมณีวัฒนา	เกล	F	47	45.4658

Fig. 12. Example of modified BMI estimation for female celebrities.

Out of 33 female celebrities with attributed height and weight, 10 female celebrities have BMI estimation being within 1 kilogram of the obtained weight.

Then, weight estimation based on Berkhan's formula is used. It was found that no celebrity with attributed weight meets the "ripped" weight or higher, suggesting lower muscle mass and likely poor suitability of the formula outside of athletic circles. Example of ripped weight estimation is shown in Fig. 13 below:

FName	LName	NickName	G...	Weight	BMIEstlean
ณปภา	ตันตระกูล	แพท	F	43	67
ตฤณญา	มอร์สัน	แคท	F	51	72
คณัสนันท์	นักตะเข่	มาร์ค	M	69	80
พิชชาภา	พันธุมจินดา	แพร์	F	49	70
นราวิชญ์	จิตรบรรจง	เขม	M	68	77
วัทธิกร	เพิ่มทรัพย์หิรัญ	เกี๊ยก	M	68	80
ณัฐวรา	วงศ์วาสนา	มิ้นท์	F	45	65
ธนวรรธน์	วรรธนะภูติ	โป๊ป	M	65	75
พรรัมภา	สุขใต้พึ่ง	แพร	F	49	73
กัญจน์ณิช	กิตติพรภาณุวงศ์	แก้วใส	F	45	65

Fig. 13. Example of ripped weight estimation (the rightmost column) compared with the obtained weight.

V. Discussion

Although conviction is the most accurate feature, at least one record (Ann Thitima's birthday), has 8 February 1988 and 4 July 1979 as possible candidates. Although correct, the 4 July candidate has conviction of only 1.09302 compared with the erroneous 8 February 1988 (actually another celebrity's birthday on the same page) that has conviction of 1.175. In another case, the 8 February 1988 is also a candidate for Bow Sunita (who was actually born in 1975), and has higher lift and conviction than the correct candidate. Despite this, high confidence (0.0434782 compared to only 0.101449) ensure that the 1975 candidate is correct.

In addition, misspelling or use of old names can lead to incorrect candidate extraction. In our experiment, 2 celebrities had their correct weight information under their old names and as a result were not selected.

VI. Conclusion

In conclusion, we have developed a system to automatically extract personal information candidates using novel rules. Moreover, association rule measures and statistical methods were used to select the possibly correct information. Furthermore, a modified BMI-based weight estimation method is proposed to overcome absence of data weight problem. We tested the methods with Thai celebrity from MThai.com and our method gained more information than MThai.

In future works, we plan to employ machine learning to find other information such as work/romantic relationship between actors, films, or production crewmembers.

Authors' Contribution

The first author conducted the experiment and drafted the manuscript. The last author guided the experiment and co-drafted the manuscript. The first author and the last author contributed 85% for this research article. The second, third, and fourth authors reviewed the manuscript and provided feedback.

References

[1] X. Liu and H. Chen, "AZDrugMiner: an information extraction system for mining patient-reported adverse drug events in online patient forums," International conference on smart health, pp. 134-150, 2013.

[2] D. Xu, Meizhuo Z, and et al., "Data-driven information extraction from Chinese electronic medical records," PloS one, vol. 10, no. 8, pp. 1-18, 2015.

[3] S. S. Sazali, N. A. Rahman, and Z. A. Bakar, "Information extraction: Evaluating named entity recognition from classical Malay documents," in 2016 Third International Conference on Information Retrieval and Knowledge Management (CAMP), 2016, pp. 48-53.

[4] M. De Choudhury, S. Sharma, and E. Kiciman, "Characterizing dietary choices, nutrition, and language in food deserts via social media," in Proceedings of the 19th ACM conference on computer-supported cooperative work & social computing, 2016, pp. 1157-1170.

[5] J. Li, G. Jiang, A. Xu, and Y. Wang, "The Automatic Extraction of Web Information Based on Regular Expression.," JSW, vol. 12, pp. 180-188, 2017.

[6] Y. Chen, J. Zhou, and M. Guo, "A context-aware search system for internet of things based on hierarchical context model," Telecommunication Systems, vol. 62, no. 1, pp. 77-91, Mar. 2016.

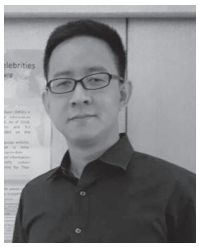
[7] J. Li, A. Ritter, and E. Hovy, "Weakly supervised user profile extraction from twitter," in Proceedings of the 52nd Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers), vol. 1, pp. 165-174, 2014.

[8] Y. Chen, S. Y. M. Lee, and C.-R. Huang, "A robust web personal name information extraction system," Expert Systems with Applications, vol. 39, no. 3, pp. 2690-2699, 2012.

[9] M. Aboaoga and M. J. Ab Aziz, "Arabic person names recognition by using a rule based approach," Journal of Computer Science, vol. 9, no. 7, pp. 922, 2013.

[10] J. Qu and Y. Lu, "Automatic identification and multi-translatable translation of vocabulary terms with a combined approach," in 2016 Eighth International Conference on Advanced Computational Intelligence (ICACI), 2016, pp. 342-348.

[11] A. Imsombut and C. Sirikayon, "An alternative technique for populating thai tourism ontology from texts based on machine learning," in 2016 IEEE/ACIS 15th International Conference on Computer and Information Science (ICIS), 2016, pp. 1-4.



Chinorot Wangtragulsang was born in 1988 in Bangkok, has a Bachelor's degree in Computer Science from Sirindhorn International Institute of Technology (SIIT), Thammasat University (graduated in 2012). After graduation, he was drafted into the Royal Thai Army in 2014 and discharged in the following year with outstanding contribution to the army. After that, he works as a teaching assistant at SIIT and also takes up other part-time professions such as a freelance translator (since 2016), computer instructor at SIAM Computer (since 2019) and a military interpreter working for various Army and Police units (since 2017).



Nattakarn Phaphoom is currently a lecturer at Panyapiwat Institute of Management, Thailand. She obtained a Ph.D. from Free University of Bozen-Bolzano, and double master's degree in software engineering from Blekinge Institute of Technology, Sweden, and Free University of Bolzano-Bozen, Italy. Prior to studying the master's degree, she worked for 3 years for IBM Solutions Delivery Co., Ltd., Thailand. Her research interests include emerging technologies, innovation adoption, cloud computing, data analytics, and agile methods.



Phannachet Na Lamphun received the Master of Science (Computer Engineering), Polytechnic institute of New York University, New York, USA and Doctor of Engineering (Information and Communications Technologies), Asian Institute of Technology.

Past work experience is at IndexInternational Group Co.,Ltd. as a system engineer for Project Management Consultation of MRTA Blue Line, Dustfree Road Projects, and Water Forecast and Flood Alarm Project.



Pisit Charnkietkong has the M.Eng. and D.Eng. in Electrical & Computer Engineering from Yokohama National University, Japan.

Currently, he is a dean of Panyapiwat Institute of Management. In the past, he was a dean of Faculty of Information Technology, Rangsit University, a head of Electrical Engineering department, Faculty of Engineering, Sripatum University.



Jian Qu is a full-time lecturer at the Faculty of Engineering and Technology, Panyapiwat Institute of Management. He received Ph.D. in information science with Outstanding Performance award from Japan Advanced Institute of Science and Technology, Japan, in 2013. He received B.B.A with Summa Cum Laude honors from Institute of International Studies of Ramkhamhaeng University, Thailand, in 2006, and M.S.I.T from Sirindhorn International Institute of Technology, Thammasat University, Thailand, in 2010. He was a program director and lecturer for School of information technology, SIU, Thailand from 2013 to 2017, and secretary to CEO and international marketing manager at Eason Paint PCL from 2007 to 2010. His research interests are natural language processing, intelligent algorithms, machine learning, machine translation, information retrieval and image processing.

PIM
PANYAPIWAT
INSTITUTE OF MANAGEMENT
สถาบันการจัดการปัญญาภิวัฒน์

The Comparison's Food Nutrition of Roasting of Cocoa Bean from some Private Company in Thailand and Taiwan

Korawit Chaisu

Faculty of Innovative Agriculture Management, Panyapiwat Institute of Management, Nonthaburi, Thailand
Email: Korawitchaisu@gmail.com, Korawitcha@pim.ac.th

Received: August 27, 2019/ Revised: October 28, 2019 / Accepted: November 18, 2019

***Abstract*— Cocoa, a fruit product of *Theobroma cacao* L., is the third most important agricultural crop in the world. Cocoa is the main ingredient in chocolate manufacture. The consumption of cocoa is increasing due to the demand in international market and chocolate industries. The aim of this research paper studied and compared on food nutrition of cocoa beans some private company in Thai and Taiwan. The results found that total calories, calories from fat, crude fat, saturated fatty acids, dietary fiber, cholesterol, cholecalciferol (Vitamin D3), and total flavonoids content of cocoa beans from Thailand were higher than Taiwan. On the other hand, carbohydrate, ash, calcium, iron, potassium, and ergocalciferol (Vitamin D2) of cocoa beans from Taiwan. Therefore, this research paper is the first report database on food nutrition from private company in Thailand and Taiwan. For the future can be applies to advance cocoa research, sharing to smart farmer for cocoa industries.**

***Index Terms*—food nutrition, thai, taiwan, cocoa beans.**

I. Introduction

Cocoa, a fruit product of *Theobroma cacao* L. (*Malvales: Sterculiaceae*), is the third most important agricultural crop in the world and also have long story about high antioxidant. The cocoa beans, it is an important commodity in the world and the major ingredient in chocolate manufacture. Now a day the consumption is increase in the demand of cocoa at the international market and chocolate industries (Fig. 1, 2).

The world production and consumption of cocoa in 2018, the highest consumption of cocoa was in Europe as 1,852 thousand tonnes. In addition, the highest production of cocoa was from Cote devoirs as 2,000 thousand tonnes. The most production area is in tropical countries in Africa (76%), Latin America (16%), and Asia & Oceania (7%) (UNCTAD, April 2018). Recently, Thai government is introducing cocoa as new economic crop in the country by promoting and planning for cocoa industry (Fig 2). Food nutrition is including 1) Macronutrients such as carbohydrates, protein, fiber, fat, essential fatty acids, water and alcohol (ethanol). 2) Micronutrients such as minerals; macro minerals, trace minerals, vitamin and Phytochemicals. Phytochemicals (Phytonutrients) are biological substances found only in plants. One of them is Polyphenols: Flavonoids. Cocoa is an important source of Polyphenol, which is a healthy antioxidant. It can be seen that cocoa has many beneficial nutrients [1]. The aim of this research paper studied and compared on food nutrition of cocoa beans some private company in Thai and Taiwan.



Fig. 1. Supply chain of cocoa [2].

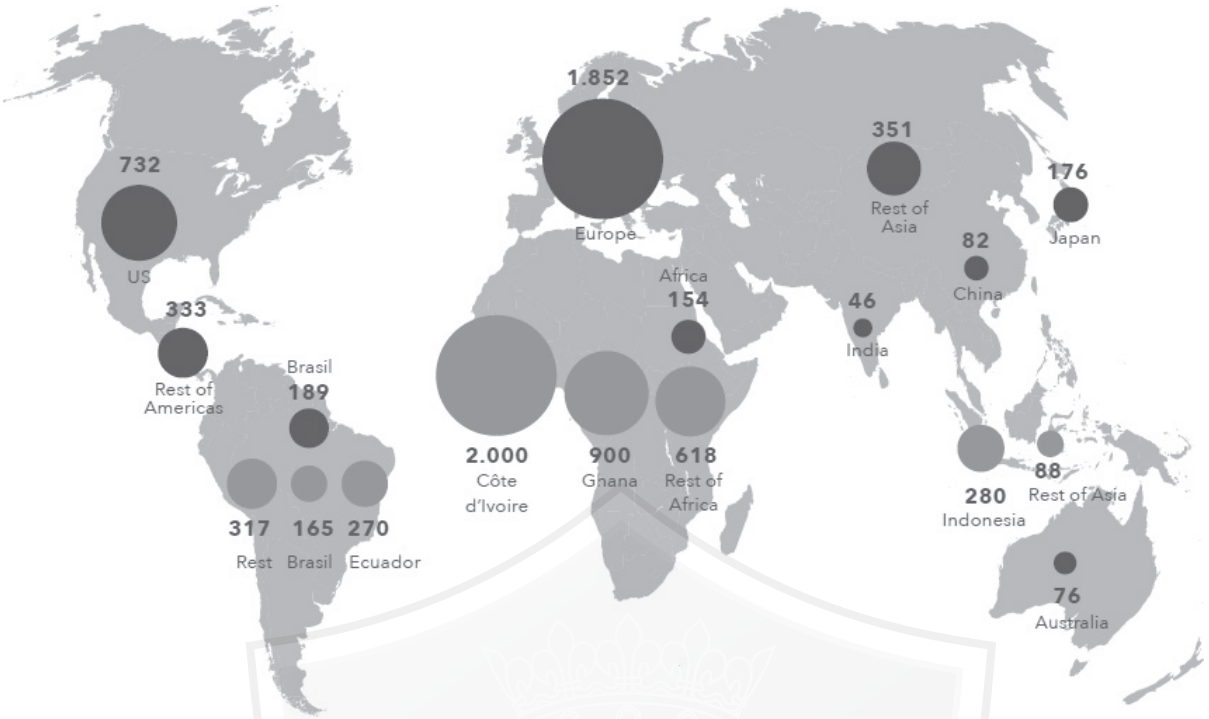


Fig. 2. Production and consumption of cocoa in the world in 2018 [2].

II. Materials and Methods

A. Cocoa bean sample preparation

Thai cocoa beans sample Chumphon#1 from Thai coffee-cocoa company after processing at 120˚C within 20 minute, formula A (cocoa beans from Thailand) and formula B (cocoa beans from Taiwan) from Taiwan company as same condition.

B. Analysis Methods

- Calories
- Calculation formula: [9(crude fat)+4(Crude protein)+4(carbohydrate-dietary fiber)].
- Calories from fat
- Calculation formula: [9(crude fat)].
- Carbohydrate
- Calculation: (100-moisture-ash-crude protein-crude fat).
- Saturated fatty acids

The analysis of saturated fatty acids is according to the method of DOH food 0961800343 announced.

- Trans fat
  The analysis of trans fat is according to the method of DOH food 0961800343 announced.
- Sodium
  Refer CNS 12869/N6231, A.O.A.C. 969.23 and A.O.A.C. 973.54.
- Moisture
  Refer CNS 5033 and CNS 2770-3.
- Ask
  Refer CNS 5034 and CNS 2770-9.
- Crude protein
  Refer CNS 5035 and CNS 2770-5.
- Crude fat
  Refer CNS 5036 and CNS 2770-4.
- Total sugar
  Calculation formula: [Glucose+Fructose+Sucrose+Lactose+Maltose] Refer CNS 12634/N6223.
- Dietary fiber
  Refer AOAC methods of analysis (1990) 15ED and AOAC methods of analysis (2000) 45.4.07(AOAC985.29).

DOH = Department of Health
CNS = National Standards of the Republic of China
AOAC = Association of Official Analytical Chemists

All analysis methods under Agriculture and Aquaculture Product Inspection and Certification, Department of Food Science, National Pingtung University of Science and Technology, Taiwan (http://www.caapic.npust.edu.tw/)

C. Total flavonoid content analysis

Total flavonoid content analysis by High Performance Liquid Chromatography (HPLC) technique from Agriculture and Aquaculture Product Inspection and Certification, Department of Food Science, National Pingtung University of Science and Technology, Taiwan (http://www.caapic.npust.edu.tw/)

C.1 Extraction of Flavonoids from cocoa bean

About 1 g (accurately weighed to 0.0001 g) of cocoa bean was extracted with 25 mL of 95% ethanol under 200 rpm shaking for 24 hr. After filtration, the filtrate was adjusted to 25 mL with 80% ethanol and stored in an amber bottle. In solid form, 0.1 to 1 g

(accurately weighed to 0.0001 g) was first dissolved with 10 mL of 80% ethanol. After centrifugation at 1,000 x g for 10 min, the supernatant was collected and the precipitate was then extracted with 5 mL of 80% ethanol twice. Finally, the supernatant was combined with previous supernatant and adjusted to 25 mL with 80% ethanol. Liquid sample were directly diluted with 80% ethanol to the concentrations appropriate for colorimetric analysis [3].

C.2 Estimation of total flavonoid content

1) Aluminum Chloride Colorimetric Method, The aluminum chloride colorimetric method was modified from the procedure reported by [3-6]. Quercetin was used to make the calibration curve. Ten milligrams of quercetin was dissolved in 80% ethanol and then diluted to 25, 50 and 100 µg/mL. The diluted standard solutions (0.5 mL) were separately mixed with 1.5 mL of 95% ethanol, 0.1 mL of 10% aluminum chloride, 0.1 mL of 1M potassium acetate and 2.8 mL of distilled water. After incubation at room temperature for 30 min, the absorbance of the reaction mixture was measured at 415 nm with a Shimadzu UV-160A spectrophotometer (Kyoto, Japan). The amount of 10% aluminum chloride was substituted by the same amount of distilled water in blank. Similarly, 0.5 mL of ethanol extracts or 15 flavonoid standard solutions (100 ppm) were reacted with aluminum chloride for determination of flavonoid content as described above.

2) 2,4-Dinitrophenylhydrazine Colorimetric Method The current method was modified from the procedure described by [6-7]. (±)-Naringenin was used as the reference standard. Twenty milligrams of (±)-naringenin was dissolved in methanol and then diluted to 500, 1000 and 2000 µg/mL. One milliliter of each of the diluted standard solutions was separately reacted with 2 mL of 1% 2,4-dinitrophenylhydrazine reagent and 2 mL of methanol at 50˚C for 50 min. After cooling to room temperature, the reaction mixture was mixed with 5 mL of 1% potassium hydroxide in 70% methanol and incubated at room temperature for 2 min. Then, 1 mL of the mixture was taken, mixed with 5 mL of methanol and centrifuged at 1,000 x g for 10 min to remove the precipitate. The supernatant was collected and adjusted to 25 mL. The absorbance of the supernatant was measured at 495 nm. The ethanol extracts of propolis and 15 flavonoid standard solutions (1000 ppm) were similarly reacted with 2, 4-dinitrophenylhydrazine for determination of flavonoid content as described above [3-4].

C. Statistical analysis

Statistical analysis was using PASW Statistics 18 software. Difference between two means was evaluated using t-test. Differences were considered significant when the *P*-value was less than 0.05. (Values was expressed as the mean (SD) at n = 3)

II. Results and Discussion

Table I presented the results from Thai cocoa beans analysis was including total calories; 576±2 kcal/100g. and calories from fat; 497±2 kcal/100g, crude protein; 13.1±0.3 g/100g, crude fat; 55.2±0.2 g/100g, saturated fatty acids; 35.74±0.1 g/100g, carbohydrate; 28.7±0.2 g/100g, sodium; 4 g/100g, moisture; 1.3±0.3 g/100g, ash; 1.7±0.2 g/100g, dietary fiber; 22 g/100g, cholesterol; 21.7±0.2 mg/kg, calcium; 923±3 mg/kg, Iron; 24.8±0.3 mg/kg, potassium; 8170±5 mg/kg, Ergocalciferol (Vitamin D2); 1.83 mg/kg, Cholecalciferol (Vitamin D3); 2.69±0.1 mg/kg and total flavonoids content 131.74±0.24 mg/100 g. (Table I) respectively.

In addition, the results from Taiwan cocoa beans analysis was including total calories; 535±3 kcal/100g. and calories from fat; 425 kcal/100g, crude protein; 14.3±0.4 g/100g, crude fat; 47.2 g/100g, saturated fatty acids; 25.6 g/100g, carbohydrate; 33.4±1.8 g/100g, sodium; 3 g/100g, moisture; 2.3±0.5 g/100g, ash; 2.8±0.7 g/100g, dietary fiber; 20.15±3.1 g/100g, calcium; 1300±1.3 mg/kg, Iron; 31.7±0.3 mg/kg, potassium; 9400±5 mg/kg, Ergocalciferol (Vitamin D2); 2.1±1.3 mg/kg, and total flavonoids content 4.84±0.7 mg/100 g. (Table 1) respectively.

Therefore, this report was compare 24 items of food nutrition from Thai and Taiwan cocoa bean after roasted at 120˚C within 20 minute. Especially for phytochemicals; total flavonoids content from Thai cocoa bean was very high more than 100 mg/100 g. (Table I). Similarly to [8] the comparison of cocoa beans from China, Indonesia and Papua New Guinea. This database will be benefit for deep future research about phytochemicals (flavonoids content) in cocoa beans (Fig. 3).

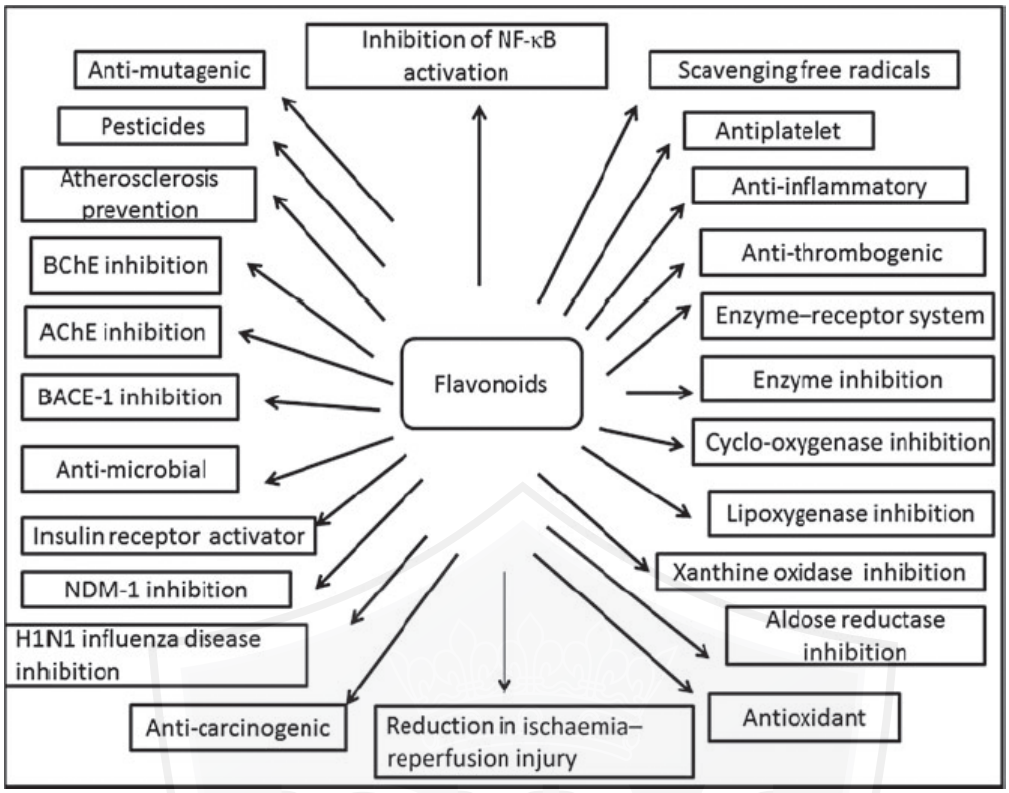


Fig. 3. The beneficial effect of flavonoids [9].

TABLE I
THE FOOD NUTRITION OF THAI AND TAIWAN'S COCOA BEANS

No	Items	Thailand cocoa bean (A)	Taiwan cocoa bean (B)	Units
1	Total calories	576±2a	535±3b	kcal/100 g
2	Calories from fat	497±2a	425b	kcal/100 g
3	Crude protein	13.1±0.3a	14.3±0.4a	g/100 g
4	Crude fat	55.2±0.2a	47.2b	g/100 g
5	Saturated fatty acids	35.74±0.1a	25.6b	g/100 g
6	Trans fat	N/A	N/A	g/100 g
7	Carbohydrate	28.7±0.2b	33.4±1.8a	g/100 g
8	Sodium	4a	3a	g/100 g
9	Moisture	1.3±0.3a	2.3±0.5a	g/100 g
10	Ash	1.7±0.2b	2.8±0.7a	g/100 g
11	Total sugar	N/A	N/A	g/100 g
12	Glucose	N/A	N/A	g/100 g
13	Fructose	N/A	N/A	g/100 g
14	Sucrose	N/A	N/A	g/100 g
15	Lactose	N/A	N/A	g/100 g
16	Maltose	N/A	N/A	g/100 g
17	Dietary fiber	22a	20.15±3.1b	g/100 g
18	Cholesterol	21.7±0.2a	N/A	mg/kg
19	Calcium	923±3b	1300±1.3a	mg/kg
20	Iron	24.8±0.3b	31.7±0.3a	mg/kg
21	Potassium	8170±5b	9400±5a	mg/kg
22	Ergocalciferol (Vitamin D2)	1.83b	2.1±1.3a	mg/kg
23	Cholecalciferol (Vitamin D3)	2.69±0.1a	N/A	mg/kg
24	Total Flavonoids Content	131.74±0.2a	4.84±0.7b	mg/100 g

N/A = Non-detectable

III. Conclusion

This research using 24 items for analysis. The results found that total calories, calories from fat, crude fat, saturated fatty acids, dietary fiber, cholesterol, cholecalciferol (Vitamin D3), and total flavonoids content of cocoa beans from Thailand were higher than Taiwan. On the other hand, carbohydrate, ash, calcium, iron, potassium, and ergocalciferol (Vitamin D2) of cocoa beans from Taiwan. Therefore, this research paper is the first report database on food nutrition from private company in Thailand and Taiwan. For the future can be applies to advance cocoa research, sharing to smart farmer for cocoa industries. For the future research can be applies to advance and sharing to smart farmer and add value for cocoa industries (in term of cocoa industry value chain Fig. 4).

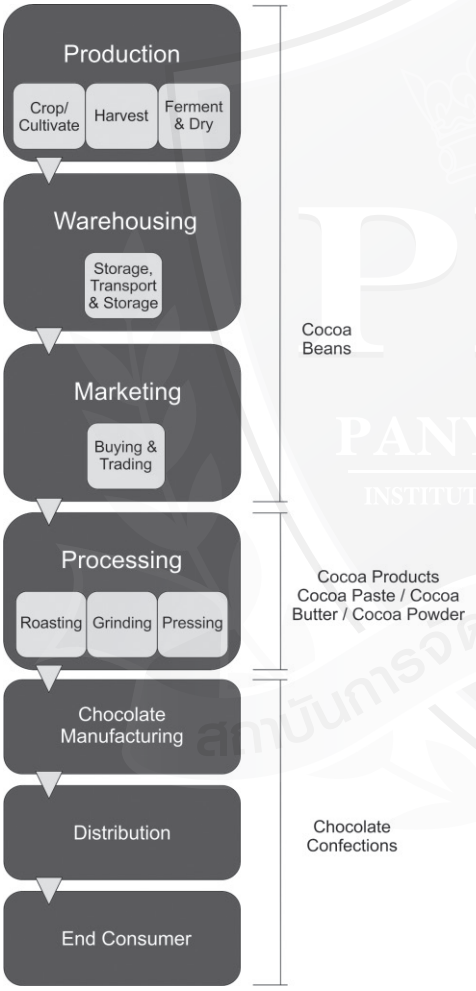


Fig. 4. Cocoa industry value chain [10].

Acknowledgment

This research was supported by Faculty of Innovative Agriculture Management, Panyapiwat Institute of Management, Thailand and Agriculture and Aquaculture Product Inspection and Certification, Department of Food Science, National Pingtung University of Science and Technology, Taiwan

References

[1] C. Korawit and C. Chiu-Hsia., "Antioxidant (Flavonoid) in Thai Cocoa bean," in Proc. PIM 9 th National and 2nd International Conference, 2019, pp. I1-I6.

[2] A. Fountain and F. Huetz-Adams, "Cocoa barometer". Creative Commons License Attribution-ShareAlike 4.0 International. pp. 1-72. 2018.

[3] D. Oduro-Mensah, A. Ocloo, S. T. Lowor, and et al., "Bio-detheobromination of cocoa pod husks: reduction of ochratoxin A content without change in nutrient profile," Microbial Cell Factories, vol. 17, no. 1, pp. 79, Dec. 2018.

[4] C. C. Chang. M. H. Yang., H. M. Wen, and J. C. Chan "Estimation of Total Flavonoid Content in Propolis by Two Complementary Colorimetric Methods," Journal of Food and Drug Analysis, vol.10, no. 3, pp. 178-182, Sep. 2002.

[5] A. Soraya Putri, W. Sutopo, S. Prihawantara, and R. C. D. Matheos, "Value Chain Improvement for Cocoa Industry in Indonesia by Input-Output Analysis," in *Proc. International Multi Conference of Engineers and Computer Scientists*, 2015, pp. 18-20.

[6] R. Woisky and A. Salatino, "Analysis of propolis: some parameters and procedures for chemical quality control," Journal of Apicultural Research, vol. 37, no. 2, pp. 99-105, Mar. 1998.

[7] M. Nagy and D. Grancai, "Colorimetric determination of flavanones in propolis," Pharmazie. vol. 51, no. 2, pp. 100. 1996.

[8] F. Gu, L. Tan, H. Wu, and et al., "Comparison of Cocoa Beans from China, Indonesia and Papua New Guinea". Foods. Vol. 2, no. 2, pp.183-197. May. 2013.

[9] A. N. Panche, A. D. Diwan and S. R. Chandra, "Flavonoids: an overview," Journal of Nutritional of Science. vol. 5, no.e47, pp. 1-15, Dec. 2016.

[10] A. Lateef, A. M. Azeez, B. T. Asafa, and et al., "Cocoa pod husk extract-mediated biosynthesis of silver nanoparticles: its antimicrobial, antioxidant and larvicidal activities," Journal of Nanostructure in Chemistry. vol. 6, no. 2, pp. 159-169, Jun. 2016.



Korawit Chaisu received his Ph.D. in food Biotechnology (NPUST), Taiwan in 2014. He also earned his Master of Science in Food Biotechnology from NPUST, Taiwan in 2011 and Bachelor of Biotechnology for Maejo University, Thailand in 2009.

He is currently a full-time lecturer in Faculty of Innovative Agriculture Management, Panyapiwat Institute of Management, Thailand. His research interests are in agriculture (cocoa and application), food biotechnology, microbiotechnology and applied microbial, Innovation Process and Bioplastic. Moreover, he is expert in Thai Lanna culture and perfomance.

PAPER FORMAT
(IEEE Style)

A. FORMAT

• Articles not more than 15 pages in length, single-sided A4 paper, margins (top, bottom, left, right) are 1 inch (2.54 cm)
• Abstract and References and content set to double columns,
• English font is Times New Roman, as follows:

Content	Font Size	Labelling
Title (single column)	24 (CT)	bold
Authors (single column)	11 (CT)	bold
Authors information (single column)	10 (CT)	regular
Abstract	10 (LRJ)	bold
Index Terms (Key words)	10 (LRJ)	bold
Content	10 (LRJ))	regular
Heading1	10 (CT)	bold (Capitalization)
Heading 2	10 (LJ)	regular
Table title (Place above the Table)	8 (CT)	regular
Table content	8 (CT)	regular
Figure caption (Place below the Figure)	8 (LJ)	regular
Reference Head	10 (CT)	regular (Capitalization)
Reference	8 (LJ)	regular
Author profiles	10 (LRJ)	bold author name / profile regular

CT=Centre Text, LJ=Left Justified, RJ=Right Justified, LRJ=Left & Right Justified

COMPOSITION OF THE ARTICLE

1) Article title

2) Authors information, Write (all) the author's name, affiliation, department, city, country and E-mail (set to Single Column) all.

3) Abstract, Must be under 200 words and not include subheadings or citations. Define all symbols used in the abstract. Do not delete the blank line immediately above the abstract.

4) Index Terms, Enter key words or phrases in alphabetical order, separated by commas.

5) Content

5.1 Academic article, should include: Introduction, Content, and Conclusion.

5.2 Research article, should include: introduction, literature review, Materials methods, Results, Discussion, and conclusion.

Clearly summarize the important findings of the paper. It should contain such as objectives, methods and major results.

6) Introduction

The Introduction section of reference text expands on the background of the work (some overlap with the Abstract is acceptable). The introduction should not include subheadings.

7) Pictures, table, etc., Must be use in numerical order in the article, provided the source correctly, cannot use other people' copyright.

Chart should be colored contrastingly or in black and white.

8) Reference

8.1 Cited in the main text. Indicate the number in the [ ] mark at the end of the text or the name of the referring person. Let the numbers be in the same line of content as [1].

8.2 Cited after the article. Put all bibliographical reference after articles, and order according to the author's name, please refer IEEE format. The footer reference format is as follows.

RERERENCES

References in research articles and scholarly articles. For academic and research journals, INTERNATIONAL SCIENTIFIC JOURNAL OF ENGINEERING AND TECHNOLOGY (ISJET). The technology defines referrals according to the IEEE format.

All references should be listed at the end of the paper using the following.

Basic format for books:

[1] J. K. Author, "Title of chapter in the book," in *Title of His Published Book,* xth ed. City of Publisher, Country if not
[2] USA: Abbrev. of Publisher, year, ch. x, sec. x, pp. xxx–xxx.

Examples:

[3] G. O. Young, "Synthetic structure of industrial plastics," in *Plastics,* 2nd ed., vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 15–64.
[4] W.-K. Chen, *Linear Networks and Systems.* Belmont, CA: Wadsworth, 1993, pp. 123–135.

Basic format for periodicals:

[5] J. K. Author, "Name of paper," *Abbrev. Title of Periodical*, vol. x, no. x, pp. xxx-xxx, Abbrev. Month. year.

Examples:

[6] J. U. Duncombe, "Infrared navigation—Part I: An assessment of feasibility," *IEEE Trans. Electron Devices*, vol. ED-11, no. 1, pp. 34-39, Jan. 1959.

[7] E. P. Wigner, "Theory of traveling-wave optical laser," *Phys. Rev*., vol. 134, pp. A635–A646, Dec. 1965.

[8] E. H. Miller, "A note on reflector arrays," *IEEE Trans. Antennas Propagat*., to be published.

Basic format for reports:

[9] J. K. Author, "Title of report," Abbrev. Name of Co., City of Co., Abbrev. State, Rep. xxx, year.

Examples:

[10] E. E. Reber, R. L. Michell, and C. J. Carter, "Oxygen absorption in the earth's atmosphere," Aerospace Corp., Los Angeles, CA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.

[11] J. H. Davis and J. R. Cogdell, "Calibration program for the 16-foot antenna," Elect. Eng. Res. Lab., Univ. Texas, Austin, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.

Basic format for handbooks:

[12] *Name of Manual/Handbook*, x ed., Abbrev. Name of Co., City of Co., Abbrev. State, year, pp. xxx-xxx.

Examples:

[13] *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, 1985, pp. 44-60.

[14] *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, 1989.

Basic format for books (when available online):

[15] Author. (year, month day). *Title.* (edition) [Type of medium]. *volume (issue).* Available: site/path/file

Examples:

[16] J. Jones. (1991, May 10). *Networks.* (2nd ed.) [Online]. Available: http://www.atm.com

Basic format for journals (when available online):

[17] Author. (year, month). Title. *Journal.* [Type of medium]. *volume (issue),* pages. Available: site/path/file

Examples:

[18] R. J. Vidmar. (1992, Aug.). On the use of atmospheric plasmas as electromagnetic reflectors. *IEEE Trans. Plasma Sci.* [Online]. *21(3),* pp. 876–880. Available: http://www.halcyon.com/pub/journals/21ps03-vidmar

Basic format for papers presented at conferences (when available online):

[19] Author. (year, month). Title. Presented at Conference title. [Type of Medium]. Available: site/path/file

Examples:

[20] PROCESS Corp., MA. Intranets: Internet technologies deployed behind the firewall for corporate productivity. Presented at INET96 Annual Meeting. [Online]. Available: http://home.process.com/Intranets/wp2.htp

Basic format for reports and handbooks (when available online):

[21] Author. (year, month). Title. Comp an y . C ity, State or Country. [Type of Medium]. Available: site/path/file

Examples:

[22] S. L. Talleen. (1996, Apr.). The Intranet Architecture: Managing information in the new paradigm. Amdahl Corp., CA. [Online]. Available: http://www.amdahl.com/doc/products/bsg/intra/infra/html

Basic format for computer programs and electronic documents (when available online): ISO recommends that capitalization follow the accepted practice for the language or script in which the information is given.

Examples:

[23] A. Harriman. (1993, June). Compendium of genealogical software. Humanist. [Online]. Available e-mail: HUMANIST @NYVM.ORG Message: get GENEALOGY REPORT

Basic format for patents (when available online):

[24] Name of the invention, by inventor's name. (year, month day). *Patent Number* [Type of medium]. Available: site/path/file

Examples:

[25] Musical toothbrush with adjustable neck and mirror, by L.M.R. Brooks. (1992, May 19). Patent D 326 189 [Online]. Available: NEXIS Library: LEXPAT File: DESIGN

Basic format for conference proceedings (published):

[26] J. K. Author, "Title of paper," in *Abbreviated Name of Conf.*, City of Conf., Abbrev. State (if given), year, pp. xxxxxx.

Examples:

[27] D. B. Payne and J. R. Stern, "Wavelength-switched pas- sively coupled single-mode optical network," in *Proc. IOOC-ECOC,* 1985, pp. 585-590.

Example for papers presented at conferences (unpublished):

[28] D. Ebehard and E. Voges, "Digital single sideband detection for interferometric sensors," presented at the 2nd Int. Conf. Optical Fiber Sensors, Stuttgart, Germany, Jan. 2-5, 1984.

Basic format for patents:

[29] J. K. Author, "Title of patent," U.S. Patent x xxx xxx, Abbrev. Month. day, year.

Examples:

[30] G. Brandli and M. Dick, "Alternating current fed power supply," U.S. Patent 4 084 217, Nov. 4, 1978.

Basic format for theses (M.S.) and dissertations (Ph.D.):

[31] J. K. Author, "Title of thesis," M.S. thesis, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

[32] J. K. Author, "Title of dissertation," Ph.D. dissertation, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

Examples:

[33] J. O. Williams, "Narrow-band analyzer," Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993.

[34] N. Kawasaki, "Parametric study of thermal and chemical nonequilibrium nozzle flow," M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

Basic format for the most common types of unpublished references:

[35] J. K. Author, private communication, Abbrev. Month, year.
[36] J. K. Author, "Title of paper," unpublished.
[37] J. K. Author, "Title of paper," to be published.

Examples:

[38] A. Harrison, private communication, May 1995.
[39] B. Smith, "An approach to graphs of linear forms," unpublished.
[40] A. Brahms, "Representation error for real numbers in binary computer arithmetic," IEEE Computer Group Repository, Paper R-67-85.

Basic format for standards:

[41] *Title of Standard*, Standard number, date.

Examples:

[42] IEEE Criteria for Class IE Electric Systems, IEEE Standard 308, 1969.
[43] Letter Symbols for Quantities, ANSI Standard Y10.5-1968.



First A. Author and the other authors may include biographies at the end of regular papers. Biographies are often not included in conference-related papers. The first paragraph may contain a place and/or date of birth (list place, then date). Next, the author's educational background is listed. The degrees should be listed with type of degree in what field, which institution, city, state, and country, and year the degree was earned. The author's major field of study should be lower-cased.

The second paragraph uses the pronoun of the person (he or she) and not the author's last name. It lists military and work experience, including summer and fellowship jobs. Job titles are capitalized. The current job must have a location; previous positions may be listed without one. Information concerning previous publications may be included. Try not to list more than three books or published articles. The format for listing publishers of a book within the biography is: title of book (city, state: publisher name, year) similar to a reference. Current and previous research interests end the paragraph.

The third paragraph begins with the author's title and last name (e.g., Dr. Smith, Prof. Jones, Mr. Kajor, Ms. Hunter). List any memberships in professional societies. Finally, list any awards and work for committees and publications. If a photograph is provided, the biography will be indented around it. The photograph is placed at the top left of the biography, and should be of good quality, professional-looking, and black and white (see above example). Personal hobbies will be deleted from the biography. Following are two examples of an author's biography.



Second B. Author was born in Greenwich Village, New York City, in 1977. He received the B.S. and M.S. degrees in aerospace engineering from the University of Virginia, Charlottesville, in 2001 and the Ph.D. degree in mechanical engineering from Drexel University, Philadelphia, PA, in 2008. From 2001 to 2004, he was a Research Assistant with the Princeton Plasma Physics Laboratory. Since 2009, he has been an Assistant Professor with the Mechanical Engineering Department, Texas A&M University, College Station. He is the author of three books, more than 150 articles, and more than 70 inventions. His research interests include high-pressure and high-density nonthermal plasma discharge processes and applications, microscale plasma discharges, discharges in liquids, spectroscopic diagnostics, plasma propulsion, and innovation plasma applications. He is an Associate Editor of the journal *Earth*, *Moon*, *Planets*, and holds two patents.

Mr. Author was a recipient of the International Association of Geomagnetism and Aeronomy Young Scientist Award for Excellence in 2008, the IEEE Electromagnetic Compatibility Society Best Symposium Paper Award in 2011, and the American Geophysical Union Outstanding Student Paper Award in Fall 2005.

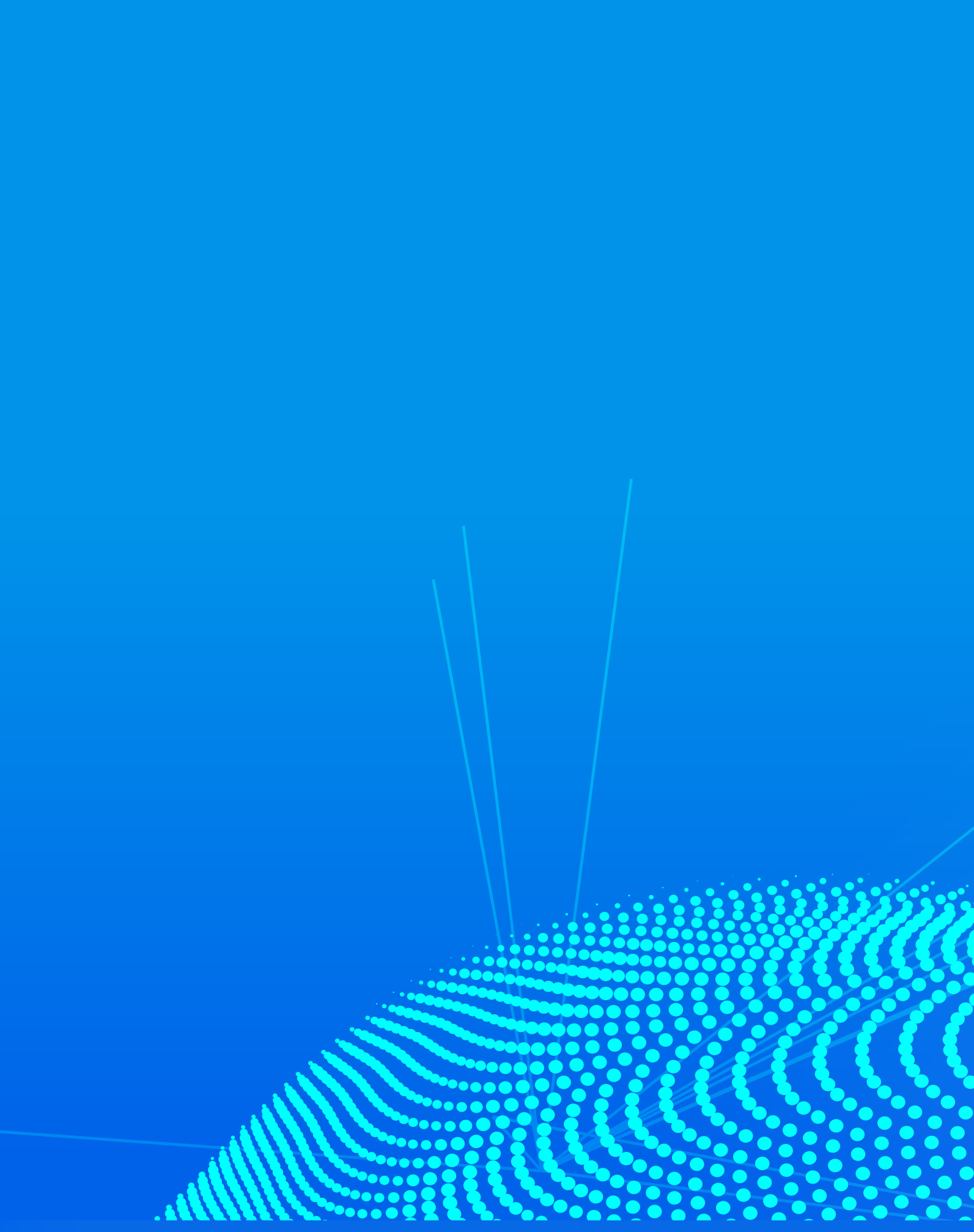


Third C. Author received the B.S. degree in mechanical engineering from National Chung Cheng University, Chiayi, Taiwan, in 2004 and the M.S. degree in mechanical engineering from National Tsing Hua University, Hsinchu, Taiwan, in 2006. He is currently pursuing the Ph.D. degree in mechanical engineering at Texas A&M University, College Station.

From 2008 to 2009, he was a Research Assistant with the Institute of Physics, Academia Sinica, Tapei, Taiwan. His research interest includes the development of surface processing and biological/medical treatment techniques using nonthermal atmospheric pressure plasmas, fundamental study of plasma sources, and fabrication of micro- or nanostructured surfaces.

Mr. Author's awards and honors include the Frew Fellowship (Australian Academy of Science), the I. I. Rabi Prize (APS), the European Frequency and Time Forum Award, the Carl Zeiss Research Award, the William F. Meggers Award and the Adolph Lomb Medal (OSA).

Remark: More detail information, Pleases read Preparation of Papers for INTERNATIONAL SCIENTIFIC JOURNAL OF ENGINEERING AND TECHNOLOGY (ISJET), htt://isjet.pim.ac.th



Panyapiwat Institute of Management (PIM)
85/1 Moo 2, Chaengwattana Rd,
Bang Talad, Pakkred, Nonthaburi 11120, Thailand
Tel. 0 2855 1560 Fax. 0 2855 0392
https://www.tci-thaijo.org/index.php/isjet/index
https://isjet.pim.ac.th
E-mail: isjet@pim.ac.th