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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, 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.

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

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- Research article
- Academic article
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Welcome to INTERNATIONAL SCIENTIFIC JOURNAL OF ENGINEERING AND TECHNOLOGY (ISJET), I am delighted to inform you that our journal is now indexed in Thai-Journal Citation Index (TCI), the largest database of peer-reviewed literature in Thailand. This important milestone ensures that articles have published in our journal are qualified and easily found when searching in TCI science database.

ISJET seeks articles in all fields of sciences: Engineering, Technology, Innovation, Information Technology, Management Information System, Logistics and Transportation, Agricultural Science, Animal Science and Aquaculture, Food Science, and other areas in Sciences and Technology.

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With kind regards,

Assoc. Prof. Dr. Parinya Sanguansat
Editor-in-Chief
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A Generic Form of Evolutionary Algorithms and Manifold Drift Concept

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***Abstract*—Most of optimization problems in various fields are in NP-class. This implies that the time to find the optimum solution of any problem is obviously non-polynomial. Although the development of high speed computer architectures and the concept parallel computing is practically successful, some of these problems are constrained by the problem of tight data dependency which prevents the possibility of deploying a parallel architecture as well as processing to solve the problem. Evolutionary algorithms which are based on *guessing* solutions have been developed to find an acceptable solution in a short time. However, the processing time based on *guessing* to achieve the acceptable solution is unpredictable and uncontrollable. In this paper, we compare the guessing process in some popular algorithms to define a generic structure of searching process and solution finding process. This structure will help develop a new evolutionary algorithm. Furthermore, a new concept of *manifold drift* for avoiding the guessing process in order to speed up the solution search is also discussed.**

***Index Terms*—Optimization, Evolutionary algorithms, opposite gradient search**

I. INTRODUCTION

Optimization is a process to find the best solution for a studied problem. There are several academic, business, and social areas such as science, engineering, management requiring the best solutions for the studied problems. For example, one of the problems in this domain is finding the best solution to pack boxes of different sizes as many as possible into the trunk of a truck where the volume is fixed. These problems usually belong to a class of algorithmic problem called *NP class* where the time complexity to find the best solution is non-polynomial, usually exponential. This time complexity is defined by the computational model of *deterministic Turing machine* (DTM). However, it is possible to speed up the best-solution finding process by employing the computational model of *non-deterministic Turing machine* (NDTM). This type of machine has an additional computing module attached to the DTM to perform the guessing process of the next state of NDTM. By guessing, it is possible to find the best solution at the first iteration of the algorithm or in a polynomial time. Unfortunately, the actual random guessing process cannot to be implemented by using the current computer technology because all hardware components are built on the concept of Boolean algebra. To alleviate this obstacle, several evolutionary algorithms [12], [13] have been invented to imitate the random guessing process to some certain limits.

In this paper, we summarize the popular evolutionary algorithms and derive a generic form of those evolutionary algorithms so that any one can further develop more evolutionary algorithms from this generic form with the relevant interpretation on the behaviours of new animal species. Further, we discuss a new approach of very fast solution searching algorithm without any imitation of animal behaviour.

The rest of this paper is organized as follows. Section II summarizes all popular evolutionary algorithms. Section III discusses the generic form of evolutionary algorithm. Section IV introduces a new approach to find the best solution based on manifold searching concept. Section V concludes the paper.

II. POPULAR EVOLUTIONARY ALGORITHMS

Several evolutionary algorithms [3] have been proposed since the classical inventions of simulated annealing and genetic algorithms. Most recently proposed algorithms are based on the observation of the behaviour of one animal or a group of animals such as bee, ant, whale, bat, and others. Only two algorithms, i.e. brain storm optimization and election campaign optimization are based on human activities. All these algorithms are briefly summarized in the following sections.

A. Whale Optimization Algorithm

This method [17] observes the process of chasing a swarm of prey. When a whale finds its prey, it blows bubble to its prey and encircle the prey. However, the whale must search the location of prey which is unknown in advance. Thus, the location of prey is used to represent the solution of the problem. Let $\mathbf{x}_i(t)$ be solution i and $\mathbf{x}_{best}(t)$ be the best solution found so far at time t. Each solution $\mathbf{x}_i(t)$ is evaluated by a fitness function $f(\mathbf{x}_i(t))$. A new solution can be computed from the current solution by the following equations.

$$\mathbf{D} = |C \times \mathbf{x}_{best}(t) - \mathbf{x}_i(t)| \quad (1)$$

$$\mathbf{x}_i(t+1) = \mathbf{x}_{best}(t) - A \times \mathbf{D} \quad (2)$$

$$A = a \times r_1 - a \quad (3)$$

$$C = 2 \times r_2 \quad (4)$$

t is the current iteration. $\mathbf{x}_i(t)$ is the i^{th} solution at iteration t. $\mathbf{x}_{best}(t)$ is the best solution found at iteration t. A and C are scalar coefficients. r_1 and r_2 are random numbers. a is a constant linearly decreased from 2 to 0.

Algorithm: Whale Optimization

1. Set iteration count $t = 1$.
2. Generate a set of solutions $\mathbf{x}_i(t)$, $1 \leq i \leq N$.
3. **For** each solution $\mathbf{x}_i(t)$ **do**
4. Compute the value of fitness function $f(\mathbf{x}_i(t))$.
5. **EndFor**
6. Let $\mathbf{x}_{best}(t)$ be the solution found so far from step 3.
7. **Repeat**
8. **For** each decreased value of a from 2 to 0 **do**
9. **For** i from 1 **to** N **do**
10. Compute constants A and C from Eqs. (3) and (4).
11. Set p to a random number in between 0 and 1.
12. **If** $p > 0.5$ **then**
13. Update $\mathbf{x}_i(t+1)$ by Eq. (2)
14. **else**
15. **If** $|A| \geq 0.5$ **then**
16. Update solution $\mathbf{x}_i(t+1)$ by Eq. (2).
17. **else**
18. Compute the difference between $\mathbf{x}_{best}$ and $\mathbf{x}_i(t)$.
19. **EndIf**
20. **EndIf**
21. **EndFor**
22. **EndFor**
23. $t = t + 1$.
24. **Until** $t > Max$.

B. Artificial Bee Colony

This method [5] is based on the process of a bee while collecting the nectar. The location of each nectar source represents a solution of optimization problem. A bee evaluates the information related to the amount of nectar at the current source with respect to the information from all other sources to determine whether it should fly away to other sources. Let $\mathbf{x}_i = [x_{i,j}, x_{i,2}, \ldots, x_{i,d}]^T$ be the i^{th} solution in the swarm. d is the number of dimensions. Solution $\mathbf{x}_i$ generates a new candidate solution $\mathbf{v} = [v_{i,1}, v_{i,2}, \ldots, v_{i,D}]^T$ in the neighborhood of its present position by using the following equations. The first equation computes the probability to collect more nectar at current source determined from the fitness function $fit(\mathbf{x}_i)$ of solution $\mathbf{x}_i$. The second equation computes the new source location apart from source $\mathbf{x}_i$.

$$p_i = \frac{fit(\mathbf{x}_i)}{\sum_{j=1}^{SN} fit(\mathbf{x}_j)} \quad (5)$$

$$v_{i,j} = x_{i,j} + \phi_{i,j}(x_{i,j} - x_{k,j}) \quad (6)$$

where $-1 \leq \phi_{i,j} \leq 1$ is a random constant. If there are too many close nectar sources, then instead of using $\mathbf{v}_i$, $x_{i,j}$ is redefined as follows.

$$x_{i,j} = x_{min,j} + rand(0,1) \cdot (x_{max,j} - x_{min,j}) \quad (7)$$

$\mathbf{x}_{min}$ is the source having minimum fitness value and $\mathbf{x}_{max}$ is the source having maximum fitness value at the present iteration. p_i is the probability of accepting solution $\mathbf{x}_i$. The steps of bee colony algorithm is shown below. Let $0 < \tau \leq 1$ be a random constant.

Algorithm: Artificial Bee Colony

1. Initialize a set of solutions $\mathbf{X} = \{\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_n\}$.
2. Evaluate the fitness of each solution $fit(\mathbf{x}_i)$ for $1 \leq i \leq n$ and find $\mathbf{x}_{min}$ and $\mathbf{x}_{max}$.
3. **While** terminating condition is unsatisfactory **do**
4. **For** each $\mathbf{x}_i \in \mathbf{X}$ **do**
5. Compute a new solution by using Eq. (6). by randomly selecting $\mathbf{x}_k$.
6. Evaluate the fitness $fit(\mathbf{x}_i)$.
7. **EndFor**
8. Select a set of some solutions $\mathbf{X}'$ having high fitness values.
9. Compute the probability of selected solutions in $\mathbf{X}'$ from Eq. (5).
10. Select a set of some solutions $\mathbf{X}''$ from $\mathbf{X}'$ where each selected solution $\mathbf{x}_k \in \mathbf{X}'$ has $p_k > \tau$.
11. Compute new solution from $\mathbf{X}''$.
12. Evaluate the fitness of solutions in $\mathbf{X}''$.
13. Select a set of some solutions $\mathbf{X}'''$ having high fitness values.
14. **If** the distance between any two solutions is too close **then**
15. Randomly generate a new solution using Eq. (7).
16. **EndIf**
17. Find $\mathbf{x}_{min}$ and $\mathbf{x}_{max}$ solutions.
18. **EndWhile**

C. Particle Swarm Optimization

This method [7] imitates the behaviour of a particle in a swarm during food search. At time t, each particle i has a solution (position) $\mathbf{x}_i(t) = [x_{i,1}(t), x_{i,2}(t), \ldots, x_{i,d}(t)]^T$, where d is the dimensionality of solution. A set of particles $\mathbf{S}(t) = \{\mathbf{x}_1(t), x_2(t), \ldots, \mathbf{x}_m(t)\}$ is called *swarm*. Each particle i has its own velocity defined as a d-tuple $\mathbf{v}_i(t) = [v_{i,1}(t), v_{i,2}(t), \ldots, v_{i,d}(t)]^T$ of velocity in each dimension. For evaluating the best solution, there are two types of best solutions to focused. The first best solution is the local best solution found with respect to each particle itself. The second best solution is the global best solution found with respect to all particles in the swarm $\mathbf{S}$. Each particle has its own best solution found so far at time t. This best solution is called *personal best* solution. Let $\mathbf{p}_i(t) = [p_{i,1}(t), p_{i,2}(t), \ldots, p_{i,d}(t)]^T$ be the personal best solution of particle i. When considering all particles, the leading particle among all particles has the global best solution. Let $\mathbf{p}_g(t) = [p_{g,1}(t), p_{g,2}(t), \ldots, p_{g,d}(t)]^T$ be the global best solution found at particle g. The velocity and position in dimension j of particle i are updated by the following equations.

$$v_{i,j}(t+1) = w \cdot v_{i,j}(t) + c_1 \cdot r_1 \cdot (p_{i,j} - x_{i,j}(t)) + c_2 \cdot r_2 \cdot (p_{g,j} - x_{i,j}(t)) \quad (8)$$

$$x_{i,j}(t+1) = x_{i,j}(t) + v_{i,j}(t) \quad (9)$$

Constants $c_1, c_2 \in R$ are weighting factors for personal best and global best solutions, respectively. $r_1, r_2 \in [0,1]$ are random constants to adjust the moving direction of a particle during the search process. w is an inertia weight to control the impact of the past velocity over the current velocity. The algorithm for particle swarm optimization is shown below. The final solution is the *global best* solution.

Algorithm: Particle Swarm Optimization

1. Set $t = 1$.
2. Initialize a set of solutions $\mathbf{S}(t)$.
3. Evaluate each solution in $\mathbf{S}(t)$.
4. Find *personal best* $\mathbf{p}_i(t)$ and global best $\mathbf{p}_g(t)$.
5. **While** $t \leq N$ **do**
6. **For** each solution $\mathbf{x}_i(t) \in \mathbf{S}(t)$ **do**
7. Compute new velocity of $\mathbf{x}_i(t)$ using Eq. (8).
8. Compute new solution $\mathbf{x}_i(t+1)$ from $\mathbf{x}_i(t)$ using Eq. (9).
9. Evaluate $\mathbf{x}_i(t+1)$.
10. Find *personal best* solution $\mathbf{p}_i(t)$.
11. **EndFor**
12. Find *global best* solution $\mathbf{p}_g(t)$.
13. **If** $t < \delta \times N$ **then**
14. Update $\omega = \omega - \frac{\omega_{start} - \omega_{end}}{\delta \times N}$.
15. **EndIf**
16. $t = t + 1$.
17. **EndWhile**

$0 < \delta \leq 1$ is a random constant and N is the maximum number of iterations. The inertia weight ω is in the range of $[\omega_{start}, \omega_{end}]$.

D. Ant Colony Optimization

The objective is to find the shortest path in a graph. It is based on the observation of how an ant finds the best path to reach the food from its current location [9]. An ant deposits some pheromone to tell other ants to follow it. From the graph, a vertex is referred by a location representing a solution of the optimization problem. Each edge (i, j) with is associated with a pheromone variable $\tau_{i,j}$. Let $\mathcal{N}_i$ is the neighbouring vertices of vertex i where ant a is present. At time t, the probability of ant a to move to vertex $j \in \mathcal{N}_i$ is defined as follows.

$$p_{i,j}^{(a)}(t) = \begin{cases} \frac{\tau_{i,j}(t) \cdot d_{i,j}^{-\beta}}{\sum_{k \in \mathcal{N}_i} \tau_{i,k}(t) d_{i,k}^{-\beta}} & \text{if } j \in \mathcal{N}_i \\ 0 & \text{otherwise} \end{cases} \quad (10)$$

$\beta > 0$ is a constant defining the relative importance of pheromone and the distance $d_{i,j}$ between vertices i and j. The amount of pheromone $\tau_{i,j}(t)$ at time $t+1$ is updated by the following equation.

$$\tau_{i,j}(t+1) = (1 - \alpha) \cdot \tau_{i,j}(t) + \sum_{k=1}^{m} \Delta\tau_{i,j}^{(k)} \quad (11)$$

where m is the number of ants and $\Delta\tau_{i,j}^{(k)}$ is defined as follows.

$$\Delta\tau_{i,j}^{(k)} = \begin{cases} L_a^{-1} & \text{if } (i,j) \text{ is in the tour of ant } a \\ 0 & \text{otherwise} \end{cases} \quad (12)$$

L_a is the total tour distance of ant a.

Algorithm: Ant Colony Optimization

1. Initialize the values of parameters
2. **Repeat**
3. Randomly select a staring vertex for each ant.
4. **For** each ant a **do**
5. Compute the moving probability and update pheromone.
6. Move ant a to the vertex with the highest probability.
7. **EndFor**
8. **Until** the ending condition is satisfied.

E. Election Campaign Optimization

The optimization [20] involves a set of candidates, a set of local and global voters, the location of each voter, the location of each candidate, the influence of each candidate on his voters, and the prestige of each candidate. The locations of all candidates are used to compute the best cost function. A candidate c_i is placed at location x_{c_i} and a global voter g_j is placed at location x_{g_j}. Each candidate c_i has a set of local supporters $l_{i,j}$ located at $x_{l_{i,j}}$. The prestige of a candidate c_i is computed by the cost function $f(x_{c_i})$ of the problem whose variable is the location of candidate c_i as follows.

$$p_{c_i} = f(x_{c_i}) \quad (13)$$

Obviously, the value of prestige can be either increased or decreased according to the location of the candidate. The range of area size covering the local and global voters of each candidate c_i can be defined by using the values of prestige and the predefined range of the candidate in the following equations.

$$R_{c_i} = \frac{p_{c_i} - p_{c_i}^{(min)}}{p_{max} - p_{min}}(R_{max} - R_{min}) + R_{min} \quad (14)$$

$$p_{max} = \max_{\forall c_i}(p_{c_i}) \quad (15)$$

$$p_{min} = \min_{\forall c_i}(p_{c_i}) \quad (16)$$

R_{max} and R_{min} are predefined values of maximum range and minimum range, respectively. During the campaign, each candidate will survey the opinions of local sampled voters about his prestige. The deviation local survey of prestige is defined as follows.

$$\delta_{c_i} = \delta_{max} - \frac{p_{c_i} - p_{max}}{p_{max} - p_{min}}(\delta_{max} - \delta_{min}) \quad (17)$$

δ_{max} and δ_{min} are the predefined maximum and minimum deviations, respectively. The location of each global voter x_{g_i} in the range in between x_{max} and x_{min} with the uniform probability u is defined by the following equation.

$$x_{g_i} = x_{max} + u(x_{max} - x_{min}) \quad (18)$$

But the location of each local voter $x_{l_{i,j}}$ of candidate c_i is defined by using normal distribution with the mean at x_{c_i} and standard deviation δ_{c_i} as follows.

$$x_{l_{i,j}} = N(x_{c_i}, \delta_{c_i}^2) \quad (19)$$

Each candidate c_i can influence his voter's decision. The degree of influence on a global voter g_j and a local voter $l_{i,j}$ are defined by the following equations.

$$I_{c_i,g_j} = \begin{cases} \frac{R_{c_i}-d(x_{c_i},x_{g_j})}{R_{c_i}} p_{c_i} & \text{if } R_{c_i} \geq d(x_{c_i},x_{g_j}) \\ 0 & \text{otherwise} \end{cases} \quad (20)$$

$$I_{c_i,l_{i,j}} = \begin{cases} \frac{R_{c_i}-d(x_{c_i},x_{l_j})}{R_{c_i}} p_{c_i} & \text{if } R_{c_i} \geq d(x_{c_i},x_{l_{i,j}}) \\ 0 & \text{otherwise} \end{cases} \quad (21)$$

$d(x_{c_i}, x_{g_j})$ and $d(x_{c_i}, x_{l_{i,j}})$ are the Euclidean distances between candidate c_i and global voter g_j and local voter $l_{i,j}$, respectively. Each global and local voters have different degree preferences to vote each candidate c_i, which can be measured by these equations.

$$P_{g_j,c_i} = \frac{I_{c_i,g_j}}{\sum_{\forall c_i} I_{c_i,g_j}} f(x_{g_j}) \quad (22)$$

$$P_{l_{i,j},c_i} = \frac{I_{c_i,l_{i,j}}}{\sum_{\forall c_i} I_{c_i,l_{i,j}}} f(x_{l_{i,j}}) \quad (23)$$

These preferences are used further to compute the degree of support from global and local voters for any candidate in the following equation.

$$S_{c_i} = \sum_{\forall g_j} P_{g_j,c_i} + \sum_{\forall g_j} P_{l_{i,j},c_i} \quad (24)$$

Once the candidate knows his degree of support from global and local voters, his moves to the new location toward his voters by using the following equation.

$$x_{c_i} = \sum_{\forall g_j} x_{g_j} \frac{P_{g_j,c_i}}{S_{c_i}} + \sum_{\forall g_j} x_{l_{i,j}} \frac{P_{l_{i,j},c_i}}{S_{c_i}} \quad (25)$$

The new value of cost function is re-computed from this new location x_{c_i}. The computing process to find a set of new locations of candidates with better values of cost function is iterated until a satisfactory value is found.

F. Bat Algorithm

This approach [4], [8] is based on the observation of how a bat exploits and avoids the obstacles to find food. Each bat emits a signal and analyzes the signal echo to avoid obstacles. This behavior involves the signal frequency, loudness of signal, location of bat, and flying velocity. At time t, bat i emits a pulse signal of $f_i^{(t)}$ frequency with loudness $l_i^{(t)}$. The pulse signal has a pulse rate of $p_i^{(t)}$. Bat i is at location $\mathbf{x}_i^{(t)}$ with flying velocity of $\mathbf{v}_i^{(t)}$. For a given problem, the candidate solution corresponding to bat i is evaluated by a cost function $c(\mathbf{x}_i^{(t)})$. Let $f_i^{(t)}$ be the frequency emitted by bat i at time t. The flying velocity and location of bat i at time $t+1$ are computed by the following equations.

$$f_i^{(t)} = f_{min} + (f_{max} - f_{min}) \times rand(0,1) \quad (26)$$

$$\mathbf{v}_i^{(t+1)} = \mathbf{v}_i^{(t)} + (\mathbf{x}_i^{(t)} - \mathbf{x}_{best}) f_i^{(t)} \quad (27)$$

$$\mathbf{x}_i^{(t+1)} = \mathbf{x}_i^{(t)} + \mathbf{v}_i^{(t)} \quad (28)$$

f_{min} and f_{max} are respectively the minimum and maximum frequencies. If the objective is to find the minimum cost value, then $\mathbf{x}_{best}$ at current time is computed by equation (29). Otherwise, $\mathbf{x}_{best}$ is computed by equation (30).

$$\mathbf{x}_{best} = \arg\min_i (c(\mathbf{x}_i^{(t)})) \quad (29)$$

$$\mathbf{x}_{best} = \arg\max_i (c(\mathbf{x}_i^{(t)})) \quad (30)$$

The loudness and pulse rate are temporally adjusted by these equations.

$$l_i^{(t+1)} = \alpha l_i^{(t)} \quad (31)$$

$$p_i^{(t)} = p_i^{(0)}(1 - e^{-\gamma\epsilon}) \quad (32)$$

α and γ are constants and ϵ is a scaling factor. The values of $l_i^{(t)}$ and $p_i^{(t)}$ are in between 0 and 1 and used to select and accept the best solution among the generated solutions. In this bat algorithm, the location $\mathbf{x}_i^{(t)}$ is used to denote the i^{th} solution of the optimization problem. The process of bat algorithm is briefly given as follows.

Algorithm: Bat Algorithm

1. Define a cost function $c(\mathbf{x}_i^{(t)})$ in terms of bat location $\mathbf{x}_i^{(t)}$ of bat i at time t.
2. Initialize a set of locations of bats with their own velocities $\{\mathbf{x}_i^{(0)}, \mathbf{v}_i^{(0)} \mid 1 \leq i \leq n\}$.
3. Initialize the value of f_{min} and f_{max}.
4. Initialize pulse rate $r_i^{(0)}$ and loudness $l_i^{(0)}$ of each bat.
5. Define the maximum number of iterations N and set $t = 1$.
6. **While** $t \leq N$ **do**
7. Generate and update a set of new locations and velocities by using equations (26), (27), and (28).
8. **If** $\exists i$ $(rand(0,1) > p_i^{(t)})$ **then**
9. Find $\mathbf{x}_{best}$.
10. Generate a new location $\mathbf{x}^{(t)}$ around $\mathbf{x}_{best}$ by $\mathbf{x}^{(t)} = \mathbf{x}_{best} + \epsilon l_i^{(t)}(2 \cdot rand(0,1) - 1)$.
11. **EndIf**
12. Randomly generate a new bat at location $\mathbf{x}_j^{(t)}$ and velocity $\mathbf{v}_j^{(t)}$, loudness $l_j^{(t)}$, and pulse rate $p_j^{(t)}$.
13. **If** $(rand(0,1) < l_j^{(t)})$ and $(c(\mathbf{x}_j^{(t)}) < c(\mathbf{x}^{(t)}))$ **then**
14. Accept location $\mathbf{x}_j^{(t)}$.
15. Compute the pulse rate $p_j^{(t+1)}$ and loudness $l_j^{(t+1)}$.
16. **EndIf**
17. Find the current $\mathbf{x}_{best}$.
18. $t = t + 1$.
19. **EndWhile**

G. Fish Swarm Intelligent Algorithm

The algorithm [1], [21] is based on the following moving behaviours of fish: *random move, search for food, chase for food*, and *follow the swarm*. This imitation of fish behaviour may be stuck at a local best solution. Thus, one extra process called *leap* is attached at the end of algorithm. For a given problem, the solution of the problem is encoded in forms of the location of fish i in a d-dimensional space. Let $\mathbf{x}_i = [x_{i,1}, x_{i,2}, \ldots, x_{i,d}]^T$. A cost function $f(\mathbf{x}_i)$ is defined to evaluate the value of solution $\mathbf{x}_i$. A fish selects a moving type by determining the visual result. Each fish has its own visual range or scope. In this algorithm, a visual scope refers to a region around a fish where it looks for food. This region may be empty (no fish), not so crowed (having some fish), or very crowded (full of fish). The determination of moving types of fish i at current location $\mathbf{x}_i$ and its new location is described in the following algorithm.

Algorithm: Fish Swarm Intelligent Algorithm

1. Initialize a swarm of m fish and their locations $\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_m$.
2. Set $t = 1$.
3. **While** $t \leq$ maximum number of iterations **do**
4. **For** each fish and its location $\mathbf{x}_i$ **do**
5. **If** the visual scope is empty **then**
6. use *random move* to define a new location $\mathbf{y}_i$.
7. **EndIf**
8. **If** the visual scope is crowded **then**
9. use *search move* to define a new location $\mathbf{y}_i$.
10. **EndIf**
11. **If** the visual scope is not so crowded **and** the center of swarm gives better result **then**
12. use *follow-the-swarm move* to define the first tentative location $\mathbf{y}_i^{(1)}$.
13. **else**
14. use *search move* to define the first tentative location $\mathbf{y}_i^{(1)}$.
15. **EndIf**
16. **If** location $\mathbf{y}_i^{(1)}$ does not give better result than the current location $\mathbf{x}_i$ **then**
17. use *chase move* to define another new tentative location $\mathbf{y}_i^{(2)}$.
18. **else**
19. use *search move* to define another new location $\mathbf{y}_i^{(2)}$.
20. **EndIf**
21. Set $\mathbf{y}_i = \arg \min_{\{\mathbf{y}_i^{(1)}), \mathbf{y}_i^{(2)}\}} (f(\mathbf{y}_i^{(1)}), f(\mathbf{y}_i^{(2)}))$.
22. Set $\forall i \ \mathbf{x}_i = \arg \min_{\{\mathbf{x}_i, \mathbf{y}_i\}} (f(\mathbf{x}_i), f(\mathbf{y}_i))$.
22. **If** the current result is not better than the previous M-iterations results **then**
23. use *leap* process to jump to the new location.
24. **EndIf**
25. **EndFor**
26. $t = t + 1$.
27. **EndWhile**

There are lower bound l_j and upper bounds u_j for each dimension j to initialize the value $x_{i,j}$ of each fish i as follows.

$$x_{i,j} = l_j + \alpha_j \cdot rand(0,1) \tag{33}$$

The location $\mathbf{x}_i$ is used to evaluate the result by using a cost function $f(\mathbf{x}_i)$ with $\mathbf{x}_i$ as its variable. The best result is defined by the following equations depending on the objective to achieve minimum (eq. (34)) or maximum (eq. (35)) solution.

$$f_{best} = \min_i (f(\mathbf{x}_i)) \tag{34}$$

$$f_{worst} = \max_i (f(\mathbf{x}_i)) \tag{35}$$

The width w of visual scope for any fish is set by using the lower and upper bounds and a constant parameter ν as follows.

$$w = \nu \cdot \max_{1 \leq j \leq d} (u_j - l_j) \tag{36}$$

This width is used for setting a new location in *random move*. A new location of each type of move is computed in the following equation.

Random move: Let $y_{i,k} \in \mathbf{y}_i$ be a new location $\mathbf{y}_i$ of fish i in dimension k. $\lambda_1, \lambda_2 \in [0,1]$ are two random constants.

$$\mathbf{y}_{i,k} = \begin{cases} x_{i,k} + \lambda_2 \cdot w & \text{if } u_k - x_{i,k} > w \text{ and } \lambda_1 > 0.5 \\ x_{i,k} + \lambda_2 \cdot (u_k - x_{i,k}) & \text{if } u_k - x_{i,k} \leq w \text{ and } \lambda_1 > 0.5 \\ x_{i,k} + \lambda_2 \cdot w & \text{if } x_{i,k} - l_k > w \text{ and } \lambda_1 \leq 0.5 \\ x_{i,k} + \lambda_2 \cdot (x_{i,k} - l_k) & \text{if } x_{i,k} - l_k \leq w \text{ and } \lambda_1 \leq 0.5 \end{cases} \tag{37}$$

Search move: For fish i, a new location $\mathbf{y}_i$ is randomly generated within the visual scope. Fish i moves to this location $\mathbf{y}_i$ if $f(\mathbf{y}_i) < f(\mathbf{y}_i)$. Otherwise, it stays at location $\mathbf{x}_i$.

Follow-the-swarm move: Fish i moves towards the center of visual scope of fish i. Let $\mathbf{V}_i$ be a set of fish in visual scope of fish i. The new location is set to $\mathbf{c}_i$ which is defined in the following.

$$\mathbf{c}_i = \frac{\sum_{\mathbf{x}_k \in \mathbf{V}_i} \mathbf{x}_k}{|\mathbf{V}_i|} \tag{38}$$

Chase move: Fish i moves towards the location $\mathbf{x}_{min}$, whose cost function is minimum, along the moving direction $\mathbf{m}_i = [m_{i,1}, m_{i,2}, \ldots, m_{i,d}]^T = \mathbf{x}_{min} - \mathbf{x}_i$. Each new location $y_{i,k}$ is computed as follows.

$$y_{i,k} = \begin{cases} x_{i,k} + \beta \frac{d_{i,k}}{|\mathbf{m}_i|} (u_k - x_{i,k}) & \text{if } m_{i,k} > 0. \\ x_{i,k} + \beta \frac{d_{i,k}}{|\mathbf{m}_i|} (x_{i,k} - l_k) & \text{if } m_{i,k} \leq 0. \end{cases} \tag{39}$$

$\beta \in [0,1]$ is a random constant.

Leap process: Set a new location $y_{new,k}$ in dimension k to avoid being stuck at local cost by the following equations. Let $\lambda_1, \lambda_2 \in [0,1]$ be two random constants.

$$y_{new,k} = \begin{cases} x_{r,k} + \lambda_2 \cdot (u_k - x_{r,k}) & \text{if } \lambda_1 > 0.5 \\ x_{r,k} - \lambda_2 \cdot (x_{r,k} - l_k) & \text{if } \lambda_1 \leq 0.5 \end{cases} \tag{40}$$

$x_{r,k}$ is the value of dimension k of a new randomly selected location $\mathbf{x}_r$ from the initial swarm of fish.

H. Cuckoo Search

The search concept [2], [6], [10] is based on the concept of *Levy* flight. A cuckoo deposits one egg at a time in a selected nest of a host bird. The host bird may get rid of some eggs, including the the eggs of cuckoo, in its nest in order to increase the hatching probability of its eggs. A solution of a given problem is viewed as a host nest. A cuckoo randomly flies to select any nest for laying its eggs and evaluates the quality of nest by a cost function defined in terms of nest variable. Let $\mathbf{x}_i^{(t)} = [x_{i,1}, x_{i,2}, \ldots, x_{i,d}]^T$ be the i solution at iteration t and $f(\mathbf{x}_i^{(t)})$ be the cost function. There are n host nests. The algorithm for cuckoo search is shown as follows.

Algorithm: Cuckoo Search Algorithm

1. Generate a set of initial solutions $\{\mathbf{x}_1^{(0)}, \mathbf{x}_2^{(0)}, \ldots, \mathbf{x}_n^{(0)}\}$.
2. Set $t = 1$.
3. **While** *the satisfactory solution is not found* **do**
4.   Randomly pick a solution $\mathbf{x}_i^{(t-1)}$.
5.   Compute each new solution $\mathbf{x}_i^{(t)}$ from $\mathbf{x}_i^{(t-1)}$ by applying *Levy* flight.
6.   Evaluate the quality of solution by $f(\mathbf{x}_i^{(t)})$.
7.   Randomly pick a solution $\mathbf{x}_j^{(t-1)}$.
8.   **If** $f(\mathbf{x}_i^{(t)}) > f(\mathbf{x}_j^{(t)})$ **then**
9.   Replace $\mathbf{x}_j^{(t-1)}$ by $\mathbf{x}_i^{(t)}$.
10.   **EndIf**
11.   Randomly delete some fraction of low quality solutions and generate new solutions.
12.   Evaluate the quality of all solutions.
13.   Keep some best solutions.
14. $t = t + 1$.
14. **EndWhile**
15. Pick the best quality solution.

Lévy flight was proposed by Paul Pierre Lévy to measure the traveling distance of object in a random walk. In a simple random walk, the traveling distance d_t of an object at time t is defined as a sum of t displacements Δd_t, shown in equation (41).

$$d_t = \sum_{i=1}^{t} \Delta d_i \tag{41}$$

Δd_i is an independent and identically distributed random variable. Lévy flight is similarly described as the simple random walk but each step size Δd_i of displacement is defined by the following probability

$$p_{\Delta d_i}(\beta) = \frac{1}{\Delta d_i^{\beta}} \tag{42}$$

where $1 \leq \beta \leq 3$. In cuckoo search, each step size Δd_i is set equally but it is scaled by the probability $p_{\Delta d_i}(\beta)$. Therefore, the new solution $\mathbf{x}_i^{(t)}$ in step 5 is computed by the concept of Lévy flight as follows.

$$\mathbf{x}_i^{(t)} = \mathbf{x}_i^{(t-1)} + \Delta d \cdot p_{\Delta d_i}(\beta) \tag{43}$$

I. Group Search Optimization

This approach [18] is based on the observation of foraging strategy of some animals living in a group. Each animal has three types of foraging strategies. The first strategy is searching food by itself within a certain direction and a fixed distance. The direction is defined in terms of searching angles with respect to the current location. This strategy is called *producing*. The animal uses the first search strategy is called *a producer*. The second strategy is joining the group to search food. This strategy is called *scrounging* and the animal uses the strategy is called *scrounger*. The last strategy is similar to the first strategy but the direction and distance of food search are random. This strategy is called *dispersing*. The location of each animal in group search is encoded as the solution of optimization problem. Let $\mathbf{x}_i \in R^n$ be the location of animal i at current time. The location of a producer at time t is denoted as $\mathbf{x}_p$. Each location $\mathbf{x}_i$ is evaluated by a cost function cost $f(\mathbf{x}_i)$. Cost $f(\mathbf{x}_i)$ is better than $f(\mathbf{x}_j)$ if $f(\mathbf{x}_i) < f(\mathbf{x}_j)$. The overview of group search optimization is shown as follows.

Algorithm: Group Search Algorithm

1. Initialize the set of locations, $\mathbf{X} = \{\mathbf{x}_i \mid 1 \leq i \leq n\}$.
2. Compute the cost of each location by $f(\mathbf{x}_i)$.
3. **While** the stopping conditions are not satisfactory **do**
4.   **For** each $\mathbf{x}_i \in \mathbf{X}$ **do**
5.   Random pick a location $\mathbf{x}_p$ from $\mathbf{X} - \{\mathbf{x}_i\}$ as the location of producer.
6.   Tentatively compute 3 new locations in 3 directions: go straight ($\mathbf{x}_{p1}$) , go right ($\mathbf{x}_{p2}$), go left ($\mathbf{x}_{p3}$) by using producer strategy from $\mathbf{x}_p$.
7. $\mathbf{x}_{best} = \arg \min_{\mathbf{x}_{p1}, \mathbf{x}_{p2}, \mathbf{x}_{p3}} (f(\mathbf{x}_{p1}), f(\mathbf{x}_{p2}), f(\mathbf{x}_{p3}))$.
8.   **If** $\mathbf{x}_{best} = \mathbf{x}_p$ **then**
9.   Compute new location $\mathbf{x}_{new}$ from $\mathbf{x}_p$ by using a new random degree angle and put it in $\mathbf{X}$.
10.   Let $\mathbf{y}$ be the producer from past t iterations.
11.   **If** $f(\mathbf{x}_{new}) > f(\mathbf{y})$ **then**
12.   Replace $\mathbf{x}_{new}$ in $\mathbf{X}$ with $\mathbf{y}$ from past t iterations.
13.   **EndIf**
14.   **EndIf**
15.   Randomly select 80% of locations from $\mathbf{X}$ to create a set of scroungers $\mathbf{S}$.
16.   Compute new locations for all elements in $\mathbf{S}$ by using scrounger strategy.
17.   **For** each $\mathbf{x}_j \in \mathbf{X} - \mathbf{S} - \{\mathbf{x}_p\}$.
18.   Compute new location of $\mathbf{x}_j$ by using dispersion strategy.
19.   **EndIf**
20.   Compute the cost function of all locations in $\mathbf{X}$.
21.   **EndFor**
22. **EndWhile**

The new location computed by using producer strategy, scrounger strategy, and dispersion strategy are summarized in the followings.

Producer strategy: A new location in producer strategy is controlled by a directional vector having a angle vector as its variable. Let $\mathbf{d}_i(\theta) = [d_{i,1}, d_{i,2}, \ldots, d_{i,n}]^T$ be a directional vector of location $\mathbf{x}_i$ in n-dimensional space. $\theta = [\theta_1, \theta_2, \ldots, \theta_n]^T$ be an angle vector. Each $d_{i,j}$ is computed from a set of angles $\{\theta_1, \theta_2, \ldots, \theta_n\}$ as follows.

$$d_{i,1} = \prod_{k=1}^{n-1} \cos(\theta_k) \quad (44)$$

$$d_{i,j} = \sin(\theta_{j-1}) \cdot \prod_{k=1}^{n-1} \cos(\theta_k); \quad 2 \leq j \leq n-1 \quad (45)$$

$$d_{i,n} = \sin(\theta_{n-1}) \quad (46)$$

There are three directions to go for each $\mathbf{x}_i$, i.e. go straight, go right, and go left. Let L be the maximum food pursuit distance and A be the maximum food pursuit angle. The new location of each direction is computed in the followings.

Go straight:

$$\mathbf{x}_{p1} = \mathbf{x}_p + \alpha \cdot L \cdot \mathbf{d}_p(\theta) \quad (47)$$

Go right:

$$\mathbf{x}_{p2} = \mathbf{x}_p + \alpha \cdot L \cdot \mathbf{d}_p(\theta + \frac{A}{2}\mathbf{c}) \quad (48)$$

Go left:

$$\mathbf{x}_{p3} = \mathbf{x}_p + \alpha \cdot L \cdot \mathbf{d}_p(\theta - \frac{A}{2}\mathbf{c}_1) \quad (49)$$

$\alpha \in [0, 1]$ is a random constant and $\mathbf{c}$ is a random constant vector whose each element is in $(0, 1)$.

Scrounger strategy: The new location $\mathbf{x}'_i$ of $\mathbf{x}_i$ in this strategy can be simply computed with respect to the producer $\mathbf{x}_p$ as follows.

$$\mathbf{x}'_i = \mathbf{x}_i + \mathbf{c}_2 \circ (\mathbf{x}_p - \mathbf{x}_i) \quad (50)$$

where $\mathbf{c}_2$ is a random constant vector whose each element is in $(0, 1)$ and the operator $\circ$ refers to Hadamard product.

Dispersion strategy: The new location $\mathbf{x}'_i$ of $\mathbf{x}_i$ in this strategy is governed by a new set of random angles θ' and the current location $\mathbf{x}_i$. This is different from other strategies. The equation is as follows.

$$\mathbf{x}'_i = \mathbf{x}_i + \alpha \cdot \beta \cdot L \cdot \mathbf{d}_i(\theta') \quad (51)$$

$\beta \in (0, 1]$ is a random constant.

J. Brain Storm Optimization

This method [19] is based on the process of brain storming process to solve one particular problem. A group of persons from different or the same background are gathered to discuss the problem and to suggest a good solution to the problem. In terms of evolutionary algorithm, each person is referred to a solution of the problem. Thus, a person can be represented by a vector whose element are the variables of the solution. Let $\mathbf{s}_i$ be solution i being evaluated by a cost function $f(\mathbf{s}_i)$. The best solution $\mathbf{s}_{best}$ is a solution whose $f(\mathbf{s}_{best})$ is minimum.

Algorithm: Brain Storm Algorithm

1. General a set of random solutions $\mathbf{S} = \{\mathbf{s}_1, \mathbf{s}_2, \ldots, \mathbf{s}_n\}$.
2. **While** the satisfactory solutions are not found **do**
3.   Partition $\mathbf{S}$ into m clusters of equal size, $\mathbf{C}_1, \mathbf{C}_2, \ldots, \mathbf{C}_m$.
4.   **For** each cluster $\mathbf{C}_i$ **do**
5.   Set its center $\mathbf{c}_i = \arg\min_{\mathbf{s}_j}(f(\mathbf{s}_j))$.
6.   **EndFor**
7.   Set $p = rand(0, 1)$.
8.   **If** $p < \tau_1$ **then**
9.   Randomly select one center $\mathbf{c}_\alpha$.
10.   Replace $\mathbf{c}_\alpha$ with a new randomly generated solution $\mathbf{s}_a$.
11.   **EndIf**
12.   Set $p = rand(0, 1)$.
13.   **If** $p < \tau_2$ **then**
14.   Set $p = rand(0, 1)$ and randomly select a cluster $\mathbf{C}_\beta$ with center $\mathbf{c}_\beta$.
15.   **If** $p < \tau_3$ **then**
16.   Generate a random vector $\mathbf{v}$.
17.   Generate a new solution $\mathbf{s}_a = \mathbf{c}_\beta + \mathbf{v}$.
18.   **else**
19.   Randomly select $\mathbf{s}_k \in \mathbf{C}_\beta$ and generate a random vector $\mathbf{v}$.
20.   Generate a new solution $\mathbf{s}_b = \mathbf{s}_k + \mathbf{v}$.
21.   **EndIf**
22.   **else**
23.   Set $p = rand(0, 1)$.
24.   Randomly select two centres $\mathbf{c}_i$ and $\mathbf{c}_j$.
25.   Generate two random vectors $\mathbf{v}$ and $\mathbf{w}$.
26.   **If** $p < \tau_3$ **then**
27.   Set $\mathbf{c}_k = \mathbf{c}_i + \mathbf{c}_j + \mathbf{v}$.
28.   **else**
29.   Randomly select solutions $\mathbf{s}_{i_1} \in \mathbf{C}_i$ and $\mathbf{s}_{j_1} \in \mathbf{C}_j$.
30.   Generate two new solutions $\mathbf{s}_e = \mathbf{s}_{i_1} + \mathbf{v}$ and $\mathbf{s}_e = \mathbf{s}_{j_1} + \mathbf{w}$.
31.   **EndIf**
32.   **If** number of newly generated solutions is not equal to n **then**
33.   Go to step 12.
34.   **EndIf**
35. **EndWhile**

$\tau_1, \tau_2, \tau_3 \in (0, 1)$ are constants used as the decision probability.

K. Genetic Algorithm

This method [22], [23] imitates the natural process of genetic reproduction. A solution of a problem is encoded in a form of n-bit chromosome. A set of chromosomes is called *population*. Two major genetic reproductions which are mutation and crossover are employed to produce a new generation of population. To reach the satisfactory result, several chromosome reproductions are iterated. Any good chromosomes will be filtered by a cost function to reproduce the next generation but the bad ones are destroyed. Let

$\mathbf{x}_i = [x_{i,1}, x_{i,2}, \ldots, x_{i,n}]^T$ be a chromosome in a form of n-bit vector. Each chromosome is evaluated by a cost function $f(\mathbf{x}_i)$. The overview of genetic algorithm is shown in the following.

Algorithm: Genetic Algorithm

1. Generate an initial set of chromosome population $\mathbf{P}^{(1)} = \{\mathbf{x}_i \mid 1 \leq i \leq n\}$.
2. Evaluate $f(\mathbf{x}_i)$ of each chromosome $\mathbf{x}_i \in \mathbf{P}^{(1)}$.
3. Set $t = 1$.
4. **While** terminating conditions are not satisfactory **do**
5. Select m best chromosomes according to their cost functions from $\mathbf{P}^{(t)}$ and put them in $\mathbf{B}$.
6. Set $\mathbf{P}^{(t)} = \mathbf{P}^{(t)} - \mathbf{B}$.
7. Use crossover reproduction with some selected chromosomes in $\mathbf{P}^{(t)}$ to generate a new set of chromosomes $\mathbf{C}$.
8. Use mutation reproduction with some selected chromosomes in $\mathbf{P}^{(t)}$ to generate a new set of chromosomes $\mathbf{M}$.
9. $t = t + 1$.
10. Set $\mathbf{P}^{(t)} = \mathbf{P}^{(t-1)} \cup \mathbf{C} \cup \mathbf{M}$.
11. Set $\mathbf{C} = \mathbf{M} = \emptyset$.
12. **EndWhile**

The mutation reproduction requires only one chromosome $\mathbf{x}_i$ to randomly produce another bit pattern of chromosome $\mathbf{x}_i$ by flipping one of $(x_{i,1}, x_{i,2}, \ldots, x_{i,n})$ or a subset of $(x_{i,1}, x_{i,2}, \ldots, x_{i,n})$. For example, suppose $\mathbf{x}_i = [11011]^T$. One possibility to mutate $\mathbf{x}_i$ is to flip the bit 0 to 1 to obtain this new bit pattern $[11111]^T$.

On the other hand, the crossover reproduction requires two chromosomes to randomly exchange some bit patterns to obtain two new chromosomes. There are no formal rules of how to select the locations from both chromosomes to perform crossover reproduction. One simple crossover scheme is to randomly select a fixed position as the crossover position in both chromosomes and then exchange the bit patterns to the left and to the right of the crossover position from both chromosomes. For example, suppose chromosomes $(x_{i,1}x_{i,2} \ldots x_{i,\alpha}x_{i,\alpha+1} \ldots x_{i,n})$ and $(x_{j,1}x_{j,2} \ldots x_{j,\alpha}x_{j,\alpha+1} \ldots x_{j,n})$ are selected for performing crossover reproduction. Let α be the crossover position. After crossover reproduction, two new chromosomes are $(x_{j,1}x_{i,2} \ldots x_{j,\alpha}x_{i,\alpha+1} \ldots x_{i,n})$ and $(x_{i,1}x_{i,2} \ldots x_{i,\alpha}x_{j,\alpha+1} \ldots x_{j,n})$.

L. Simulated Annealing

This method [15], [16] is based on the observation of the process of hardening the surface of metal by heating the molecules of metal and then rapidly cool them down. By repeating this process several times, the molecules will rearrange their positions in a very compact structure to harden the surface. Let $\mathbf{x}_i = [x_{i,1}, x_{i,2}, \ldots, x_{i,n}]^T$ be solution i with n variables. These variables are referred to the molecules and the solution is referred to the result of each annealing trial. The performance of each annealing result $\mathbf{x}_i$ is evaluated by a cost function $f(\mathbf{x}_i)$. To select an acceptable solution, a temperature variable T is introduced and used to computed the probability of accepting the solution. The simulated annealing algorithm is shown as follows.

Algorithm: Simulated Annealing Algorithm

1. Initialize the value of temperature T, maximum number of iterations M, and probability threshold p.
2. Set $t = 1$;
3. Randomly generate a solution $\mathbf{x}_t$.
4. **While** T is still high **do**
5. **While** $t \leq M$ **do**
6. Generate a new solution $\mathbf{x}'_t$ by perturbing each $x_{t,j}$.
7. Compute $\Delta f = f(\mathbf{x}'_t) - f(\mathbf{x}_t)$.
7. **If** $\Delta_f < 0$ **then**
8. Replace $\mathbf{x}_t$ with $\mathbf{x}'_t$ as a new solution.
9. **else**
10. **If** probability $e^{-\frac{\Delta f}{T}} > p$ **then**
11. Replace $\mathbf{x}_t$ with $\mathbf{x}'_t$ as a solution.
12. **EndIf**
13. **EndIf**
14. $t = t + 1$.
15. **EndWhile**
16. $T = \alpha \cdot T$.
17. **EndWhile**

To reduce the temperature T, the value of α is constantly set as $0 < \alpha < 1$.

III. Generic Structure of Evolutionary Algorithms

As shown in the previous Sections, all algorithms mainly deployed three main processes of randomly generating the solutions, filtering those heuristically unsatisfactory solutions by using a cost function, and randomly regenerating new some solutions either from either the probably good solutions after filtering process or from newly generated solutions. A solution is usually encoded in a forms of vector and interpreted as an animal or human. The process of filtering unsatisfactory solutions and generating new solutions are interpreted as the behavior of animal. Thus, the generic structure of these meta-heuristic algorithm can be established as follows.

Generic Structure of Evolutionary Algorithm

1. Generate a set of solutions $\mathbf{S} = \{\mathbf{s}_1, \mathbf{s}_2, \ldots \mathbf{s}_n\}$.
2. **While** terminating conditions are not reached **do**
3. Evaluate each $f(\mathbf{s}_i)$.
4. Select some best solutions according to $f(\mathbf{s}_i)$ by its actual value or by a probability value.
5. Generate some new solutions either from the selected solutions or from newly generated solutions.
6. **EndWhile**

The terminating conditions may be the maximum number of iterations or the heuristically acceptable $f(\mathbf{s}_i)$. A new solution can be obtained by several methods such as perturbing the solution by adding a random vector to a selected current solution, using random number generator, using mutation concept with the current solution, using crossover concept with two current solutions. From the generic structure, it is noticeable that the evolutionary algorithm has two major groups of steps to reach an acceptable solution. The first one is step 3 which is the evaluation step of solutions. Another one is from steps 4 and 5 for filtering and generating new solution without scrutinizing how the cost function evaluate any solution and the geometrical structure of the cost function in n-dimensional space. Generally, due to the steps 4 and 5, the number of iterations to find an acceptable solution cannot be estimated in advance. This is the disadvantage of evolutionary algorithm although it might produce the best solution in only one iteration.

IV. Opposite Gradient Search on Manifold of Cost Function

This method [24] takes a new approach by searching along the manifold of a cost function. It starts from the cost function $E(\mathbf{x}_i)$ of solution $\mathbf{x}_i$ and views the cost function as a non-linear manifold in a n-dimensional space. A starting location on the manifold is randomly generated as a coordinates $(\mathbf{x}_i, E(\mathbf{x}_i)$. The location of any local maximum or minimum value on the manifold of cost function must have zero gradient, $\nabla E(\mathbf{x}_i) = 0$, and furthermore it must lie in between the positive gradient, $\nabla E(\mathbf{x}_i) > 0$, and negative gradient, $\nabla E(\mathbf{x}_i) < 0$. Figure I shows this observation.

To find the best solution, a set of random solutions is generated as a set of coordinates on the manifold of cost function. Next, two solutions $\mathbf{x}_1$ and $\mathbf{x}_2$ with opposite gradients are randomly selected. The solution with zero gradient must be somewhere in between $\mathbf{x}_1$ and $\mathbf{x}_2$. The next better solution $\mathbf{x}_3$ can be computed by using both $\mathbf{x}_1$ and $\mathbf{x}_2$ and their gradients as follows. Suppose $|\nabla E(\mathbf{x}_1)| > |\nabla E(\mathbf{x}_2)|$.

$$\mathbf{x}_3 = \mathbf{x}_1 + \omega \times \frac{|\nabla E(\mathbf{x}_1)|}{|\nabla E(\mathbf{x}_1)| + |\nabla E(\mathbf{x}_2)|} \times ||\mathbf{x}_1 - \mathbf{x}_2|| \quad (52)$$

where $0 < \omega \leq 1$ is a constant for adjusting the searching speed. An example of searching process is illustrated in Figure II. The subscript of each solution denotes the searching sequence.

The advantage of this method is its searching speed which is much faster than the other methods. but similar to the other methods, this method may be stuck at local minima or maxima due to the set of initial solutions. If the best solution lies within the initial solutions, then the searching steps will eventual reach the best solution.

V. Conclusion

Evolutionary algorithms were proposed to guess the best solution which may or may not be actually the best one but rather be an acceptable one. There were many algorithms in this domain having been introduced so far by adapting the behavior of various types of animal. The disadvantage of these algorithms is due to the lack of considering and examining the geometrical structure of fitness function or cost function as a part of solution generating and finding. The solutions are randomly generated and then evaluated by the fitness function. Some of these solutions are selected by using the value of fitness function with probability and a threshold constant. Although this is a serious disadvantage but it still has an advantage of this approach. A new evolutionary method can be easily developed. Since there is no direct mathematical link between solution generating step and fitness function, it is rather arbitrary to adapt the behavior of new animals with empirical setting of relevant parameters. To overcome the disadvantage, only the approach introduced in [24] transformed a fitness function into a manifold and deployed the observation of where the turning points can be detected by using a fast opposite gradient search. The experiments in [24] signified the faster searching speed and more accurate results than other methods. The research direct should move towards the construction of convex manifold from fitness function and the fast searching step.

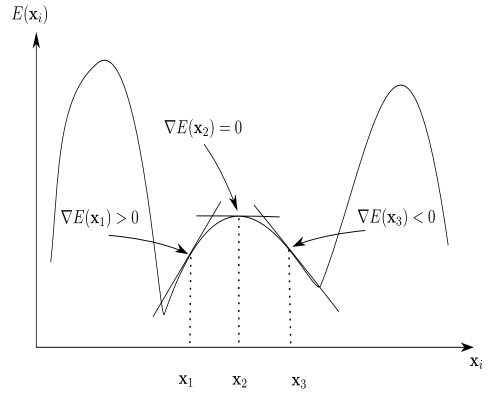

Fig. I. The observation of how to find best solution by using the opposite gradients and zero gradient of manifold of the cost function.

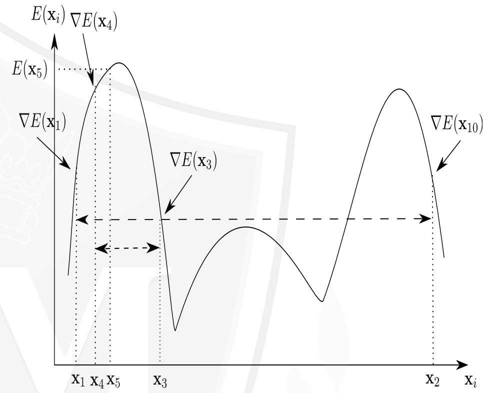

Fig. II. Searching sequence starting from solutions $\mathbf{x}_1$ and $\mathbf{x}_2$.

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Determination of Waste Treatment Fee Pricing Mechanism for Municipal Solid Waste by Mechanical Biological Treatment Method utilizing the Public Private Partnership Model in Thailand

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Abstract — **The participation of the private sector in equity investment and operation of municipal solid waste treatment facilities through the Public-Private Partnership (PPP) model promotes the implementation of sustainable solid waste treatment technologies without creating excessive financial burden in governmental infrastructure investment. The introduction of preset pricing mechanism to regulate potential waste treatment fee structure based on pre-determined project internal rate-of return mitigates multi-party risks, such as the potential developer project losses or the opportunity to profiteer. Research encompasses technical assessment of project requirements for implementation of required technologies, commercial analysis of project capital expenditure (CAPEX), operational expenditure (OPEX) and assessment of revenue streams of the facility. Computer simulation of commercial data computes the case study of a 600 tonne per day MBT facility's first-year waste treatment fee of THB 546.00, THB 709.00 and THB 890.00 based on pre-determined project internal rate of returns of 8.00%, 10.00% and 12.00% respectively. Macroeconomic data influences within pricing mechanism determines long-term effects to facility pricing fee structure to further mitigate project commercial risks.**

***Index Terms* — Solid Waste Management, Municipal Solid Waste, Waste Treatment Fee, Mechanical Biological Treatment, Pricing Mechanism, Infrastructure Sector**

I. Introduction

Municipal solid waste (MSW) is defined as unwanted products which have been discarded by households, but can include similar waste products that are discarded from commercial, public areas and offices which are collected by municipal or private haulers for disposal through the waste management system [1].

Current municipal solid waste generation (as of year 2015) in Thailand amounts to 26.85 million tonnes, of which almost 51% (13.53 million tonnes) are disposed improperly such as in waste dumps, 31% (8.34 million tonnes) disposed at lined landfills and 18% (4.94 million tonnes) utilised for recycling activities or energy generation [2]. Most MSW generated is disposed of at one of 106 landfills in operation across Thailand.

In 2015, Thai government announced sustainable municipal solid waste management as National Agenda No. 1, to promote proper, clean and sustainable methods for disposal of municipal solid waste, with the "emphasis on resource recovery wherever possible & energy recovery whenever possible".

This research presents an appropriate waste treatment fee calculation mechanism under the Public-Private Partnership (PPP) model which is transparent, flexible and repeatable that scrutinizes investor profitability within an acceptable project internal rate-of-return (IRR) range, reducing the potential of project developer "profiteering".

The proposed 600 tonne per day Mechanical Biological Treatment (MBT) facility in Bangkok, developed under a 20-year PPP model is utilised as the case study for this research. The pricing mechanism is formulated and validated using the case study's technical and commercial data, with long-term macroeconomic data utilised to forecast external market scenarios over the 20-year operating lifetime of the facility.

A. Mechanical Biological Treatment Concept

The mechanical biological treatment (MBT) concept is defined as the combination of recycling (material recovery) and anaerobic digestion or aerobic waste treatment concepts for the comprehensive treatment of mixed municipal solid waste. In general, a MBT plant consists of mechanised sorting facility, aerobic rotating (or anaerobic) bioreactors, forced-aeration stabilisation air-tunnels, ripening platforms and a sanitary landfill site [3]. In assessing the use of anaerobic digestion in the treatment of solid waste, Braber [4] determined that anaerobic digestion is a viable technology in the production of energy from the organic portion of municipal solid waste, with end product potential in closing the carbon cycle and promoting environmental sustainability. Eichner & Pethig [5] had utilised a general equilibrium model for determination of waste constituents to determine the benefits of material recovery in relation to potential environmental damages and evaluate policy instruments to optimize green waste recovery processes. Fig. I illustrates the technologies utilised under the MBT concept within overall MSW treatment hierarchy.

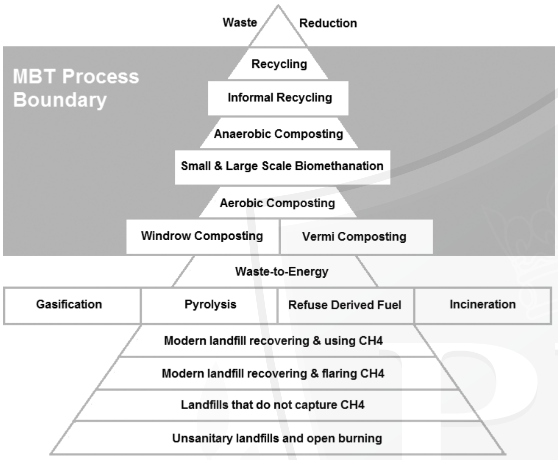

Fig. I. Mechanical biological treatment technology utilisation within the MSW treatment hierarchy [6].

B. Waste Treatment Fee Collection Structure

At present, MSW treatment fee collection from consumers are divided into "flat rate" and "unit-based" payment structures. The "flat rate" concept encompasses lump sum payment for a fixed period of service, usually over an annual period (property or general assessment payment). Advantages of this method include the constant, recurrent revenue generation for the administrative council but may not promote waste reduction initiatives among waste generators due to the lack of economic incentive in this regard, reducing the ability of administrative councils to introduce any improvement to current waste management processes [7]. The "unit-based" concept charges by actual use of service. This promotes waste reduction and recycling through economic incentive without limiting the waste generator's access to the service [8]. Table I lists literature review findings of current national waste fee collection tariff collection method and payment vehicles for selected countries within Asia.

TABLE I
WASTE FEE COLLECTION STRUCTURE WITHIN ASIA

Country	Income Status	Tariff Method	Payment Vehicle	Ref.
Japan	High Income	Unit-Based	Weight-based	[9]
China	Lower Middle Income	Flat Rate	General tax	[10]
Indonesia	Lower Middle Income	Flat Rate	Direct charge	[11]
Malaysia	Upper Middle Income	Flat Rate	Property Assessment	[12]
Singapore	High Income	Flat Rate	Property Assessment	[13]
Thailand	Lower Middle Income	Flat Rate	Direct Charge	[14]
Bangladesh	Low Income	Flat Rate	Direct Charge	[15]
India	Lower Middle Income	Flat Rate	Property Assessment	[16]
South Korea	High Income	Unit-Based	Weight-based	[17]
Sri Lanka	Lower Middle Income	Flat Rate	Property Assessment	[18]
Philippines	Lower Middle Income	Flat Rate	Direct Charge	[19]

C. Privatization of the Waste Management Sector

In assessing the entry of the private sector into the market, Bel & Warner [20] concluded that while cost savings through privatisation of waste treatment are not systemic, transaction costs are best regulated when contracts are given as complete packages with pre-set market and operating structures. Additionally, oversight and regulation play an important role in optimizing privatisation of services. While solid waste management policies remain incomplete, economic literature shows that current treatment fees for rationalization of investment in waste management technologies remain incorrect.

Turley & Semple [21] stated that private sector's investment and participation in public infrastructure projects must, at the least be able to cover initial principal investment and corresponding interest incurred through project financing either by debt finance or equity finance; with sufficient dividends paid for project involvement.

Zhang [22] had proposed that a project's concession period be sufficient to cover the project developer's equity and debt-financing responsibility while providing sufficient profit to ensure a "win-win" situation between the government and the private sector, with the typical cash flow of a BOT project.

This research is intended to introduce an independent pricing mechanism philosophy that can be considered for determining acceptable MSW treatment fees for Mechanical Biological Treatment (MBT) facilities based on pre-determined project internal rate of return (IRR).

II. Methodology

Research framework divides the study into 5 sections, i.e. (1) determination of MSW characteristics, (2) selection of mechanical biological treatment method, (3) determination of project capital (CAPEX) & operational (OPEX) expenditure and revenue streams, (4) formulation of the waste treatment pricing mechanism, and (5) designing a software to generate MSW treatment fee.

A. Determination of MSW Characteristics

MSW quantitative and qualitative data was conducted at the case study's current waste transfer station utilizing ASTM D5231-92(2008): Standard Test Method for Determination of Composition of Unprocessed Municipal Solid Waste. Further qualitative analysis was conducted on the recovered organic portion for mass and energy balance formulation purposes.

B. Selection of MBT Method

MBT process encompasses the integration of 4 separate waste treatment processes as follows.

a) pre-treatment/volume reduction
b) biological treatment
c) product/quality refining
d) preparation for market

Selection of the treatment process is dependent on project objectives, technological viability, commercial value of intended resources for recovery, and project budget.

C. Determination of Project CAPEX & OPEX

Investment costs for a MBT facility is dependent on several key factors such as plant development size, treatment capacity, location, intended operation life, level of automation, pollution control, intended processes and redundancy requirement. Figure II breakdowns a MBT facility's capital expenditure into 8 separate categories.

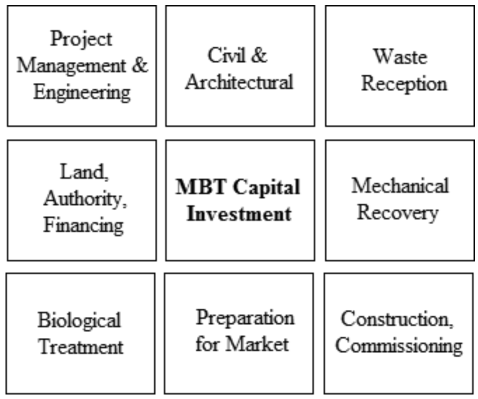

Fig. II. Capital expenditure (CAPEX) categories of a MBT facility.

A MBT facility's operation expenditure is divided into fixed and variable operating costs. Fixed costs comprise of expenses that the facility incurs irrespective of plant operational status such as manpower, financing charges, licenses while plant variable costs consists of all expenditure incurred such as utility costs and maintenance costs. Figure III divides a MBT facility's capital expenditure into 8 separate categories.

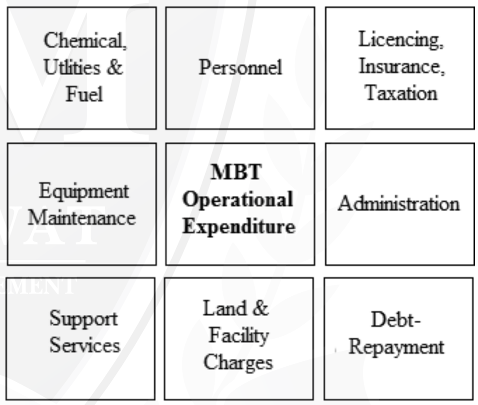

Fig. III. Operational expenditure (OPEX) categories of a MBT facility.

A MBT facility's income stream evaluation shall be based on 2 categories, i.e. (1) contracted income and (2) open-market determined income. Both income categories are performance-dependent, with open-market determined income further dependent on prevailing market rates.

D. Formulation of Waste Pricing Mechanism

The creation of the pricing mechanism to determine the suitable waste treatment fee based on pre-set internal rate-of-return (IRR) rates for the proposed mechanical biological treatment (MBT) facility to be built under the PPP model, which is derived from the general IRR formula, as shown in Equation (1).

$$NPV = \sum_{t=1}^{n} \frac{NCF_t}{(1+k)^t} - NCF_0 \quad (1)$$

Where NCF_0 = initial cash outlay of the project
NCF_t = net cash flow at time t
n = life of the project
k = required rate of return

Equation (1) is refined to incorporate total waste receipt, facility availability rate and expected inflation rate over the life of the facility to determine the waste treatment fee per tonne processed. The IRR formula is reconstructed to present the waste treatment fee based on listed variables, aptly summarised as Equation (2).

$$\text{Waste Treatment Fee/Tonne (THB)} = \left\{ \frac{\left(\frac{\text{Waste Treatment Fee}}{\text{Facility Design Throughput}} \right) \times \text{Facility Availability}}{\text{Consumer Pricing Index}} \right\} \quad (2)$$

Equation (2) is digitally incorporated into a computational software to allow for instantaneous data processing for the determination of possible waste treatment fees.

E. Computer Simulation Generation

The computer simulation is created on the Microsoft Excel 2013 platform. Individual spreadsheets are created within a singular workbook for purposes of data entry and processing, with respective outputs from each spreadsheet hyperlinked to the master spreadsheet for determination of the expected MSW waste treatment fee value based on case study data generation. The computer simulation is further utilised to analyze waste treatment fee structures based on potential plant efficiency and economic scenarios over the expected operating life of the facility, principally 1) plant availability, 2) changes in core inflation rate, and 3) effects on changes of biological treatment product sale pricing.

III. Data Collection

A. MSW Quantitative & Qualitative Data

A total of 28 MSW samples were collected and analyzed over a 7-day period. Table II summarises mean qualitative results for the organic components collected during the MSW sampling exercise.

TABLE II

MSW qualitative sampling mean results

Chemical Property	Unit	Mean Results
MSW Moisture	%	70.92
pH	-	6.73
Total Solid Content	%	29.08
Carbon Content (C)	%	42.58
Nitrogen Content (N)	%	1.89
Sulphur Content (S)	Mg/kg	1,003
C/N Ratio	-	23.30
Calorific Value (Dry)	kJ/kg	15,510
Calorific Value (Wet)	kJ/kg	2,388

Table III reports the summarised mean weight and volume results (by percentage) for all samples collected during the MSW quantitative sampling exercise.

TABLE III

MSW quantitative sampling mean results

<table>
<tr><th>MSW Component</th><th>Percentage (by weight) $\overline{X}$</th><th>Percentage (by volume) $\overline{X}$</th></tr>
<tr><td>Food Waste</td><td>46.86</td><td>28.32</td></tr>
<tr><td>Yard & Garden Waste</td><td>5.53</td><td>10.80</td></tr>
<tr><td>Mixed Paper</td><td>10.75</td><td>12.06</td></tr>
<tr><td>Mixed Plastics</td><td>21.03</td><td rowspan="13">48.82</td></tr>
<tr><td>Wood & Fibre</td><td>0.73</td></tr>
<tr><td>Rubber & Leather</td><td>0.55</td></tr>
<tr><td>Ferrous Metal</td><td>0.46</td></tr>
<tr><td>Stainless Steel</td><td>0.02</td></tr>
<tr><td>Copper</td><td>0.03</td></tr>
<tr><td>Aluminum</td><td>0.16</td></tr>
<tr><td>Glass</td><td>3.03</td></tr>
<tr><td>Ceramic, Tiles & Stones</td><td>1.76</td></tr>
<tr><td>Foam</td><td>0.83</td></tr>
<tr><td>Fabric & Textiles</td><td>3.96</td></tr>
<tr><td>Hazardous Waste</td><td>0.14</td></tr>
<tr><td>Other Waste (undefined)</td><td>4.16</td></tr>
</table>

B. Selection of MBT Method

In analyzing MSW component recovery and utilisation potential, waste component is grouped by main recovery or treatment method, dependent on the intended use of each product. Table IV outlines recovery method of MSW components by recovery/ treatment method and use.

TABLE IV
MSW COMPONENT RECOVERY METHOD & USE

	Waste Component/ By-Product	Recovery/ Treatment Method	Intended Use of Product
Mechanical Recovery	Ferrous Metal	Magnetic Recovery	Scrap Metal "as is" Basis
	Stainless Steel	Eddy-Current Separation	
	Copper		
	Aluminium		
	Glass	Densimetric Table, Near Infra-Red Optical Separation & Manual Picking	Disposal" as is" Basis
	Ceramics & Stones		
	Household Hazardous Waste (HHW)		Disposal in Secured Landfill
Biological Treatment	Food Waste	Size Separation, followed by Anaerobic Digestion	Biogas & Digestate for further processing
	Yard & Garden Waste		
	Recovered Leachate		
Market Prepared	Fabric, Foam & Textiles	Fine Shredding & Baling	Refused Derived Fuel (RDF) for Export
	Mixed Paper		
	Mixed Plastics		
	Wood & Fibre		
	Rubber & Leather		
	Other Wastes		
	Biogas	Biogas Scrubbing & Biogas Engine Use	Electricity
	Digestate	Dewatering & Aerobic Composting	Compost & Liquid Fertiliser

Figure IV. summarises the process flow for the mechanical recovery phase of the MBT facility.

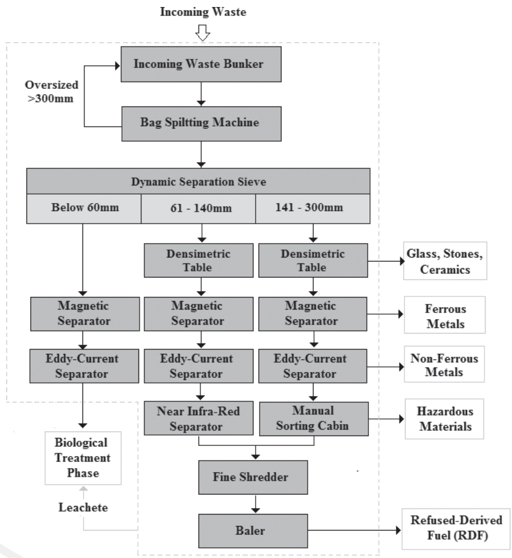

Fig. V. Process flow of case study's mechanical recovery phase.

Fig. V. summarises the process flow for the biological treatment phase of the MBT facility.

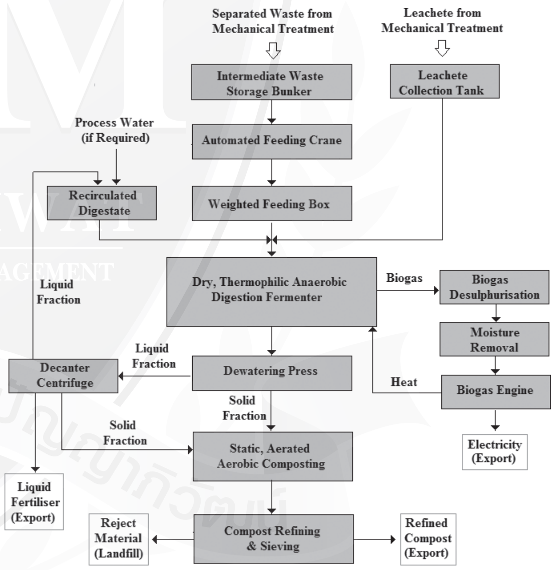

Fig. V. Process flow of case study's biological treatment phase.

C. Case Study CAPEX and OPEX Data Collection

Project capital expenditure categories are consolidated from 8 categories to determine the overall project cost. Additionally, the project's contingency budget is determined above the project base cost estimate either through range estimating, expected value or probabilistic method. The case study sets a contingency budget and construction budget of 10% and 5% respectively, above the based cost estimate. Table V summarises the case study's capital expenditure.

TABLE V
CASE STUDY CAPITAL EXPENDITURE (CAPEX)

Capital Expenditure	**Cost (THB)**
Land, Authority & Financing	21,670,200.00
Engineering & Project Management	80,808,569.00
Civil & Architectural Works	153,096,240.00
Waste Reception	11,690,800.00
Material Recovery	130,525,384.77
Biological Treatment	556,973,886.00
Preparation for Market	240,500,500.00
Construction & Commissioning	352,984,354.00
Project Capital Base Costs	**1,548,249,933.77**
Project Contingency	154,824,993.38
Construction Financing	77,412,496.69
Overall Project CAPEX	**1,780,487,423.84**

A MBT facility's operational income and expenditure is dependent on macro-economic changes such as core inflation and market demand. Table VI breakdowns the case study's first-year forecasted operational expenditure.

TABLE VI
CASE STUDY 1ST YEAR OPERATIONAL EXPENDITURE

Capital Expenditure	**Cost (THB)**
Personnel	30,343,575.00
Land & Facility Charges	4,413,312.00
Equipment Maintenance Expenditure	46,768,700.00
Chemicals, Utilities & Fuel	33,242,544.50
Support Services	9,766,400.00
Licensing & Insurances	3,220,000.00
Administration	3,597,150.00
Debt Repayment	211,607,752.00

A MBT facility's income encompasses tangible and measurable revenues obtained for the receipt, processing and sale of raw or processed products. Table VII highlights the case study's first-year forecasted operational revenue.

TABLE VII
CASE STUDY 1ST YEAR REVENUE STREAMS

Revenue Streams	**Income (THB)**
Mechanically-recovered Products	14,917,663.40
Biological Treatment Products	156,985,840.00
Market-prepared Products	79,739,487.00

All data collected and project assumptions are incorporated into a dedicated computer simulation created on the Microsoft Excel for simultaneous result generation.

IV. RESULTS

On incorporation of case study data into the computer simulation, the case study's likely waste treatment fee is computed based on Internal Rate-of-Return (IRR) scenarios of 8%, 10% and 12%. Each IRR scenario generates a complete set of project financials as the differing waste treatment fee changes the project's overall margin and cash flow over the project's intended life cycle. Figure VI presents expected waste treatment fee based on pre-determined IRR from 7.5% to 12.5%.

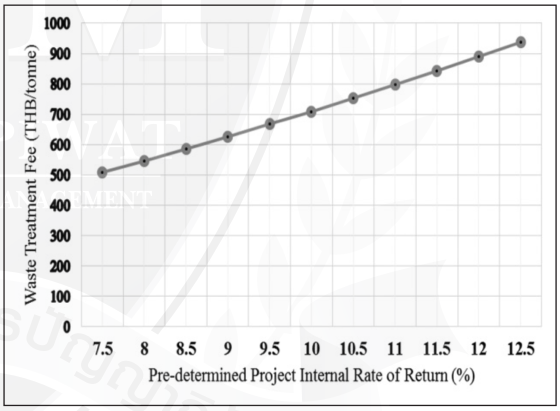

Fig. VI. Waste treatment fee based on pre-determined IRR

The simulation computed first-year waste treatment fees of THB 546.00, THB 709.00 and THB 890.00 based on pre-determined project internal rate of returns of 8.00%, 10.00% and 12.00% respectively. Results observe near-linear growth correlation between pre-determined IRR and the chargeable waste treatment fee.

The case study's computed waste treatment fee is subjected to annualised increases based on expected core inflation rate over the lifetime of the project. Based on modelling results, waste treatment fee/tonne ranges for the following IRR is observed at the following rates: 8% IRR (THB 546.00 – THB663.59), 10% (THB 709.00–THB 861.69) and 12% (THB 890.00 – THB 1081.67). Figure VII present annualised waste treatment fee pricing at pre-determined IRR over the facility's operating period.

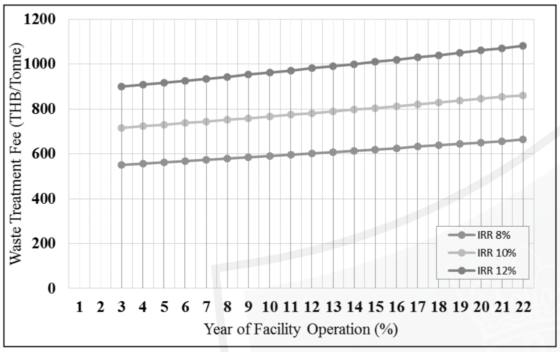

Fig. VII. Annualised treatment fee based on pre-determined IRR

The computer simulation is utilised to further analyse waste treatment fee structures based on potential plant efficiency and economic scenarios over the expected operating life of the facility.

Plant Availability

Simulation results at differing plant availability rates demonstrate that the case study's waste treatment fee rate changes by 9.30% based on annualised plant availability rate changes of 5%. Figure VIII illustrates waste treatment fee changes based on plant availability rates of 80%, 85% and 90%.

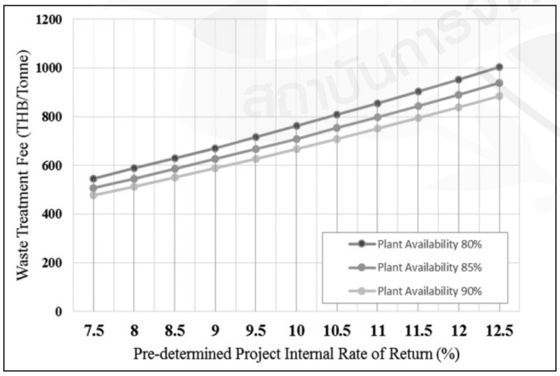

Fig. VIII. Waste treatment fee based on differing plant availability

B. Changes in Core Inflation Rates

The simulation is utilised to the case study predict waste treatment fee based on flat and increased inflation rate scenarios respectively. Table IX presents waste treatment rates based on pre-determined IRR rates between 7.50% and 12.50%, at case study pre-adjusted core inflation rates of 0% p.a., 0.98% p.a. and 1.96% p.a., respectively.

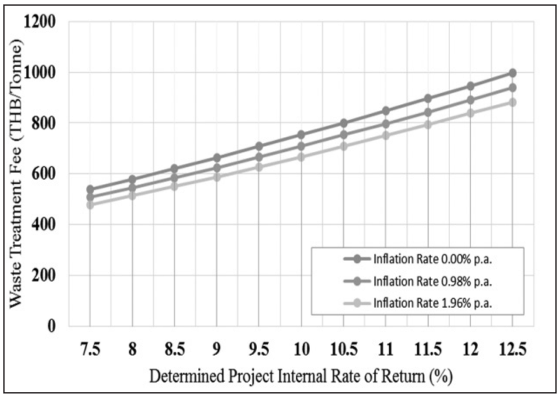

Fig. IX. Waste treatment fees by differing core inflation rates

C. Changes in Biological Product Sale Prices

The simulation is utilised to determine an appropriate waste treatment fee based on 2 differing biological sale pricing scenarios: 1) inability to monetise the sale of biologically-treated products and 2) sale price of biologically-treated products as per sale prices recorded in North Thailand (THB 3,500/tonne for finished compost and THB 1,700/m^3 for liquid fertilizer. Figure X lists waste treatment rates based on pre-determined IRR rates between 7.50% and 12.50%, at case study pre-adjusted biologically-treated product sale prices.

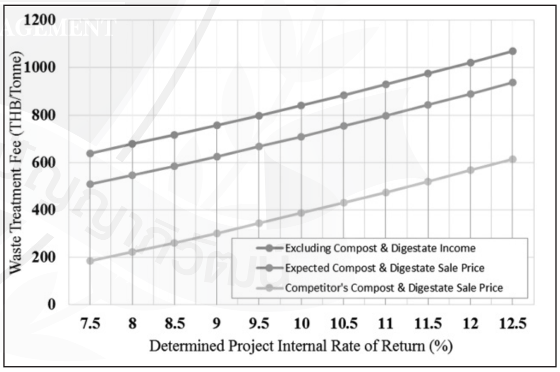

Fig. X. Waste treatment fee based on changes to sale prices of finished compost and liquid fertilizer.

V. Conclusion

The research observes that public policy and regulation play a key role in the setting of non-tariff income streams, with implementation of source separation, combination taxation, disposal taxes and disposal-refund relief contributing significantly to income potential of MBT facilities. Sampling results of Bangkok's MSW conclude that MBT processing is the best suited method for treating MSW in Bangkok, compared to direct thermal treatment.

Technical assessment indicate that dry, thermophilic anaerobic digestion is the best suited AD process for treatment of sorted organic waste due to high-levels of non-organic material contamination. While effort is taken to incorporate external market conditions, a waste treatment fee structure is highly dependent on ever changing economic conditions, on the assumption of (unlikely) fixed MSW composition over the lifetime of the facility.

The fixing of a pre-set project internal rate-of-return as the basis of determining concession rates for waste treatment facilities allow for better transparency in the awarding of projects, reducing the potential for "profiteering" and mismatched tariffs rates.

The implementation of an independently verifiable pricing mechanism as presented, increases stakeholder confidence by offering a check and balance system to confirm appropriate facility treatment fee rates set forth, while mitigating project long-term commercial risks.

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Generalized Information Extraction for Thai Web Boards

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Abstract—**Web content extraction is a process to extract user specified information from web pages. Traditionally, the main approaches of web content extraction have been performed via rule based or pattern based. Typically, rule or pattern set is manually prepared by hand-engineering and can only be applied to each individual web site. To increase the efficiency, we have proposed a machine learning based approach by applying Long Short-Term Memory (LSTM) which is a sequence to sequence learning for dynamic extraction of title and content from web pages. Based on our error analysis, misclassified tokens are considered minority among the total correct sequence. To improve the performance, in this paper we propose a post processing technique by merging predicted tokens with minority tags into the majority one in the token sequence. To evaluate the performance, we use the same data set from our previous work which is a collection of web pages from 10 different Thai web boards such as *Dek-D*, *MThai*, *Sanook* and *Pantip*. The results of our post processing technique helps improve the accuracy up to 99.53%, an improvement of 0.11% from the previous proposed model. The overall improvement may seem little, however, for Title extraction, the accuracy is significantly improved from 88.04% to 100%.**

Index Terms— **Web Content Extraction, LSTM, Sequence-to-Sequence Learning, Post processing**

I. INTRODUCTION

Web content extraction task is to extract information from web site which is important for business in several fields. At present, amount of social media has rapidly increased because people can simply access to the web including the social media through several devices such as desktop, mobile and tablet. It causes a large number of people to access the social media and web boards. In many web boards, there are many user comments about the products and services, that is very useful for business to tell them about how good or bad of their products and services. These data should be monitored and analyzed for improving the marketing. The information extraction is very important in this part. However, these data are huge and variety that is very hard to manage them manually.

In this paper, our main focus is to dynamically extract information from web pages. Our goal is to propose a web content extraction model which is more general for various web sites with high extraction accuracy.

This paper is organized as follows: Section II describes related work. Section III explains the proposed method for dynamically extract information. Section IV gives the experiments with the performance evaluation of our approach. Section V presents the conclusions.

II. Related work

There are several previous works in this field. Mohammed et al. [1] explored several techniques for information extraction from web pages which can be summarized to five techniques as follows:

1) Wrappers

Wrappers for content extraction is creating rules for extracting particular content from web pages. Baumgartner et al. [2] proposed the technique called *Lixto*. They implement *Lixto* by using wrapper technique in web information extraction. The pattern in a hierarchical order is used to create wrapper for translation from HTML into XML through extraction mechanism. The extraction mechanism is implemented by using both data extraction tree and string extraction. The data extraction tree use rule in program called *Elog* for specifying each element corresponding to tree path of HTML, while the string extraction is used to specify attribute conditions for required string out of tree path.

2) Template

Template detection for extracting is created by algorithms to detect HTML of web page. The content is plugged into the template for content extraction from web pages. Arasu et al. [3] proposed an algorithm, called *EXALG* for automated information extraction from templates of web pages without preparing new learning examples. The *EXALG* processes in two stages. The first stage makes association each token with the same constructor in unknown templates to use as the input pages. The second stage uses setting of first stage to create template for extracting information from web pages.

3) Machine learning

Machine learning based content extraction is studying of system that can learn from the training data for clustering and classifying data in web content extraction. Soderland et al. [4] Information Extraction (IE presented Open Information Extraction system (OIE) by using *TextRunner*. A self-supervised learner is Naïve Bayes classifier to automatically label tuples for all possible relations which is used in the *Extractor* module. The *Extractor* generates candidate tuples and sends to the classifier. The tuple is assessed by assigning the probability by the *Assessor* for to extract tuples.

4) Visual Cues

Content extraction using visual cues is assumption on the structure of web page for easy extracting content from web pages. Cai et al. [5] proposed an approach by combining the Document Object Model tree (DOM) structure and the visual cues to be the vision-based content structure. Every DOM node is checked against with the visual cues. When all blocks are checked, these blocks are identified weight with *Visual separators* based on properties of its neighbour blocks. After all of blocks are processed, the final gets vision-based content structure for extraction content from the web page.

5) HTML features

Content extraction based on HTML features is extracting content from HTML's tag of web page. Gupta et al. [6] presented an approach by using several techniques from many previous works in content extraction. Their key concept is using the Document Object Model tree (DOM), rather than HTML markup in the web content extraction.

However, all of above techniques are not generalized for many web pages. To solve this problem, the machine learning approach is applied in our work. Finkel et al. [7] proposed a technique based on a sequence model by combining Gibbs sampling and CRF model for extracting information. They use Gibbs sampling to find the most possibly state sequence and then training by CRF model. They evaluate their technique by using the CoNLL NER task and CMU Seminar. Sun et al. [8] used Support Vector Machine (SVMs) in web content extraction task for classification web pages. They use data in WebKB data set. This data set was trained with SVMs and is extracted context features for classifying into four categories, i.e. student, faculty, course and project. Wu et al. [9] proposed an approach in automatic web content extraction by combination of learning and grouping. They apply DOM tree to extract element follow HTML tag and train each node DOM tree with learning model. Then the output from the learning is grouped candidate nodes, the noisy groups are removed and the selected group is refined.

Currently, Neural Networks (NN) is popular in the field of machine learning to solve difficult problems in natural language processing (NLP) task such as chunking, named entity recognition and part of speech tagging. Normally, NN is trained by backpropagation but PSO can be used for training [10]. NN have achieved excellent performance in NLP tasks. Chau et al. [11] proposed an approach to filter web page by applying machine learning-based which combines web content analysis and web structure analysis. They proposed NN-WEB and SVM-WEB which are compared with lexicon-based approach (LEXICON) and keyword-based support vector machine (SVM-WORD). Jagannatha et al. [12] presented technique for extracting text in Electronic Health Record (EHR) notes. They apply machine learning base on recurrent neural network (RNN) frameworks.

In our previous work, we apply recurrent neural network, named Long Short-Term Memory (LSTM), which learns token sequences to make prediction of label sequences in filtering title and content out of HTML for web content extraction. Our result is good for overall but not for the most important information, that is the title of each page.

In this paper, we extend our previous work to improve performance in post processing. Homma et al. [13] proposed an approach by applying hierarchical neural network for extracting information from documents. They use DOM tree to extract information out of HTML tag. Then these extracted data are trained with hierarchical network for classify a sentence.

Obviously HTML tag is a couple of beginning and ending tags which we can adopt this principle to capture HTML tag for improving our approach. Our previous work, the accuracy of title extraction is not good. Therefore, we want to extent our previous work for improve the performance of title extraction. We use the characteristic of web page design that it has only one title in one page. We apply this rule to post processing to correct the title extraction. The post processing will be applied after the LSTM results.

III. The Proposed Method

In previous work, we proposed an approach for web content extraction [14] which consists of three steps, i.e. web crawler, data preprocessing and processing. In this paper, we extend our previous work to improve performance with post processing which overall of our approach is shown in Figure I.

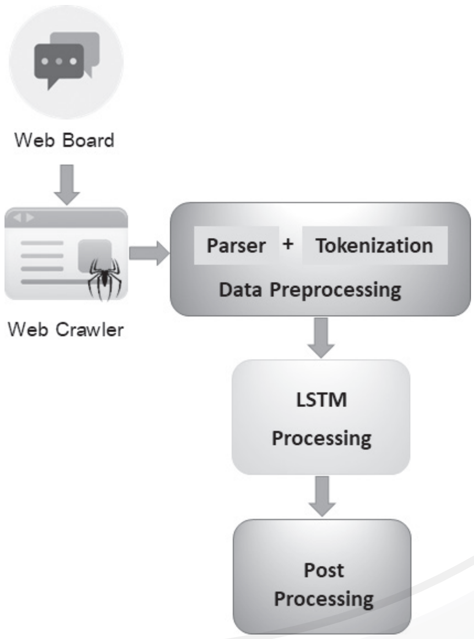

Fig. I. Overview of our approach for generalized information extraction.

A. LSTM Networks

Recurrent Neural Network (RNN) is a neural network that is feed forward general sequence learning. The data sequence is fed forward for learning sequence to sequence between input and output [15] In backward part, RNN maintains historical information for adjusting parameter of network to predict the current output [16] RNN is shown in Figure II In practice, if there are a large number of learning sequences, RNN will not be able to capture long term dependencies [17]. Long Short-term Memory (LSTM) which are invented by Sepp Hochreiter and Urgen Schmidhuber [18] can solve this problem to capture long term dependencies. LSTM is improved from standard RNN which hidden layer of LSTM is replaced with memory block [19] In memory block, it can add or remove data that is controlled by a gate [17]. For this advantage, LSTM can store information in long periods of time and it can avoid the vanishing gradient problem [19].

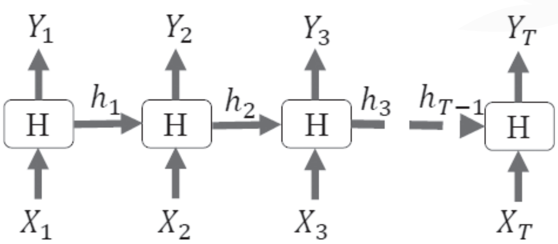

Fig. II. A sample feedforward RNN model.

In previous paper [14], we proposed our model as shown in Figure III.

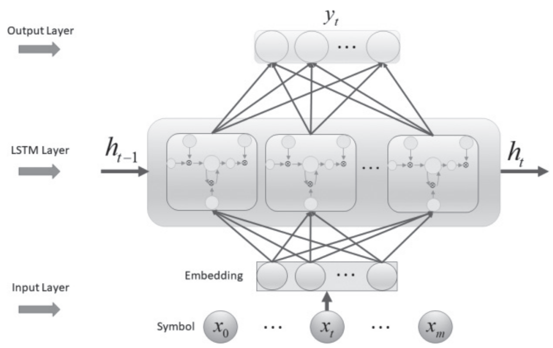

Fig. III. The proposed model for web content extraction.

This LSTM model is applied directional LSTM network by considering only forward direction of input sequence, i.e., input sequence is fed from left to right direction [20] This model has one input layer which the input is fixed dimensionality as maximum length (15,576) of tokens per one sequence. LSTM layer is consist of 128 nodes and using only one output layer by softmax activation function that the number of nodes is equal to the number of labels.

B. Our Proposed Approach

The performance for generalized information extraction relies on design in Figure I. This diagram consists of four steps. The first three steps will be described in this subsection and the last step will be presented in the next subsection.

The first step, we crawl data from the target web boards. We clean HTML tags that are not necessary such as script, style, link, meta and button. The example result is shown in Figure IV.

```
<html>
<head>
</head>
<body >
<h1> This is title </h1>
<div> Content is here </div>
</body>
</html>
```

Fig. IV. Example of cleaned result.

The second step is data preprocessing. we parse the crawled data into token sequence as shown in Figure V by each text string is parsed and tokenized automatically to achieve word sequence. In Figure VI., we show inserting markers to cover title and content sequences. For title sequence, the opening marker is “<<<T>>>” and the closing marker is “<<</T>>>”. For content sequence, the opening marker is “<<<C>>>” and the closing marker is “<<</C>>>”.

After that, we automatically insert labels by reading maker to cover word sequence as shown Figure VII. The title token is labeled with T, while the content token is labeled with C and other tokens are labeled with O.

Fig. V. Example of tokenized result.

Fig. VI. Example of marked result.

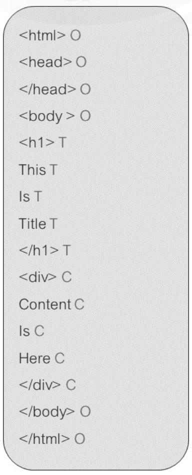

Fig. VII. Example of labeled result.

In the third step, the prepared data is fed in input layer of LSTM model. Each token is mapped into an embedding in embedding layer with 512 of embedding size. Then feed in LSTM layer. After that, the result is computed at output layer by finding highest probability which correspond with label which is shown in Figure VIII.

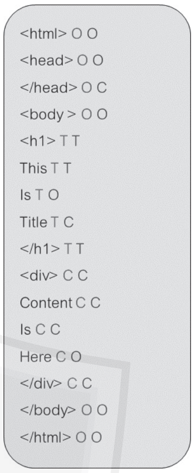

Fig. VIII. Example of classified result.

C. Post Processing

In this paper, the post processing is proposed for improving the performance of our approach. This process is applied after the LSTM classification. The procedure is shown in Figure IX which is consist of four steps as follows:

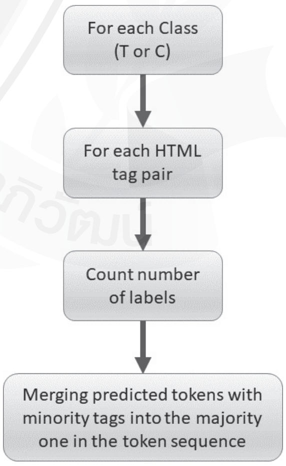

Fig. IX. Post processing procedure.

Firstly, all of tokens, that are classified into title and content, are investigated. By look around the HTML tags that cover them, counting the number of major labels and then reassign this major label to all tokens in this HTML tag.

Example result of the first three steps is shown in Figure X which the second column is target and third column is answer of system. From this example, the major label in the third column is “T” and they are bounded by HTML tag of <h1>…</h1>.

Fig. X. Example of classified result by the first three steps.

Finally, after the major label is defined that is “T” in this example. All of tokens in detected tag <h1> will be changed to T. That makes the result correct.

Fig. XI. Final result example.

IV. Experimental Results

For our experiment, we crawl data from web page and then parse and tokenize before classification. The labels are title, content and others. We compare our current method with our previous one to show the improvement.

A. Data sets

Data are collected from 10 Thai web board i.e. *Dek-D*[1], *MThai*[2], *Sanook*[3], *Jeban*[4], *Pantip*[5], *Khaosod*[6], *Kaohoon*[7], *Kapook*[8], *Beartai*[9] and *Postjung*[10]. Obviously, these web boards are popular web board in Thailand that can be indicated by the number of posts and number of viewers. Each collected web boards are divided into two sets; a training set of 16 web pages and a test set of 4 web pages. Therefore, we have entire data which consists of 200 web pages. In classification, we classify in three labels i.e. Title, Content and Others. The title token is labeled with T. The content token is labeled with C. The other tokens are labeled with O. Table I shows number of each token in labeled T, C and O on the train and test data sets. The number of samples is different from the numbers in our previous work [14] because we change the positions of parsing and tokenizing of the HTML tag.

TABLE I
Label Statistics of Each Token

Label	Number of Labels	
	Train	Test
T	3,433	853
C	85,865	21,490
O	733,389	181,160

B. Results

We train our training data set with our LSTM model as described in Section III. We create the LSTM model using *Keras* [21] with *Tensorflow* [22] as the back engine. We test our approach with test data set. We compare our previous work that is trained by LSTM only with this approach which is combine with the post processing. Table II shows averaging accuracy on our data sets. We achieved 99.96% in results of training. The results of testing, it improved from 99.42% to 99.53%. The classification results in each label is shown in Table III. In label T, LSTM with post processing achieved the accuracy rate of 100% which is higher than LSTM only (88.04%). And LSTM with post processing achieved the accuracy rate of 97.72%, which is higher than 97.11% of previous one for label C on the test data set. Obviously, the post processing improves all performances, especially for title. That is very useful for business because we can aware what people is interesting now. The classification results of each web boards are shown in table IV. *Dek-D* gets the highest accuracy with scored of 100% because the structure of *Dek-D* is simpler in capturing HTML tag pair than others. *Pantip* gets the lowest accuracy with scored of 98.51% because it has the same pattern for contents and comments.

TABLE II
Average Accuracy (%)

Data set	LSTM	LSTM + Post processing
Test	99.42	99.53

[1] Dek-D, https://www.dek-d.com/
[2] MThai, https://talk.mthai.com/
[3] Sanook, https://news.sanook.com/
[4] Jeban, http://www.jeban.com/
[5] Pantip, https://pantip.com/
[6] Khaosod, https://www.khaosod.co.th/
[7] Kaohoon, https://www.kaohoon.com/
[8] Kapook, https://www.kapook.com/
[9] Beartai, https://www.beartai.com/
[10] Postjung, https://board.postjung.com/

TABLE III
AVERAGE ACCURACY (%) OF EACH LABEL

Label	LSTM	LSTM + Post processing
T	88.04	100
C	97.11	97.72
O	99.75	99.75

TABLE IV
AVERAGE ACCURACY (%) OF EACH WEB BOARD

Web board	LSTM	LSTM + Post processing
Dek-d	99.68	100
MThai	98.98	99.10
Sanook	99.91	99.94
Jeban	99.92	99.92
Pantip	98.42	98.51
Khaosod	99.89	99.89
Kaohoon	99.85	99.85
Kapook	99.06	99.13
Beartai	99.01	99.05
Postjung	99.58	99.85

V. CONCLUSION

In this paper, we presented a generalized information extraction for Thai web boards. We improve the performance from our previous work by including the post processing. Our previous technique achieved the accuracy of 99.42% when processed with post processing, it can achieve the accuracy of 99.53%. In classification of title, we achieved the score of 100% which is the best of result. Moreover, the post processing depends on LSTM classification results because the post processing count number of classified labels before correct them to the major one. For content classification, we achieved the scored of 97.72%, which is a better than the old result. Obviously, the post processing has improved overall performance of our proposed approach. The technique has to use high quality hardware because training set has a large number of data. This is important problem in this research. For future study, data set preparing for training is an important portion for in this field because this is one part of achieved high accuracy.

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Materials on Wheels: Moving to Lighter Auto-bodies

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Abstract—**The weight of the automobile body has been the serious concerned as it has negative effect on the fuel consumption and pollution emission. Steel materials have been applied as body parts since the beginning of the automotive industry development. Continuous research and development in term of composition, melting and refining, heat treating, etc., resulted in variety of many high quality materials such as Dual -Phase (DP) Steel, Transformation-Induced Plasticity Steel (TRIP) , Interstitial Free (IF) Steel., etc. Non ferrous and reinforce polymers are also applied as alternatives for lighter weight and ease of fabrication. Historical development of these materials with technical implication is discussed with the aim for better understanding of materials application for body parts.**

Index Terms— **Steel sheet materials, automobile, light weight materials, formability**

I. Introduction

The drive to reduce the weight of auto-bodies began during the mid-1970's when the price of oil was significantly raised by the oil producers. This accelerated the development and application of sheet steels with higher strength levels than the traditionally used conventional mild (low carbon) steels in order to save weight by the use of thinner gauge sheet material for body pressings. Since then a number of higher strength grades such as Low Carbon High Strength Low Alloy (HSLA) Steels, Rephosphorized, Bake Hardening, Dual-Phase (DP) and Transformation Induced Plasticity (TRIP) steels, etc. have been increasingly used as structural automotive body parts. Their use has also served to reverse the trend of vehicles becoming heavier with each new model as a result of added refinements for customer comfort and to meet improved and stricter safety requirements.

Experience in the earlier applications of these higher strength steels showed that their processing and formability was different to that of the conventional mild steels used for auto body pressings. Some high strength grades could only be used for relatively shallow pressings and, in order to give consistent performance, all grades required modifications to design of the body part, press tooling, forming conditions, welding and finishing operations.

Towards meeting the need for improved fuel efficiency and better overall performance, from 1975 to 1990 the proportion of lighter weight materials i.e. polymers, rubbers and aluminium (Al) alloys used in motor cars gradually increased. Over that period, in a typical mid-range car, the percent volume proportion of steel used decreased from 33 to 22%, that of cast iron fell from 8 to 2%, while Al use increased in volume from 6 to 13%, polymers increased from 22 to 37% and rubbers from 22 to 37% [1]. Increased use was made of Aluminium-base casting alloys to replace cast irons in power train and transmission castings, and of wrought Al alloys in sheet form as alternatives to steel for body panels. In the UK for example, the weight of equivalent family saloon models was reduced from around 1300 kg in 1975 down to just over 1000 kg until the mid-late 1980s when increasing customer demands for extra refinements and government safety and environment legislation meant that, in spite of some use of thinner gauges of steel, lighter alloys, and more polymers, etc., the weights of cars began to increase. Forecasts in the mid 1980's suggested that conventional mild steels would continue to be used as the main car body material until tooling design and production techniques were sufficiently well developed to enable the full exploitation of higher strength steels [2]. At that time the general comment on replacement of steel by aluminium was that *"it* halves *the weight at double the cost"*.

Nevertheless, interest in aluminium alloy as a body material continued to grow due in part to the establishment in 1993 of the United States Automotive Materials Partnership LLC (USAMP) which was part of the Partnership for a New Generation of Vehicles (PNGV) initiative between the US Dept. of Energy and Chrysler, Ford and General Motors. The initial general aims included the development of prototypes of low emission, fuel efficient family saloon cars that could provide the same space and comfort as conventional models, and not least, at the same price. PNGV was succeeded in 2003 by the FreedomCAR and Vehicle Technologies Program (FCVT) under which the materials focus was on light-weighting through use of dissimilar materials and on the problems of non-destructive evaluation of both structures and joints [3]. At the same time as PNGV was being started the Al producers, seeing future market opportunities, increased their efforts for the development of Aluminium Intensive Vehicles (AIVs).

To address the increasing competition from Al-Alloys 35 of the main steel producers from 18 countries joined together in a project to develop a lightweight steel body structure under the Ultra Light Steel Auto Body (ULSAB) Consortium in 1994. ULSAB together with Porsche Engineering Services (PES) set out to design and build a lightweight steel autobody that met strict performance and cost criteria. One aim of the study was to show the capability of the HSLA steels in achieving body weight savings without the need for downsizing, and also in improving safety, comfort and overall performance [4].

Conventional Aluminium killed mild steels (AK steels) that were traditionally used have yield strengths of 150-190 MPa. The ULSAB project defined 2 main groups of higher strength steels as (a) High Strength with Yield Strengths of 210-550 MPa, and (b) Ultra-High Strength with Yield Strengths greater than 550 MPa. The sheet thicknesses used ranged from 0.65 to 2.00 mm. All of the sheet used for ULSAB was either electrolytically or hot dip double-sided zinc coated reflecting consumer and legislative demands for extended corrosion warranties. It must be noted that right up to the 1990s, and particularly during the 60s and 70s, the major complaint from customers was inadequate corrosion resistance of body parts (due to both unsuitable design and poor protection) which led to expensive repair work or early end of vehicle life, in spite of the engine and other parts still being in good condition [5].

In 1994, higher strength steel grades accounted for up to about 50% of the body weight of the latest cars but the ULSAB work showed that there was a potential for their 90% usage in auto-bodies [4]. Weight savings of up to 36% were said to be achievable when compared to the heaviest benchmark vehicle. In particular weight savings were achieved with improved structural integrity by the use of tailored blanks, which matched the strength and gauge of the steel to design requirements. Laser welded tailored blanks made up 50% of the structure, the rest being mainly conventional pressings with some sheet & tube hydroforming and steel sandwich forming. The use of such blanks enabled mass that did not contribute to performance to be removed and also allowed economies of production by reducing the total number of parts and associated tooling, reducing the number of spot welds and of assembly steps. Laser welding of the tailored blanks provided much higher dimensional accuracy than that previously achieved in steel bodies. The use of tube hydroforming enabled the production of thinner walled side roof rails with sheet hydroforming used to form the roof panels. Steel sandwich material with an inner core of polypropylene was used to press the spare tire tub and for the dash panel. This sandwich material could be processed in the same way as steel sheet but required joining by adhesive bonding and riveting instead of welding.

In response to progress in Al alloy application, e.g. the Acura NSX–the first production car to have an all-Al body saving 200 kg compared to a steel body [6], and in the use of fibre reinforced polymers (FRP) for closures (bonnet boot lid and doors) [7], the ULSAB project was followed by the ULSAC project on closures, the ULSAS project on suspensions, and the overall ULSAB-AVC (Advanced Vehicle Programme) [8, 9]. For the last 10 years light-weighting and other development work has focused on the future need for electric and hybrid vehicles that reduce greenhouse gas emissions, the steel producers initiating the Future SteelVehicle (FSV) programme in 2008 [10-12]. During the extensive R&D carried out by the steel industry the processing and performance of a wide variety of higher strength sheet steels has been examined leading the industry to provide comprehensive guidelines to their application [13]. The range of properties available in these steels is illustrated by the strength-ductility relationships shown in Figure I Steels that contain significant alloy additions and contain 2 or more phases are often referred to as Advanced High-Strength steels (AHSS) in order to differentiate them from the conventional grades.

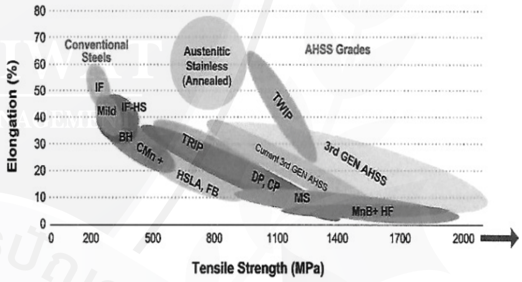

Fig. I. Tensile strength – ductility relationships in steels for use in auto-body parts [3, 9, 13]

This review article considers some key aspects in the physical metallurgy and processing of the various higher strength steels that may be used in auto-bodies and comments on the competition from light alloys, such as aluminium and magnesium, and polymer-based composites.

II. Formability of low carbon steels

Most steel auto-body parts are formed by pressing operations which involve a combination of stretching and deep drawing. Stretching behavior is controlled by the uniform elongation of the steel as measured in a tensile test since the limit of deformation is the onset of a localized region of thinning (necking) in the sheet. The greater the ability of the steel to undergo work (strain) hardening then the greater is its resistance to necking during stretching deformation. Work hardening capacity can be described by the Work (Strain) Hardening Exponent (n) of the steel [14], where n is related to true stress (and true strain (ε) by the empirical equation:

$$\sigma = K.\varepsilon^{n}$$

where K is the strength coefficient.

The true strain at the point when necking begins at the end of uniform elongation is numerically equal to the value of n. Hence the higher the value of n the greater is the strain to which the steel can be stretched before local thinning occurs. Values of n for typical steel grades are listed, together with tensile properties, in Table I For conventional AK, Interstitial Free (IF) and HSLA steels the n values are taken as constant with respect to the amount of deformation and they are normally determined for the range of 10 to 20% elongation. Dual phase (DP) and Transformation-Induced Plasticity (TRIP) steels demonstrate different work hardening behaviour such that their n values are found to vary with amount of deformation [13]. The DP steels have microstructures consisting essentially of ferrite + islands of martensite which contain small amounts of bainite and retained austenite. Hence they exhibit different deformation behaviour to the essentially ferritic grades (AK, IF). In particular, DP steels undergo greater work hardening at engineering strains below 8%. Hence for DP grades n values are also quoted for the 4 to 6% engineering strain range [13, 15].

Table I.
Some examples of typical mechanical properties and n values [13].

GRADE	YS (MPa)	UTS (MPa)	El (%)	YPE (%)	n-value (10%-UE)	n-value (4-6%)
IF	163	282	49.0	-	0.240	-
DDS	163	314	42.9	-	0.230	-
CMn440	354	455	39.0	3.6	0.156	
HSLA340	377	443	28.4	2.8	0.170	-
SF600	490	615	28.6	3.2	0.148	-
HSLA480	487	604	28.0	2.2	0.128	-
HSLA550	641	672	13.5	3.3	0.040*	-
DP600	340	602	29.0	-	0.170	0.208
T600	393	631	34.0	-	0.230	-
DP800	459	838	17.2	-	0.115*	0.168
T800	475	822	28.0	0.6	0.240	-
DP1000	726	1003	10.8	-	0.060*	0.08

Compared to DP steels TRIP steels contain higher amounts of retained austenite in their microstructures. This austenite transforms to martensite during deformation giving transformation induced plasticity such that higher n values are obtained throughout deformation and the danger of localized thinning is reduced during stretch forming [16]. For the DP, TRIP and other Advanced High Strength Steels (AHSS) data from plots of instantaneous n value against engineering strain must be used when predicting forming limit diagrams and in computer modeling of forming behavior [13, 15, 16].

Deep drawing behavior depends on tooling design and on the Plastic Strain Ratio r. The r value is controlled by the crystallographic texture (preferred orientation) that is developed during production of the sheet. The value of r is given by:

$$r = \frac{\textit{true strain in width direction}}{\textit{true strain in thickness direction}}$$

This is normally expressed as a mean value, r_m, from determinations using sheet tensile specimens taken at 0, 45 and 90° to the rolling direction. If the crystallographic texture in the sheet is such that it minimizes through the sheet thickness plastic strain then the sheet will be resistant to thinning and hence deep drawability is increased. For high formability an r_m value of nearly 2.0 is required. When $r_m < 1$ the sheet will have poor resistance to thinning on forming. In addition, for minimum earing tendency (i.e. uniform plastic flow in all directions in the plane of the sheet) during forming then the difference, Δr, between r values at 0, 45 and 90° should be as small as possible.

In low carbon (C) sheet steels for pressing the aim is to achieve the maximum amount of {111} texture [17, 18]. This means that the {111} planes in the ferrite are parallel to the rolling plane. High formability is achieved in the conventional continuously cast AK steels by close control of composition and hot & cold rolling + sub-critical annealing schedules. Batch annealing of cold rolled material, with a slow heating rate, allows controlled precipitation of Aluminium Nitride (AlN) at sub-boundaries in the un-recrystallized ferrite matrix which promotes the development of the "cube on corner" annealing texture. This is {111}<110> and gives r_m values of 1.8 to 2.0 and hence a high degree of formability during subsequent pressing. Continuous annealing, in which the cold rolled coils are uncoiled and passed through an annealing chamber involves faster heating rates and shorter times resulting in finer recrystallized grain sizes and hence higher yield strengths but with less favorable textures for formability. However, steels with very low (< 0.01%) C and N levels can be produced to give good formability even after continuous annealing [19]. These are called Interstitial Free (IF) steels and are processed by ladle decarburization under vacuum degassing conditions. Small additions of titanium and/or niobium are added to tie up interstitial C and N as carbides/carbonitrides resulting in lower yield strengths than for continuously annealed AK steels but providing potentially superior formability especially for the production of more difficult complex forms [20]. After forming the shape of a pressing must be maintained and there should be minimal tendency for springback, which has to be counteracted by over-bending parts. Springback causes variation from part shape design and it is caused by the elastic recovery of the pressing upon unloading when parts are removed from the tooling. It increases with increasing yield stress and decreasing sheet thickness of the steel being formed. Hence springback is more severe in thin gauge high strength grades than in conventional low C steel [21]. A further problem is that springback in AHSS steels, DP and TRIP grades, is observed to be time-dependent at ambient temperatures: this is not the case in conventional mild and HSLA steels [22]. The AHSS grades show similar springback behavior to formed aluminium alloy sheet with time-dependent shape changes being proportional to log time ,however the final amount of change is about ⅓ that for aluminium. In general, it can be summarized that higher strength steels present greater formability problems since in addition to springback they tend to have lower ductility, and less favorable n and r_m values.

III. Strengthening in low C automotive sheet steels

The main strengthening mechanisms in low C steels include ferrite grain refinement, solid solution hardening of ferrite by Manganese (Mn), Phosphorous (P), Silicon (Si), etc., dispersion hardening of ferrite by carbide & carbonitride precipitates, and not least by the introduction of controlled amounts of martensite, bainite and retained austenite as in DP and TRIP grades. Additional minor strengthening can also be obtained by strain ageing, dislocation substructure hardening and texture hardening. Figure II shows typical tensile stress- strain curves for a mild steel, a conventional HSLA steel and a DP steel.

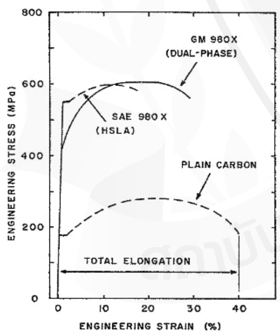

Fig. II. Example of tensile engineering stress-strain relationships for plain C (mild), HSLA & DP grades. Yield behaviour in the plain C and HSLA steels is discontinuous [30, 31]

Relatively small amounts of alloying elements can be added to low C (mild) steels to give dispersion strengthening via formation of very small niobium, titanium, or vanadium carbide/carbonitride precipitates, and to encourage the formation of fine ferrite grains [23-29]. The alloy carbides influence the austenite grain size and shape during hot rolling by pinning austenite grain boundaries and by controlling the recrystallisation behavior of the austenite. Nb is believed to be the most effective addition in retarding austenite recrystallisation since it not only pins grain and sub-boundaries in the austenite by forming Nb carbonitride precipitates but also the Nb in solid solution exerts a solute drag effect on interstitial atoms and lattice defects delaying recovery [25-27]. The carbides limit recrystallisation such that "pancake" shaped grains of austenite are retained after hot rolling. This distorted austenite structure has a large grain boundary area available for subsequent nucleation of ferrite during the austenite to ferrite transformation on cooling and hence leads to fine ferrite grain sizes. In addition, some fine carbonitrides precipitate in the ferrite giving precipitation strengthening. As controlled hot rolled products the yield strengths obtained can be as high as 550 MPa. Similar fine ferrite structures and carbide/nitride precipitation are responsible for strengthening in the cold rolled reduced grades in which the precipitates also influence ferrite recrystallisation during annealing. The distribution of strengthening precipitates can be significantly affected by process variables during hot rolling notably temperature control and coiling temperature. Such variation influences the effects of annealing after cold rolling during both batch and continuous treatments. For example, higher coiling temperatures tend to give coarser precipitate particle dispersions leading to coarser mean final grain sizes and wider scatter in grain sizes and in mechanical behavior. Continuous annealing, as for mild steels, gives finer grain sizes and also enables inter-critical annealing + controlled cooling to be applied to produce DP and TRIP grades [31-33].

If a steel can be processed to produce a "dual phase" microstructure a significant amount of additional strengthening is gained from work hardening effects. This extra hardening is due to the presence of about 20-25% by volume of islands of martensite surrounded by a matrix of fine ferrite grains. In these islands small amounts of bainite and residual austenite are also present. Dual phase (DP) steels can be produced by intercritical annealing or by controlled hot rolling. Originally these steels were produced by continuous annealing in the austenite + ferrite (720-780^{o}C) range where there is 15-25% by volume of austenite islands [31]. This austenite will contain segregated carbon atoms (up to about 0.3-0.5% C) and if sufficient Mn, Si and Cr is present the austenite will have sufficient hardenability to transform essentially to martensite on cooling. Some bainite and retained austenite will also be present in association with this martensite. DP steels normally contain 0.06-0.15wt%C and 1.5-3wt%Mn + small additions of Cr and Mo to prevent pearlite and excessive bainite formation with Si to form ferrite and Nb + V for structural refinement and precipitation hardening. Thicker gauge material is now usually produced by controlled hot mill processing of C-Mn grades by spray quenching after hot rolling [27, 31].

It can be seen from Figure II that DP steel has a lower yield strength than conventional HSLA grades and that it also exhibits continuous yield behavior due to the presence of highly mobile dislocations in the ferrite. This high density of mobile dislocations coupled with the deformation of the "martensite" islands is responsible for the initial high rates of work hardening. The result is improved formability while the absence of discontinuous yielding avoids the need for temper rolling prior to pressing.

As mentioned earlier, the textures that are developed during processing of DP steels and in conventional HSLA grades are not as favorable for deep drawability as in AK steels or other mild steels. For pressings where formability is the major concern, then solid solution hardened grades of AK steel are available. Phosphorus, silicon and manganese are used to solid solution strengthen the ferrite. P, in particular, has a strong solid solution hardening effect in ferrite. In the Rephosphorized AK steel for each 0.01% P addition yield strength is increased by about 10MPa with little effect on deep drawability. In steel P level is normally kept below 0.03wt%. However a P content of up to 0.1wt% is used in the Rephosphorized steels to provide yield strengths of 260-300 MPa. Solid solution hardening from P combined with the strengthening achieved during the low temperature baking treatment used to cure paint finishes is the basis for the Bake Hardening (BH) steels. In these grades C level is controlled between 0.010-0.015% to allow sufficient free C atoms to diffuse to dislocations generated during temper rolling and press forming. Such diffusion is possible at the curing temperatures (about 170^{o}C for 20 minutes) used in the paint bake ovens. The dislocations are then pinned resulting in a strength increase, due to strain ageing, of around 40 MPa. The bake hardening effect is less significant if the ferrite is not fine grained and/or if there is significant work hardening during forming. Yield strength levels from 270–340 MPa can be achieved by using Ti and Nb additions to control the amount of C and N in solid solution [34]. An added advantage of DP and other AHSS steels is that, depending on composition and forming conditions, they can also demonstrate BH strengthening.

In DP steels ductility was found to be influenced by the amount of retained austenite that is present in the martensite islands [35]. This led to the development of the low alloy TRIP steels in which composition and processing are controlled to provide a fine grained ferrite matrix with dispersed areas of martensite, bainite and at least 5% by volume of retained austenite. As introduced above, transformation of the additional retained austenite to martensite (compared to DP grades) provides a high degree of work hardening over the full strain range not just up to 4-6%. At equivalent strength levels (yield strength of 350 MPa/ UTS 600 MPa) a DP steel has an engineering strain of around 25% while a TRIP steel has 32% [13].

TRIP steels are produced by intercritical annealing followed by cooling to an isothermal transformation temperature to allow transformation of some of the austenite fraction to acicular (bainitic) ferrite [36-38]. TRIP grades are typically based on 0.2%C-1.5%Mn steel. Additions of 1.2-1.5%Si or 2%Al are used to prevent M_3C cementite carbides forming in the bainitic ferrite, the C atoms then becoming concentrated in the untransformed austenite.

The DP and TRIP grades have high capacity for energy absorption and hence have become increasingly used for parts requiring crash-worthiness such as safety cage components (B-pillar, engine cradle, floor panel, front sub-frame, etc.). Due to their lower C contents DP steels have better weldability than TRIP and also give better surface quality. The higher Si content in TRIP steel can cause defects in cast surfaces and also problems due to oxidation during processing and galvanizing [39]. It is possible to avoid problems due to high Si by producing low Si TRIP-assisted multiphase steels, e.g. 0.16wt%C-1.3wt%Mn-0.4wt%Si [38]. This steel is processed in the same way as a DP steel but is isothermally treated and then spray quenched to give a multiphase structure of ferrite, bainite, martensite and 10% residual austenite. Multiphase strengthening is assisted by a TRIP effect during subsequent forming.

A number of interacting factors are believed to influence the mechanical and other properties of the DP, CP and TRIP multi-phase steels. These include the ferrite grain size, secondary phase morphology, volume fractions of each phase (especially austenite), austenite stability, relative strengths of each phase, precipitation hardening, etc.

The DP, CP, TRIP and martensitic steels are quite often referred to as the 1St Generation of AHSS. The 2nd Generation includes the Austenitic Stainless Steels (ASS) and high Mn Twinning Induced Plasticity (TWIP) steels.

The TWIP steels are based on fully austenitic microstructures that are stabilized by the inclusion of up to 30%Mn and up to 9%Al in the steel composition [40-43]. The high solute content in the austenite imparts a low stacking fault energy such that slip mechanisms are restricted and plastic deformation takes place by twinning. High rates of work hardening are produced via a combination of deformation twinning, dynamic strain ageing and the FCC→HCP transformation of austenite to ε-martensite. The use of the 2nd Generation steels remains limited due to the high cost of alloying and due to problems such as obtaining consistent properties and the tendency for delayed cracking. The latter, environment assisted cracking (EAC), tends to occur in unstable austenitic stainless steels when high residual tensile stresses are present (as in a deep drawn part), and when some martensite is presence together with hydrogen [43]. One source of hydrogen is from electrolytic galvanizing in coating to protect against corrosion.

Extensive R&D is continuing towards the development of a 3rd Generation of AHSS, which can provide, at low cost, a required property combination of UTS at 1200MPa + 30% ductility [e.g. 29, 32, 39, 44, 45]. Much of this work focuses on gaining improved understanding of how composition and processing parameters influence mechanical properties and formability. The key areas of development include Quenching and Partitioning Processing (Q&P), higher Mn TRIP-steels, and nano-structured steels.

In Q&P treatment austenite is quenched to a temperature QT below the martensite start (M_S) temperature to produce a controlled amount of initial martensite and then held at a partitioning temperature PT for a certain time to allow C atoms to diffuse into the untransformed austenite, and hence control austenite stability when the steel is cooled to ambient temperature [45, 46]. This treatment is illustrated in Figure 3. As in conventional TRIP steels Si is added to prevent cementite formation. Up to 4% of alloying elements (Mn, Si, Ni & Mo) can be used to control microstructure. Q&P treated steel is reported to be used for A- and B- pillar reinforcement [47]. Q&P treatment is also applied to intercritically annealed steel where the initial microstructure consists of austenite + ferrite.

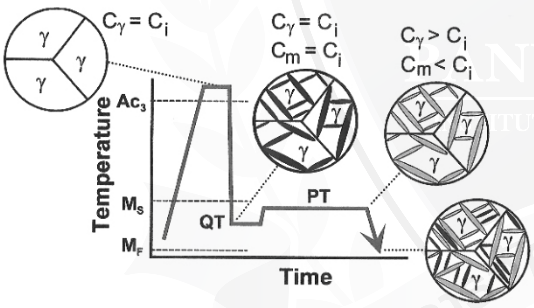

Figure III. Outline of Q&P treatment of a fully austenite matrix to obtain fine mixtures of martensite and residual austenite, Ci, Cm and Cγ represent C levels in the initial alloy, in martensite and in γ-austenite [45, 46].

Medium Mn-low C steels containing 5-7wt% Mn can be intercritically annealed to produce microstructures of very fine grained ferrite and austenite, the stability of the austenite phase being increased by enrichment with Mn during annealing [48].

An alternative processing method for medium Mn steels is being developed by making use of the "Ghost Pearlite" effect [49]. This is the fine-scale chemical patterning of Mn in the austenite produced by austenitising a pearlite structure that was formed at 500-600^{o}C. Such pearlite has a strong partitioning of Mn into the cementite. On cooling this pattern enriched austenite only partly transforms during isothermal treatment to form a layered microstructure of ferrite/martensite and metastable residual austenite on a size scale similar to that of the original pearlite. This fine structure can be tempered to give UTS levels of 1600-2100 MPa and 7-10% elongation. This is comparable to the properties that can be obtained from the nano- or super-bainites outlined below, however the chemical patterning effect involves much shorter treatment times than those needed to produce nano-bainites.

Very fine bainitic structures have been developed in 0.8C-1.5Si-2Mn-1Cr-0,25Mo steels using low temperature isothermal treatment at 200^{o}C, however holding times of up to 96 hours may be needed. The fine platelets of bainite ferrite are only 20-40 μm in thickness hence the ferrite + austenite mixture produced has been termed nanostructured bainite [50]. Although there is interest in nano-complex phase structures the slow rate of structure formation of nano-bainite seems much more suited to thick sectioned parts rather than sheet metal forms. However, isothermal transformation time may be reduced by alloying with Al and/or Co [51]. Nano-structured steels are considered to have microstructures containing a very high density of strong interfaces rather just contain a small amount of nano-sized precipitates [50].

Nano-lath martensitic structures can be produced by Q&P treatment followed by tempering, i.e. Q-P-T. Tensile strengths over 2000 MPa with elongation over 10% have been observed in a medium C steel (0.48C-1.19Mn-1.18Si-0.98Ni-0.21Nb) with nano-micro-structures of lath martensite, thin films of residual austenite and fine dispersed Nb-containing carbides [52].

A further group of interest are the Press hardening steels (PHS). C-Mn steels alloyed with up to 0.005wt%B are austenitised and then subjected to hot-stamping in an internally cooled die-set. The cooling rate in the die designed to be sufficient to allow transformation to martensite giving strengths of around 1500 MPa [53, 54]. These are used as reinforcements for the roof, door, windscreen upright and b-pillar, etc.

The various HSLA and AHSS steels can be made to meet mechanical property requirements by use of different chemical compositions depending upon the experience of the steel plant used for production a nd the various process variables during casting and subsequent thermo-mechanical treatments. Such differences give microstructural and texture variations that can lead to inconsistent formability, weldability, corrosion resistance and surface finish. In particular batch to batch inconsistency can present significant problems in formability [55, 56].

IV. Competition from light alloys and reinforced polymers.

As mentioned in the introduction continually increased competition for steel from aluminium alloys was one of the main reasons for ULSAB and the subsequent R&D programmes such as FSV. Aluminium sheet alloys have been in use for many years in motor cars [1, 6, 57-60] with examples ranging from the very early Rolls Royce models with an Al body on a timber (ash) frame to the 1954 Panhard Z1 in the USA and then later to a number of Rover cars, the Land Rover and Range Rover series in the UK [1]. In 1989 the first all-Al monocoque body was used for the Honda Acura NSX in which a 40% saving in bodyweight was made by the replacement of steel by aluminium alloys when using conventional design and assembly, effective use being made of extruded sections for structural subframe and sills [6]. This was followed by the Jaguar Sport XJ220 in 1992, and subsequently by the Audi A8 , the Ford AIVs, e.g. Taurus P2000, through to current Mercedes-Benz S class and Jaguar XK models [57]. These and other developments have resulted from the efforts of the Aluminium industry to advance aluminium vehicle technology (AVT) in order to make full advantage of the relative low density of their material.

The main alloys used have been from the 5XXX (Al-Mg) series and from the heat treatable 6XXX (Al-Mg-Si) series. Relative to steel, Al alloys have lower elastic modulus, lower ductility with smaller values for R_m and greater springback. To achieve satisfactory formability and stiffness sheet thicknesses have to be increased so that the potential 65% weight saving from density differences cannot be fully achieved. However, Al alloys can be readily produced in forms other than sheet, notably in extruded profiles with complex cross-section designs and thin-walled die-castings of intricate shape.

The Audi A8 in 1994 used a complete Al body frame made of Al extruded sections joined by Al base cast nodes with bonded Al body panels. Superplastic forming of Al is another process that has become used for body parts, e.g. In the late 1990's Morgan sports cars began to be fitted with one piece wings from superplastically formed aluminium (SPF). The classic shape of the sports car was maintained but the previous 3 piece steel wings were replaced by the SPF wings with improved corrosion resistance & reduced paint protection costs as well as weight saving [61]. Many companies are now using SPF Al parts for bonnet & boot inner frames, floor pans, and quarter panels, etc. The SPF offers greater design freedom, rapid prototyping and reduced tooling costs and strengthens the competition from aluminium.

The extent of the competition is shown by the use of Al for the body of the 2012 series 4 Range Rover which is made up of, in mass %: 37% 5xxx Al alloy sheet, 37% 6xxx Al alloy sheet, 15%Al base cast parts, 6%Al extrusion and only 4% HSS + 1%PHS. The increased use of Al gave a 39% saving in weight over the previous model [57]. The use in the Range Rover shows that Al has higher potential for use in larger vehicles such as pick-ups and SUVs [60] than in smaller cars, except for electric vehicles. Al alloy has long been used for bodies in large commercial vehicles such as trucks and buses, e.g. from 1954 in the London Transport "Routemaster" double-deck bus.

Lighter than Al, Magnesium base alloy could also be considered as autobody sheet materials. However, in a critical assessment, it has been suggested their use is unlikely without research to improve mechanical properties, formability, joining methods and corrosion resistance and to reduce cost [62]. Mg base die-cast parts can and are being used for certain body parts in preference to welded steel fabrications (pressings + tubes) e.g. for cock-pit cross beams in Range Rover and Jaguar models [63]. The first Mg base chassis component was vacuum die cast in Mg-4Al-4Ce alloy and was used for the engine cradle in the 2006 Chevrolet Corvette. [58, 64]. Mg alloy diecastings have also been used for inner panels for doors and liftgates and for roof frames for convertibles [65]. The use of die cast thin section structural parts is more promising than use of wrought alloys, the latter being said to require further developments [62, 66]. Finite element based study has shown that a Mg auto-body structure giving equivalent stiffness to that in steel or Al could be respectively 60% and 20% lighter [67].

Fibre reinforced polymers with glass (GFRP) or carbon fibres (CFRP) must also be considered since they can be rapidly processed into complex shapes and by appropriate design can give equivalent impact resistance to steels. They have been used mainly for specialist sports cars and cab, panels and roof parts for commercial vehicles. Mixed Al alloy/CFRP designs have been used for chassis construction [57]. CFRP can offer attractive combinations of strength and weight but because it is difficult to use in mass production it is limited to very low-volume specialist sports cars. Even for low volumes, at 30 cars/day, Ferrari is using Al rather than CFRP [68].

In achieving an optimized balance between weight saving, performance (safety, longevity, etc.) and cost multi-material bodies need to be built containing combinations from AHSS, cast, extruded or sheet form Al alloys, die-cast Mg alloys and fiber reinforced polymers. Hence hybrid-joining technology is just as important as the base material. Materials and process selection has to consider spot and laser welding, riveting, clinching, high speed nailing, friction stir welding, adhesive bonding , etc. with regard to joint integrity and the ease of robot operation [69-71]. For example, the problem of joining Al to B containing PHS is being tackled by combining punctual joining methods such as self-pierce riveting with adhesive bonding to improve bond shear strength [71].

To minimize life cycle environmental impacts in materials selection, attention must also be paid to sustainability including emissions from materials production and the many problems associated with recycling vehicles at the end of their life. To this end an increasing number of life cycle analysis studies are being reported [e.g. 72-75]. The results of such complex studies not only depend on the models/ parameters/data accuracy, etc. used in the study but also on the specific circumstances in production of both raw materials and the vehicles, use of the vehicles and end of life recycling/re-use. Nevertheless it is recently claimed that the use of AHSS produces lower greenhouse gas emissions than light weighting with Al. [76].

V. Thai Situation

As an international manufacturing base for automobile industry, the domestic body parts supplier in Thailand, with highly dependent on the overseas major makers, have to employ any raw materials that complied with the specification of the makers. After nearly five decades of development, there are at least three to four medium to large domestic companies that can supply body parts with almost all steel specification. There is a company that starts to supply aluminium body parts to an electric vehicle manufacturer in USA last year. However, some Japanese car makers developed their in-house press parts for special steel sheet forming. The steel specification includes JSH400W, JAC 270D and E, JACUN440H, JAC340H, and JAC440P. The thickness ranges from 0.70 mm for hood outer, 1.00 mm for Plat Form (CREW), to 8 mm for Cross Member: Trunion, etc. These steel materials come in as steel sheet to be press forming in the factory.

One of the major hurdles for the development of Thai industry that depend on the high quality iron and steel materials is the lack of integrated steel manufacturer. The strong political will and understanding of policy makers of industry development will be the key for economic expansion of Thailand in the years to come.

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Time Series Outlier Detection for Short-Term Electricity Load Demand Forecasting

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***Abstract*—Forecasting of working-days' electricity demand is vital for short-term planning. However, demand variations due to outliers can reduce the accuracy of forecasts. Therefore, a time series data cleaning technique is proposed to remove these disturbances of electricity data. First, holidays' and bridging holidays' data are replaced by Moving Average. The k-sliding window filtering band is proposed to detect the time series outliers and replace by forecasted regular load demand using Moving Average. Data from the Electricity Generating Authority of Thailand (EGAT) and a Neural Network (NN) model with six inputs and one output are used to demonstrate the performance of time window data cleaning process. The sample dataset contains data from 1stMay 2012 to 31stMay 2013 where May 2013 is used for testing. The Time-Window based data cleaning technique increases the performance of forecasting outcomes by 11.60% for non-holidays. Results from the proposed technique are compared with the results from the robust version of locally weighted smoothing (r-LOESS) and identified that the proposed technique is superior for taking results for non-holidays.**

***Index Terms*—Data Preprocessing, Data Cleaning, Outliers Detection, Filtering Band, Short-Term Load Forecasting and Neural Network**

I. Introduction

Load forecasting is an indispensable section on designing, planning, and operating of electric utilities. It is generally classified according to the time interval into three main classes; Short-Term Load Forecasting (STLF) ranging from one hour to one week, Middle-Term Load Forecasting (MTLF) ranging from one month up to one year, and Long-Term Load Forecasting (LTLF) ranging for more than one year. The conventional time series models or computational intelligence-based models are used for forecasting under the above three classes. Traditional time series models such as regression analysis [1-4], moving average [5], and stochastic time series [6-8] have been applied by several researchers. Artificial intelligence [9-15], deep learning [16], machine learning [17-19], fuzzy time series [20, 21], and expert systems [22] have been appliedunder intelligence based models [23].

The load data consist of repeated data patternsdue to daily, weekly, and seasonally variations [24, 25]. However, identifying of these patterns is a quite complex task because load data are affected by different other factors such as weather, temperature, and unusual consumption patterns. The quality of data is also complex the forecasting process. Therefore, data preprocessing plays an important role in electricity forecasting. It consists noise removal and data cleansing.

A large amount of data can consist outliers due to randomness or noises. All these unpredictable patterns and undetectable outliers can reduce the forecasting accuracy. Proper detection of outliers and replacing them with clean data help to improve the forecasting accuracy. Therefore, this research proposes a data preprocessing step before using itin the forecasting stage. There are two types of outlier detection methods called univariateand multivariate methods [26]. Examplesfor univariate outlier detections are Single-step Procedures, Sequential Procedures, Inward and Outward Procedures, Univariate Robust Measures, Statistical Process Control (SPC). Example for multivariate methods is Statistical Methods, Multivariate Robust Measures, Data-Mining Methods, and Preprocessing Procedures. However, the Time-Window based model proposed in this research is novel and contrastive to the above methods.

In the second section of this paper, related works on detecting outliers and replacing outliers are reviewed. The proposed data cleaning process are discussed in the third section Then, Artificial Neural

Networks for forecasting are discussed in the fourth section. In the methodology section, the design of experiments to evaluate the performances of data cleaning process is explained. Results of the research are discussed in the next section. Finally, conclusions are stated based on the obtained results for then tire research.

II. Literature Review on Data Cleansing Techniques

A Outlier Detection

The outliers can be identified as the data that deviate so much from the other data as they have generated by a different mechanism [27]. In other words, outliers are the data which exhibit an inconsistent behavior compared to the remaining data set [28]. Outliers can be categorized into two groups: outliers in the x-axis and outliers in the y-axis. However, in time series analysis, outliers in y-axis are more important which can be re-categorized into another three groups called random, non-random, and gross errors [29]. Thus, the identification and treatment of outliers are important for the time series analysis before identifying the patterns in them.

Electric energy consumption is recorded for daily operations such as system analysis, visualization, reliability performance, energy saving, and system planning. However, it cannot be avoided that historical load data consist missing values and corrupted values due to the random failures in metering and transferring processes. Conventional outlier detection methods are based on the assumptions such as raw data is identically and independently distributed. Usually, statistical distribution methods are not used to detect outliers because it has bulk data. However, numerous outlier detection methods have been used by researchers for different applications such as clinical trials, weather prediction, and electricity forecasting. Especially in forecasting, historical data with outliers cause for low forecasting accuracy. Proper outlier detection methods can remove those outliers and increase the forecasting accuracy. Therefore, following powerful data cleaning processes is an important phase in forecasting [30].

Liu, Shah [31] proposed an on-line outlier-resistant model combining with a modified Kalman filterto detect and clean outliers. Thesugges ted filtering technique is simple and reliable since it has a high break down points and one or two parameters.Trueck, Weron [32] discussed different outlier detection techniques such as low-pass filtering, percentage thresholds, and fixed price thresholds to detect the outliers in the electricity price data. Hadi [33] introduced a model comprising several steps to identify multiple outliers in multivariate data. The model is started with arranging data into the ascending order. In addition to that, Basic Subset of Full Rank, Basic Subset Not of Full Rank, and Increase Size of Basic Subset are the other steps to identify outliers. Hadi [34] proposed a modified model changing the parameters in his previous model to get better re sultsin detecting multiple outliers in multivariate data.

Janssens et al., [35] proposed outlier detection methods to utilize Machine Learning (ML) and Knowledge Discovery in Databases (KDD). They compared the Support Vector Machines Data Description (SVDD), Parzen Windows (PW), and K-Nearest Neighbors (KNN) methods for the field of ML and the Local Correlation Integral (LCI) and the Local Outlier Factor (LOF) methods for KDD. Another technique is Replicator Neural Networks (RNNs) algorithm which has been introduced to detect the outliers of both small and large datasets [36, 37]. During the training process, common patterns have a higher impact on adjusting the weights while the patterns representing outliers have a less impact. There fore, during the testing phase, the data with higher errors are identified as outliers. Three statistical outlier detection techniques namely, cluster outliers, radial outliers, and scattered outliers are set as a benchmark for the proposed model.

Chen, Li [38] had used B-Spline smoothing based techniques to clean the corrupted and missing values in the data from British Columbia Transmission Corporation (BCTC) while [39] used B-spline approach to clean the temperature and historical load data as a preprocessing step for short-term (24-hour) load prediction in British Columbia. Experimental resultsindicate that the overall performance of the load prediction has improved after the data cleansing process.Tang, Wu [40] discusseda new approach for outlier detection of load data under three different casesnamely, Outlier Detection for Normal Distributed Data, Outlier Detection for Gamma Distributed Data, and Outlier Detection for Small-Size Portrait Data. Outlier detection using small size portrait data-based approach significantly improves the outliers' detection process compared with other approaches.do Nascimento, Oening [41] summarized diverse outliers' detection and filling algorithms for load time series data in the metering centers of smart grids called Extreme Studentized Deviate (ESD), Generalized Extreme Studentized Deviate (GESD), Z-Score, Test Box Plot, Thompson, Adjusted Box plot, and Exponential Smoothing. Considering the problem as the presence of null values in the readings, they propose a method using the modified Z-Score technique. The proposed method detects outliers at two stages called Pre-Detection and Post-Detection.

Statistical inference methods for power monitoring tasks against the outlier effects due to faulty readings and malicious attacks were discussed byMateos and Giannakis [42]. They developed a novel load cleansing and imputation scheme leveraging the low intrinsic-dimensionality of spatiotemporal load profiles. The concept of a robust estimator based on

Principal Components Pursuit (PCP) is usedin the technique. Finally, Hodge's review [43] identifies causes for outliers such as changes in system behavior, instrument errors, fraudulent behavior, and mechanical faults. He summarized outlier detection techniques and brought the idea that principled and systematic techniques are highly used in the recent research.

B. Outlier Estimation

A research had been conducted to replace the outliers and missing values of time series related to the sludge wastewater treatment plant in Edinburgh, U.K[44]. Due to the limited amount of data, missing values and outliers cannot be discarded. Therefore, they suggest the Kohonen Self-Organizing Map (KSOM: one of Artificial Neural Network algorithms) technique and unsupervised neural networks to forecast the missing values. They identify the advantages of using KSOM as higher accuracy, computationally efficient, and the simplicity. However, usage of back propagation artificial neural network in replacing outliers decreases the performance of the model when the number of output variables is particularly high [45] or output variables of the ANN are not highly correlated [46]. Simple linear regression methods to estimate the missing values are discussed by MacDonald and Zucchini [47] and Harvey [48]. They identified that the results are getting better when the series has less missing data points while they use their method to check the water quality parameters.

Apart from these specific outlier replacing methods, researchers have used some basic forecasting techniques to replace the missing values and outliers: Moving Average [26], Exponential Smoothing [49], Regression methods [50]. Some of them had used some advanced techniques such as Neural Networks, Machine Learning for the same purpose. Selected outlier replacing technique used in this research is discussed in the methodology.

III. Data Cleaning Process

In this section, we discuss the proposed Time-Window based data cleaning process for load and temperature data. The load data obtained from Electricity Generating Authority of Thailand (EGAT) consist of abnormal patternsdue to holidays, outliers, or missing values. However, temperature data has only outliers and missing values as they do not change with holidays. Therefore, these irregular rpatterns of both load and temperature data have to beidentified and replaced by estimated data. A sample data set is selected from 1st of April 2012 to 31st of May 2013 from Bangkok and Metropolitan regions.

A. Detecting and Replacing Holidays

Holidays are one of the major reasons to fluctuate the regular electricity consumption and it is the easiest type to identify. Connor[51]showed that the proposed Neural Network based outlier detection technique can detect holidays as outliers during the research. Since almost all the factories and industries do not continue their works on holidays, there is an obvious electricity demand depression on holidays. Including the holiday demand values in the training data can reduce the forecasting results' accuracy. Therefore, as the first step of the data cleaning process, holidays have to be identified and replaced by forecasted or estimated demand. Simply the calendar holidays in the selected period are identified and replaced by the Weighted Moving Average method as given in Eq. (1).

$$L_t(d) = [w_1 * L_t(d-7) + w_2 * L_t(d-14)] \quad (1)$$

Where, $L_t(d)$ is the electricity load of day d at time period t. The regular demand from the previous two weeks is selected as they have the same pattern throughout the day. w_1 and w_2 are the adjustable weight values. For the most recent week has the most relevant information, w_1 and w_2 are fixed at 0.7 and 0.3.

B. Detecting and Replacing bridging holidays

When there is a non-holiday between two holidays or when there is a non-holiday between a holiday and a weekend, we call it as a bridging holiday. Normally, people tend to take leaves on bridging holidays to extend their holiday-period. As a result, unexpected demand decrements can be seen compared to the regular non-holiday demand. Therefore, we identify and replace them using the same method used to replace the calendar holidays as the second step of the data cleaning process.

C. Detecting and Replacing Outliers

Other than the load values in holidays and bridging holidays, some load values show irregular patterns (e.g. due to measurement errors). Finding such abnormal load values as outliers and replacing them by estimated load will improve the forecasting performance. Therefore, the third preprocessing step is to detect and replace these outliers.

1. Time Series Outlier Detection

A time series is a set of observations which are collected between equal time intervals. The electricity data use in this research has been gathered for every 30-minute. Therefore, the time series of the load consumption can be arranged in many ways by dividing them into different time intervals Fig. I. shows three possible ways of arranging electricity consumption data. The first graph (a) is drawn using the data at 11.00 a.m. of all Fridays from 1st of May, 2012 to

31st of May 2013. The second graph (b) has data at 11.00 a.m. of all the days from 1st of May, 2012 to 20th September 2012 while the third graph (c) consists with the data of all the time periods of all the days from 1st of May, 2012 to 7th of May, 2012. The standard deviations of the given series are 427.82, 975.88, and 1197.50, respectively. This reveals that the 2nd and the 3rd series have higher demand variations compared to the 1st series. Therefore, detecting outliers in the second and third series is not easy as they have higher standard deviations which lead to weakening the outlier detection process. Outliers in the first series are easier to recognize as it has a stable series.

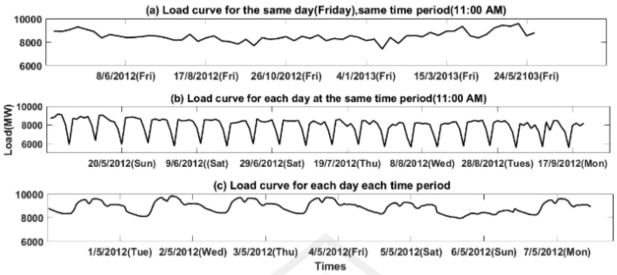

Fig. I. Load demand variation of each time period arranging

A filtering band is used to classify the outliers in the time series where the data that are outside the filtering band areclassified as outliers. The previous works on the filtering bands were constructed by using all data in the time series (all d with all t) as the data arrangement given in the series (c) [38, 45, 52]. However, to minimize the error of misclassifying outliers as non-outliers, the data is arranged as given in the series (a) of the Fig. I. There fore, the time interval of the time series is one week and 7×48 individual Time-Window vectors are identified. These data from different Time-Windows with one week time intervals are put in the vectorsas given in Eq. (2).

The set of days in each day of week can be defined as $\{d', d'-7, \ldots, d'-7m\}$ and d' represents the last 7 days in the selected data set.

$$V_t(d') = [L_t(d'), L_t(d'-7), L_t(d'-14), \ldots L_t(d'-7\times m)] \tag{2}$$

Where, $V_t(d')$ is the vector for Time-Window of day, d', and time period, t, for$m$ weeks. Where m is equal to 60 for the vectors with d' equal to Saturday as thereare 60 Saturdays in the selected sample data set and m is equal to 61 for all the other vectors.

k period filtering bands for each Time-Window vector is created. The k period filtering band of time period t on day d', $B_t(d')$,is given in Eq. (3). It is constructed with the k^{th}period moving average and the standard deviation of the vector or, $SD(V_t(d'))$, which is calculated for the vector $V_t(d')$.

$$B_t(d') = \frac{[\sum_{i=1}^{k} L_t(d'-7\times i)]}{k} \pm N \times SD(V_t(d')); \quad t = 1, \ldots, 48, \forall d' \tag{3}$$

The width of thek-sliding window filtering band varies with the size of N. Small N detects a large number of outliers which leads to detect non-outliers as outliers. At the same time, large N detects a small number of outliers which leads to miss the actual outliers. The optimal N in this research is used as 1.6. The moving average is calculated by previous recent four weeks ($k = 4$).

2. Replacing Outliers

Outlier replacement is the most important part before continuing the forecasting phase. In this paper, we discuss two data replacement techniques; Moving Average (MA) and Interpolation.

a. Moving Average (MA)

Moving average is a simple time series forecasting method where it is used to estimate the regular demand of the identified outliers in the previous section. The arithmetic moving average is selected due to its simplicity as given in Eq. (4).The average of the load of n previous weeks of day, d, at the time period, t, is used to replace the identified outliers.

$$L_t^p(d) = \frac{[\sum_{i=1}^{n} L_t(d-7\times i)]}{n} \tag{4}$$

Where,

$L_t^p(d)$= Forecastedregular load of day d at time period t

b. Interpolation

Another simple method is linear interpolation which is used to find the values between the data points. The points are connected in a simple manner joining by straight line segments. Each segment bounded by two points can be interpolated independently. The purpose of the interpolation is to replace a set of data points with a function given analytically.

$$L_t^p(d) = L_t(d-7) + \frac{m_2 - m_1}{(m_3 - m_1)}(L_t(d+7) - L_t(d-7)) \quad (5)$$

Where, $L_t(d-7)$ = Previous week same day load at time period t

$L_t(d+7)$ = Next week same day load at time period t

m = The time axis positions of load values where m_1 is the position of $L_t(d\text{-}7)$, m_2 is the position of $L_t(d)$, and m_3 is the position of $L_t(d+7)$.

The vector of Wednesday at 1.30 p.m. is drawn in Fig II. The interpolation just connects the adjacent points and completes it by a straight line while there is an acceptable variation when outliers are replaced by the moving average.

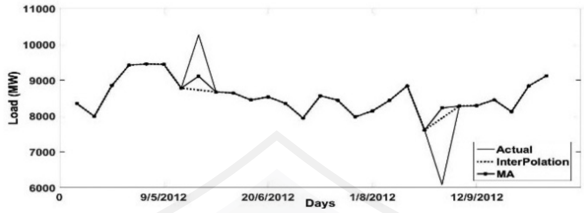

Fig. II. Replacing outliers by MA and Interpolation

Therefore, moving average is used as the outlier replacement method in all the other the future experiments of this research. One of the strong points of Time-Window based data cleaning technique is, even if we miss holidays or bridging holidays and leave them without replacing, those days can be detected by the proposedk-sliding window filtering band.

3. r-LOESS

Locally weighted smoothing or the LOESS is a special case of Linear Regression. Instead of finding the relationship for the entire dataset directly, LOESS considers the surrounded points within a span to make the curve smoother than Linear Regression does. Weight values for the points within the span are calculated using a regression weight function. These weight values along with the magnitude of the surrounded data points define the value to be smoothed while there is no influence by the points outside the span [53, 54].

Outliers in the data set can distort the shape of the LOESS curve. Therefore, the robust smoothing procedure is applied to LOESS (r-LOESS) with the purpose of eliminating the effect of outliers on LOESS. The robust smoothing helps to put zero weights on the outliers and then there is no influence by outliers on the data to be smoothed.[55] The robust procedure calculates the Mean Absolute Deviation (MAD) of the data within the span. All the data outside the 6×*MAD* is identified as outliers and put zero weights on them. Finally, the weighted regression analysis is performed within the span and this process is repeated 5 times before getting the final results.

After replacing holidays and bridging holidays using the Eq. (1), all the data is taken to a single vector as given in series (c) of Fig I. This vector is fed into the MATLAB software for using it with the "rloess" pre-defined function.

4. Detecting and Replacing Outliers of Temperature Data

Considering the smooth variations in temperature curves throughout the months, weeks, and days, data are not separated into separate vector sand consider only one Time-Window. Since holidays do not make changes on temperatures, raw temperature data is directly checked with the filtering band as given in Eq. (6).

$$BT_t(d) = \frac{[\sum_{i=1}^{k} T_{t-i}(d)]}{k} \pm N \times SD(V(T)); \quad t = 1,\ldots,48 \quad (6)$$

The filtering band of time period t on day d, $BT_t(d)$ for temperature data is created using the above equation. $T_t(d)$ is the temperature value at time t on day d and $V(T)$ is the vector for the only Time-Window that contain all the temperature data. Therefore, the time interval for the time series for the temperature $V(T)$ is 30-minutes. When $k = 4$, the filtering band $BT_t(d)$ is defined by the four period moving average and the standard deviation of the vector $V(T)$. These identified outliers in temperature data are replaced by moving average method as given below.

$$T_t^p(d) = \frac{[\sum_{i=1}^{n} T_t(d-i)]}{n} \quad (7)$$

Where $T_t^p(d)$ is the estimated temperature value for time period t on day d. This is calculated with $n = 3$, as it takes the average of the same time period from 3 recent days.

The complete process from raw data to evaluating forecasting performance with the Time-Window based data cleaning process is illustrated by the following steps and evaluation process with its results are discussed in the following section.

1. Raw Data
   a. Load values for each 30-minute from March 2009 to December 2013 are gathered by EGAT
   b. A sample from April 2012 to May 2013 is selected in this research
2. Replacing Holidays
   a. Calendar holidays from April 2012 to April 2013 are identified
   b. Replace each time period of holidays by Eq. (1)
3. Replacing Bridging Holidays
   a. Days between two holidays or holidays and weekends are identified as bridging holidays
   b. Replace each time period of bridging holidays by Eq. (1)
4. Detecting outliers
   a. Average of adjacent periods and Standard Deviation of data series are calculated to construct the equation (3) and (6) for each Time-Window
   b. Eq. (3) and (6) are used to identify the outliers of load and temperature, respectively
5. Replacing outliers
   a. Detected outliers are replaced by moving average (Eq. (4) and (7) for load and temperature, respectively)
6. Training the forecasting models
   a. Data are separated into each time interval (48)
   b. Data from May 2012 to April 2013 are selected as the training data
   c. To forecast one day, 48 training sets are required with separate models for each time interval
   d. Neural Network sare used in the forecasting phase
7. Test with unseen data
   a. May 2013 is selected as the testing month
   b. Each day, each time period is forecasted with the suggested method and calculate MAPEs for actual and forecasted loads

IV. Forecasting Technique

This research is conducted to forecast the next day electricity demand consisting of 48 periods. As given in the Eq. (8), previous day load, previous week load, previous day temperature, and the same day forecasted temperature for the same time interval are used to forecast the next day electricity demand. In addition to that, we use the *Day of Week* and *Month of Year* for recognizing the weekly and monthly demand variations of the data.

$$\begin{aligned} F_t(d) &= a_1 L_t(d-1) + a_2 L_t(d-7) \\ &+ a_3 T_t(d) + a_4 T_t(d-1) \\ &+ a_5 Day\ of\ Week \\ &+ a_6 Month\ of\ Year \end{aligned} \quad (8)$$

$F_t(d)$ = Forecasted load on day d at period t

$L_t(d)$ = Actual load on day d at period t

$T_t(d)$ = Temperature on day d at period t

(a_i) = Coefficients which are represent the weight values of the NN, where i = 1,2,3,4,5,6

Day of Week = 1-Sunday, 2-Monday, …, 7-Saturday

Month of Year = 1-January, 2-February, …, 12-December

Since Neural Networks (NNs) have the ability of learning and recognizing non-linear patterns of complex data sets, the NN is used in this research to demonstrate the improvement of data preprocessing. An example of a simple NN structure is shown in Fig.III. Based on the data arrangement given in Eq. (8), the Neural Network, NN_t^d is trained separately for forecasting the load values of period t on day d. For each NN_t^d, there aresix input nodes and one output node.

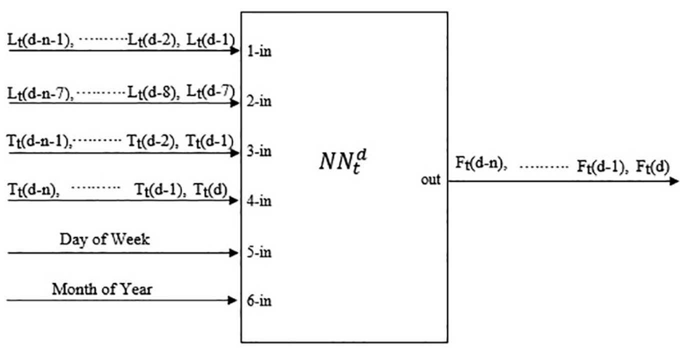

Fig. III. Artificial Neural Network input and output structure

V. Methodology

Data from Electricity Generating Authority of Thailand (EGAT) is used to test the Time-Windowbased data cleaning technique. A sample dataset is selected for training and testing the NN where it contains Bangkok and Metropolitan region's data ranging from 1st of May, 2012 to 31st of May, 2013 for every 30-minute. One-year data is used to trainthe selected forecasting model. The model performance is tested on May data as it is one of the hardest months to forecast due to several reasons. The the temperature in Thailand is at the peak in May. Moreover, forecast performance of May always gets higher errors in forecasting as April data has a lot of holiday sand it is included in the training dataset. Therefore, May is selected as the testing month to demonstrate the performance of the Time-Window based technique.

The example data arrangement given in Table I is for the testing data of May 1, 2013. It includes six inputs of data for a given forecasting load. The same structure can be used to forecast the other days in the testing month. There are different 358 training datasets for each of the testing day. The same NN parameters and the structure are used with both raw and preprocessed data sets. The number of hidden layers is equal to 1, the number of neurons is equal to 7, and the number of epochs is equal to 1000.

TABLE I

An example of training and testing dataset

	No.	Input-1 [Lt(d-1)]	Input-2 [Lt(d-7)]	Input-3 [Tt(d-1)]	Input-4 [Tt(d)]	Input-5 [DoW]	Input-6 [MoY]	Target Lt(d)
Training Data	1	7/5/2012 (Wed)	1/5/2012 (Thu)	7/5/2012 (Wed)	8/5/2012 (Thu)	5	5	8/5/2012 (Thu)
	2	8/5/2012 (Thu)	2/5/2012 (Fri)	8/5/2012 (Thu)	9/5/2012 (Fri)	6	5	9/5/2012 (Fri)
	3	9/5/2012 (Fri)	3/5/2012 (Sat)	9/5/2012 (Fri)	10/5/2012 (Sat)	7	5	10/5/2012 (Sat)
	4	10/5/2012 (Sat)	4/5/2012 (Fri)	10/5/2012 (Sat)	11/5/2012 (Sun)	1	5	11/5/2012 (Sun)
		. . .	. . .	. . .	. . .	. . .	. . .	. . .
	358	29/4/2013 (Wed)	23/4/2013 (Thu)	29/4/2013 (Wed)	30/4/2013 (Thu)	5	4	30/4/2013 (Thu)
Testing-Data	No.	Input-1 [Lt(d-1)]	Input-2 [Lt(d-7)]	Input-3 [Tt(d-1)]	Input-4 [Tt(d)]	Input-5 [Dow]	Input-6 [Moy]	Output Ft(d)
	1	30/4/2013 (Thu)	24/4/2013 (Fri)	30/4/2013 (Thu)	1/5/2013 (Fri)	6	5	1/5/2013 (Fri)

The walk-forward testing routine is applied to test the performance of the 1- year training data set with 1 testing data to set. The data consist of the training and testing datasets. Each training data set consists of 358 pairs and each testing datasetconsists of 1 pair. Figure IV shows that for each experiment, the testing data slides one pair forward (1-31 testing dataset) and the ANN is trained with the new training data set that also slide forward to the future pair of data.

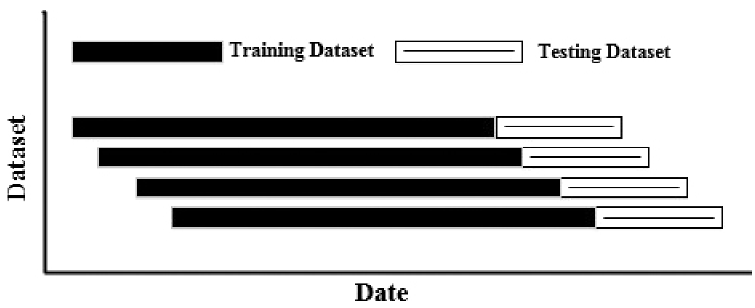

Fig. IV. The walk forward routine for dividing the dataset

In this research, Mean Absolute Percentage Error (MAPE) is used to evaluate the forecasting accuracy. MAPEs for all the testing days are calculated using the Equation (9).

$$MAPE_d = \left[\left(\frac{1}{48} \right) \times \sum_{t=1}^{48} \left| \frac{e_t(d)}{L_t(d)} \right| \right] \times 100 \qquad (9)$$

The MAPE can be calculated using the error, $e_t(d) = F_t(d) - L_t(d)$ where $F_t(d)$ is the forecasts obtained with regular load demand, $e_t^p(d) = F_t^p(d) - L_t(d)$ where $F_t^p(d)$ is the forecasts obtained with cleaned or replaced load with the proposed Time-Window based data cleaning technique, and $e_t^r(d) = F_t^r(d) - L_t(d)$ where $F_t^r(d)$ is the forecasts obtained with smoothed data with r-LOESS. $MAPE_d$, $MAPE_d^p$, and $MAPE_d^r$ for all the testing days (d = 1,2,3….,31) in May, 2013 are compared in the results section.

VI. Results

The data set for outlier detection and replacing has 426 days with a total of 20,448 demand values from April 1, 2012 to May 31, 2013. Demand values of April 2012 are also included in the data set as they required to replace the outliers in May 2012. There are 39 calendar holidays and 18 bridging holidays within the selected period. Therefore, 2736 of demand values are replaced by weighted moving average. Additionally, 1200 outliers are identified and replaced by two-period moving average.Since holidays and bridging holidays do not make any change in temperature values, raw temperature data are directly checked with the filtering band. These results, before moving them with NN are summarized in Table II.

TABLE II
Summary of outlier detecting and replacing

	Total Days	Total Points	No. of Holidays	No. of Holiday points	No. of B. Holidays	No. of B. Holiday points	No. of Outliers
Load	426	20,448	39	1,872	18	864	1200
Temperature	426	20,448		-	-	-	1074

Figure V. shows the load curve before and after replacing holidays, bridging holidays, and outliers. December 8, 2012 is a Saturday and no outliers have been identified. A few outliers on Sunday, December 9, 2012 have been identified and replaced by the estimateddata. A higher number of outliers on Monday, December 10, 2012have been identified and replaced byestimateddata. Likewise, all the outliers are identified by the k-sliding window filtering band and replaced by the estimated data.

Figure VI shows the curve after replacing outliers with its k-sliding window filtering band. Since the outliers have already been replaced by two-period moving average, the curve is well within the k-sliding window filtering band. Even though the graph in Figure VI has been drawn with all data for just to be clear, all outliers are detected and replaced as explained in 4.3.1 and 4.3.2.

Considering the smooth variations in temperature curves throughout the months, weeks, and days, raw temperature values are directly checked with the filtering band. Figure VII shows the actual temperature curve before replacing the outliers and after replacing outliers with the filtering band. During the given period of the figure, few sudden reductions of temperatures have been identified and replaced by the moving average.

MAPE values before and after replacing outliers with the Time-Window based data cleaning technique and r-LOESSfor all the testing days in May, 2013 are summarized in Table III. $MAPE_d^p$ of almost all the non-holidays have been reduced. However, $MAPE_d^p$ of all the holidays have been increased by considerable amounts becausethe forecasting model is trained to forecast only the non-holidays' load. The minimum $MAPE_d$ is recorded on Sunday, May 12, 2013 (1.9381) and the maximum (21.7383) is on Wednesday, May 1, 2013 which is a holiday. The minimum $MAPE_d^p$ and $MAPE_d^r$ are recorded on Wednesday, May 29, 2013 (1.3801) and Sunday, May 12, 2013 (2.1669), respectively. All the maximum $MAPE_d$ (21.7383), $MAPE_d^p$ (26.0934), and $MAPE_d^r$ (19.2670) are recorded on Wednesday, May 1, 2013. $MAPE_d$ tend to be high on holidays and$MAPE_d^p$ and$MAPE_d^r$are even higher as seenin May 24, 2013 (Friday).

May 25, 2013 (Saturday)is not a holiday but still gives a higher $MAPE_d^p$and $MAPE_d^r$ even though the $MAPE_d$ is low. $MAPE_d^p$ and the $MAPE_d^r$ of May 25, 2013 are examples to show the relationship between the total load, peak load, and the $MAPE_d^p$ and $MAPE_d^r$. According to the Table III, the $MAPE_d^p$ and $MAPE_d^r$ are higher compared to $MAPE_d$ of a particular day if the total load and the peak load is low compared to the other days of May 2013. However, May 24, 2013

(Friday) is a holiday and this can be the reason to have a low electricity consumption on May 25, 2013 (Saturday) compared to the other Saturdays in the same month. This demand variation on May 25, 2013 (Saturday) compared to the other Saturdays is illustrated by Fig.VIII.

Figure IX shows how outlier replacement helps in forecasting on non-holidays. The best $MAPE_d^p$ is recorded on May 29, 2013 which is equal to 1.3801. Therefore, the forecasted outputs before and after replacing outliers have been plotted against the actual electricity consumption on Wednesday, May 29, 2013.

The forecasted curve which is after replacing outliers with the proposed Time-Window based technique behaves almost the same with the actual curve. However, forecasted curve using the raw data is significantly below the actual curve and shows the instability throughout the day.

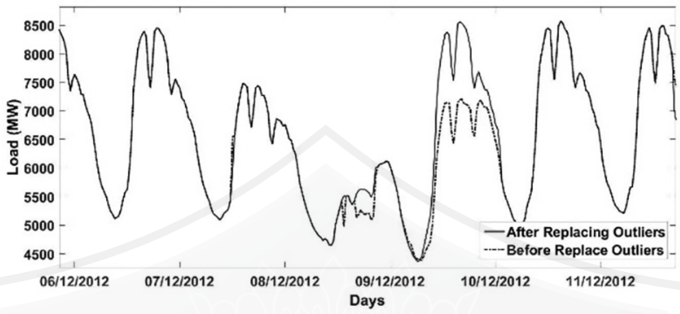

Fig. V. The load curve before and after replacing all outliers

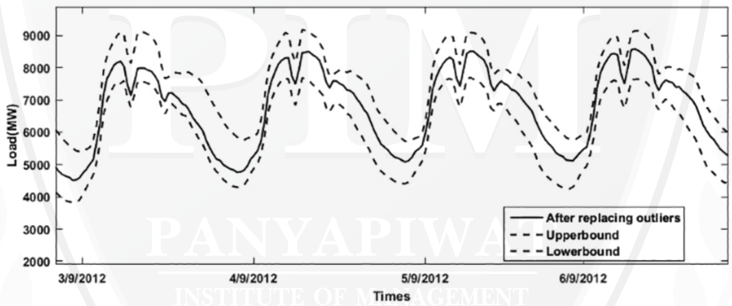

Fig.VI. The load curve after replacing outliers with the Time-Window based data cleaning technique

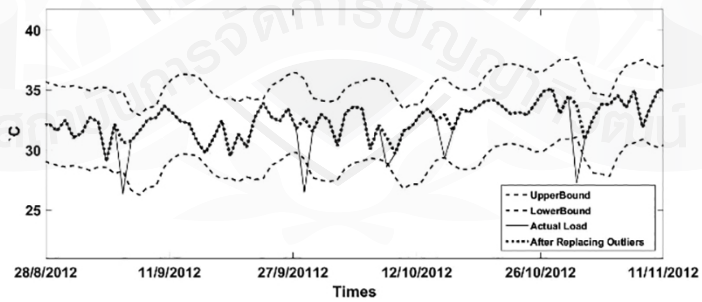

Fig.VII. Replaced outliers of the temperature data with the proposed filtering band

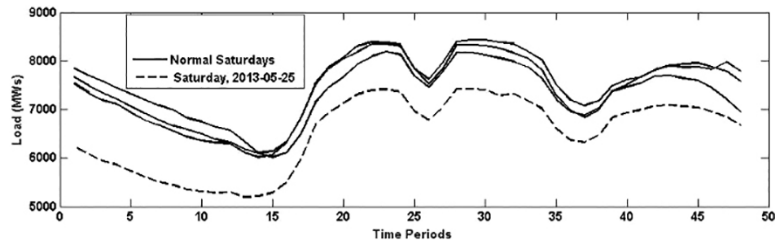

Fig. VIII. Demand depression on Saturday, 25.05.2013 compared to the other Saturdays

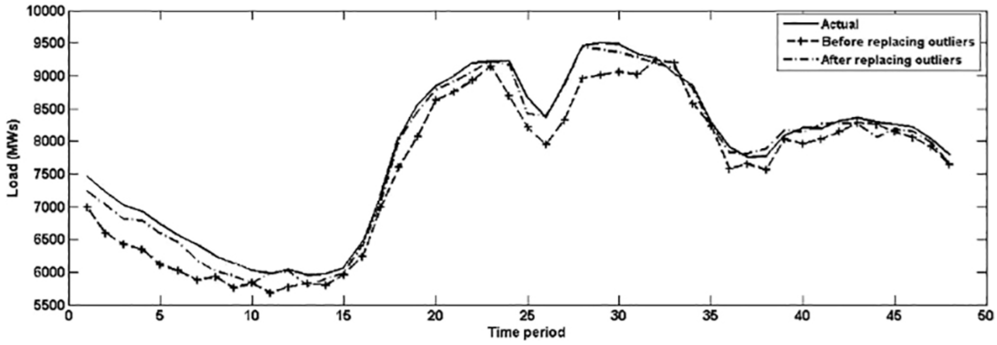

Fig. IX. Forecasted curves for a non-holiday (29/05/2013) before and after replacing outliers

VII. Discussion

The results given in Table III are summarized in Table IV to get a clear idea about the effect of data cleaning on electricity forecasting accuracy. According to the Table IV, non-holidays' MAPE can be re-categorized into Monday's MAPE, Weekdays' (from Tuesday to Friday) MAPE, and weekends' MAPE. For the decrease of average non-holidays' MAPE with both Time-Window based and r-LOESS techniques there is a higher effect from average Mondays' MAPEs which are reduced from 4.5231 to 2.5830 and 4.5231 to 3.7532, respectively. The average MAPEs for other weekdays are reduced from 4.6810 to 4.1798 with the Time-Window based technique and reduced from 4.6810 to 4.1980 with r-LOESS. The average MAPEs for weekends is reduced from 4.2141 to 3.9430 when the data is cleaned with the Time-Window based technique and this value is reduced from 4.2141 to 3.5500 when data is cleaned with r-LOESS. Again, the holidays and outliers are disturbances in the training data when the NN forecasts the non-holidays' demand. Therefore, removing holidays and outliers from the training data set and replacing them by non-holidays help removing the disturbances in the training data. Therefore, this improves MAPEs for non-holidays.

However, the total average $MAPE_d^p$ is higher compared to the $MAPE_d$ and $MAPE_d^r$, but this does not affect to the research's objective. The increase of the total average $MAPE_d^p$ has a higher effect from $MAPE_d^p$ of holidays. Average holidays' MAPE is increased from 8.9902 to 11.8418, when the holidays and outliers are detected and replaced by the Time-Window based technique. This value is increased from 8.9902 to 9.7366 when the raw data are smoothed with r-LOESS. Before replacing the holidays, the NN could see the holiday-patterns in the training data. But after replacing holidays in training data by non-holidays' data according to the Time-Window based technique, the NN always forecasts assuming that the next day is a non-holiday. This is the reason to get higher $MAPE_d^p$ on holidays.

May 25, 2013 (Saturday) is a special day. Even though it is not a holiday, it has a low electricity consumption compared to the other days. However, May 24, 2013 (Friday) is a holiday and that is the reason May 25, 2013 has a low electricity consumption. Therefore, after cleaned the training data with both Time-Window based and the r-LOESS methods, the NN forecasts electricity consumption assuming the next day is a regular non-holiday. This increases $MAPE_d^p$ and $MAPE_d^r$ from 2.8118 to 12.0632 and from 2.8118 to 11.8075, respectively.

When compared the results between the Time-Window based data cleaning technique and r-LOESS, the total average MAPE is lower with r-LOESS since its holidays' average MAPE is lower compared to that MAPE with the Time-Window based data cleaning technique. Except weekends' average MAPE, all the other categories under non-holidays' MAPE are better with the Time-Window based data cleaning technique.

TABLE III
MAPE TABLE FOR ALL TESTING DAYS OF MAY 2013

Date	Day	Holiday (Yes/No)	Bridging Holiday (Yes/No)	Before Cleaning the Data	Data cleaning with Time-Window based technique	Data cleaning with r-LOESS	Total load (MWs)	Peak load (MWs)
				$MAPE_d$	$MAPE_d^p$	$MAPE_d^r$		
5/1/2013	Wed	Yes	No	21.7383	26.0934	19.2670	296,571.70	7,322.55
5/2/2013	Thu	No	No	6.6505	5.4363	5.6952	363,797.25	9,537.35
5/3/2013	Fri	No	No	6.7731	7.3694	6.2955	387,590.85	9,701.85
5/4/2013	Sat	No	No	3.9711	6.1252	3.4097	359,577.75	8,437.05
5/5/2013	Sun	Yes	No	5.6705	6.1357	3.9256	290,664.45	7,345.95
5/6/2013	Mon	Yes	No	5.1747	8.3640	8.5274	323,167.15	7,926.00
5/7/2013	Tue	No	No	3.3561	3.1451	4.4690	367,490.50	9,507.30
5/8/2013	Wed	No	No	6.9022	4.9940	3.7939	380,694.75	9,550.95
5/9/2013	Thu	No	No	4.2302	4.5996	5.3194	381,441.25	9,494.70
5/10/2013	Fri	No	No	4.2388	5.0188	3.1330	381,153.45	9,595.35
5/11/2013	Sat	No	No	3.3115	1.6169	2.4811	355,820.90	8,392.10
5/12/2013	Sun	No	No	1.9381	2.1589	2.1669	309,370.50	7,369.85
5/13/2013	Mon	Yes	No	2.6903	2.7093	3.3696	359,441.65	8,876.80
5/14/2013	Tue	No	No	5.4659	4.8397	5.5129	385,717.65	9,647.85
5/15/2013	Wed	No	No	5.8322	4.3823	3.9455	393,716.25	9,863.95
5/16/2013	Thu	No	No	3.1152	4.4602	2.6372	395,520.63	10,013.35
5/17/2013	Fri	No	No	2.4634	3.7614	3.0470	393,245.39	9,869.10
5/18/2013	Sat	No	No	3.1881	4.5823	4.1989	353,273.55	8,190.75
5/19/2013	Sun	No	No	5.8933	5.0643	4.8445	294,841.75	7,054.20
5/20/2013	Mon	No	No	3.7583	3.0981	3.9825	353,309.25	9,305.40
5/21/2013	Tue	No	No	4.5056	2.5373	3.4726	369,124.30	9,380.60
5/22/2013	Wed	No	No	2.8888	2.4395	3.6217	364,559.50	9,332.60
5/23/2013	Thu	No	No	2.5068	2.4525	4.4883	362,643.35	9,360.00
5/24/2013	Fri	Yes	No	9.6774	15.9066	13.5930	313,282.05	7,262.55
5/25/2013	Sat	No	No	2.8118	12.0632	11.8075	312,171.45	7,423.50
5/26/2013	Sun	No	No	6.9823	4.1106	4.1985	287,719.05	7,178.20
5/27/2013	Mon	No	No	5.2878	2.0680	3.5238	351,069.15	9,278.10
5/28/2013	Tue	No	No	4.6061	2.7756	3.9788	373,677.00	9,456.45
5/29/2013	Wed	No	No	3.8512	1.3801	2.4095	376,834.90	9,508.60
5/30/2013	Thu	No	No	2.5948	3.3701	3.3582	368,693.38	9,224.75
5/31/2013	Fri	No	No	9.1448	8.5141	6.1866	347,458.50	8,963.65

TABLE IV
Average MAPEs different day categories in May 2013

	Before	Data cleaning with Time-Window based technique	Data cleaning With r-LOESS
Total average	5.2006	5.5346	5.1826
Holidays' average	8.9902	11.8418	9.7366
Non-Holidays' average	4.5383	4.0120	4.3069
Mondays' average	4.5231	2.5830	3.7532
Weekdays' (Tue–Fri) average	4.6810	4.1798	4.1980
Weekends' average	4.2141	3.9430	3.5500
May 25th	2.8118	12.0632	11.8075

VIII. Conclusion

The main objective of this research is to propose an effective data preprocessing step for electricity demand forecasting. Thefocus is on reducing the forecasting errors on non-holidays as it is one of the most important phases in the short-term load forecasting. The NN outputs with raw data and data which arecleaned with the r-LOESS technique are set as the benchmark to compare the NN outputs with cleaned data where holidays, bridging holidays, and outliers were replaced with the Time-Window based technique. MAPEs are calculated for all three categories, separately.

The testing data (May, 2013) can be divided into two groups as holidays and non-holidays. All the results for non-holidays convene to reduce the average MAPE both with the Time-Window based technique and r-LOESS. As the Time-Window based preprocessing phase increases the performances of forecasting outcomes by 11.60% for non-holidays, we strongly recommend this preprocessing step for electricity demand forecasting.

For increasing the overall forecasting performances by decreasing the forecasting errors on holidays and bridging holidays, this research can be extended further with a new preprocessing stage. The concept of creating the filtering band should be changed and new outlier replacement techniques has to be used. At the same time, use of secondary experiments such as trial and error methods within the research has to be reduced in order to decrease the total research or experiment times. However, in this research, we had to conduct several secondary experiments to bring the best overall outcomes. But the use of statistical methods and optimizations would reduce the number of experiments. These points can be performed and improved in the future research for reducing the overall forecasting errors.

Acknowledgment

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Social implementation of biomass energy for SDGs in East Asia

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***Abstract*— After proposing "Biomass Asia Strategy" and arranging "Biomass Asia Workshop", we have promoted bilateral collaboration of biomass energy between ASEAN countries and Japan under support of NEDO, JICA and JST. We also discussed region wide collaboration on biomass energy at "International Policy Dialogue". After Paris Agreement, our "Biomass-Asia Project Team" in the Engineering Academy of Japan made the policy proposal to ASEAN countries (International Collaboration on Biomass Energy). Now we are promoting our e-ASIA project among ASEAN countries and Japan (Feasibility Study on Social Implementation of Bioenergy in East Asia) as international industry-academia-government collaboration.**

***Index Terms*— Renewable energy, Biomass energy, Low Carbon Society, SDGs**

I. Introducion

We proposed "Biomass Asia Strategy" as a collaborative subject among East Asia to establish equal partnership, and arranged "Biomass Asia Workshop" among East Asia countries [1, 2]. Figure 1 shows concept of "Biomass Asia Strategy". Based on discussions at workshops in Japan and ASEAN (Association of South-East Asian Nations), bilateral collaboration such as Thailand-Japan [3] or Vietnam-Japan have been established under support of NEDO (New Energy and Industrial Technology Development Organization), JICA (Japan International Cooperation Agency) and JST (Japan Science and Technology Agency).

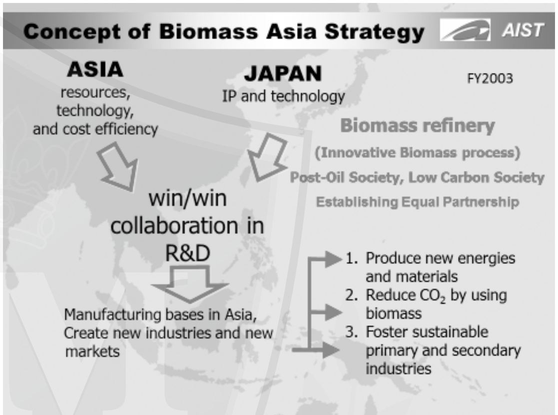


Fig. I. Concept of Biomass Asia Strategy

II. Thailnad-Japan Collaboration on Biomass Energy

After laboratory scale research and bench scale research and development, a pilot plant test for high-quality BDF (Bio Diesel Fuel) production was successfully carried out between Thailand and Japan as SATREPS (Science and Technology Research Partnership for Sustainable Development) project.

National Institute of Advanced Industrial Science and Technology (AIST), WASEDA University (WU), National Science and Technology Development Agency (NSTDA), Thailand Institute of Scientific and Technological Research (TISTR), and King Mongkut's University of Technology North Bangkok (KMUTNB) participated in the joint research and development (Innovation on production and automotive utilization of biofuel from non-food biomass) from Japan and Thailand. Figure II shows our Thailand-Japan collaboration on biomass energy (BDF) [3]. This JICA-JST project was also supported by MOST (Ministry of Science and Technology) and MOEd (Ministry of Education) in Thailand.

A feasibility study committee was established to take up the practical use of the high-quality BDF. This committee, in addition to researchers of Japan and Thailand, is composed of experts from engineering and trading companies. We discussed with Kasetsart University and Thai industry. An actual vehicle test was successfully conducted in Thailand using B20 (20% BDF with mineral diesel) after engine-bench tests in Japan and Thailand.

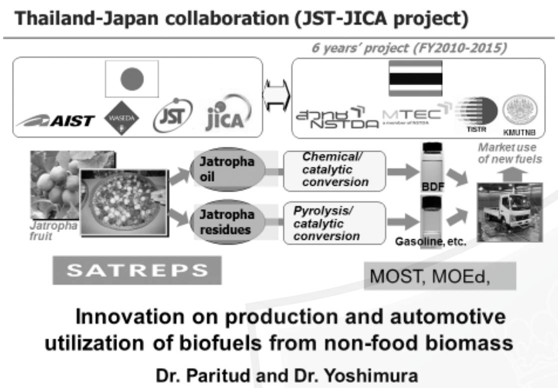


Fig. II. Thailand-Japan Collaboration on BDF

While there still remain many issues for further feasibility study with the objective of future commercial use. For instance, target cost, possible project size, possible area of plantation, possible capacity of BDF supply and a production scenario are our next targets. Optimization of the manufacturing process including co-production with chemical and identification of suitable business partners are also necessary for the next feasibility study of the BDF.

We visited other ASEAN countries (Vietnam, I ndonesia, Malaysia, Laos and Myanmar) and discussed practical use of the high-quality BDF. We also discussed "local production and local consumption" of biomass energy for power generation and transportation. "Entrance strategy" (Production of promising non-food biomass), "Exit strategy" (LCA and Economic efficiency), "Technology strategy" (Advanced technology) and human development were main issues of our discussions. Because Pongamia was chosen as the most promising non-food biomass, we visited India and Australia where research and development is most advanced.

III. International Policy Dialogue

Then region wide collaboration on biomass energy in East Asia was discussed as a major wide area research project at "International Policy Dialogue" (Regional collaboration in Science and Technology in East Asia). This International Policy Dialogue was held for 3 years by Takeda Foundation, the National Graduate Institute for Policy Studies (GRIPS), the Engineering Academy of Japan (EAJ), JICA and JST [4]. After policy recommendation related to the utilization of biomass energy in East Asia has been publicized, EAJ set up the study group for accelerating social implementation of biomass energy in East Asia (" Biomass-Asia Project") (2015).

A. Biomass-Asia Project at EAJ

Basic concept of "Biomass-Asia Project" is shown in Table 1. The study group has focused on ASEAN countries among East Asian countries. ASEAN is now integrating economically and trying to strengthen its S&T capacities to achieve sustainable growth. Since ASEAN countries have a lot of biomass resources, they have great interest in biomass energy.

ASEAN started its economic integration in 2015. Japan should participate in the development of biomass energy in ASEAN countries as an equal partner by promoting regional innovation based on region wide collaboration and accelerating the cross-border movement of human resources between ASEAN and Japan.

After Paris Agreement we made policy proposal to ASEAN countries (A Policy Proposal for International Collaboration on Biomass Energy between ASEAN and Japan) (Jan. 2016).

TABLE I

Concept of Biomass-Asia Project Team

Basic Concept of Biomass Asia Project at EAJ

Multilateral Collaboration on Biomass Utilization in East Asia towards Low Carbon Society

1. East Asia is an Engine of global economy.
2. East Asian countries share many common issues such as shortage of energy and environmental problems.
3. East Asia region is rich in biomass resources.
4. Biomass utilization is one of the most feasible approach toward sustainable development of the region.
5. While no single country can address these common issue alone.
6. So, bilateral and region wide collaboration on biomass utilization is essential for our sustainable development.

Akio Nishijima, EAJ, Biomass-Asia Project Team

IV. e-ASIA Joint Research Project

A. Feasibility Study on Social Implementation of Bioenergy in ASEAN

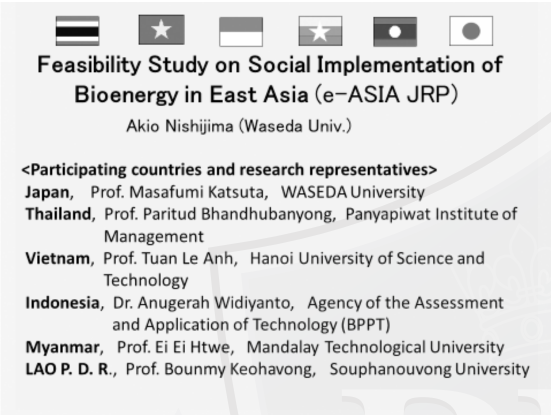
Last year we started our e-ASIA joint research project (Feasibility Study on Social Implementation of Bioenergy in East Asia) among ASEAN countries (Thailand, Vietnam, Indonesia, Myanmar and Lao PDR) and Japan. Our goals of the project are as follows.

1. Data base and priority setting for social implementation of bioenergy in East Asia
2. Feasibility study (economic evaluation, LCA and Social acceptability) on bioenergy
3. Region wide networking for the utilization of biomass in East Asia

4. Understanding of local needs and sustainable supply of feedstocks
5. Optimization of local production for local consumption and international market
6.Training young human resources of ASEAN and Japan
7. Attain Sustainable Development Goals (SDGs)

Table II. shows participating countries and research representatives of our e-ASIA project.

TABLE II
e-ASIA JOINT RESEARCH PROJECT


Feasibility Study on Social Implementation of Bioenergy in East Asia (e-ASIA JRP)
Akio Nishijima (Waseda Univ.)

<Participating countries and research representatives>
Japan, Prof. Masafumi Katsuta, WASEDA University
Thailand, Prof. Paritud Bhandhubanyong, Panyapiwat Institute of Management
Vietnam, Prof. Tuan Le Anh, Hanoi University of Science and Technology
Indonesia, Dr. Anugerah Widiyanto, Agency of the Assessment and Application of Technology (BPPT)
Myanmar, Prof. Ei Ei Htwe, Mandalay Technological University
LAO P. D. R., Prof. Bounmy Keohavong, Souphanouvong University

This e-ASIA joint research project is now being carried out by international industry-academia-government collaboration. In Japan main participating organizations are WU, EAJ, AIST, the Takeda Foundation and industry (power generation, engineering, chemical and etc.).

Last fiscal year we discussed and exchanged information regarding research potential of each country in the field of biomass utilization. We also received many proposals from each country such as biomass power generation or transportation biofuel related to cooperation between the two countries. Local production and local consumption was the core of our discussions.

Based on bilateral meetings with ASEAN countries, 6 countries workshop was held in Bangkok (Oct. 2017) for promoting multilateral collaboration and region wide network. Several major discussion topics of the workshop are biomass power generation and transportation biofuel (ethanol, BDF, Jet fuel). We discussed "Entrance strategy" (Sustainable plantation, Sustainable supply of inexpensive starting materials,), "Exit strategy" (LCA, Economic efficiency and Social acceptability) and "Technology strategy" (Integrated process from the inlet to the outlet, Torrefaction of biomass residue, Co-production of material and fuel, Cascade utilization of biomass).

This fiscal year we will identify significant specific research and development areas to be jointly examined in light of future utilization of biomass in the ASEAN region followed by formation of international research groups among six countries. We are also arranging to foster young researchers' activities through the participation of this program.

Figure III shows Asia Biomass Community for SDGs. International industry-academia-government collaboration and creation of "Asian Biomass Community" (Biomass refinery and Sustainable industry) are now required for our sustainable development in East Asia.

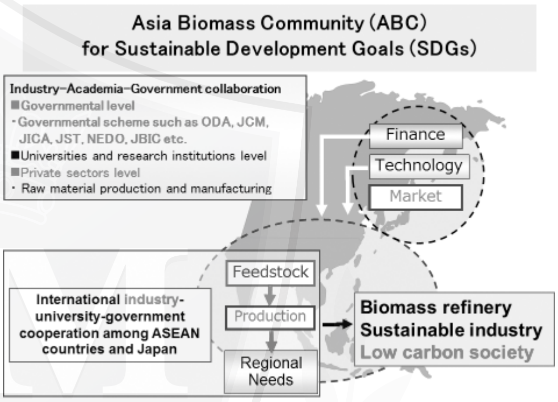


Fig. III. Asia Biomass Community for SDGs

ACKNOWLEDGEMENT

This e-ASIA project is supported by JST (Japan Science and Technology Agency). We would like to express our gratitude to e-ASIA members of ASEAN countries and Japan.

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[4] Proceeding of "The e-ASIA Regional Collaboration in Science and Technology in Asia", published by the Takeda Foundation with a grant from Strategic Funds of MEXT Japan.

Akio Nishijima is now a member of the Engineering Academy of Japan (EAJ). He is a chair of Biomass Project team in EAJ. He is also working for WASEDA University and National Institute of Advanced Industrial Science and Technology (AIST). More than 200 papers have been published and 14 patents have been filed by him. He has contributed to various academic and governmental committees.

He obtained academic B.S., M.S. and Ph.D. degrees in applied chemistry from the University of Tokyo. He joined National Chemical Laboratory in MITI in 1975. He has been engaged in various research projects such as clean air, clean fuel, renewable energy and nanotechnology. Another his research field is advanced characterization using SR and material design. During his stay in AIST, he arranged and promoted international collaboration such as US-Japan and EU-Japan in the field of energy and environment. He moved to WASEDA University in 2006 and has been engaged in young researcher's fostering. He is promoting collaboration with China, Korea and ASEAN countries concerning human development of young researchers. Recently he is promoting collaboration in the field of biomass utilization among East Asia countries towards Low Carbon Society and SDGS.

Hideo Samura is now a member of the Engineering Academy of Japan (EAJ) and a coordinator of Biomass Project team in EAJ. He is a president and CEO of FS Corporation Inc., that is promoting a large scale of Pongamia plantation in ASEAN, Director, Nosaer Co. Ltd., Director, Nobel Crystal Technology Co. Ltd.,. Director, Japan-Israel Commerce of Chamber Kansai and Executive Managing Director, Connected Society Business Consortium. He has been holding titles including Executive Managing Director, Japan Industrial and Technology Association (2005 to 2011), President, AIST Innovations (2005 to 2011), Executive Managing Director, Kansai Research Institute Inc., (1991 to 2001), Director, New Business Development Department, Sanyo Chemical Industry Co. Ltd., (1985 to 1991), Senior Research Scientist, Research Center, Sanyo Chemical Industry Co. Ltd., (1980 to 1984), Research Scientist, Research Center, Sanyo Chemical Industries Co. Ltd., (1973 to 1979). He graduated from the school of Engineering, the University of Kyusyu in 1969, and obtained academic M.S. and Ph.D. degrees in synthetic chemistry from the University of Kyusyu in 1973.

Tomoko Saiki is currently Professor emeritus, Tokyo Institute of Technology (TITEC). She is a member of the Engineering Academy of Japan (EAJ) and a coordinator of Biomass Project team in EAJ.

She obtained B.S. and M.S. degrees in Pharmacology from Osaka University. Then she joined the Japan Patent Office (JPO) in 1972 and is a former Director of Medical and Science Division. She had been engaged in examination of patent applications and management thereof until 1996. After she worked as a patent attorney, she joined Fancl cooperation in 2000 and is a former general manager of Intellectual Property Department. And then she joined TITEC as a professor in 2002. She had been engaged in education and research in Intellectual Property Management until 2013. Papers and books in the fields of Intellectual Property Strategy, Management of Intellectual Property and Information of Intellectual Property in Mergers and Acquisitions and Intellectual Property management for Life Science technology have been published by her.

Norio Ohto is Senior Managing Director, the Takeda Foundation. He has been holding titles including Director, the Takeda Foundation (2009 to 2012), Director, the Sasakawa Peace Foundation (2005 to 2009), Program Officer, the Takeda Foundation (2001 to 2003), Director, Pharmaceuticals and Bio Business Division, Mitsui Chemicals, Inc. (1998 to 2001), Director, Department of Pharmaceutical Research, Institute of Biological Sciences, Mitsui Pharmaceuticals, Inc., (1995 to 1998), Senior Research Scientist, Life Science Laboratory, Mitsui Toatsu Chemicals, Inc., (1984 to 1995), Research Scientist, Research Center, Mitsui Toatsu Chemicals, Inc., (1977 to 1984), and Postdoctoral Research Scientist, Louisiana State University, Department of Chemistry (1980 to 1982).

He graduated from the School of Engineering, the University of Tokyo in 1972, and obtained academic M.S. and Ph.D. degrees in applied chemistry from the University of Tokyo in 1977. He promoted planning and management of drug discovery research and pharmaceutical business during his stay in chemical industry

He is now promoting planning and management of the international awarding and funding programs. Evaluation of technological innovations including the Internet, DNA Chips and DNA microarrays, and large-scale genome sequencing systems. He is also promoting planning and management of international symposiums and receptions.

Paritud Bhandhubanyong holds a B. Eng. (1972) and M. Eng. (1976) (Industrial Engineering) from Chulalongkorn University, MBA (1976) from Thammasart University and D.Eng. (Metallurgy) in 1983 from the University of Tokyo. He joined the State Railway of Thailand as a junior engineer then moved to work as an instructor in the Faculty of Engineering, Chulalongkorn University. He was Head of Department of Metallurgical Engineering, Vice Dean of Planning and Development before joining the National Metal and Materials Technology Centeras Executive Director. He then moved to be the Executive Director of the Technological Promotion Association Thai-Japan (TPA) before joining the Panyapiwat Institute of Management as Executive Director in the office of the President and acting Head of Department of Automotive Manufacturing Engineering. His research interest included Casting Technology, TQM, TPM, TPS. and work-based education (WBE) practices. His recent papers and publication included a chapter in the Report on ASEAN Automotive Industry 2016 (in Japanese) , Business Continuity Management (TPA, 2015) and a paper on WBE presented at ISATE 2016.

Dr. Paritud is a member of the Japan Foundry Engineering Society, The Iron and Steel Institute of Japan, former Chairman of the Foundation of TQM Promotion of Thailand, committee member of the Standard and Quality Association of Thailand, advisor to the Thai Foundry Association of Thailand and the Materials and Corrosion Society

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- Articles not more than 15 pages in length, single-sided A4 paper, margins (top, bottom, left, right) are 1 inch (2.54 cm)
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- English font is **Times New Roman**, as follows:

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Title	24 (CT)	bold
Author	11 (CT)	bold
Author's affiliation amd E-mail	11 (CT)	regular
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[4] W.-K. Chen, *Linear Networks and Systems.* Belmont, CA: Wadsworth, 1993, pp. 123-135.

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

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[18] R. J. Vidmar. (1992, Aug.). On the use of atmospheric plasmasaselectromagneticreflectors. *IEEETrans. PlasmaSci.*[Online]. *21(3),* pp. 876-880. Available: http://www.halcyon.com/pub/journals/21ps03-vidmar

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