A LOW-COST PORTABLE DISTRESS-SIGNALING (PDS) FOR ELDERLY LIVING ALONE IN DONYAIHOM DISTRICT, NAKHONPATHOM PROVINCE, THAILAND

Navapadol Kittiamornkul[1,*], Watcharawit Saensupho[1] and Mantana Watcharinrat[2]
[1]Department of Biomedical Engineering, Faculty of Health Sciences, Christian University of Thailand, Thailand
[2]Department of Innovation in Food Technology and Nutrition, Faculty of Health Sciences,
Christian University of Thailand, Thailand

ABSTRACT

This research proposes a low-cost emergency network system for elderly (senior citizens) living alone in Donyaihom district, Nakhonpathom province, Thailand. The prototype proposed connects Portable Distress-Signaling (PDS) using network system to hospital and promoting health care industries / volunteers. A proposed prototype of portable emergency distress signal is developed by a small microcontroller board connecting to SIM900 module in order to help elderly aged individuals to call for help during the emergency or distress situation. The designed prototype is lightweight, small size, waterproof (IP53), daily use, low cost and easy to use. The elderly persons can wear it all the time. According to the experiment, the prototype signal can cover in Donyaihom district, Nakhon pathom province, Thailand. Moreover, the prototype can operate for a period of 23-24 hours which is enough for all day long use per 1 charge. Finally, the prototype robust to water sprays and dust with IP53. This research can add more functions in order to improve the effective usage and its efficiency such as GPS monitoring function, sensor-based fall detection function and automatic calling function.

Keywords: microcontroller, SIM900 module, elderly, Distress-Signalling.

1. INTRODUCTION

In present, the aged individuals >60 years of age in the world is increasing linearly. According to the information from United Nation (UN), in 2047 the number of elderly people who has more than 60 years of age will be more than children [1]. In Thailand, the population structure is getting converted into ageing society due to birth rate and mortality rate which is decreasing rapidly. The number of children and adult ratio seems to be disturbing, but the trend seems to be increasing for elderly people from 13.2% to 32.1% in 2040 [2]. The advance in medical technology the people have long life time. Therefore, the ratio of elderly people is getting higher.

According to this situation, Thai government must prepare to take proper measures against the ageing society using new policies to support and improve the quality of life. According to Thai 12th National Economic and Social Development Plan, Thai government has policies to improve working skill of elderly people who has 60-69 years old, and supports markets, funds and occupation services to each community [3].

However, there are many elderly people who live alone in Thailand because their relatives need to go for work all day long or weeks. So, elderly people living alone has higher risk than the elderly living with their relatives. If any emergency / distress occurs on any circumstances with elderly citizens, they cannot help themselves. Since, there are many elderly people living alone in Thailand, the emergency / distress that causes death of elderly people happens frequently. Some accidents are not fatal, if someone lives around. Hence, this work emphasis on such aged citizens those who are in emergency need and help them by a single click away to signal the concerned authority to rush them to their nearest hospitals or health care system by preventing fatal deaths.

There are many situations in that cause death for elderly people in Thailand. For example, grandson found that his grandmother, a 76-year old woman, die in her orchard after passing 3 days reported by ASTV in 2015 [4]. For another example, a 75-year old woman died in her bathroom. Her neighbor found after 3 days pass reported by Nation TV in 2015 [5]. There are many examples in Thailand that elderly people die when they live alone. Therefore, it is necessary to reduce a great loss from this problem.

Since Thailand has many rural poor people, the service has to be a low cost in order to cover all the people in rural area. This research proposes the low-cost emergency Portable Distress-Signaling (PDS) using network system for elderly living alone. Donyaihom district, Nakhonpathom province, Thailand is used as a case study area because it has many alone elderly people living in this area (1,147 elderly people from 6,537 people) [17] as shown in Figure 1.

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*Corresponding author E mail: metalicaed@hotmail.com
Department of Biomedical Engineering, Faculty of Health Sciences, Christian University of Thailand, Thailand.

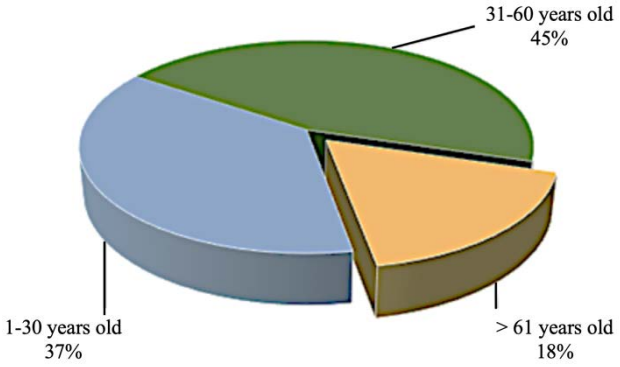

Figure 1. Population in Donyaihom district, Nakhonpathom province, Thailand in 2018 [17]

Donyaihom district, Nakhon pathom province, Thailand has 4640 square kilometers. Most people in this area are farmer and pastoralist. This area can be divided into 12 communities. It has only 1 health promoting hospital. In order to improve the quality of life of people in this area, any services provided should be cost effective.

This research creates the low cost small portable emergency called device connected to health promoting hospital in order to send Village Health Volunteer (VHV) for their immediate help when the emergency situation occurs.

2. BASIC CONCEPT

This paper, consist of three basic concepts that relates to the research: Falling theories, Falling in elderly people and microcontroller.

2.1 Falling theories

Falling relates to a change in the center of gravity, COG of human body. According to many researcher, COG of human body located near pelvis in front of hipbone in standing posture [6, 7, 8]. Normally, COG located at the same position of bearing point. The COG will change the position while walking or moving. If the COG diverges from the bearing point, Falling occurs [6, 7, 8].

Now, in developed countries such as United states of America and Japan, it has commercial falling detection device that sends for help to hospital immediately, but this system has expensive cost. Some people cannot use this service due to its higher cost ($34.00 – $45.99/month approximately) [9, 10, 11, 12].

2.2 Falling in elderly people

The important problem of elderly people is falling that leads to breaking of their bone. Sometimes it causes death. Moreover, in elderly people hipbone breaking ricks to complication diseases. More than 90% of hipbone breaking patients cannot walk again, if they don't have surgery. In addition, complication diseases make patient cannot move. It causes bedsore and other dangerous diseases to patient. Falling is the most accident causing to elderly people. The National Safety Council reported that in 1995 [13], more than 9,923 American people who had age more than 65 years old died from falling which was 75% of death in elderly people.

2.3 Mobile Module and Microcontroller

This research uses mobile phone technology module applied to the emergency Portable Distress-Signaling (PDS) using network system for elderly living alone. It is controlled by microcontroller. Mobile phone module is used in this research called SIM900 module shown in Figure 2. It can call, receive call, use SMS with fast operation [14]. Some modules can use internet and GPS features like smart phone. Microcontroller board works like small computer consisting with CPU, RAM and Ports. It can apply to many works in both analog and digital applications such as sensor application, computer application, IOT application and mobile application.

Arduino is one of the most favorites microcontroller module because it is developed by open source that can be modified, added and developed by developer. Moreover, it has cross-platform system that can be develop by many operating system [15]. There are many types of Arduino microcontroller board depending on applied work. In this research, Arduino micro pro mini which has small size, lightweight and low energy consumption is used in the present work and shown in Figure 3.

Figure 2. SIM900 module

Figure 3. Arduino micro pro mini board

3. THE PROPOSED EMERGENCY PORTABLE DISTRESS-SIGNALING (PDS) USING NETWORK SYSTEM

In Thailand, it has many health promoting hospitals located in every district to serve people in remote areas where civilization is less. This research cooperated with health promoting hospital in Donyaihom district, Nakhonpathom province, Thailand in order to send village health volunteer to help when emergency situation occurs.

In Donyaihom district has only healthcare service which is the health promoting hospital. This hospital give priority to elderly people because there are thousands of elderly people in this area. In order to improve the healthcare services. The hospital connects to village healthcare volunteer unit in order to service when the emergency is required.

The diagram of proposed network is shown in the Fig.4 and as follows:

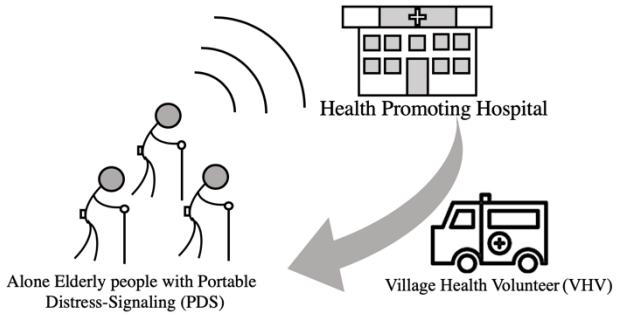

Figure 4. The proposed emergency network system

4. INSTRUMENTATION OF PORTABLE DISTRESS-SIGNALING (PDS)

The instrumentation used to develop PDS is from mobile phone module in order to define its parameter such as calling function, energy consumption, cover material including cost.

The prototype was designed and divided into 4 parts which are power supply unit, processing unit, emergency switch and calling unit. The diagram of prototype design is shown in Figure 5.

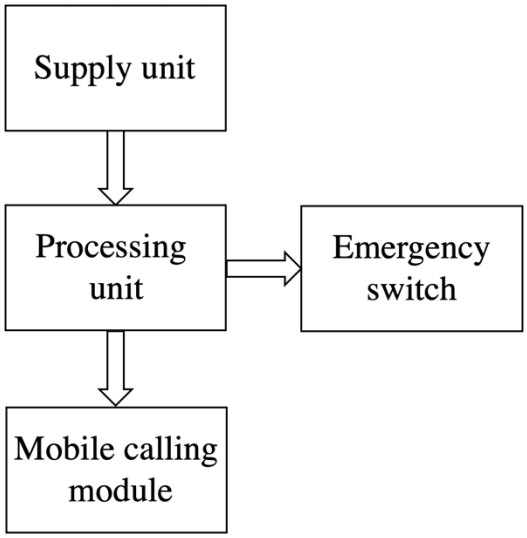

Figure 5. Diagram of portable Emergency call device (PDS)

According to Figure 5, this device starts from supply unit that designed to standby for approximately 1 day (24 hours). The supply unit is connected to processing unit for main operation provide to the device. The processing unit is connected to emergency switch and mobile calling module (SIM900 module). If elderly people need help, they can push emergency switch. The signal from emergency switch will be sent to processing unit. Finally, the processing unit commands mobile calling module to call health promoting hospital for immediate help.

Since elderly persons need to wear the proposed prototype all the time, the wearing position would be our need of concern. Various requirements on body posture specifically need to be taken care on body position such as waist, hands, arms, wrist. However, placing sensor on the elderly body will lead to temporary discomfort [16]. In this research, the prototype is designed to place at waist of the elderly people because it will disturb their routine.

5. HARDWARE SPECIFICATION

The research work uses 5V, 2500 mA rechargeable Lithium polymer battery which can supply proposed device for all day long. The processing unit is Arduino micro pro mini which has small size and low energy consumption. Mobile calling module is GSM SIM900 module. Finally, emergency push button as switch is used to provide distress signal to nearby health volunteer or hospital. This device is designed for dust and water proof with International Protection Standard 53 (IP53).

6. EXPERIMENT AND RESULT

The prototype of portable emergency call device Portable Distress-Signaling (PDS) is designed for elderly people which are easy to use, small size, waterproof (IP53), daily use and low cost. This device has only 2

switches which are on/off and emergency call switches shown in Figure 6.

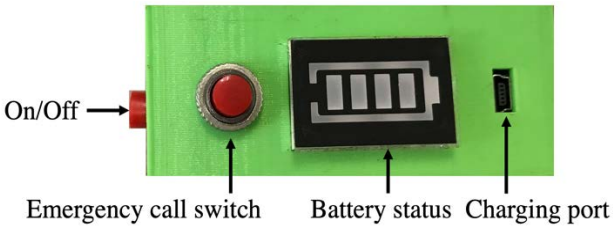

Figure 6. The prototype of emergency call device

The prototype of emergency call device was experimented in order to evaluate its performance in Donyaihom district, Nakhonpathom province, Thailand.

In order to evaluate the efficiency of the prototype, the statistic evaluation is used. The average and standard deviation are used as shown in equation (1) and (2):

$$\bar{X} = \frac{\sum X_i}{N} \quad (1)$$

where $\bar{X}$ is the total average of measurement data

X_i is the measurement data.

$$\delta = \sqrt{\frac{\sum(X_i - \bar{X})^2}{N-1}} \quad (2)$$

where δ is sample standard deviation

N is number of measurements.

This research has 4 experiments to evaluate the efficiency of the proposed system which are mobile phone network test, connecting time test, battery efficiency test and water and dust proof test explained later sections.

6.1 Mobile phone network test

Proposed mobile networks connect between prototype portable emergency call device Portable Distress-Signaling (PDS) carried by elderly people and health promoting hospital in Donyaihom district, Nakhonpathom province, Thailand. Therefore, the mobile signal should cover all the area of Donyaihom district.

The 1800 MHz and 900 MHz of frequency are selected in this research because it has low service fee that poor villagers can use this service. Moreover, the frequency of 1800 MHz and 900 MHz can cover all over the Donyaihom district.

In this experiment, the 10 mobile network testing points are located as shown in Figure 7. The result shows that all the mobile network testing points can connect to health promoting hospital in Donyaihom district.

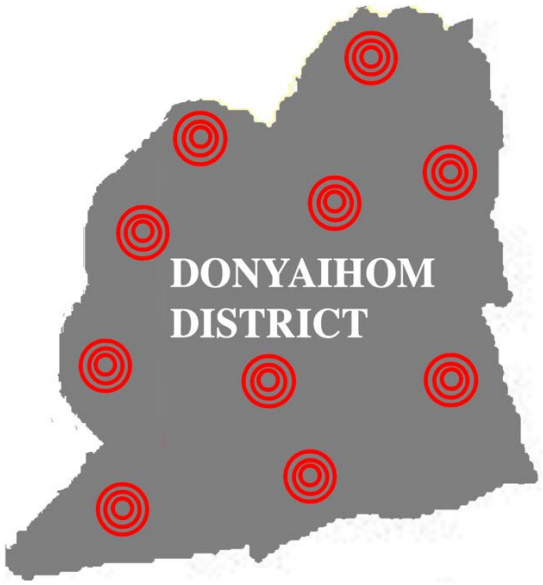

Figure 7. Mobile network testing points

According to the experiment, the result show that the mobile network signal cover all the area in Donyaihom district, Nakhonpathom province, Thailand.

6.2 Connecting time test

This experiment is a test for connecting time after push button is pressed for emergency call switch in order to test how fast the help could activate. The result shows 10 different connecting times of calling as shown in Table.1 and Figure 8.

Table.1 Connecting time of proposed device

Test No.	Connecting time (second)
1	10.21
2	9.83
3	8.76
4	11.19
5	10.56
6	10.83
7	11.34
8	9.02
9	11.28
10	10.34
Average ($\bar{X}$)	10.34
Standard Deviation (δ)	0.91

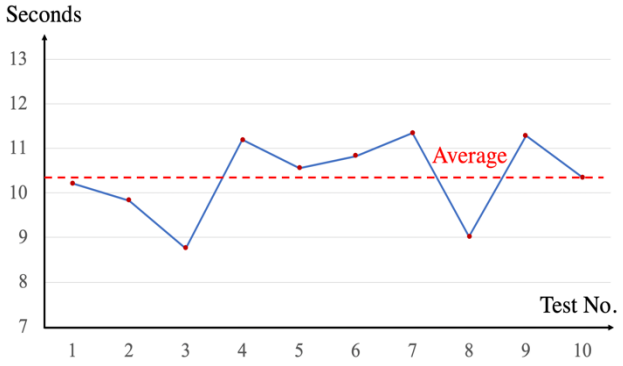

Figure 8. Chart of the connecting time of the proposed device

According to Figure 8, the result has average connecting time and standard deviation that are 10.34 seconds and 0.91 respectively.

6.3 Operating time test

This section is the experiment to test the energy management of the prototype. The operating time of the prototype was tested. The 2500 mA lithium polymer battery which has high efficiency and safety used by smart phone normally used. This experiment was tested for battery durability for 5 operating times which started from 100% to 0% of the battery. The efficiency result of the battery is shown in Table.2 and Figure 9.

Table.2 Standby time of proposed device

Test No.	Standby time (hour)
1	23
2	22
3	24
4	23
5	26
Average ($\bar{X}$)	23.6
Standard Deviation (δ)	1.52

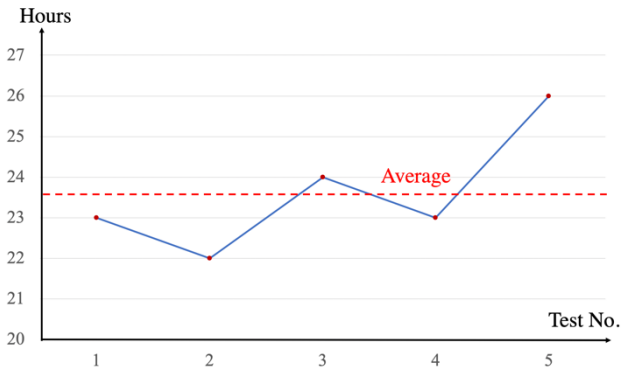

Figure 9. Chart of standby time of proposed device

According to Figure 9, the result has average connecting time and standard deviation that are 23.6 hours and 1.52 respectively. The charging time of the prototype from 0% to 100% is 6 hours approximately.

6.4 Water and dust proof test

The package of the proposed prototype was tested for water and dust proof in order to protect the electronic circuit and modules inside.

The research used International Protection Standard method to test the prototype. The water was sprayed with 50 kPa for 1 minute. The result shows that the prototype has IP53 that can protect sprayed water and some dusts can pass the package but they don't have any effect to the system.

7. DISCUSSION

This research emphasis on Portable Distress-Signaling (PDS) device works with 4 experiments which are mobile phone network test, connecting time test, battery efficiency test and water and dust proof test to evaluate the efficiency of the proposed system.

According to the result of mobile phone network test, normally the frequency of 1800 MHz and 900 MHz of mobile signals cover all over Thailand. This experiment is to confirm that the proposed system can be used in Donyaihom district area, Nakhonpathom province, Thailand.

In connecting time test, the prototype has low connecting time that the average of connecting time shows 10.34 seconds. The standard deviation of the result obtained is 0.91. It is proved from several experiments that the prototype has stable connecting period.

For battery efficiency test, at the beginning of the experiment the lithium ion battery was used due to heavy weight and cannot lasts for one day hence, it was replaced with lithium polymer battery. The Lithium polymer battery is lightweight and long lasting than lithium ion battery. The result shows that the 2500 mA lithium polymer battery can standby for 23.6 hours averagely. The charging time is 6 hours approximately.

Finally, water and dust proof test are evaluated which show that the prototype is robust to water and dust. The result shows that the prototype can protect dust and spraying water. It is enough to use for elderly routine.

This prototype is cost effective and can work finely with low cost which averagely accounts to $3/month comparing with commercial device which is $34.00 – $45.99/month approximately [9, 10, 11, 12]. Therefore, every elderly people in Donyaihom district, Nakhonpathom province can use.

There are 2 limitations of this research which are low signal in elevator. Because of metal structure, most of the mobile signal can be reflexed according to the Faraday cage effect. Therefore, elderly cannot call for help when they are in elevator. The other limitation is no GPS function in this prototype. Elderly individual need to use

the device at their home / house network area. In the future, the prototype could be added with GPS enabled functions to track the elderly individuals.

8. CONCLUSION

This research develops a low-cost emergency network system for elderly living alone in Donyaihom district, Nakhonpathom province, Thailand. The elderly people who live alone can call for help when emergency / accident occurs. Novel Portable Distress-Signaling (PDS) device is been designed. There are 4 experiments to evaluate the efficiency of the proposed system which are mobile phone network test, connecting time test, battery efficiency test and water and dust proof test. The results show that the prototype can be used in every area in Donyaihom district, Thailand. It has low connecting time which is 10.34 seconds approximately. The battery of the prototype can standby all day long with 6 hours of charging time. Moreover, the prototype robust to water and dust with IP53.

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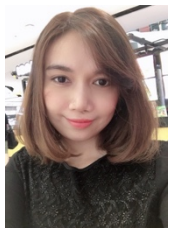
Navapadol Kittiamornkul was born in Pichit, Thailand in 1982. He received the B.Sci. in Applied Physics from King Mongkut's University of Technology Thonburi (KMUTT), Bangkok, Thailand in 2005, M.Eng. in Electrical and Information Engineering (international program) in 2006 and Ph.D. in Electrical and Computer Engineering in 2016 at the same university. Currently, he is a instructor at Christian university of Thailand. His interests include electromagnetic wave and non-destructive microwave inspection.



Mantana Watcharinrat was born in Nakhonratchasima, Thailand in 1987. She received the B.Sci. in Medical Sciences from Naresuan University, Phitsanulok, Thailand in 2010 and M.Sci. in Anatomy in 2013 from Mahidol University. Currently, she is the instructor of Innovation in Food Technology and Nutrition department at Christian university of Thailand. Her interests include human anatomy.

Watcharawit Saensupho received his B.Eng in Khon Kaen University, Khon Kean, Thailand, and He was also received M.Eng in Mahidol University, Bangkok, Thailand. He currently is instructor at department of Biomedical Engineering, Christian university of Thailand. His interests are related to Surgical Robot.