Finger Strength Assessment Device for Thai Traditional Massage Training

Prarin Chupawa [1,*], Kiattisin Kanjanawanishkul[1] and Wanlapa Leelananthakul[2]

[1] Department of Mechatronics Engineering, Faculty of Engineering, Mahasarakham University, Maha Sarakham, Thailand
[2] Department of Applied Thai Traditional Medicine, Faculty of Medicine, Mahasarakham University, Maha Sarakham, Thailand

prarin.c@msu.ac.th*(corresponding author), kiattisin.k@msu.ac.th and wanlapa.l@msu.ac.th

Abstract. *Finger strength is essential in Thai traditional therapeutic massage. One of the most well-known finger strength exercises is called Yok Kradan training with cross-legged sitting. It is a requirement for students in the Applied Thai Traditional Medicine (ATTM) program to practice their finger power. During traditional Yok Kradan testing, four instructors evaluate the student's performance by the amount of time (using a stopwatch) that students can lift their body up. Consequently, the start time and stop time are not synchronized and the inspectors are hard to observe the student's body touching the floor. This research aims to design the finger strength assessment device in order to improve accuracy of body-lifting time measurement and standardize assessment. It consists of plywood with length, width and thickness of 120, 100, and 16 centimeters, respectively. Force Sensing Resistor (FSR) sensor are installed at 5 positions on the plywood to detect the practitioner's knees, thighs and buttocks touching the floor. The FSR sensors are also attached on the gloves. The raspberry pi single board computer are used to read the values from all sensors in order to check whether any parts of the body is touching the floor or not. The experimental results show that the accuracy of 15 FSR sensors compared to standard weights ranged from 98.21% to 98.8%. Such error values can be tolerated in assessing finger strength by Yok Kradan training. Then, we evaluated our proposed device compared with traditional assessment. The result showed that our device helped in making the assessment more reliable and less disputable since the assessment results were promptly shown on the screen after the test.*

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finger strength assessment, finger power, Thai traditional massage, Yok Kradan, cross-legged sitting, FSR sensor

1. Introduction

UNESCO has listed Thai traditional massage or Nuad Thai as an intangible cultural heritage of humanity that shows the precious wisdom of Thai traditional medicine since ancient times [1]. Nowadays, Thai traditional massage is divided into two main types: "Nuad Thai for health" and "Nuad Thai for therapy" [2]. Thai traditional massage aims to heal and rehabilitate a patient by using fingers and hands on the human body. During the treatment, the practitioners must focus on their fingers to press and knead along specific massage lines. Certainly, finger power training is at the heart of Thai traditional massage [3]. If the practitioners cannot perform a massage gently and smoothly, treatment would be less efficient. Moreover, this massage could injure the patients [4], [5]. Therefore, practitioners must practice to improve their finger power. One of the most popular methods is to use their fingertips of both hands to lift the whole body up. This practice is called Yok Kradan that consists of three postures: 1. cross-legged sitting style, 2. leg stretch style, and 3. push-ups style [6], [7].

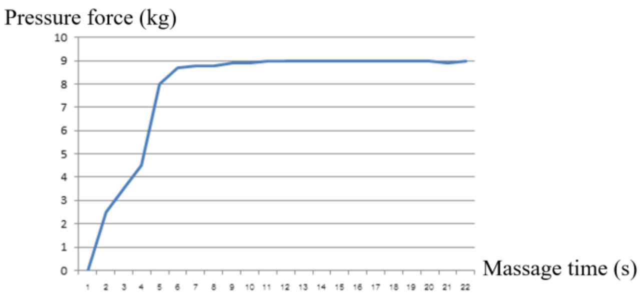
Applied Thai Traditional Medicine (ATTM) students need to practice Yok Kradan by sitting cross-legged (called in Thai - Kud Samart Pet). The students, sitting cross-legged, place their hands beside the body. Then, they make their fingertips in an inverted cup shape. During the examination, the inspector will start a timer when the practitioners use their fingertips to push the body above the floor. The inspector will instantly stop the timer if there are any other parts of the practitioner's body touching the ground [6]. In general, the practitioner should lift the body up with the finger power and stay at that position for at least 60 seconds. Furthermore, Yok Kradan testing requires more than one inspector sitting around the practitioner in order to observe the practitioner's body. Thus, there are more than one stopwatch. As a result, all inspectors cannot start the timer simultaneously and they cannot observe the practitioner's body touching the floor clearly due to the practitioner's clothes.

This research aims to design the finger strength assessment device for Thai traditional massage with Yok Kradan testing. It can improve accuracy of body-lifting time measurement and standardize assessment. The paper is structured as follows: Section 2 explains the finger force adjustment (called in Thai - Taeng Rod Mue), finger strength training with cross-legged sitting style in Thai traditional massage classroom, traditional finger strength testing and finger strength assessment device design. Section 3 shows the experimental results of the proposed device and discussion. Finally, the conclusions are drawn in Section 4.

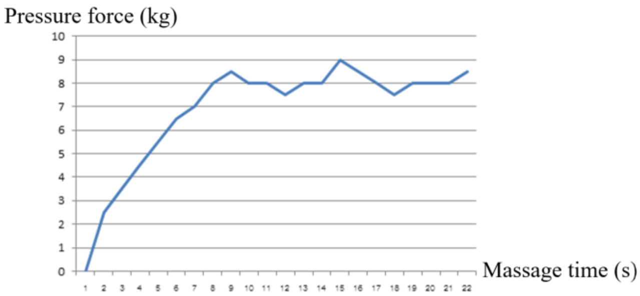
2. Research Methodology

2.1 Finger Force Adjustment

Finger force adjustment (Thai name - Taeng Rod Mue) is one of the most well-known techniques for massage. The practitioners must perform a massage gently and smoothly. So the patients are comfortable and do not feel pain. This technique can help them to control weight and direction of pressing and prevent bruising [6-8]. Well-trained practitioners can apply consistent finger force at shown in see Fig.1 (a). On the other hand, if the finger force adjustment is uncertain, the graph of applied finger force appears fluctuated (see Fig.1 (b)). Moreover, a lack of finger force consistency can cause bad effects, such as poor blood circulation, headache, vomiting, swelling, pain and bruising (see Fig. 2) [8].



(a)



(b)

Fig. 1 Comparison between pressure force and massage time: (a) consistent force and (b) inconsistent force

Fig. 2 A bruised arm caused by a practitioner with inadequate finger force adjustment training [8]

2.2 Finger Strength Training in Thai Traditional Massage Classroom

The Applied Thai Traditional Medicine (ATTM) program emphasizes finger strength by practicing a Yok Kradan technique. It is able to increase finger power and consistency of force adjustment during performing a massage. The following steps are employed by ATTM students at Mahasarakham University, who must be required to practice Yok Kradan training with cross-legged sitting.

1) Sit cross-legged on a floor that is not too soft or rough (see Fig. 3(a)).

2) Sit cross-legged in two tiers with one foot on top of the other thigh (see Fig. 3(b)) and lift the heel on top of the other thigh (see Fig. 3(c)).

3) Turn hands upside down and place both hands beside the body on the floor (see Fig. 3(d-e)).

4) Make an inverted cup-shaped hand with only the fingertips touching the floor (see Fig. 3(f)).

5) Use the fingers to lift the whole body from the ground (see Fig. 3(f)), stay in that position for at least 60 seconds, and then return to the preparatory posture.

Fig. 3 Yok Kradan training with cross-legged sitting style [6]

2.3 Traditional Finger Strength Testing

Since at least four inspectors have to measure time during Yok Kradan testing, each one will receive one stopwatch (see Fig. 4). The inspector will start the timer simultaneously when the practitioner starts pushing the body off the ground. Then, each inspector has to observe the practitioner at different views in order to check whether any other parts of the body are going to touch the floor or not.

The inspectors stop the timer immediately when the practitioner's organs or the fingers (see Fig. 5(a-b)) that extend beyond the interphalangeal joint (IP joint) of the thumb, the proximal interphalangeal joint (PIP joint) of the index, middle, ring, and little fingers (see Fig. 6) touching the floor, testing marks are based on an average elapsed time of all instructors.

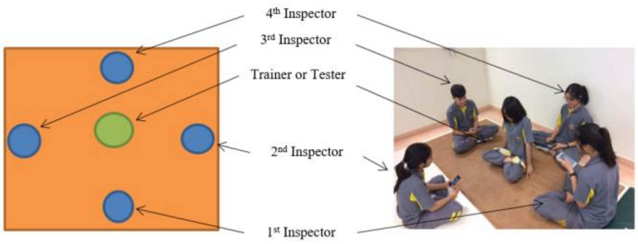


Fig. 4 Positions for traditional Yok Kradan testing

(a) (b)

Fig. 5 Criteria of stopping time: (a) knee [1], buttock or (b) fingers touching the floor

Fig. 6 knuckle position for the criteria of stopping time [9]

2.4 Finger Strength Assessment Device Design

The structural design of a finger strength assessment device (see Fig. 7) consists of plywood with length, width and thickness of 120, 100, and 16 centimeters, respectively. Force Sensing Resistor (FSR) sensor is one of the cheap and qualitatively accurate sensors for force measurement. Its resistance changes according to the applied force. It is insensitive to vibration or normal environmental stresses and holds up under long-term usage [10]. FSR sensors are installed at 5 positions (yellow circles in Fig. 7) on the plywood to detect the practitioner's knees, thighs and buttocks touching the floor.

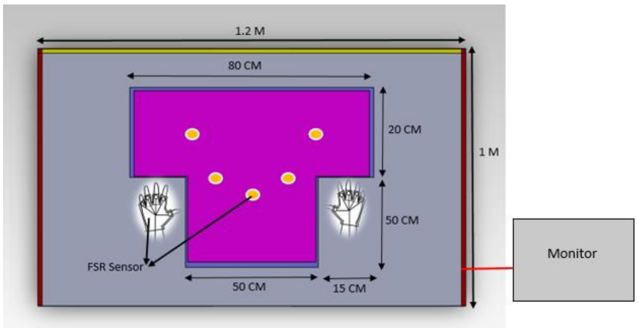


Fig. 7 Finger strength assessment device design

These FSR sensors are also attached on the gloves in the area of the IP joint of the thumb, the PIP joint of the index, middle, ring, and little fingers (see Fig 8). All sensors are connected to the input pins of the ADC IC (MCP3208). The IC output pins are connected to the raspberry pi single board computer as seen in Fig. 9 and then the sensor values are displayed on the monitor.

The program screen design (see Fig. 10) consists of 1) students' ID fill box, 2) timer display, 3) timer record button, 4) timer reset button, 5) result recording table, and 6) table reset and program exit button.

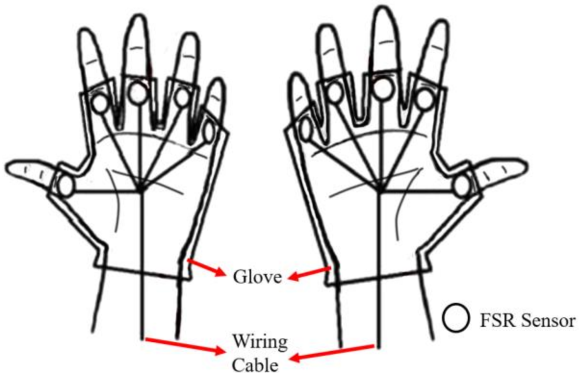


Fig. 8 Installation of FSR sensors attached on the gloves

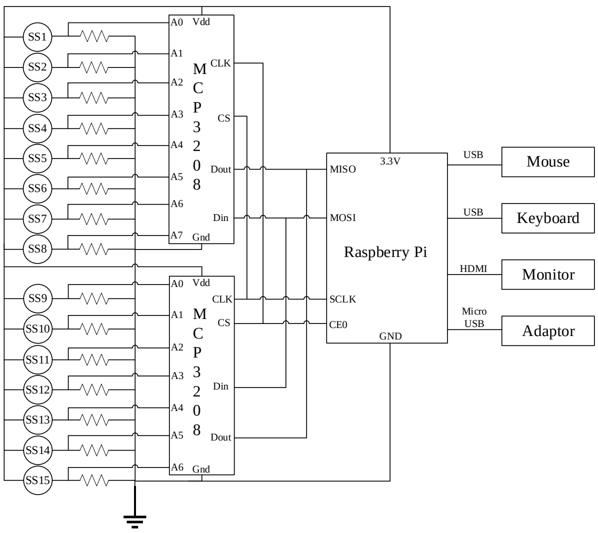


Fig. 9 Circuit diagram of finger strength assessment device

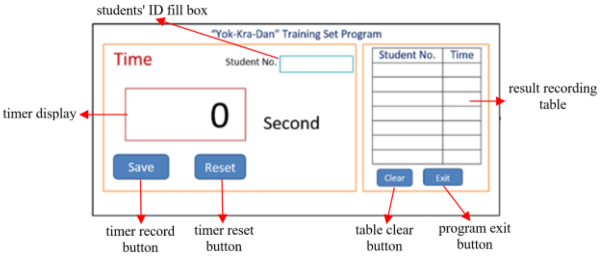


Fig. 10 Program display of finger strength assessment

First, the examinee sits cross-legged in a preparatory position on the 5 FSR sensor-mounted area. Then he/she wears gloves with built-in sensors (the IP of the thumb and the PIP of the index, middle, ring, and little fingers) and places his/her hands beside the body on the floor. Next, the inspector presses the reset button to allow the program to wait for the timer to start. When the examinee lifts his/her body off the ground with fingertips, the program starts timing. If the buttocks, knees, thighs or at least one of the fingers attached to the FSR sensor touch the ground, the program will stop timing immediately. The inspector can press the save button to save the examinee's ID and body-lifting time. The flowchart of the deigned device is shown in Fig. 11.

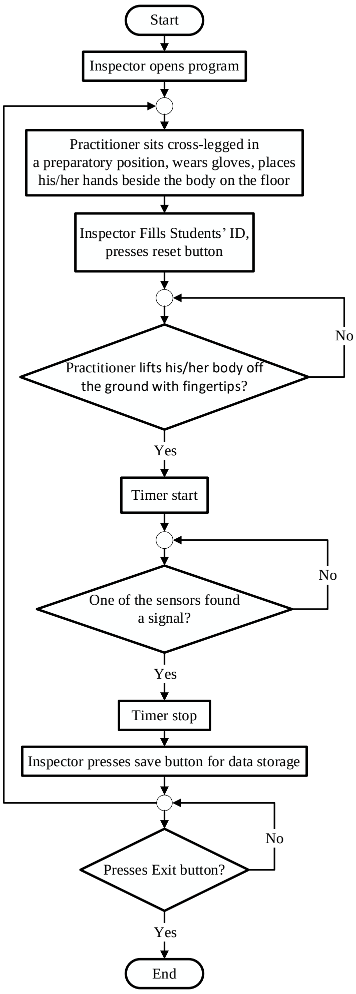


Fig. 11 The flowchart of the designed device

3. Experimental Results

In order to achieve accuracy and reliability of the finger strength assessment device, we evaluated the performance of the FSR sensors as shown in the first experiment. Prior to the actual performance test of the proposed device, we noticed that practitioners spent some time on wearing sensor-attached gloves. Thus, we measured it as shown in the second experiment. Finally, we compared the results of the proposed device with the traditional assessment as given in the last experiment.

3.1 Accuracy evaluation of FSR sensors

Fig. 12 shows the proposed finger strength assessment device that was completely built. We compared the weight measured by 15 FSR sensors with standard weights of 2 kg, 4 kg, 6 kg, 8 kg and 10 kg. The experiment was repeated 3 times. As seen in Table 1, the accuracy of 15 FSR sensors compared to standard weights ranged from 98.21 to 98.8%. Such error values can be tolerated in assessing finger strength by Yok Kradan training. In fact, the output values of FSR sensors (see Fig. 9) were analog signals and then converted into the digital values by using the ADC IC (MCP3208). When they were implemented into the finger strength assessment device, we set the digital level of 1000 (out of 4095 due to a 12-bit ADC IC) as a threshold value for ground-touching detection. That is, if the digital level from the FSR sensor was greater than 1000, the timer stopped because ground-touching criteria were met.

Fig. 12 Finger strength assessment device

Sensor No.	Standard weight (kg)					Accuracy (%)
	2	4	6	8	10	
1	2.06±0.03	4.06±0.09	6.05±0.11	8.03±0.08	10.02±0.11	98.51
2	2.02±0.08	4.05±0.1	6.01±0.16	7.99±0.11	10.03±0.15	98.27
3	2.01±0.04	4.08±0.08	6.01±0.08	8.09±0.08	9.99±0.10	98.80
4	2.06±0.04	4.09±0.07	5.99±0.09	8.05±0.09	10.11±0.14	98.49
5	1.98±0.05	4.04±0.07	6.02±0.07	8.02±0.19	10.10±0.11	98.62
6	2.04±0.07	3.97±0.1	6.04±0.13	8.09±0.16	10.06±0.10	98.38
7	2.06±0.09	4.05±0.08	6.02±0.15	8.07±0.09	10.07±0.09	98.50
8	2.05±0.07	3.98±0.08	6.00±0.08	8.05±0.16	10.11±0.23	98.48
9	2.02±0.05	4.08±0.13	6.06±0.08	8.09±0.16	10.01±0.04	98.40
10	2.03±0.06	4.08±0.07	6.07±0.09	8.09±0.12	10.02±0.20	98.33
11	2.01±0.03	4.07±0.01	6.10±0.09	8.03±0.12	9.98±0.08	98.75
12	1.99±0.03	4.05±0.11	6.08±0.15	8.05±0.17	10.09±0.12	98.29
13	2.05±0.07	4.05±0.09	6.10±0.16	8.09±0.12	10.08±0.14	98.31
14	2.04±0.06	3.96±0.13	6.06±0.15	8.03±0.11	10.07±0.20	98.21
15	2.03±0.03	4.06±0.05	6.06±0.12	8.05±0.07	10.06±0.15	98.78

Table 1 Accuracy evaluation of FSR sensors compared with standard weights

3.2 Assessment of Time Spending on Wearing Sensor-Attached Gloves

Since practitioners are required to wear sensor-attached gloves (see Fig. 8) before they perform the training test, this step needs some amount of time. There were 5 volunteers from the ATTM program. We measured time that they spent on wearing gloves. It was repeated 3 times and the experimental results are shown in Table 2.

No.	Time of wearing (seconds)			
	1	2	3	Average
1	15.88	13.42	12.16	13.82
2	16.6	14.39	13.23	14.74
3	11.33	9.98	9.56	10.29
4	10.08	8.56	9.15	9.26
5	9.92	8.42	9.53	9.29
Average				11.48

Table 2 Time spending on wearing gloves

From Table 2, we found that the time spending on wearing gloves was between 9.26 - 14.74 seconds. The average time of the 5 volunteers were 11.48 seconds. Apparently, all volunteer spent shorter time at the 2nd round and the 3rd round because they were already familiar with the sensor-attached gloves. However, we found a problem during wearing test. The signal wire was broken because the bonding between the sensor and the glove was not robust (See Fig. 13). Thus, we replaced it with a rubber finger cot as shown in Fig. 14.

Fig. 13 sensor wring damaged during wearing test

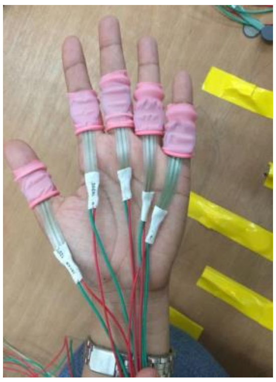


Fig. 14 Rubber finger cots with FSR sensors

Table 3 shows the time measurement of wearing rubber finger cots, ranging from 3.42 to 4.54 minutes. The average time for wearing rubber finger cots of the 5 volunteers were 4.25 minutes. Obviously, wearing rubber finger cots took longer time than wearing gloves because the volunteers had to put on a rubber finger cot on each finger. However, rubber finger cots are more robust.

No.	Time of wearing (minutes)			
	1	2	3	Average
1	5.12	4.41	4.48	4.54
2	4.03	3.36	3.27	3.42
3	4.21	4.09	5.41	4.44
4	4.55	5.01	4.13	4.43
5	4.26	4.3	5.05	4.40
Average				4.25

Table 3 Time spending on wearing rubber finger cots

3.3 Comparison of Traditional Assessment and the Finger Strength Assessment Device

We first examined the timer incorporated with the FSR sensor operation. The result showed that the program was able to stop the timer instantly if any force occurred on the FSR sensors. Then, we evaluated our proposed device by being compared with traditional assessment. Sixteen students (2 males and 14 females) of the ATTM program used this device for Yok Kradan testing (see Fig. 15) and also were assessed by four human inspectors according to traditional assessment. The results of both assessments are shown in Table 4.

Fig. 15 ATTM students performing Yok Kradan Test by using the proposed device

No.	Traditional assessment (seconds)					Assessment device (seconds)
	Inspector1	Inspector2	Inspector3	Inspector4	AVG	
1	3.08	3.05	3.22	2.5	2.96	4.52
2	3.89	4.06	3.04	3.61	3.65	5.42
3	3.63	3.56	4.25	3.43	3.72	5.23
4	3.43	3.36	3.47	3.01	3.32	4.80
5	4.66	4.92	4.31	4.45	4.59	6.15
6	5.06	6.37	5.47	5.89	5.70	7.38
7	4.53	3.25	4.75	3.93	4.11	5.21
8	7.22	7.57	6.57	7.45	7.20	8.12
9	3.57	4.15	4.14	3.85	3.93	5.04
10	7.00	6.60	6.92	5.97	6.62	8.22
11	4.63	6.28	4.14	5.66	5.18	6.31
12	4.02	4.49	5.57	6.09	5.04	6.46
13	5.64	5.57	5.03	5.72	5.49	7.07
14	6.96	5.76	5.65	6.22	6.15	7.17
15	5.58	6.23	6.14	6.70	6.16	7.29
16	6.78	6.95	5.98	5.88	6.40	8.05

Table 4 Comparison between traditional assessment and the finger strength assessment device

As seen in Table 4, four inspectors stopped the stopwatch at the different time because each one looked at the student from different points of view. In addition, some inspectors stopped the time when any part of the student touched the ground. This may be incorrect judgement because it was only some parts of the student's pant touching the ground. On the other hand, our proposed device was able to stop the time immediately when any parts of the student's body touching the ground. Thus, our device helps in making the assessment more reliable and less disputable.

The following feedbacks were obtained from the ATTM students and instructors after they participated in the test:

- The device and program were easy to use and the assessment results were promptly shown on the screen after the test.
- More sensors should be attached to the knees so that the sitting location will not be fixed on the device.
- Although sensor-attached gloves were worn easily, the sensors may be dislocated due short fingers or long fingers. Rubber finger cots with FSR sensors were used to solve this problem since sensors were fixed at the correct position of the finger. But students took more time to put them on each finger.

4. Conclusions

Finger power training is essential for Thai traditional massage. This research aimed to construct the finger strength assessment device for Thai traditional massage with Yok Kradan testing. It can improve accuracy of body-lifting time measurement and standardize assessment. 15 FSR sensors were used in this device (5 mounted on plywood, 10 mounted on gloves). The sensors were connected to the raspberry pi single board computer and then the sensor values were displayed on the monitor.

The experimental results showed that the accuracy of 15 FSR sensors compared to standard weights ranged from 98.21 to 98.8%. When they were implemented into the device, we set the digital level of 1000 as a threshold value for ground-touching detection. Next, we found that the time spending on wearing sensor-attached gloves were 11.48 seconds on average. Though, the bonding between the sensor and the glove was not robust. Thus, we replaced it with a rubber finger cot. We found that the time spending on wearing rubber finger cots were 4.25 minutes on average. However, wearing rubber finger cots took longer time than wearing gloves, they were more robust.

Then, we evaluated our proposed device by being compared with traditional assessment. The results showed that four inspectors in traditional assessment stopped the stopwatch at the different time because each one looked at the student from different points of view. On the other hand, our proposed device was able to stop the time immediately when any parts of the student's body touching the ground. Thus, our device helps in making the assessment more reliable and less disputable.

We would like to improve the proposed device for further research. For example, the device should assess the other postures of Yok Kradan training (leg stretch style and push-ups style). Sensor wiring should be more robust and more convenient to wear.

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Biographies

Prarin Chupawa was born in Khon Kaen, Thailand, in 1990. He received the B.Eng. in Mechatronics Engineering form Mahasarakham University, Thailand, in 2011. He received the M.Eng. in Mechanical Engineering from Mahasarakham University, Thailand, in 2015. He received his Ph.D. in Mechanical Engineering from Mahasarakham University, Thailand, in 2022. Since 2015, he has been employed at the Faculty of Engineering, University of Mahasarakham, Thailand. His current research interests include image processing, mechatronics, sensor fusion and automation.

Kiattisin Kanjanawanishkul was born in Trang, Thailand, in 1977. He received his B.Eng. in Electrical Engineering from Prince of Songkhla University, Thailand, in 2000. He received the M.Sc. in Mechatronics from University of Siegen, Germany in 2006. He received his Ph.D. in Computer Science from University of Tubingen, Germany, in 2010. Since 2010, he has been employed at the Faculty of Engineering, University of Mahasarakham, Thailand. His current research interests include cooperative and distributed control, model predictive control, robotic motion control, image processing, and computer vision.

Wanlapa Leelananthakul is assistant professor of applied Thai traditional medicine, Faculty of Medicine, Mahasarakham University of Thailand. She specializing in the field of Thai traditional medicine, court-type traditional Thai massage, Reusi Dat Ton: Thai hermit's exercises, holistic medicine: natural and alternative medicine. She obtained M.Sc. in Medical Science (Physiology) from Chulalongkorn University, Thailand, 2014; and B.Sc. (2nd class honors) in Applied Thai Traditional Medicine from Thammasat University, Thailand, 2010.