

The background features a large purple sphere with a white wireframe grid. A white drone with red lights is flying in front of it. Below the sphere, a robot head with a blue visor and a futuristic cityscape are visible.

# TECHNOLOGY TREND ANALYSIS of Robotics for Ageing Society

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## Objectives

This analysis report presents the analysis data and the situations relating to robotic technology, especially, robotics for ageing society which reflex the technology characteristic through the perspective of the International and Thai's patent database and by showing the trend of the said technology, the database of the main player (the patent applicant) and the trend or the characteristic of the present technology.

In which this analysis report includes the presentation of the database relating to the ageing society and the robotics technology, including the supply chain in order to present the overall perspective of the industry from the upstream level to the downstream level as a supporting data for conducting the technology analysis based on the patent data from this analysis report.

Further from the technology data and the patent perspective, this analysis report also expected to create awareness of the importance of the establishing the body of knowledge, the understanding and the uses of the patent database to reflex the industrial viewpoint in one form that the patent database could be adapted in several ways, including creating the awareness of the importance of Intellectual Property, especially, invention patent, petty patent (utility model) or design patent in the industry relating to building or developing new technologies.

## Executive Summary

Nowadays, the world is emerging in to an ageing society and several countries are aware of this condition and is preparing to enter the ageing society. Considering the fact that Thailand has completely enter into an ageing society, as a result it causes 2 impacts which are the reduction of the Thai populations causing the lack of worker in the many fields and in the other hand the elderly population is increasing whereas the medical professionals is not sufficient to care for these elderly people. Additionally, with the changing of the society making many elderly lacks caregiver causing direct effect to the wellbeing of the elderly and the increase of the elderly also effect the medical cost at the national scale for the cost to replace the insufficient medical professionals and the related medical procedure. Robotics technology is therefore one main alternative to cope with the ageing society.

Further from using the robotics technology as a replacement for human labour, robot is also a main part that is used in assisting elderly in the daily routine, as well as adapting to be use in the medical field to support the increasing elderly number. From the study of the international patent database, it shows that the number of patent applications related to robotics for ageing society in the past 10 years is total of 856 applications in which China having filed the most patent applications, follow by Korea and Japan respectively. The main players or the organization that has filed for patent applications in this group of technology, is also organizations from the 3 countries as mentioned above. This analysis has found that most patent applications are inventions related to caregiving robot, robotic arm and the main technology that is mostly used in the development of robotics for ageing society is the communication system. Patents that are in the 3 technology groups as mentioned above altogether is 66% of the total amount of patents related to robotics for the ageing society.

The amount of patent related to robotics for the ageing society in Thailand still have a very low number of inventions in this field however it still has the tendency to grow in the

future. However, the main factor that increase the patent application number is from the patent application filed by a private sector from international applicant through the national phase of the PCT application which is up to 69% whereas the nationality that have the most patent application is Japan, European union, United States of America, South Korea and Germany respectively. However, the total number of the patent applications related to robotics for ageing society in Thailand still have the proportion of the patent application from International applicant and Thai applicant have a very similar ratio.

Considering the technology features, it has shown that the international applicant has applied for patent for robot relating to robot in the form of personal service robot such as cleaning robot , robot for practice or entertainment including robot arm, whereas the patent relating to robot for the ageing society in Thailand is usually robot relating to rehabilitation and physical therapy, robot for mobility and transferring for elderly or patient, including robots for operation as well, in which all these technology features is different from the patent applied by international applicant.

Form the study, Thailand has very few patent applications, especially by the private sector, mostly the patent was mainly applied by the government sector and the educational Institute in which these technologies is highly complicated and it is relating to a robot for the use of a professional or skillful person that have a high sell value in the market. Therefore, making awareness and boosting of the technology collaboration between the government sector and the education institute to become a business venture or collaborating with the private sector should be given emphasis on. Further, promoting the technology development activity for the private sector needs to be done urgently to be able to countermeasures the large-scale incoming of patents from private sector international applicant which strongly affect the overall perspective of the country technology.

## Patent as Indicators of research performance

Patent can be used as an index indicator of the research and development (R&D) result (Griliches, 1998). Furthermore, the patent data and the patent reference ratio have a great impact on the market value (Hall, 2005) in which the patent is a certificate which certified that the product, method is novel, having an inventive step and is industrial applicable. Patent also give an exclusive right to the patent applicant to have the exclusive right to produce, use, sell, or import the product or product formed by the procedure in accordance with the patent for a certain time frame.

Patent also contains the useful information which is available for the public such as the International Patent Classification: IPC, applicant information, inventor information, the reference documents that is the foundation of the invention development (Background of the invention). Therefore, the patent data analysis by using the credible researched data for analyzing the patent data such as the inventor, the technology group, the countries that have filed for patent protection, the countries that have a patent publication through a patent search engine along with the expert advice, these factors could help us have a perspective of the essential patent activity including the scope of the invention, the collaboration between the government sector and the company, and the numbers of the patent filed.

The publicized patent specification needs to be an information concerning innovations that is industrial applicable and is a tangible innovation. As for the intangible innovation, it is hardly founded such as a creative work concerning art and appreciation, computer program or business model (WIPO, 2018).

The patent data analysis is categorized by the group of industries which the vision that is clear and familiar is not usually could be done due to the restriction of the patent information as follows:

1. One innovation is a combination of different technologies, however, the patent data is categorized into group by the technology filed in the other we cannot search the innovation

group that is composed of various technologies directly by using the International Patent Classification: IPC code for example in the cloud funding system or the distance learning system because in these innovations comprises of various technologies such as the network technology, the data input technology or the data display technology these depend on the inventors that what have they been developing the innovation in to which filed. For some instance, when the inventor solely develops the display technology for the long-distance medical technology, for this instance, this invention could be categorized in to the same group as the group concerning the broad casting for the gaming technology. For the above example, categorizing the display technologies is quite difficult.

2. The terms used in patent specification is the term that not a layman term that could be understood by most people, but it is a description of the feature or the uses for example when searching for an invention regarding “a chair” by using the search term “chair” all inventions relating to chairs would not show up due to the patent’s descriptions. The patent applicant or the patent agent will use a broad description for that certain patent, such “an instrument for sitting purpose” or “receiving plate” for example, in order to broaden the protection scope and to avoid being found by simple patent searching. For the mentioned reason making patent searching for analyzing purpose by using a search term only would not give sufficient and complete output data.

With this specific characteristic and limitation of patent as mentioned above making patent searching, technology grouping and patent data analyzing resulted in a different data results and different perspectives on the analysis report comparing to other technology analysis report, such as market analysis report and scientific experiments report for example, however this data still helps business entrepreneur or business executive to have some information to help making better decision and to have a better business strategy (T., 2015)

## Definitions

### 1. Definition of robot

Robot has a variety of external appearance and applications, meaning that there are also a variety of the definition of robot. The Dictionary of the Office of the Royal Society, Version 2011 has defined that the robots are a model comprising mechanism for performing many tasks as a substitution for humans. Even though the meaning is specified in such manner, many publications and reports still use different definition of robot. According to the analysis of technology trends and industry of industrial robot by the Chulalongkorn University Intellectual Property Institute, robots are defined as a mechanically controlled machines that is structured and works like a human and good at repetitive, complex, and intolerable work conditions (Chulalongkorn University Intellectual Property Institute, 2017). The report on "Thailand's robotic industry" by NSTDA Policy Research department has compared robot with automation and mentioned that robots have elements and functions similar to "automation", but robots can work with decision-making programs and modifiable with a variety of functions, where automation cannot. In addition to the definition of robots, the classification of robots can also be classified into various types according to robotic types, features, or the level of use of the robot. (Policy Research: PRS - NSTDA)

With the wide variety of robots defined, patent analysis in such industries is complex because the wording that appears in the patent may not indicate the word robot directly, or patents may be only some parts or systems of the robot. Moreover, the International Patent Classification is not possible to identify robotic inventions in a clear category because robots are used in a variety of purposes. The patent application filed to seek a protection in many aspects and may integrate a variety of technologies into a single invention. This making screening of related patents is more difficult, for instance, robot can be either a vending machine or a washing machine. However, robotic or complex machine is still vague and difficult to classify.

To separate robot from complex machine, robots should be able to respond to their environment to complete the task and be aware of when the work is completed (Lifewire, 2018). This report examines patents and defines robots in the same way as Medical Robotics Technology Development Roadmap for the Center for Advances Medical Robotics, Thailand Center of Excellence for Life Science (TCELS) (Thailand Center of Excellence for Life Sciences (TCELS), 2015). That has defined robot as "However, there is no clear definition of a robot that is universally acceptable, and there is no approval on what qualifies as a robot. According to the father of industrial robots, Joseph Engelberger said, "I cannot define a robot, but I know one when I see one." The most commonly accepted concept is that robots should have three basic components: sensing, actuation, and cognition, and should have one or more abilities." This is close to the interview of Asst. Prof. Thavida Maneewan, Ph.d from the Institute of Field Robotics (FIBO), King Mongkut's University of Technology Thonburi in the Electronic Journals, which mentioned that robot composed of three components, perception; action/actuation; and processing, decision, or response to the environment. (Institute for Scientific and Technological Research and Services (ISTRS), 2016)

This report examines and analyses only the invention comprise the three components, perception, action, decision and response. It also includes devices that are highly compatible with those components.

## 2. Definition of ageing society

The United Nations (UN) has defined and divided the ageing society by its characteristics into 3 levels as follows (Sukhothai Thammathirat open University, 2014)

- 1) Ageing Society means a society or country with a population aged 60 years or over more than 10% of the population or with a population aged 65 or over 7% of the population.

- 2) Aged Society means a society or country with a population over 60 years or over more than 20% of the population or with a population aged 65 or over 14% of the population.
- 3) Super-aged Society means a society or country with a population aged 65 years or over more than 20% of the population.

Currently, world population aged 65 years or over are accounted for 8.5% of the population and expected to reach 17% in 2050. In Japan, the elderly population aged 65 or over is accounted for 26% (Sukhothai Thammathirat open University, 2014). Overall, every country tends to enter the ageing society, particularly in Asian countries. For instance, Japan is facing the social situations of the elderly due to its declining of emerging population which means Japan is entering aged society faster than other country. In 2013, the World Health Organization (WHO) and the United Nations (UN) categorised Japan as a Super-aged Society, which has a population aged 65 or more over 21% and hit a record of the lowest birth rate of all time and a declining population trend. (Asia Insurance Review, 2017)

## Ageing society in Thailand

Thailand is another country facing population ageing. According to the World Bank report, or the International Bank for Reconstruction and Development, Thailand is entering the ageing society faster than other ASEAN countries. By 2016, 11% of the Thai population or nearly 7.5 million people are aged 65 or over. By the year 2040, the Thai population aged 65 years or over will be up to 17 million people (World Bank Group, 2016). In addition, according to the Thai Health Promotion Foundation report, Thailand has the numbers of the elderly accounted for over one fifth of the population which more than its child population in 2018, which means Thailand is entering fully aged society (Thaipost, 2017). Likewise, according to the National Statistical Office report, in 2021, Thailand will have a population aged 60 years or over with a proportion of 20% and will be raised up to 28% in 2031 (Thairath, 2018). Furthermore, the Thai Elderly's Development Foundation predicted that by 2030 Thailand will have an elderly population of 17.6 million or 26.3%. By 2040, the number of elderly people will reach 20.5 million, or 32.1%. According to all the reports, it can sum up that Thailand has entered the fully aged society. (Foundation For Older Persons' Development, 2015)

The ageing society affects the characteristics of the population in two main parts, the decline of the emerging population and the increase in the numbers of elderly people, as shown in Figure 1 Young Children and Older People as a Percentage of Global (United Nations, 2010).

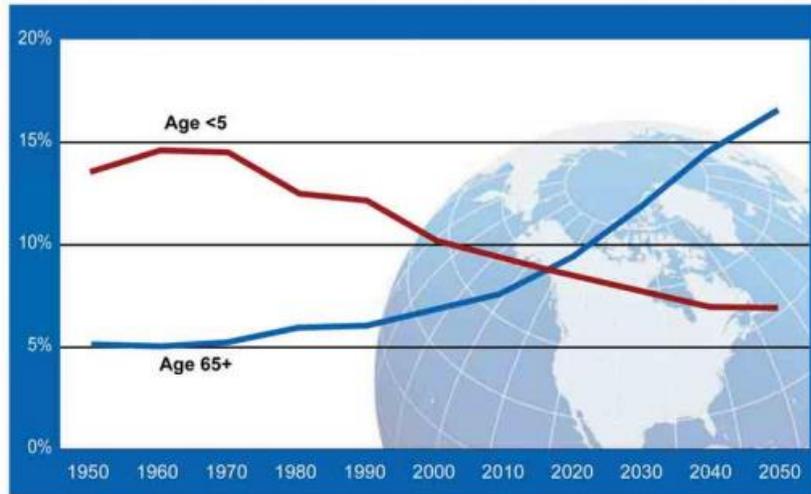


Figure 1 Young Children and Older People as a Percentage of Global

The population shortage has resulted in an insufficiency of workers in various fields. The Journal of Substance Industry discusses the current situation of the relationship of the elderly and robotics that Thailand is entering the aged society and facing the shortage of workers in the future, causing the industrial sectors to involve more automation to replace the workers who started to reduce. Due to the decline of the population, the development of robotics, automation and artificial intelligence are becoming more and more important to solve the problems in the industrial sector and labor scarcity. (Department of Industrial Promotion, 2018)

The increase of the aged population has resulted in many perspectives including the inadequate support of medical system in many countries. This includes the shortage of medical professionals, medical equipment, and personal care professionals for the elderly. In a more isolated society, caregiving is much more difficult as many older people often have health or lifestyle problems in many aspects of their lives. With social conditions, technology, and demographic factors have contributed to many problems related to the quality of life for the elderly.

## **Role of robotics in the ageing society**

Using robots in the industrial sector helps in lower industrial costs, establish standards, and precision in production. It also increases efficiency and speed in the production lines. The use of robots can also help with the labour scarcity and population shortages. But about the aged population increase, robots also play a role in many aspects including service robots, medical or rehabilitation robot to provide care for those elderly population and to address the issue of inadequate number of medical personnel. Additionally, robots can provide personal assistance in various forms, such as cleaning robots, robots for moving older people, robot for entertainment activities to interact with the elderly or to help the elderly to do some simple activities. Both medical robots and robots for general activities will greatly contribute to the quality of life for the elderly. This report focuses on robotic technology for the elderly, especially in the field of robotics for accommodating the elderly population and contributing to the improvement of the quality of life for the elderly in various fields.

## Supply chain of the robotics for ageing society industry

The supply chain of the robotic industry, especially robots for the elderly, consists of: upstream businesses, material suppliers, component and machinery manufacturers, and system integrators, such as programmers and engineers; mid-stream business, such as distributors, hospitals, retailers and department stores; downstream businesses are consumers, including the elderly, elderly caregivers, healthcare providers, and other industrial users.

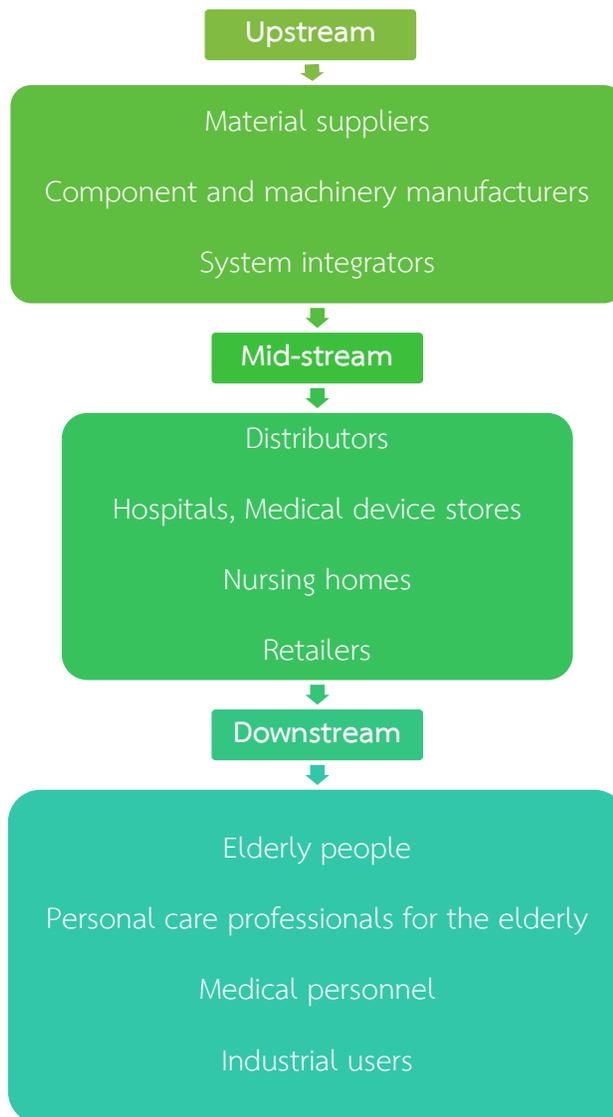


Figure 2 Supply chain of robotics for ageing society industry

The upstream business of robotic technology for the elderly industry is the supplier of materials for robotic parts, robotic systems such as circuit boards, electrical systems, mechanical systems or even material of the robot body. Some of these materials is required to be a medical grade to meet the standard for medical equipment for the safety of users. Subsequently, these materials will be used by component and machine manufacturers to form robot parts such as motors, rotor, circuit boards and so on. In addition, there are system integrators, such as engineers to assemble all the parts into a certain robot, working along with programmers to create a complete robot system.

Mid-stream businesses are distributors or dealers of each business who play a role mainly in distribution of goods from the factory to the hospitals, medical equipment stores, nursing homes and department stores to distribute the product to the user. In some cases, this mid-stream business is also a user, such as hospitals and nursing homes, where they can see robot to provides information and entertainment or even used in physical therapy for the elderly or patients, etc. Department stores and other retailers play a role in suppling service robots for household conveniences such as caregiving robot.

Downstream is the household consumer including the elderly, elderly caregiver, and other medical personnel, whose purpose is to use the robot technology to solve problems of the elderly society such as caregiving robots, exoskeleton to helps the elderly to move their own self. The industrial user is the user who use the robot or the parts to develop or in business, which can help reduce the problems and the impact of ageing society, such as the use of robots to the industry to replace the shortage of labor.

## Overview of patent related to robotics for ageing society

### 1. Overview of international patent related to robotics for ageing society

#### 1.1 Technology trend of robotics for ageing society

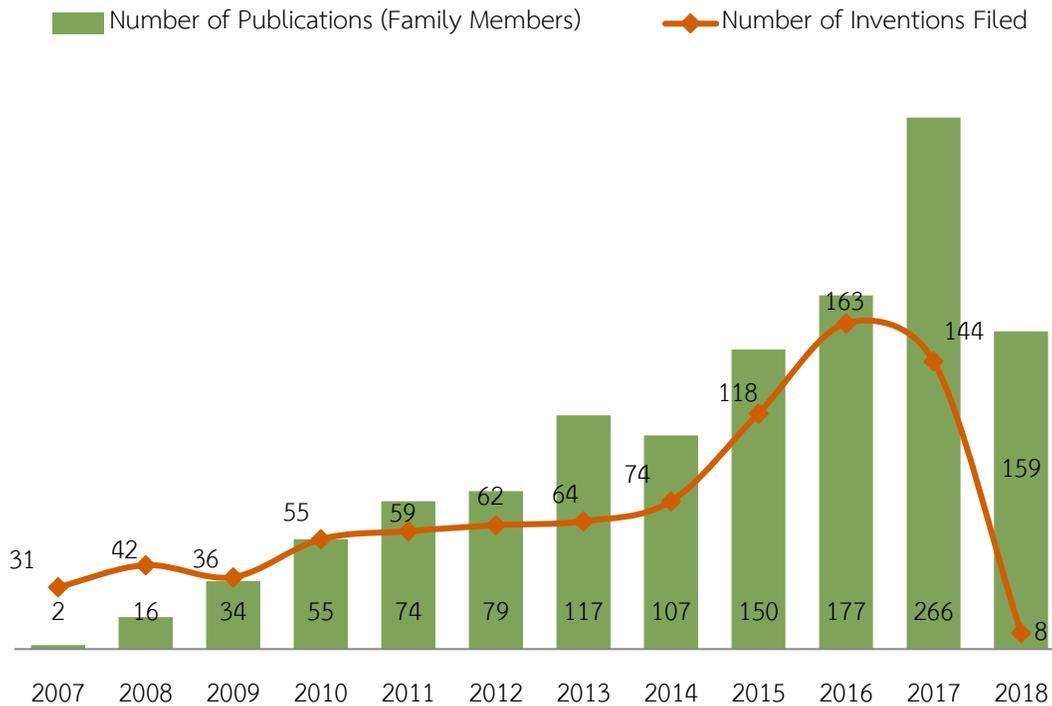


Figure 3 Number of publications and number of inventions filed related to robotics for ageing society

Figure 3 Number of publications and number of inventions filed related to robotics for ageing society shows the number of publications in comparison with the number of inventions related to robotics technology for elderly people filed between 2007 and 2018. Those number of the publication is grouped into the number of patent families. Patent family is a group of patents taken in various countries to protect only a single invention. So, this number can reflect the actual number of the invention that has been created and do not count the same invention that filed in the different jurisdictions. Whereas the numbers of publication are a count of the number of patent applications that have been published after the submission of the application to the individual country authorities, which demonstrates that the invention of each patent

family has the potential to be commercialised. However, the numbers of publication may be attributed to the preceding year, due to the time period after the filing of the patent application which may take at least 12 months. Noted that the data for 2560 - 2561 has not completed because the information has not fully disclosed.

According to Figure 3 Number of publications and number of inventions filed related to robotics for ageing society, it can be seen that the number of patents related to robotics technology for elderly people has significantly increased in the last 10 years. From only 2 published patents in 2007 to 1,236 accumulative published patents in 2018 (data retrieved in August 2018). Of which increase more than 618 times during the last 10 years. This rapid growth shows the very high demand of this technology in the existing market, to fulfil the need of ageing society. In 2017, the number of elderly people whose aged 60 years or over is accounted for 862 million people globally, or 13% of the world population. While the number of older people aged 80 years or over has raised to 137 million people in 2017 and will reach the number of 400 million people in the next 30 years according to the data from the United Nations.

## 1.2 Technological Profile

Patent collection for this patent analytics has been divided into technical categories as the following groups

### 1) Categorised by robot types

- a. Exoskeleton: this technical category includes those patents which discloses exoskeleton or exosuits to support the subjects (elderly people or handicapped persons) and help in their movement/walking.
- b. Mobility: this technical category includes those patents which discloses robots other than exoskeletons to help in movement of the subject from one place to other.
- c. Robotic arm: this technical category includes those patents which discloses robotic arms that helps the subject perform day to day activities.
- d. Caregiving robot: this technical category includes those patents which discloses robots that can perform caregiving activities to the elderly people e.g. massage, shaving, hair drying, home cleaning etc.

### 2) Categorised by robot features

- a. Artificial intelligent: this technical category includes those patents which discloses robots enabled with artificial intelligence capabilities/functionality.
- b. Health monitoring: this technical category includes those patents which discloses robots that can monitor health parameters of the elderly people and remind users to take their medication.
- c. Motion monitoring: this technical category includes those patents which discloses robots equipped with technology to track location of the subject.
- d. Infotainment: this technical category includes those patents which discloses robots with screens or audio/visual means for infotainment purposes.

- e. Telepresence: this technical category includes those patents which discloses robots equipped with telepresence features.
- f. Communication: this technical category includes those patents which discloses robots which are equipped with general means of communication e.g. wireless, Bluetooth, wired communication, NFC, Wi-Fi, emergency calling etc.
- g. Miscellaneous: this technical category includes those patents which discloses robots for assisting elderly people, patients, handicapped etc. which are relevant to the domain but could not be categorised in any of the above technical categories due to different features and/or services provided by them.

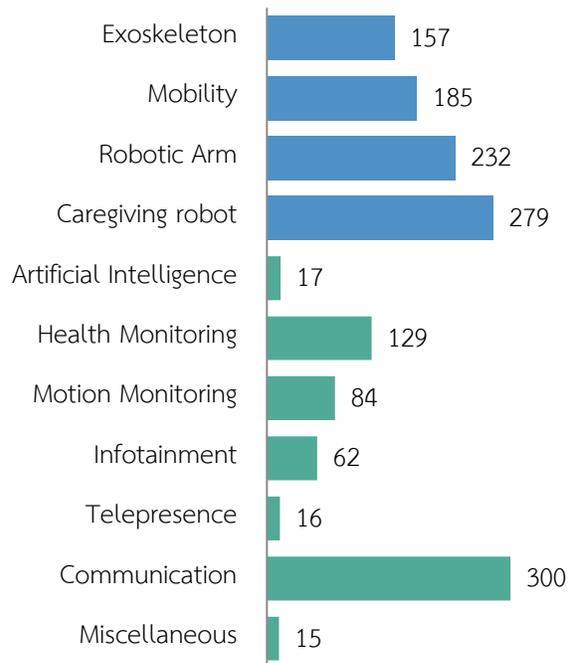


Figure 4 Number of inventions per technical category

Total of 856 inventions related to robotics technology for elderly people have been collected and sorted into technical categories as shown in Figure 4 Number of inventions per technical category. However, each invention might have been sorted into more than one category due to its various forms or features.

As shown in Figure 4 Number of inventions per technical category, the top 3 technical categories that hold the most number of patents are communication, caregiving robot, and robotics arms, of which have total of 300, 279 and 232 patents respectively. Total number of inventions of these top 3 categories is accounted for 567 patents or 66% of total number of patents related to robotics technology for elderly people.

Considering categories by robot types, caregiving robot and robotic arm are the most robot types that have been developed and filed patents. The number of patents related to caregiving robot is 279 patents, which accounted for 32.5% of total number of patents related to robotics technology for elderly people. While, the number of patents related to robotic arm is 232 patents, which accounted for 27% of total number of patents related to robotics technology for elderly people. Considering categories by robot features, communication and health monitoring are the most robot features that have been developed along with the robotic technology for elderly people. The amount of the patent related to communication and health monitoring features are accounted for 35% and 15% of total number of patents related to robotics technology for elderly people.

### 1.3 Technological trend of technical categories

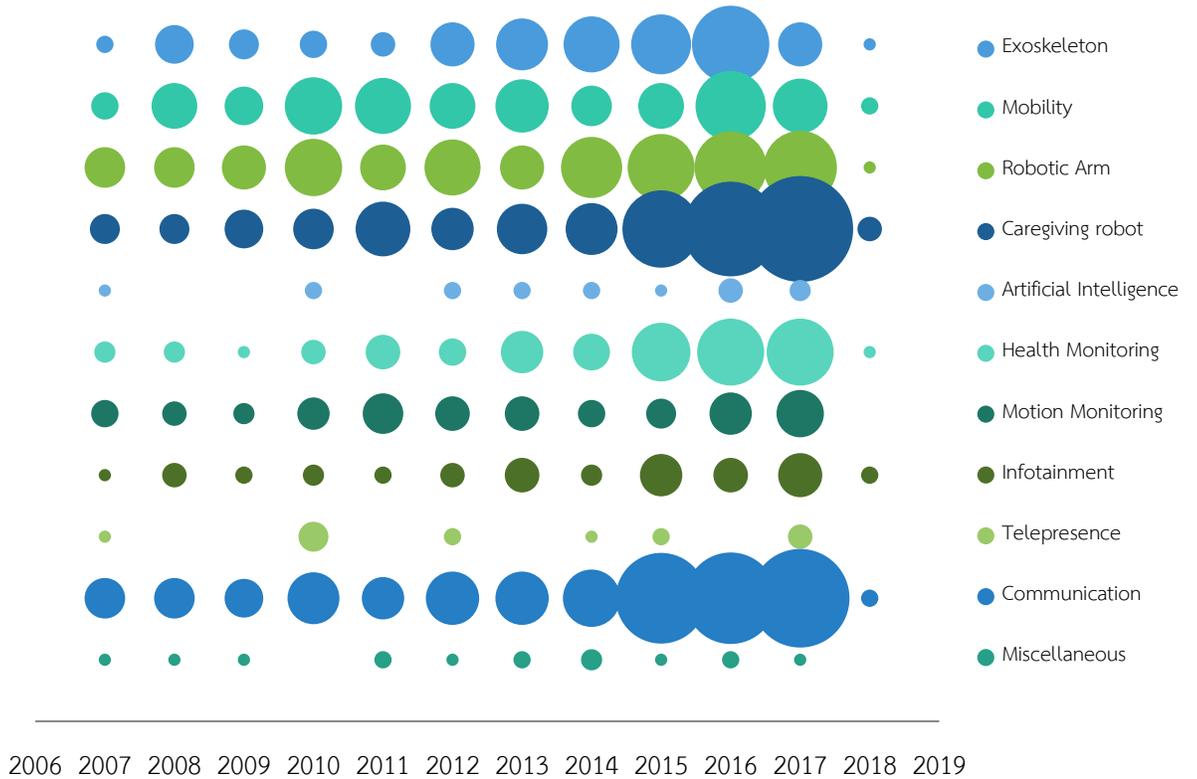


Figure 5 Timeline of activity per technical category between 2007 and 2018

Figure 5 Timeline of activity per technical category between 2007 and 2018 shows the number of patents related to robotic technology for elderly people of each technical category breaking up into yearly number. Overall it can be seen that the number of every robot type including exoskeleton, mobility, robotic arm, and caregiving robot have been rising during the past 10 years. The topic of robotic arm and caregiving robot have been growing significantly during the past 4 years, since 2015.

When consider those growing number of patents in terms of Compound Annual Growth Rate or CAGR as shown in Figure 6 Compound Annual Growth Rate, CAGR between 2012 and 2016 of patents related to robotic technology for elderly people, it can be seen that caregiving

robot has the highest CAGR among all robot types, at 71% during 2012 to 2016. While, among all robot features, the health monitoring feature has the highest growth at 82% CAGR.

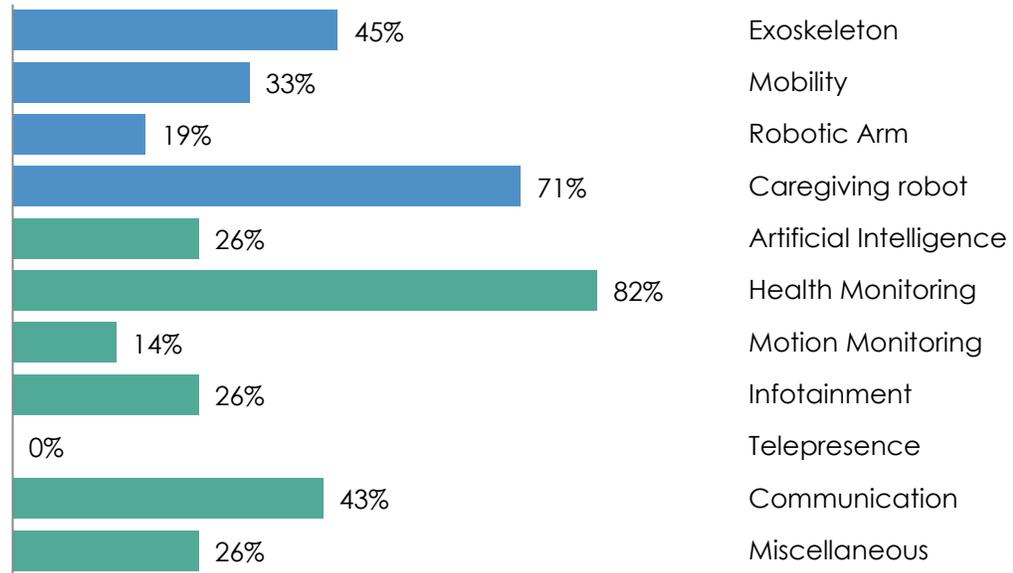


Figure 6 Compound Annual Growth Rate, CAGR between 2012 and 2016 of patents related to robotic technology for elderly people

However, it can be noticed that the group of robots with a telepresence feature has 0% CAGR during 2012- 2016. This might be the reason from limited research and development of this particular technology that can be integrated into robotic technology. Additionally, the robot with a telepresence feature might have a limitation or difficulty in developing and integration with robots for the elderly to solve very special problems such as the use of robot in the limited area with many obstacles or other complex situations while working with the elderly.

## 1.4 Market demand

In 2017, the United Nation has reported that the number of elderly people whose aged 60 years or over is accounted for 862 million people globally, or 13% of the world population and this number is still growing at approximately 3% per year. This rapid growth of number of ageing population lead to the labour shortage especially in medical and nursing professionals. This situation causes the increasing demand of not only nursing professionals, but also the robot designed for taking care of elderly people. However, robot cannot totally replace human caregiver, but they can assist with power, save time and human labour for taking care of old people. Currently, the number of robots designed for elderly people is still low comparing with robot for other purposes such as medical robotics, construction robotics, recue robot and so on.

Table 1 Number of persons aged 60 years or over by region, in 2017 and 2050

	Number of elderly people in 2017 (million people)	Number of elderly people in 2050 (million people)	Percentage-change between 2017 and 2050
World	962.3	2080.5	116.2
Africa	68.7	225.8	228.5
Asia	549.2	1273.2	131.8
Europe	183.0	247.2	35.1
Northern America	78.4	122.8	56.7
Latin America and the Caribbean	76.0	198.2	160.7
Oceania	6.9	13.3	92.6

Patent information can indicate the commercial usability of an invention or research. Study of patent information are useful in studying the patent strategy, and the markets due to filing a patent for invention in one jurisdiction shows that the country is a high value market.

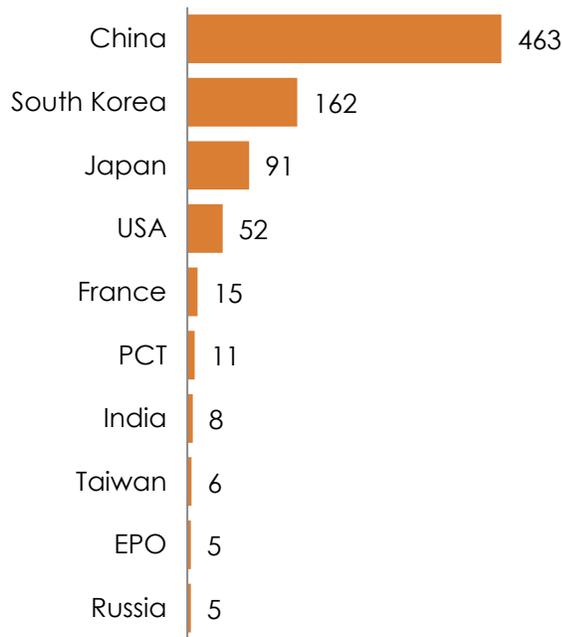


Figure 7 Number of inventions for top 10 first filing locations

As shown in Figure 7 Number of inventions for top 10 first filing locations, top 10 first filing jurisdictions of patent related to robotic technology for elderly people are China, South Korea, Japan, the USA, France, PCT route, India, Taiwan, European Patent Office or EPO, and Russia. It can be noticed that the top 3 first filing locations are all Asian countries, which are China, South Korea, and Japan. This result corresponds with the ageing population shown in Table 1 Number of persons aged 60 years or over by region, in 2017 and 2050, which shows that Asia has the highest number of elderly people aged 60 years or over at 549.2 million people in 2017 and it will increase by more than 130% to 1273.2 million people in 2050. This data demonstrates the needs of the elderly market. Not only robots for the elderly, but other inventions can fulfil the needs of the elderly society.

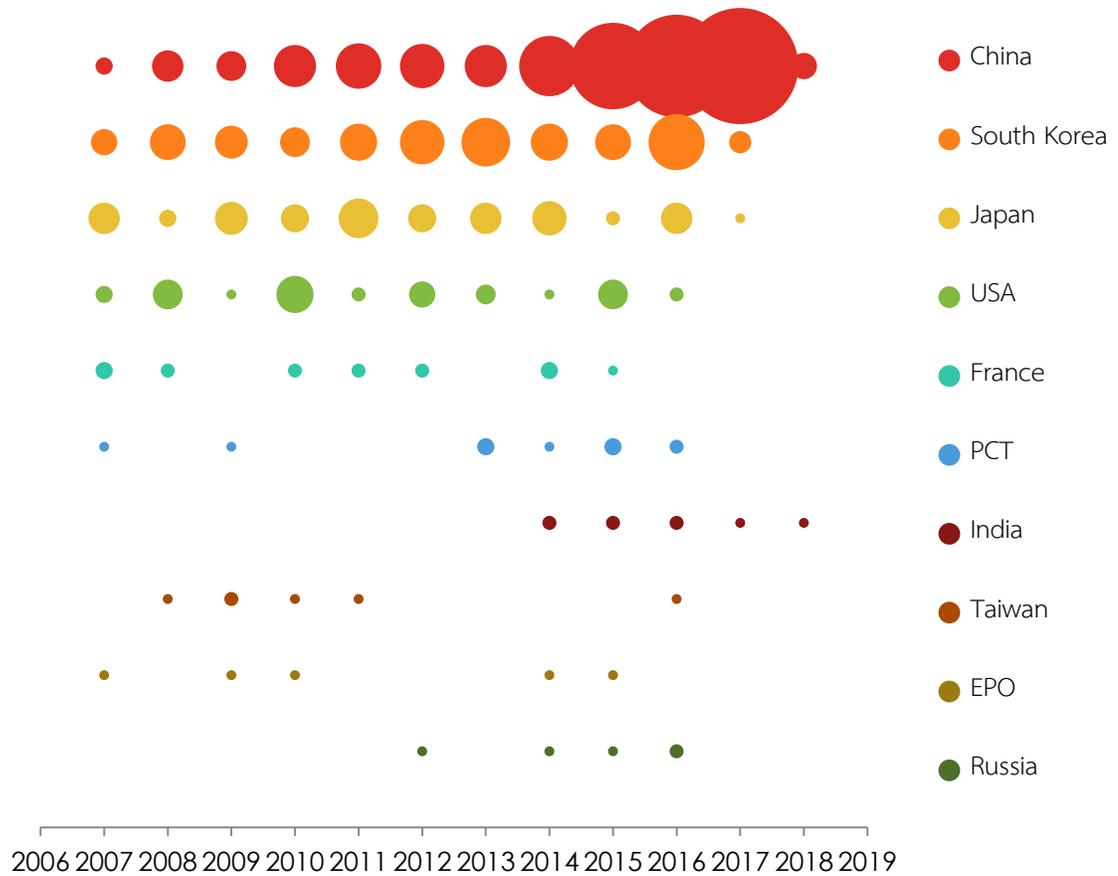


Figure 8 Timeline of activity for top 10 first filing locations, during 2007 to 2018

As shown in Figure 8 Timeline of activity for top 10 first filing locations, during 2007 to 2018, it can be seen that the patent filing rate of robotic technology for elderly people in China has outstandingly grown in the past 5 years or since 2014. While, the number of South Korea and Japan seem more stable during the past 10 years, at average filing rate of 14 and 8 patents per year respectively. During the same time that other jurisdictions have filed relatively smaller amount of patent of this technology, average of 2 patents per year.

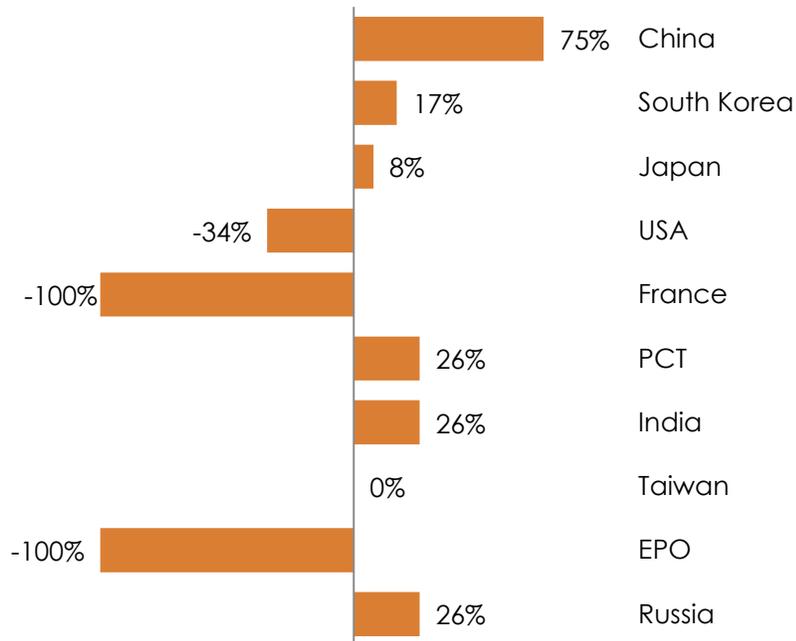


Figure 9 Compound Annual Growth/Decline Rate during 2012 -2016 of number of patents in first filing locations

According to the timeline of patent activity in top jurisdictions earlier, it can be determined the actual growth or decline rate as shown in Figure 9 Compound Annual Growth/Decline Rate during 2012 -2016 of number of patents in first filing locations. China has the highest growth rate among all the countries at 75% growth. While, The PCT route, India, and Russia have quite small number of filed patent but the expansion is accounted for 26%. The USA has faced the declining state of patent filing with a collapsing rate of -34% CAGR. However, France, Taiwan, and European Patent Office or EPO received only 1-2 patent applications related to robotics for ageing society per year, which means any change of these numbers can cause -100% CAGR.

## 1.5 Key players

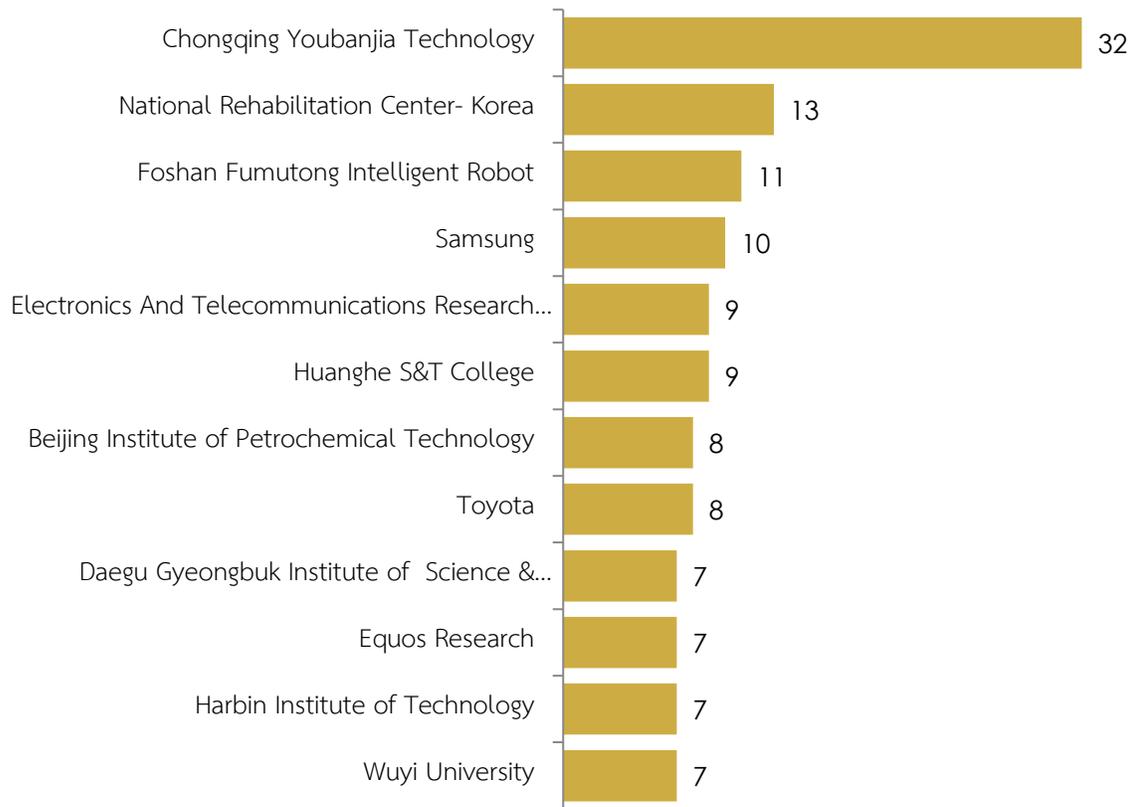


Figure 10 Number of inventions related to robotic technology for elderly people for top applicants

As shown in Figure 10 Number of inventions related to robotic technology for elderly people for top applicants, the top applicant who filed the most patents related to robotics for ageing society is Chongqing Youbanjia Technology from China, who filed total of 32 patents in the past 10 years. Following by National Rehabilitation Center from South Korea and Foshan Fumutong Intelligent Robot from China, who filed 13 and 11 patents respectively. It can be noted that all top 12 applicants are from Asia, which are China, South Korea, and Japan. Total of 6 applicants are from China, which are Chongqing Youbanjia Technology, Foshan Fumutong Intelligent Robot, Huanghe S&T College (or Huanghe Science and Technology College), Beijing Institute of Petrochemical Technology, Harbin Institute of Technology, and Wuyi University. Only

Chongqing Youbanjia Technology and Foshan Fumutong Intelligent Robot are private companies, while the rest are government research institutes and universities. Total of 4 applicants or 33% of them are from South Korea, which are National Rehabilitation Center, Samsung, Electronics and Telecommunications Research Institute, and Daegu Gyeongbuk Institute of Science and Technology. Samsung is the only one from business sector. While, National Rehabilitation Center and Electronics and Telecommunications Research Institute are the government-funded research institutes. Other than that, Toyota and Equos Research Co. Ltd represent the business sector from Japan.

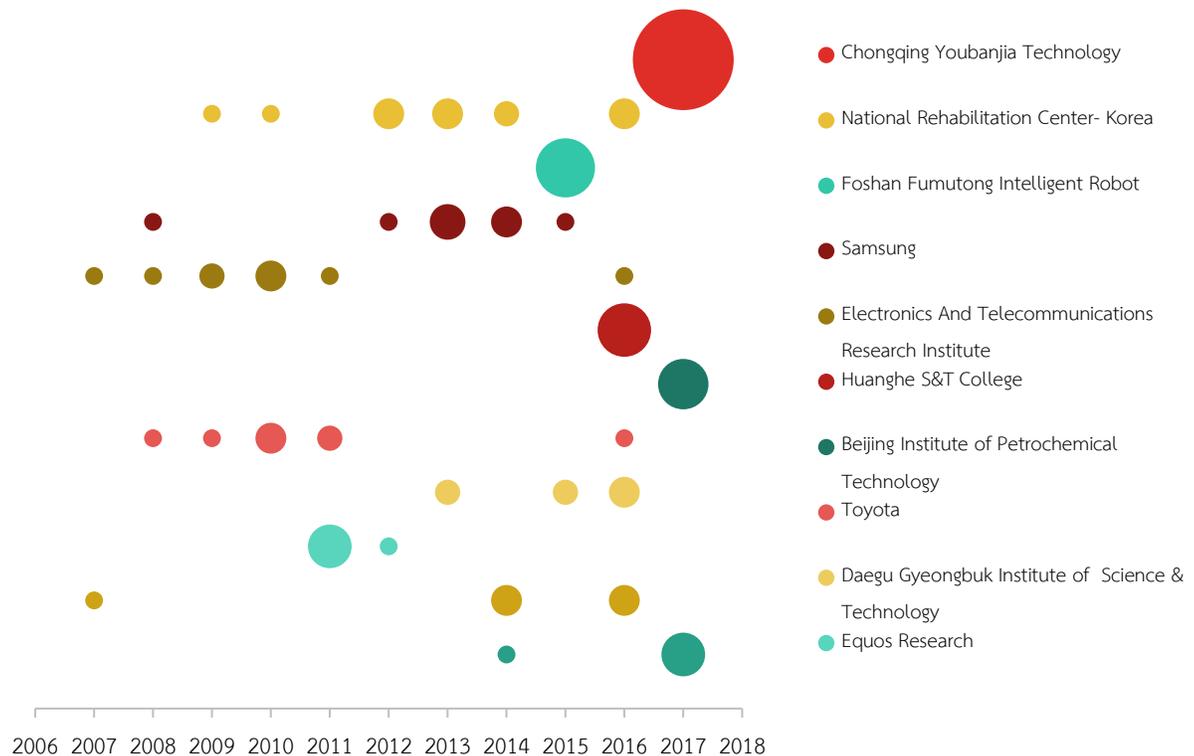


Figure 11 Timeline activity of top applicants during 2007 to 2018

As shown in Figure 11 Timeline activity of top applicants during 2007 to 2018, Chongqing Youbanjia Technology, the No. 1 player, has filed patent applications for robots for the elderly in 2017 only. Likewise, the third ranked player Foshan Fumutong Intelligent Robot from the China also filed patent application for robots for the elderly in 2015 one year only as well.

Considering the patenting trend of the major players, as shown in Figure 11 Timeline activity of top applicants during 2007 to 2018, it was found that most of the major players had filed patents on robots for the elderly irregularly. There are only four companies that have filed patents in this technology for at least five years, which are National Rehabilitation Center, Samsung, Electronics and Telecommunications Research Institute, and Toyota. This shows continued efforts in the development of this technology in this group of players. It can be noticed that these agencies are from the Republic of Korea and Japan. In addition, other major players have filed patents related to robots for the elderly for no more than 3 years in the past 10 years.

#### 1.5.1 Technological profile of the key players

Chongqing Youbanjia Technology is a tech company located in Chongqing Internet Industrial Park, Chongqing, south western of China.

The National Rehabilitation Center (NRN) is a research unit of Ministry of Health and Welfare, South Korea. The National Rehabilitation Center comprises of Rehabilitation Hospital and National Rehabilitation Research Institute (KNRRI), the main research center in the field of physical therapy in South Korea. This institute is the first government research institute specialised in developing policy for people with disabilities. While, the National Rehabilitation Research Institute (KNRRI) is focusing on rehabilitative and assistive technology research to improve the quality of life for the disabled including robotic technology, robotic arms and legs for physical therapy purpose.

Foshan Fumutong Intelligent Robot is a subsidiary of Shenzhen Shengshengtong Voice Technology Co., Ltd., the middle size private company specialised in voice activated control technology. This company located in Nanshan District, Shenzhen, China. Before 2008, this company use the name of Beijing Ziguang Youlan Robotics Co., Ltd.

### 1.5.2 Main technology of the key players

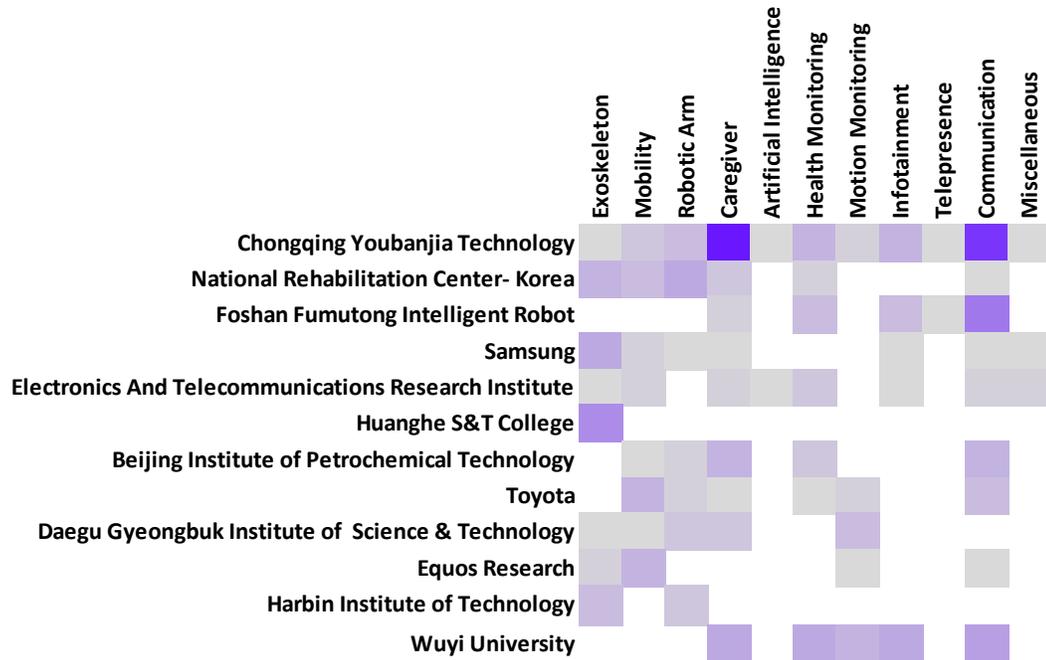


Figure 12 Analysis of top patent applicants broken down by technical sector

As show in Figure 12 Analysis of top patent applicants broken down by technical sector, it can be seen that Chongqing Youbanjia Technology from China filed patents related to robotics for ageing society mainly associated with caregiving robot and communication technology. In addition, this company also focus on development of mobility, robotic arm, and integration of health monitoring, and infotainment technology in the robot for the elderly. Youbanjia focuses on developing robots to address the shortage of caregivers for the elderly by developing a humanoid robot. For example, a robot called Youban was developed to help check the general health of the elderly in the hospital. This robot can detect blood pressure, blood sugar level, and heart rate then send the data to the network to process and collect data. The robot can also be a companion to the elderly, it can tell stories, sing songs, read poems, remind the elderly to take medication on time, alert time to have a health check, make a phone call, and video call on large display. This robot can facilitate the elderly who cannot use the cell phone.

The robot can communicate with the elderly through local voice commands. In 2017, Youban robots were introduced to nursing home in the Liangjiang New Area, where can reduce the number of personal care professionals for the elderly to only 3 people per 200 elderly.

National Rehabilitation Center from South Korea have filed patent related to robotics for ageing society mainly associated with exoskeleton, robotic arms, and mobility. Additionally, this company also focus in developing health monitoring and communication technology integrated with the robotic technology.

While, Foshan Fumutong Intelligent Robot from China have filed patent related to robotics for ageing society in terms of caregiving robot only, which is integrated with the communication, health monitoring, and infotainment technology.

### 1.5.3 Technology trend

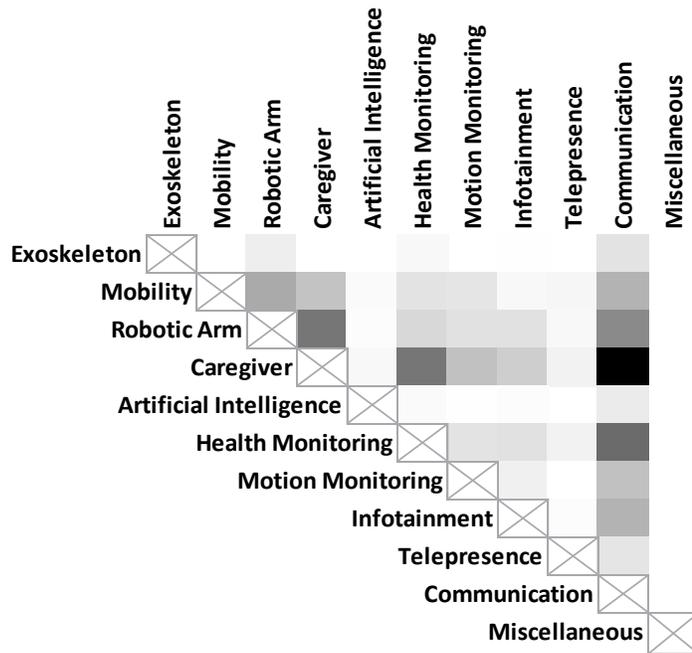


Figure 13 Analysis of overlap between technical sector

Each invention may comprise more than one technical function or feature. As shown in Figure 13 Analysis of overlap between technical sector, many technical sectors have been

developed and used mutually. Overall it can be seen that technology of communication system was developed along with the robotics for ageing society the most. It was also used with the health monitoring technology to develop a caregiving robot. Considering with the previous topic, 1.2 Technological Profile, it can be noticed that the communication technology has been disclosed in more than 35% of patent related to robotics for ageing society. This shows the necessity of communication system to the development of the robotic technology especially for the elderly. In the caregiving robot, the integration of the communication system into the robot can fulfil the need of the elderly, who want to contact with the caregiver personnel, family, or even doctor. Considering in the broader perspective, every single robot needs to transfer and transmit data between system to perform any specific function.

However, it can be noted that not many artificial intelligence technology and telepresence technology have not been integrated with the robots for the elderly yet. This can be the market gap where the researcher can improve this technological area and invest in the market.

#### 1.5.4 Filing locations

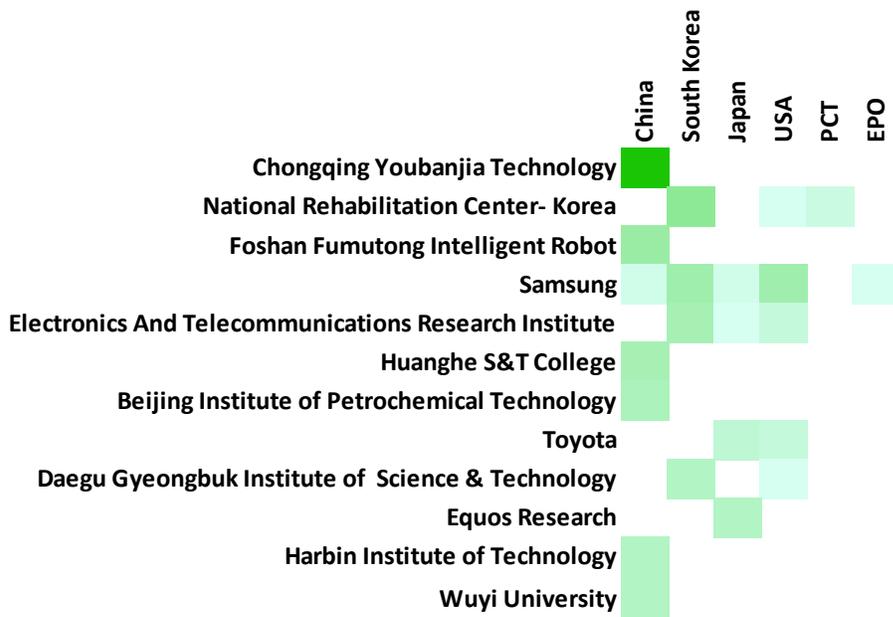


Figure 14 Analysis of top applicants broken down by filing locations

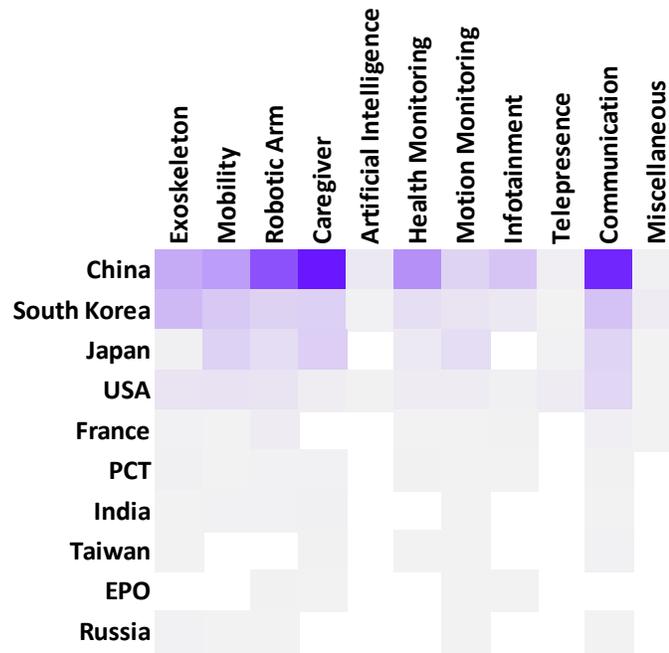


Figure 15 Analysis of first filing locations broken down by technology sector

Study of filing location of the applicants can help understand the protection strategy of each company as shown in Figure 14 Analysis of top applicants broken down by filing locations. Overall, it can be seen that every Chinese company, Chongqing Youbanjia Technology, Foshan Fumutong Intelligent Robot, Huanghe S&T College (or Huanghe Science and Technology College), Beijing Institute of Petrochemical Technology, Harbin Institute of Technology, and Wuyi University have filed their patent application only in China. While, all Korean companies which are National Rehabilitation Center, Samsung, Electronics and Telecommunications Research Institute, and Daegu Gyeongbuk Institute of Science and Technology have filed their patent other than in South Korea. For example, the National Rehabilitation Center has filed patents related to robotics for ageing society in the United States, and through the PCT system. It shows that the National Rehabilitation Center has markets in the United States and other countries that can profit from these inventions. The multinational company Samsung, who already play a main role in many countries, has filed its patents in China, South Korea, Japan, United States, and the European Patent Office (EPO). In addition, two Japanese companies - Toyota and Equos

Research Co. Ltd. - have filed patent applications for this technology mainly in Japan, where is the main market of robots for the elderly due to its highest number of elderly people in the world. However, Toyota has also filed in the US to expand the market to the East as well.

## 2. Overview of Thai patent related to robotics for ageing society

### 2.1 Technology trend and characteristics of the robotics for ageing society patents in Thailand

The overall patent perspective in Thailand shows a continuous increasing rate of patent filing. Considering from the last ten years patent and petty patent filing statistics, there were 10,578 patent application in 2008 (B.E. 2551), and 12,987 patent application in 2017 (B.E. 2560), or there was a 22% patent filing growth rate. Petty patents were filed 1,515 in 2008 (B.E. 2551), and 2,517 applications in 2017 (B.E. 2560), or there was a 66% (Department of Intellectual Property, 2017) growth rate. Additionally, according to the database of petty patent or utility model applications from World Intellectual Property Organization (WIPO), Thailand was considered the ninth (9) rank of petty patent or utility model world ranking depicting there was a great patent filing rate in Thailand. (WIPO, 2017)

However, although Thailand had a huge growth rate of patent and petty patent filings as a whole, there were very few patent applications in the industry of industrial robotics, the future industry. In accordance with a report of robotic industry in Thailand issued by a policy research division of National Science and Technology Development Agency, disclosing the past five years (2013 - 2017) numbers of patent applications and robotic-related research in Thailand, there were very few robotic research publications and patents, but only robotic research study instead. Literally, there were only 75 robotic research publications out of 14,676 all general research publications (Policy Research: PRS - NSTDA, 2017).

Furthermore, according to a robotic technology trend and industry analysis report issued by the Intellectual Property Institute of Chulalongkorn University by conducting a search and gathering patent applications related to robotics from patent database on Aug 2<sup>nd</sup>, 2017, it was found that there were 109 robotic-related patents filed between 1984 – 2017 (B.E. 2527 – 2560). (Chulalongkorn University Intellectual Property Institute, 2017)

From the data mentioned above, there were very few robotic-related patents. When the analyst used the keyword “หุ่นยนต์ (Robot)” for searching the patents on the Department of Intellectual property of Thailand database, there was found 400 the robotic-related patent applications (Aug 2018). The found patents include industrial toys and robotics. According to a scope and database acquisition of this report using keywords and International Patent Classification (IPC), the analyst team collected data and filtered the related patents and petty patents. As a result, there were 162 patents looking like or being a robotic patent, including automations and systems and apparatuses able to be applied as robotics for ageing society.

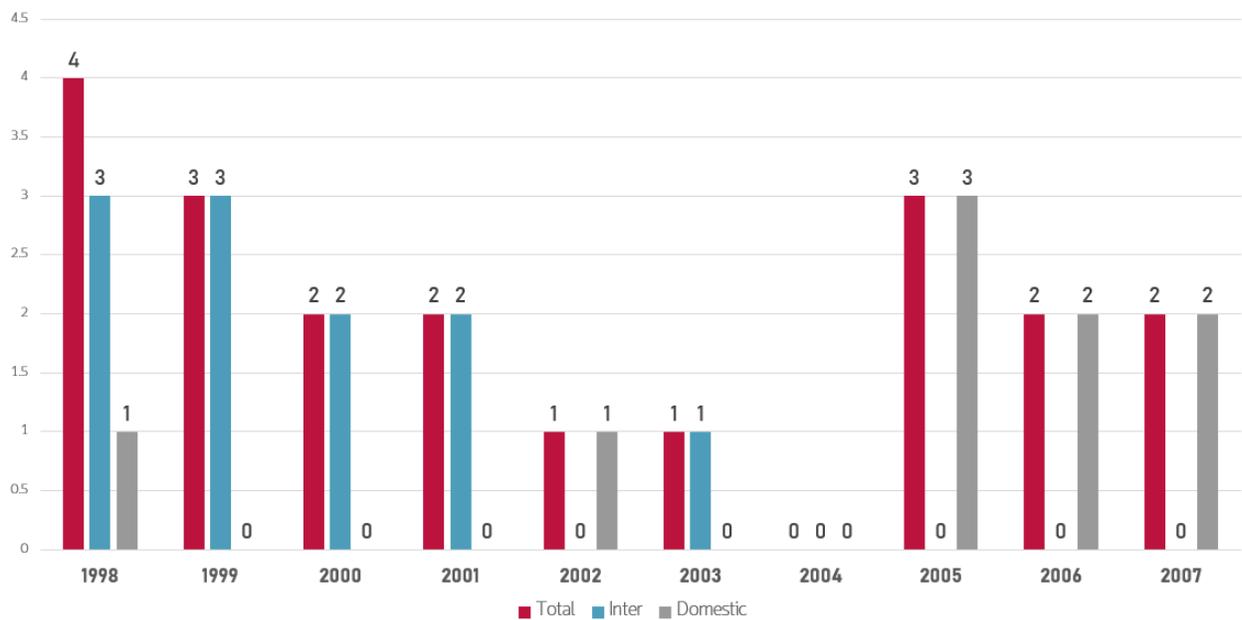


Figure 16 Numbers of patent and petty patent application filed between 1998 and 2007

The figure 16 shows patent applications filed between 1998 - 2007 (B.E. 2541 - 2550). However, the first patent related to robotics for ageing society in Thailand, the international patent, was filed in 1993 (B.E. 2536), and the related patents were continuously filed between 1998 – 2007 (B.E. 2541 - 2550), but there were very few numbers of related patents, not exceed 4 applications a year, and there was no robotic patent application in 2004 (B.E. 2547). Between

1998 – 2007 (B.E. 2541 - 2550), the filed patent numbers in that period had almost the same numbers between patents filed by international applicants and patents filed by Thai applicants.

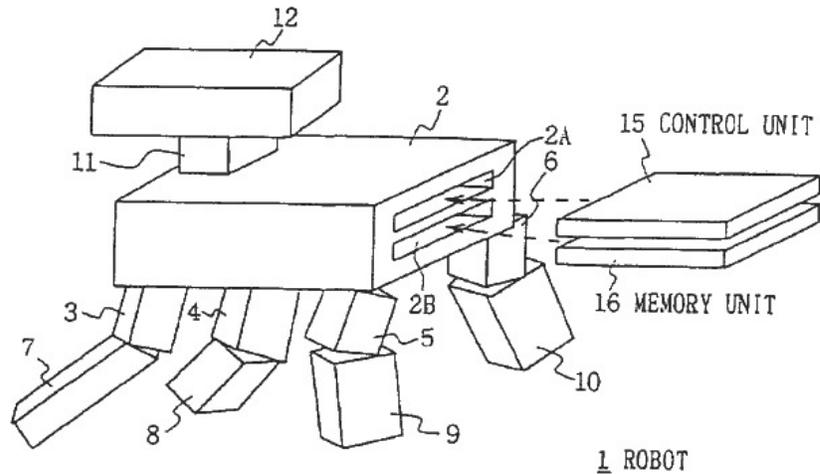


Figure 17 Drawing of Thai patent application No. 9801004877

Patents of Thai applicants filed between 1998 – 2007 (B.E. 2541 - 2550) involve in an electric train for the handicap, an intelligent robotic car for a child, a standable electric train for the handicap, an inspected robot, and a rescued robot. Patents of international applicants namely KUKA Robotic, Panasonic Healthcare Holding, or Sony Corporation. The patents of Sony Corporation were 3 applications namely a robotic apparatus, a robotic system, method for describing a robotic structure and robotic parts filed in 1998 (B.E. 2541) according to the figure 17, a robotic apparatus, patent application No. 9801004877. The said patent application has a character of the robotic dog “AIBO” disclosed in 1999 (B.E. 2542), which was a companion robot installed an artificial intelligent (AI) technology.

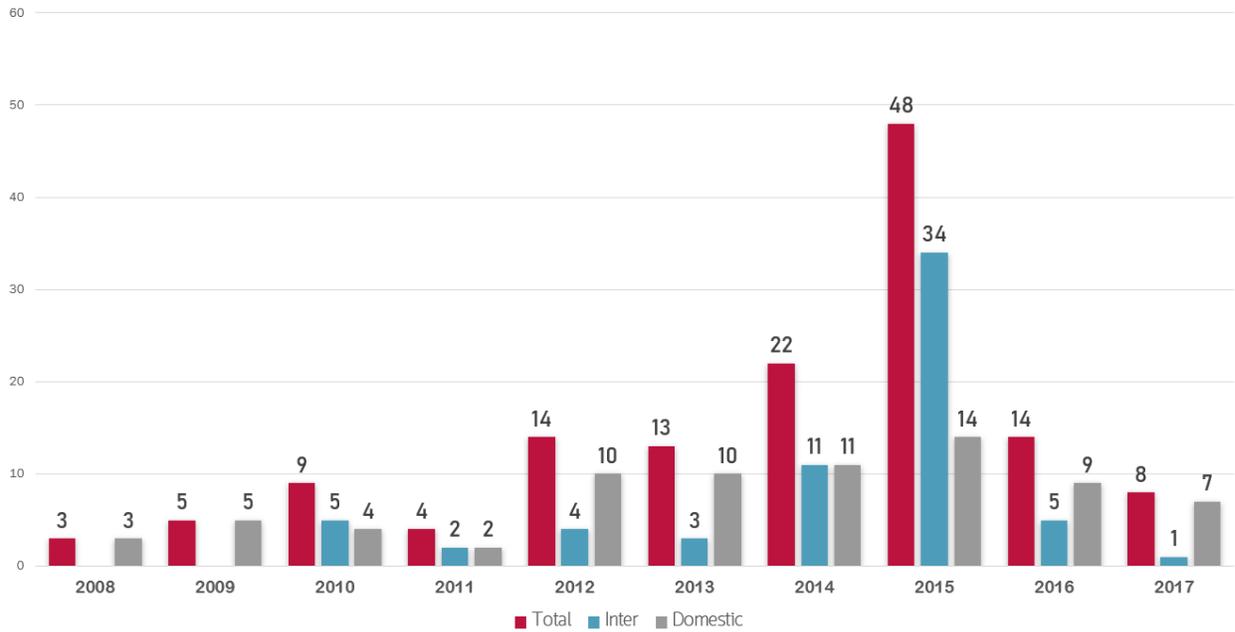


Figure 18 Number of patent and petty patent applications filed between 2008 – 2017

The figure 18 depicts patent application numbers in the past 10 years, or between 2008 – 2017 (B.E. 2551-2560). It shows the increasing continuity of patent filing with the rate of 14 patent and petty patent applications a year, namely 7.5 applications by Thai applicants, and International applicants 6.5 applications. Although, there was not a vivid increasing rate of the patents related to robotics for ageing society filed between 2008 – 2017 (B.E. 2551-2560), it was a vivid picture of the patent filing rate increasing between 1998 – 2007 (B.E. 2541 - 2550).

Thai applicants continuously began filing the patents from 2005 (B.E. 2548), and International applicants continuously began filing the patents from 2010 (B.E. 2553) with almost the same filing rate, except in 2015 (B.E. 2558) where international applicants filed more numbers of the patent applications because of the patent filing of Soft Bank Robotics Co., Ltd., and Aldebaran Co., Ltd. Took over by SoftBank Co., Ltd. (SoftBank Robotics) with the rate of 16 Thai patent applications. The filed patents included systems and apparatuses for a humanoid robot like a base for charging and re-charging battery, a humanoid robot, a humanoid robot for avoiding clash and recovering, a standby mode for a humanoid robot, method for clash

detection, and hand driving method on humanoid robot. Moreover, Toshiba Lifestyle Products & Service Corporation filed 9 patent applications involved in apparatus and method related to a robot vacuum cleaner such as a vacuum cleaner, self-mover and vacuum cleaner, and self-mover.

## 2.2 Patents filed in Thailand

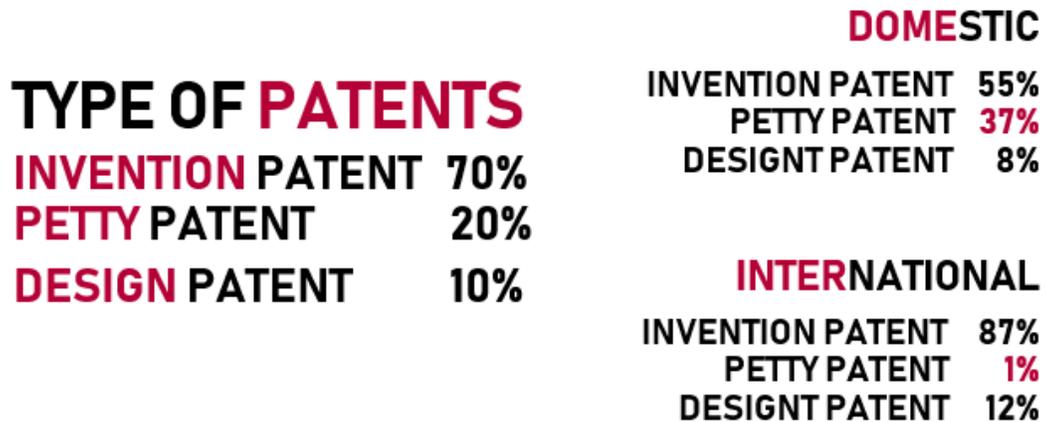


Figure 19 Proportions of invention patent, petty patent, and design patent applications

From the patents related to robotics for ageing society data according to this report retrieved from Thailand patent database between 1984 – Aug 2018 (B.E. 2527 – Aug 2561), there were 70% of patents, 20% of petty patent applications, and 10% of design applications. Additionally, the data shows 55% patent applications, 37% petty patent applications, and 8% of design applications filed by Thai applicants respectively, while, there were 87% patent applications, 1% petty patent applications, and 12% design applications filed by international applicants respectively.

From the filed applications above, design application numbers filed by Thai applicants and international applicants are almost the same. While petty patent application numbers filed by the two parties are different, which Thai applicants filed 37% petty patent applications, but international applicants filed only 1% of all applications, the analyst team analyzes to the root causes of the difference above as the 3 following causes.

### 2.2.1. Technology types

As filing procedure of patent having to consider both “novelty” and “inventive step” different from that of petty patent considering only “novelty”. It shows Thai applicants file inventions with little technological improvement.

### 2.2.2. Application types firstly filed in foreign countries

With consideration on nationality of applicants filing patents in Thailand, there were from Japan, Europe, United States of America, South Korea, and Germany. It was found that many regions have not a petty patent or utility model system such as the U.S. and Europe leading to the type of applications from those countries is the same type as that in the countries. In other words, the applications originating from the U.S. and Europe filed as patent applications in Thailand.

### 2.2.3 Procedures and substantive examination

As the number of patents filed in Thailand, it takes much more time to examine patent applications compatible with that of petty patent affecting patent filing behavior that there were more petty patent application numbers than patent application numbers in Thailand.

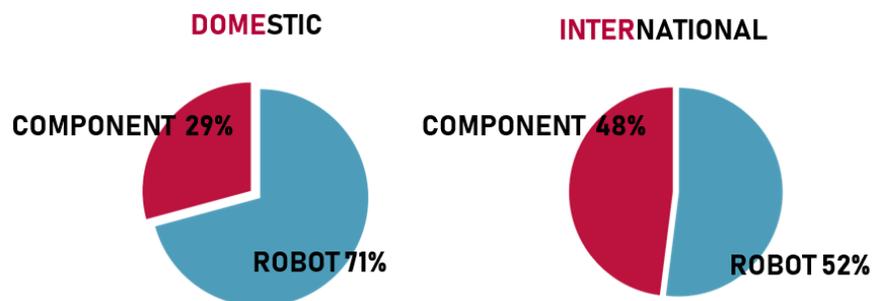


Figure 20 Proportions of robot types namely robotic components and robots

Besides, there were difference in application types, the figure 20 shows different details of applications filed by Thai applicants and international applicants. Typically, the inventions containing complexed technologies or systems usually filed as robotic components instead of the whole robot in order to gain more flexibility to implement the patent right. The figure illustrates patents filed by international applicants contain 52% of the whole robots and 48% of robotic components, while the patents filed by Thai applicants were mostly filed as the whole robots with 71% and only 29% of robotic components. It may be caused from technology types that Thai applicants combine various existing robotic technologies to file novel inventions, resulting in they were not filed their inventions as robotic component patents, or from less registration time, or from less cost of petty patent procedure so that they have made a decision to merge many robotic systems or robotic components to file one application. Another factor is the understanding of patent application procedure.

## 2.3 Technology types in Thailand

### 2.3.1 Technology types categorised by IPC class



Figure 21 Proportion of inventions categorised by International Patent Classification (IPC)

The inventions reported in this report have been existed in Thai Patent database between 1984 – Aug 2018 (B.E. 2527 – Aug 2561). The inventions are grouped into many classes, in accordance with International Patent Classification (IPC). It was found that the top patent filing class is B25J: Manipulators with 23% of all robotic patents related to robotic components, Apparatus for controlling surgical needles, including programing and controlling systems (B25J 9/00), Joint (B25J 17/00), and Robotic hands (B25J 18/00) involving in Clashing detection, Jamming protection system in robot resembling to human, Apparatus for advanced positioning and attaching organs containing human-liked detachable and flexible joints, System and method for data gathering, Hinge placed on humanoid robot driven by a motor, Knee replacement robot moving around a single referenced axis, and Mechanic hands with paralleled mechanism for gripping, positioning, and determining direction of small size open wound surgery device. The inventions in this class were mostly filed as robotic patents, which is the main class for in-depth or technical analysis for those interested in.

The top second class filed as patent is the class A61H: Physical therapy apparatus, and the class G05B: Control or regulating systems in general with 8.5% of all robotic patents having the same rate as design patents related to robotics for ageing society. The physical therapy

apparatus comprising apparatus for specific organ such as Robotic system for recovering wrist, lower part of hand, and elbow by the mechanism with one joint driver, Robotic system for recovering lower part of hand, elbow, and shoulder joint by mechanic hand, Mechanism external skeleton for hand therapy apparatus, and Hand therapy device and the method thereof. The class of controlling and determining a system involves in a controlling system and its components such as robotic system, Method for controlling hand force for robot grabbing, Method of ultrasonic detection for automatically avoiding barricades, Robot moving by wheels, Robot for improving Thai language pronunciation, and Robot rehabilitating reaching ability.

The top third class is A61G: Transport, personal conveyances with 6.7% of all robotic patents, which relates to transportation and personal movement, particularly for patients or unmovable persons such as Standable electric car for the handicap, Patient bed preventing bedsores, Semi-auto Wheelchair controlled by P300 brainwave. The top fourth class is A47L: Domestic washing or cleaning with 4.8% of all robotic patents, relating to device or robotic components which automatically move for cleaning.

Other classes include G05D: Systems for controlling or regulating non-electric variables with 3.6% of all robotic patents, A63B: Apparatus for physical training with 3.6% of all robotic patents, G06F: Electric digital data processing with 3.1% of all robotic patents, and A61B: Diagnosis: Surgery: Identification with 3.1% of all robotic patents. Furthermore, there were other classes of related patents which were very few such as G01L: Speech analysis or synthesis, Speech recognition, G08B: Signaling or calling systems, Order telegraphs, Alarm systems.

### 2.3.2 Technology types grouped by robot or robotic system applications

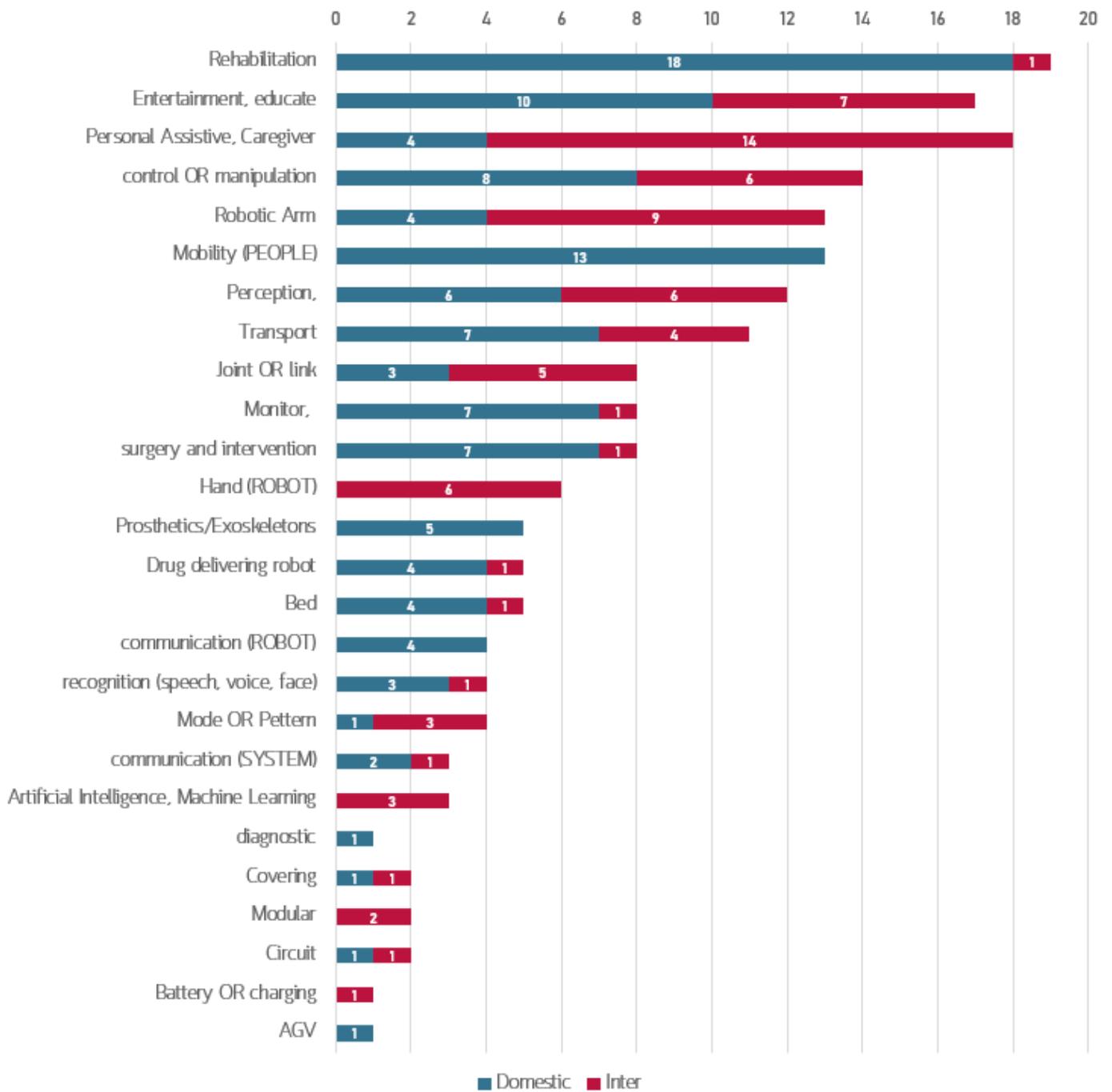


Figure 22 Number of patent applications grouped by robot, or robotic components and/or system and by applicant types

Figure 22 shows the Thai patent applications filed between 1984 – Aug 2018 (B.E. 2527 – Aug 2561). As, patent categorizations by using International Patent Classification (IPC) may not cover some types of robots, analyst team has furtherly analyzed and grouped by robot, or robotic components and/or systems application types, namely Surgical applications, Rehabilitation, External artificial organs, Robot or device for observing patient symptoms, Robot for entertaining people, Robot with mechanic hand, and Robot or device for moving persons. In the part of device or system, there are including control system, movement system of robot, Robotic hand, and system for sensing joint apparatus.

With the consideration of application types of patents related to robotics for ageing society, it is found that the top topic of patents is Robot for rehabilitation, mostly filed by Thai applicants, including Wearable robotic system for rehabilitating wrist with 3 rotating axis and 1 moving axis, Attaching device for rehabilitating body part, Robotic controlling system for rehabilitating lower part of hand, elbow, shoulder joint by mechanic hand and external skeleton, and Walking support machine for paralyzed patient.

The top second topic of patent for the elderly is Robots for Entertainment or Education which were filed 10 applications by Thai applicants and 7 applications by International applicants. However, the related patents filed by both type of applicants are quite different. The international applicants filed the patents related to apparatus for sport practice such as robot for playing a table tennis with the movement of an improved serving part, Table tennis robot and the instructing method thereof, Automatic golf ball feeding machine for practicing, and Automatic golf feeding machine for golfing practice. On the contrary, Thai applicants rather filed patents involving in Conversation practice or language development such as Robot for rectifying Thai conversation, Robot for supporting communication, and Automatic movable robot fostering child development activities, which these robots are not only applied for developing

child language communication, or those developing language deficits, but for keeping communicating with the elderly.

The top third topic for patent for the elderly is the inventions related to Personal assistance, or Caregiver, which 14 patent applications were filed by international applicants as cleaning robot or the system thereof, and 4 patent applications were filed by Thai applicants as general devices or robots like apparatus for measuring body part, Robot for communicating with the elderly as “Din-sow robot”, produced by CT Asia robotics Co., Ltd., ในนามของหุ่นยนต์ดีนสอ (Dinsow).

Furthermore, robotic patents for ageing society in Thailand filed by Thai applicants includes Robot for moving patients, Artificial organs or external skeleton, Robot for communicating purposes, Robot for diagnosis, and Navigating robot or Transportation robot. There were some topics of patents that Thai applicants file much rather than international applicants namely Monitoring robot, surgical robot, Drug feeding robot, Robot existed in the aspect of bed. The mentioned types of robots find a small number of patent applications in Thailand, it refers that there are abundant opportunities to develop the related technologies in Thailand.

### 2.3.3 Types of service robots filed in Thailand

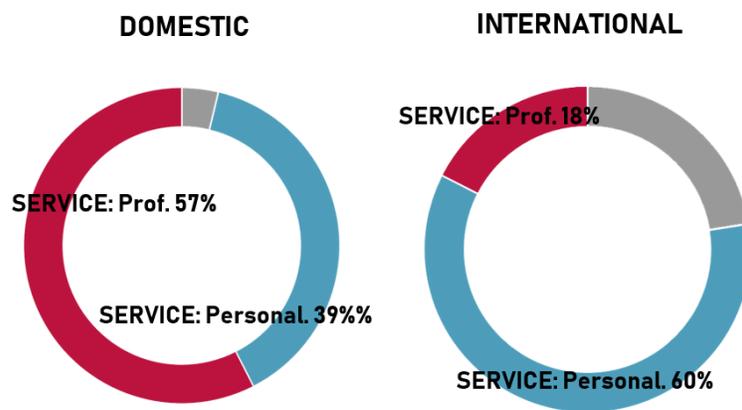


Figure 23 Proportions of service robots for general persons and skillful persons

Figure 23 shows filed patent ratio in Thailand between 1984 – Aug 2018 (B.E. 2527 - Aug 2561). Robotic patents for the elderly in Thailand were filed as service robots for skillful persons with 57%, and 39% for general persons. The patents involved in rehabilitating robots or physical therapy robots, Surgical robots, and Drug feeding robots, which are all medical robots resulting in higher return profits. However, there were few robotic patents for general persons filed by Thai applicants, which are different from those filed by international applicants with 60% of all related patent applications, which they have purposes to bring the robotic technology for general persons to commercialize in Thailand. On the contrary, robotic patents for skillful person filed by international applicants are only 18% of all robotic patents filed, by international applicants in Thailand.

#### 2.4 Applicant types and the first region filed patents before entering Thailand

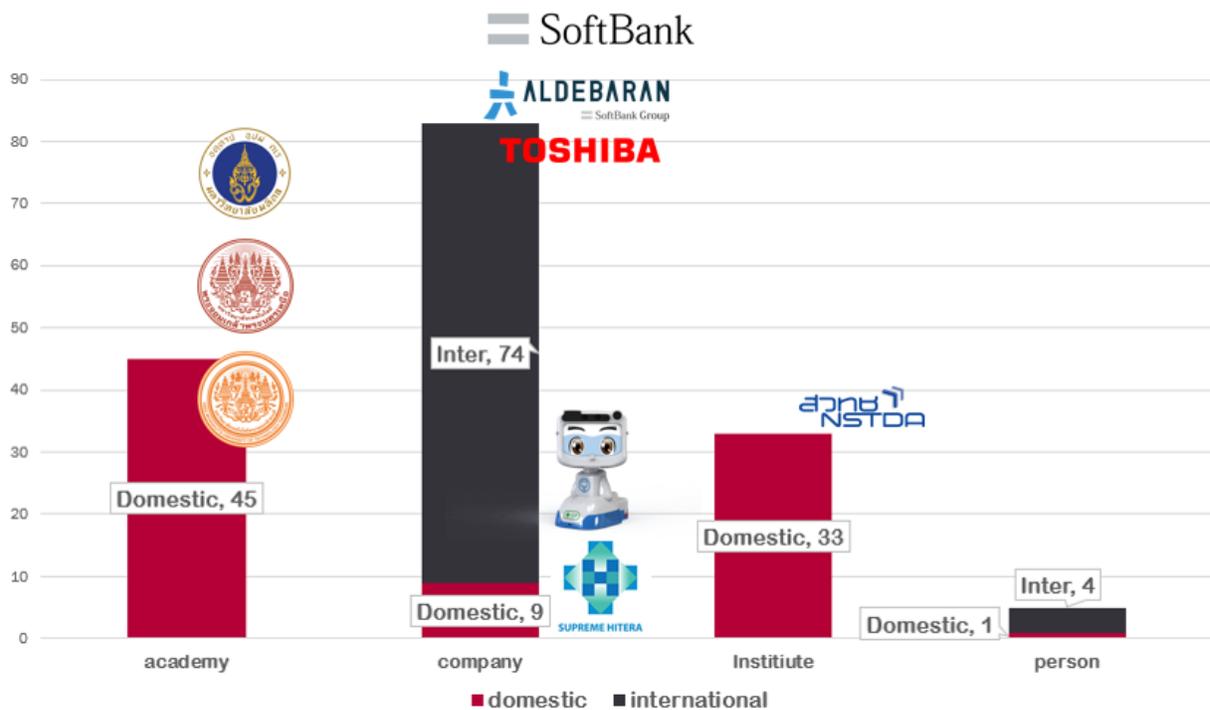


Figure 24 Number of patents grouped by applicant types

According to the figure 24, When we consider types of applicants, there were divided into 4 groups namely Academic institutes, Private companies, Public institutes, and Individuals

and separated into 2 types of applicants, Thai and International applicant. There were found the top applicants filed patents in Thailand is International private companies with 45%, following by Thai academic institutes with 27%, Thai public institutes with 20%, Thai private companies with 5%, and Thai and international Individuals with 3% of all patent applications respectively.

From the patent application ratio grouped by types of applicant above, it was found that International private companies filed patents in Thailand up to 45% with plentiful patent application numbers, such as SoftBank Robotics Co., Ltd., Aldebaran Co., Ltd., and Toshiba lifestyle products & services corporation. The numbers and ratio of patent applications filed by international private companies are much more than those filed by Thai private companies which are solely 5% of all ratio of patent applications, like CT Asia robotics Co., Ltd., and Supreme Hitera Co., Ltd. With this information, Thai private companies may have to be more caution to the patent filing rate of the international private companies in Thailand. Furthermore, in overall picture, there were 47% rate of patents filed by Thai academic institutes and Thai public institutes, as a result that the two Thai institutes paid heavy attention upon Robotic technology for ageing society as leaders. However, Thai government may foster the related technology licensing to Thai private companies in order to implement the technology into Thai business circles and products. Additionally, it is evident that patent application numbers filed by Individuals are very least. In other words, it shows the least developing rate of new companies related to robotic technologies in Thailand expected from the premise that a new company or startup company may usually file patent applications by individuals rather than by the nomination of their companies.

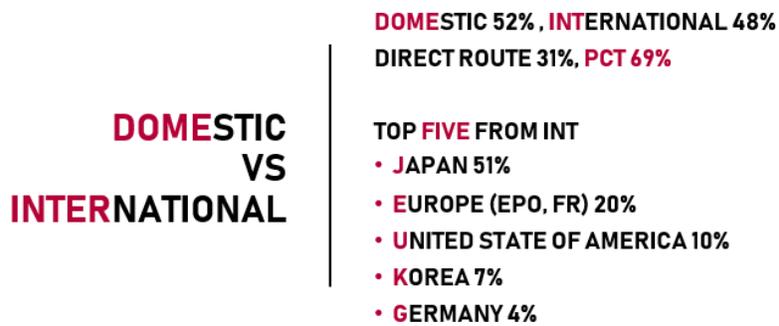


Figure 25 Proportions of Thai and international applicants and applicant nationalities filing patents in Thailand

The ratio between Thai applicants and international applicants filing patents in Thailand from Thailand patent database between 1984 – Aug 2018 (B.E. 2527 – Aug 2561) are 52% and 48% showing the very near ratio of robotic patents for the elderly. In other words, the related technology may not be popular for international applicants to file the related patents in Thailand. The international applications are divided into two application types, namely Direct route application, which were the applications firstly filed in other countries and were filed in Thailand within 12 months from the first filing date in the countries, and PCT (Patent Cooperation Treaty) route application, which were the applications firstly filed in other countries and were filed in Thailand within 31 months from the first filing date, with 31% and 69% of all international applications respectively. From the information mentioned above, a majority of international applicants filed robotic patents via PCT system, resulting from internationally patent agreement suitable for applicants who need to protect their patents in a lot of countries, and need more time to circumspectly study the market system of the countries they would like to file their patents, exceeding from 12 months to 30-31 months from the first filing date in first PCT member country<sup>20</sup>. However, Thai people are not gained into, accustomed to, and taken advantage of the system.

The patents related to robotics for ageing society, filed by international applicants, were mostly owned and filed by large-size of Japanese private companies, namely KAWASAKI HEAVY

IND LTD, Life Robotics Inc, Toshiba lifestyle products & services corporation, SHARP, SONY Corp., Honda, IWANE KENKYUSHO KK, and Panasonic healthcare holdings, related to mechanical hands or systems thereof and robots for cleaning, with 51%, 39 applications. The top second rank of applicants were European private companies, namely SoftBank Robotics, Aldebaran, and ENRAF NONIUS BVm, related to system or apparatus for robot movement or robotic components in forms of humanoid robot, with 20%, 15 applications. The top third rank of applicants were from United States of America, namely UNIVERSAL ROBOTS AS, NEWGY IND INC, and Individuals, related to Robots for practicing sports, with 10%, 8 applications

The top fourth rank applicants were from South Korea, namely Samsung electronics co., ltd., and Individuals, related to System or apparatus for cleaning robots, Surgical system, and Golf feeding machine, with 7%, 5 applications. The top fifth rank applicants were from Germany, namely DUERR SYSTEMS GMBH, and KUKA robotics, related to Design patents and Method for controlling robots, with 4%, 3 applications. Additionally, there were applicants from other countries filing patents in Thailand, such as China, Switzerland, and Great Britain.

### 2.5 Key players filing patents in Thailand

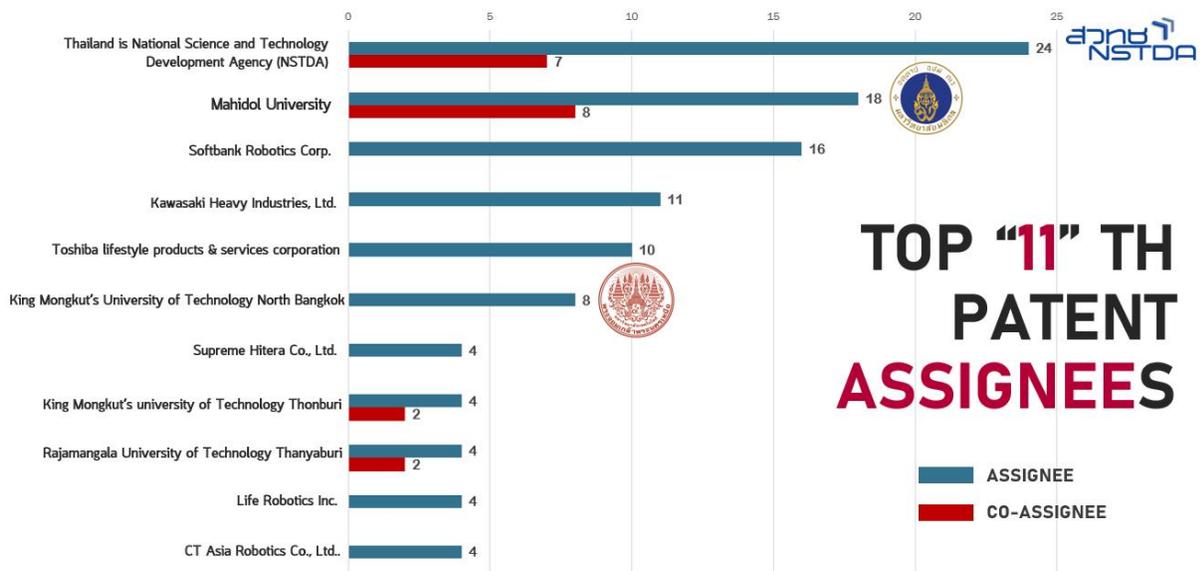


Figure 26 Number of patents categorised by applicants

The figure 26 shows applicants and numbers of patents filed between 1984 – Aug 2018 (B.E. 2527 – Aug 2561). The top filing applicants in Thailand is National Science and Technology Development Agency (NSTDA), with 24 patent applications, following by Mahidol university, with 18 patent applications. In other words, Thai public institutes and academic institutes filed patent applications as the top, and the top second on the rank. The top third to fifth ranks filing patent applications are international private companies, namely SoftBank Robotics, KAWASAKI HEAVY IND LTD, and Toshiba lifestyle products & services corporation. However, from the whole perspective, a majority of the patents related to robotics for ageing society are Thai applicants, but with a little numbers of patent applications.

The figure illustrates co-applicant numbers, which Mahidol University shares 8 patent applications with other institutes, with the rate 8 out of 18 co-patent applications. NSTDA shares 7 patent application with other institutes, following by King Mongkut’s university of Technology Thonburi and Rajamangala University of Technology Thanyaburi, filing 2 patent applications.

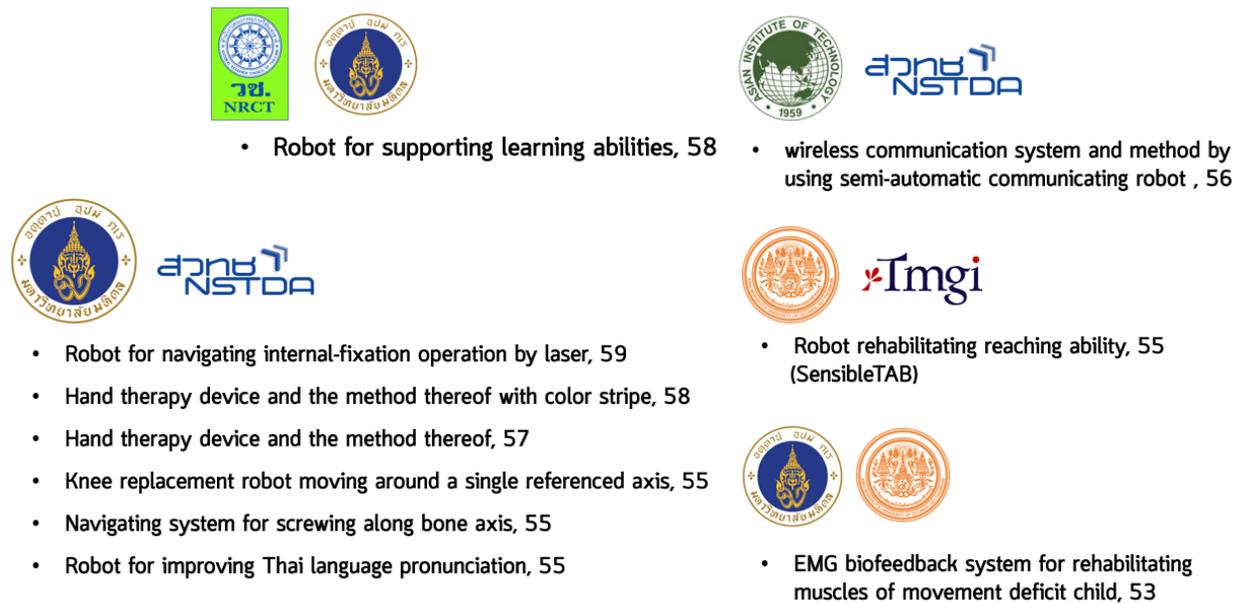


Figure 27 Coassignees' patent applications

The figure 27 shows co-patent applications in Thailand patent database filed between 1984 – Aug 2018 (B.E. 2527 – Aug 2561). Most co-patent applications were owned by Academic institute and public institute. For instance, Mahidol university and NSTDA filed 6 co-patent applications related to robots for surgery and rehabilitation, which are usually medical robots. Besides, there were co-patent applications owned by two academic institutes. For example, Mahidol university and King Mongkut’s university of Technology Thonburi related to inventions of rehabilitation or recovering from some symptoms. Furthermore, there was only one co-patent application owned between academic institute and private company, like Robot for rehabilitating reaching ability filed by TMGI Co., Ltd., and King Mongkut’s university of Technology Thonburi. It illustrates that there are very few numbers of co-patent applications between Thai academic or Thai public institutes and private company. However, there was found a collaboration between academic institute and private company in other form of collaboration, like Asian Institute of Technology and private company related to a rehabilitation robot.

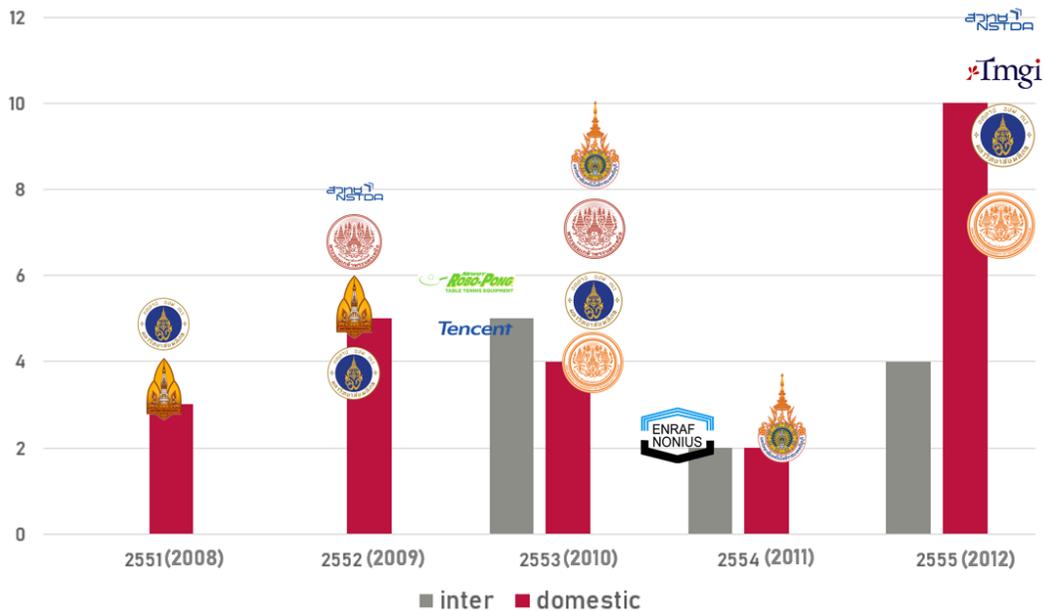


Figure 28 Number of patent applications filed by Thai and international applicants (2008-2012)

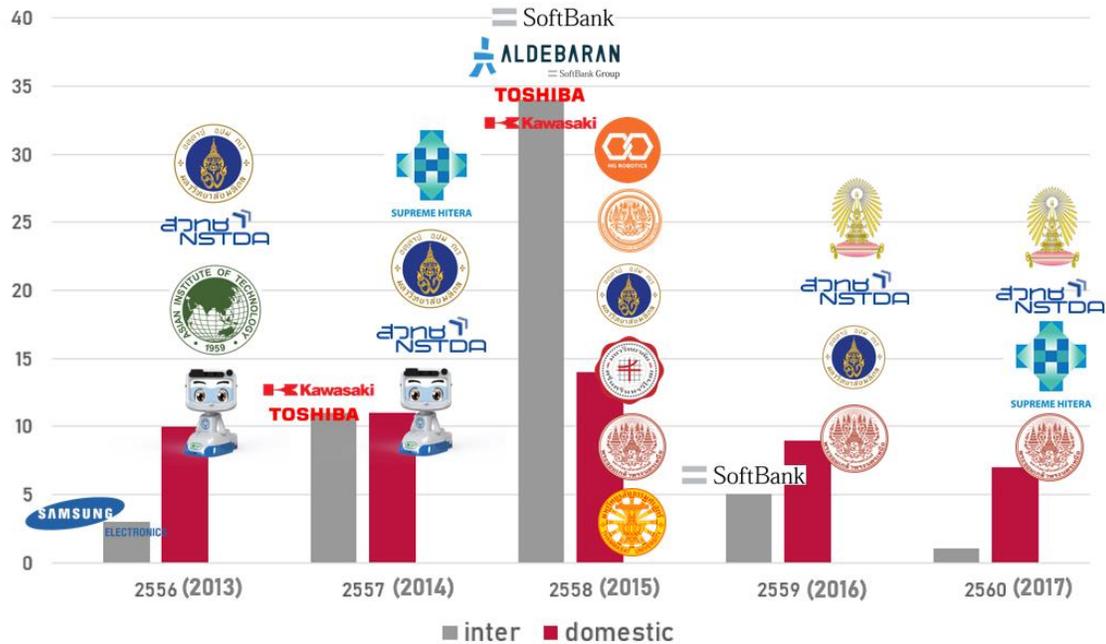


Figure 29 Number of patent applications filed by Thai and international applicants (2013-2017)

The figure 28 and figure 29 above show patent application numbers filed by Thai and international applicants between 2008 – 2012 and between 2013 – 2017 respectively. The two figures illustrate that a majority of patent activities in Thailand were done by Thai academic institutes. In the other hand, Thai private company, TMGI Co., Ltd., firstly filed in 2012 (B.E. 2555), following by CT Asia robotics Co., Ltd. filing patent applications between 2013 - 2014 (B.E. 2556-2557), as well as Supreme hitera Co., Ltd. filing patent in 2014 (B.E. 2557) and Hiveground (HG Robotics) Co., Ltd filing patent in 2015 (B.E. 2558).

Patent application numbers in Thailand reached the peak in 2015 (B.E 2558) because there were a lot of international applicants filing patents, particularly SoftBank Robotics, Toshiba lifestyle products & services corporation with 25 applications. In that year, various Thai academic institutes filed patent applications. However, Mahidol University and NSTD were the only two institutes continuously filing patent applications related to Robotics for ageing society in every year.

From the data shown above, it is evident that Thai academic institutes and public institutes play a crucial role in technology development in Thailand. However, there are very few technology licensing activities between the two institutes and Thai private companies. According to the figure 28, the inventions filed as patents by academic institutes and public institutes involve in Medical robots such as rehabilitation robots, or surgical robots filed between 2008 – 2012. According to the figure 29 depicting patents filed between 2013 – 2017, though the robots mentioned above may make a lot of profits, but they need complexed technologies to deal with, laboratory tests, and a lot of standardizations which are key factors, as a result, it may not effortless for private companies to implement these technologies into practice in the market.

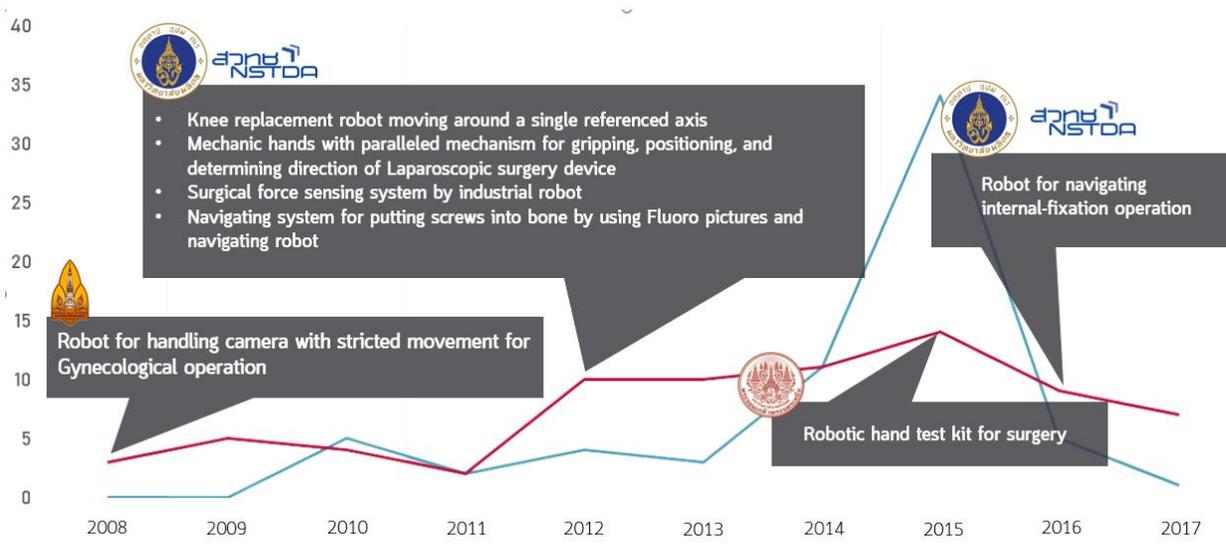


Figure 30 Number of patent applications of surgical robots broken down by year

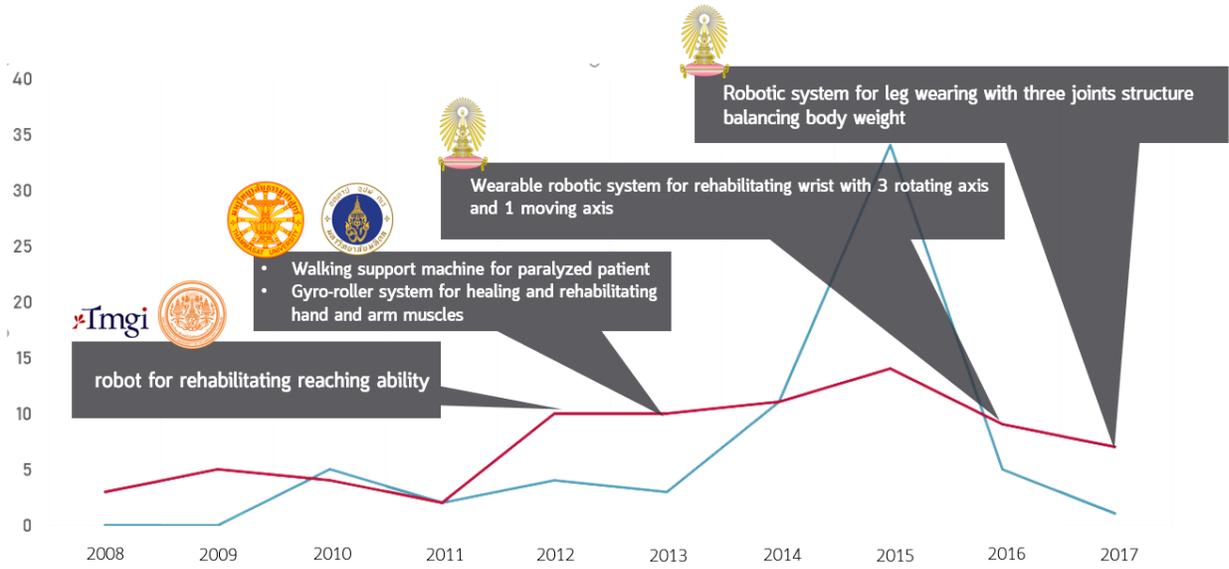


Figure 31 Number of patent applications of rehabilitation robots broken down by year

### 3. Strengths, Weakness, Opportunities and Treats of the technologies

Considering overall overview of robotic patents for the elderly, it is found that the strength of this industry is both of the public and private sectors of China, South Korea, and Japan who are the top 3 patent applicants of this technology. As Asia is the main market for the robot for the elderly industry, this encourages the agencies and inventors from these Asian countries to develop the invention in this technology. This is the result partially from encouraging and supporting by the government sector. Considering the 12 key players in the industry, as shown in Section 1.5 Key players, 7 applicants from total of 12 applicants are government agencies, both educational institutions and research agencies supported by the government. Most of these agencies have continued to apply patents in technology related to robots for the elderly. This shows the continuity of development of the invention, and the commercial usability. For example, in South Korea, the government has established a core body of research in the field of physical therapy, the National Rehabilitation Center to develop research and policy related to rehabilitation and assistive technology to improve the quality of life for people in society. The agency has filed patents related to social robots for the elderly since it has established.

Although many players have filed numerous patents, such as those from China, including Chongqing Youbanjia Technology and Foshan Fumutong Intelligent Robot, whose number of patents is much higher than that of other applicants. But these two companies are only filed patents in their own country and all filing within one year. This may be due to the establishment of subsidiary company to market one product only. Which might be the marketing strategy of most agencies in China, where the laws and rights are propitious to register and filed a patent.

Considering the technology category that has been used to develop robots for the elderly society. It has been found that artificial intelligence and telepresence are far from being compatible with robots for the elderly compared to other technologies. Therefore, the

application of artificial intelligence technology and telepresence system to develop the invention to improve the quality of life of the elderly are still a market gap that the inventor can continue to develop and invest in these technologies.

Considering the overall perspective of the patents relating to robotics for ageing society in Thailand it shows that Thailand possess several strengths points considering several universities and government sector conducting robotic researches, especially, robot for elderly society this could be seen by the numbers of researches and patents application filed relating to this topic. In particular, Mahidol University which have the Center for Biomedical and Robotics Technology (BART LAB) which specialize on the development of robotic technology for medical robotics and mechatronics in surgery and the operation technology or the King Mongkut's University of Technology North Bangkok which has the Institute of Field Robotics: FIBO), furthermore, there are several relating patents application filed by others Universities, such as Chulalongkorn University, Naresuan University, Khon Kaen University, Thammasart University and Asian Institute of Technology. Apart from the patent description relating to this matter, Thailand also have many Universities that have opened several departments directly relating to Robotic engineering and Automated systems such as Kasetsart University, Prince of Songkla University, Mahasarakham University, Suranaree University of Technology and King Mongkut's Institute of Technology Ladkrabang.

However apart from the mentioned Universities, there still are several Associations and organizations which have the resources and the knowledge concerning robotic and automated system such as, the National Science and Technology Development Agency, the Thai Robotics Society, the Thai Embedded Systems Association (TESA), the Thai-German Institute or the National Innovation. In addition, Center of Robotic Excellence (CoRE) was also established for the purpose of transferring the robotic technology from the educational sector out to the commercialize production, this started from the collaboration between the Government sector,

the education sector and the public sector in which at the present there are 9 main organizations which are the Thai-German Institute, Electrical and Electronics Institute, the Institute of Field Robotics: FIBO), Chulalongkorn University, Mahidol University, the King Mongkut's University of Technology North Bangkok, Khon Kaen University, Chiang Mai University, King Mongkut's Institute of Technology Ladkrabang.

These show that there are several organizations providing activities relating to robotics, consequently, it boosts more innovation activities that immerge into new technologies and it show that it is fully supported by the government sector in the said industry. Further, these body of knowledge will also help generate the personnel who is specialize in the robotic industry to be sufficient for the future robotic technology. Further, medical robotic related patent is usually worth a high value.

Even though, there are supporting organizations that have sufficient resources, but Thailand still have the weak point considering that the patent applications number relating to robot for elderly with a Thai nationality applicant is only at the rate of 7.5 patents per year, in which is a very low number of patents with no tendency of having an increasing rate. However, there are several inventions and researches available, concentrated in the medical robotic such as research on the robotic made for the purpose of screening, treating, operating, rehabilitation, medical service, public health and health monitoring, however, most of these inventions was not applied for patent protection. Applying these technologies and inventions for real use still have its limitation. Also, if considering all the inventions that was the results of the collaboration between the education Institution, government sector and the private sector only one patent application was filed, this shows that collaboration that push the movement to a market merchandise and the tangible protection is relatively low.

Apart from the lack of new patents and collaboration, the private sector that pertain patents is very few, there are only 4 Thai's private companies that have filed a patent such as

CT Asia Robotic Co., LTD, TMGI Co., LTD, Supreme Hitera Co., Ltd. and Hiveground Co., Ltd. which the publication information of the Intellectual Property Department only have 9 patents in total. In which the applicant from other nationalities that have filed for patent registration in Thailand is in the total number of 74 patents which this cause a high chance of technology limitation in the future from the patent applicant that have a foreign nationality.

With the low number of patents, this open more opportunities to develop other technologies within Thailand, if considering the private sector that have a patent in Thailand there will be companies that is specialized in different field such as CT Asia Robotic Co., LTD having a robot for the elderly that emphasis on the corresponding and interacting with the elderly, Supreme Hitera Co., Ltd, having robot for distributing medicine, TMGI Co., Ltd, specialized in robot for rehabilitation and Hiveground Co., Ltd. having robot for each specialty which it has a patent relating to robotic for transferring patient or elderly apart from these there are more technologies that the private sector has come to be a part of. Thai private sector still has a few amount of patents, however in the overall perspective it could be considered that the patent number of the Thai patent applicants and the foreign nationality applicant is very far apart and it have a different technology, therefore, the Thai private sector still have more opportunity to develop its technology and take over each innovations industry within the country and with the body of knowledge and the funding available in the country would make a great opportunity for business startup.

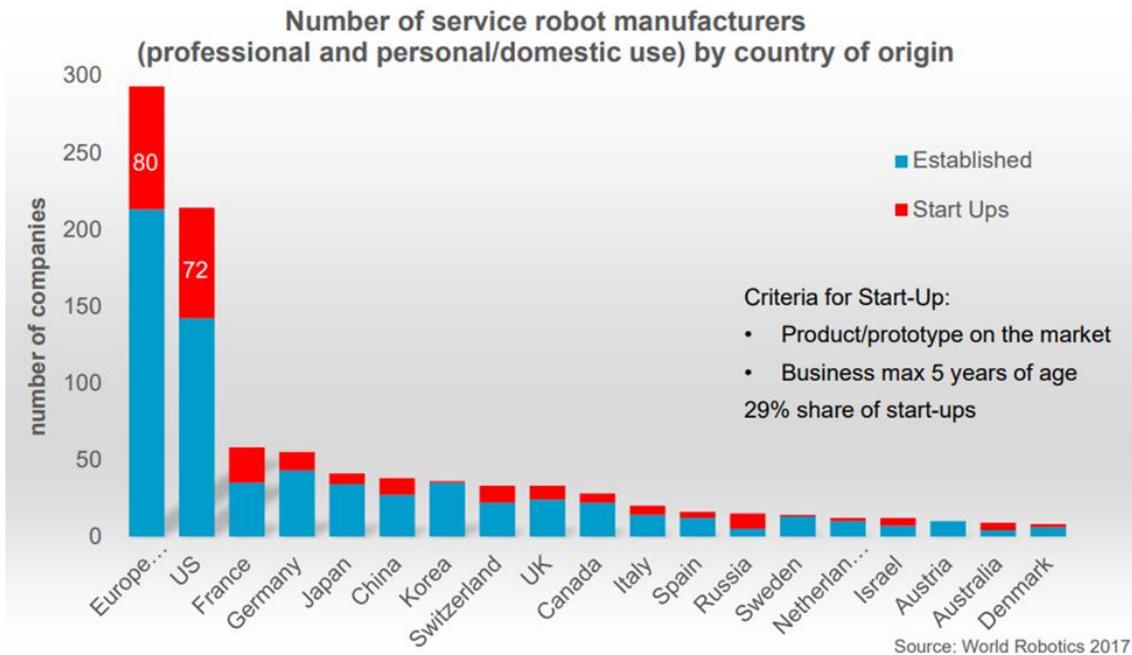


Figure 32 Proportions of the new start-up business and companies in the service robot manufacturing Industry

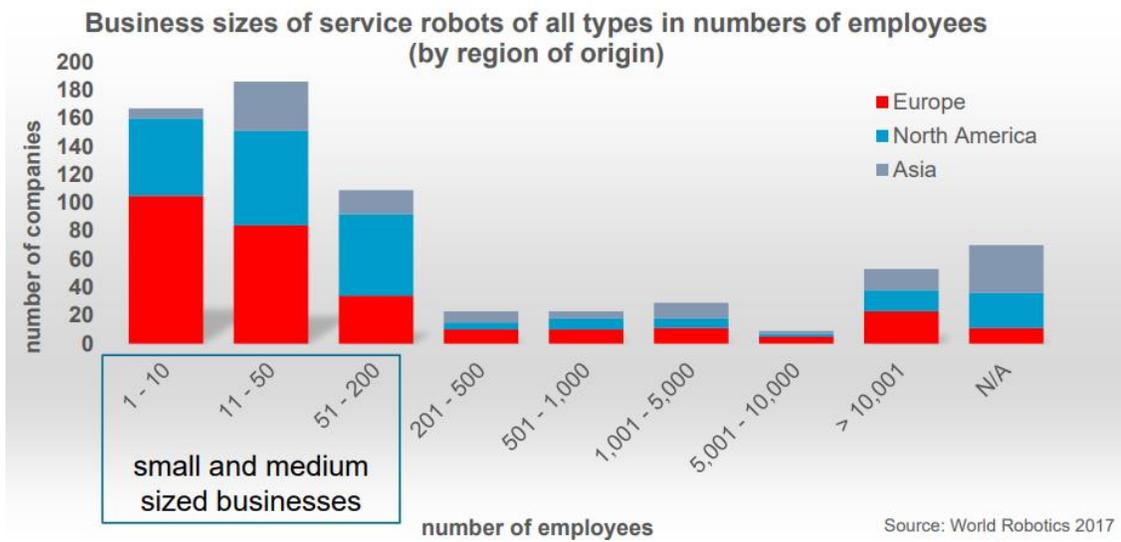


Figure 33 Size of companies in the service robot manufacturing Industry

From the Figure 32 which depicts the proportion of new start-up businesses and companies in the service robot manufacturing Industry and Figure 33 which depicts the sizes of companies in the service robot manufacturing Industry and divided by continents. It could be

seen that the Start-up companies relating to the service robotic industries, both for general consumer and for consumer with high speciality at 29%, in which the small businesses could operate the business in the industry for service robot. In each continent the business operator in the field of service robotic is mostly is the company in the medium and small size, which usually have the business size of 11-50 employees, follow by the business size of 1-10 employees only, as it could be seen that the business corporation relating to service robotic does not usually needs to be a large size company.

However, the foreign nationality patent applicant is relatively high in each time making the scope of the development and the adaptation of the technology in Thailand will be limited in the future, therefore, the inbound patent application from foreigner applicant particularly should be closely monitored. At the present, foreign nationality applicants could be divided in to several groups, especially in the robotic arm group. Robotic for ageing society patents that mostly filed in Thailand by foreigner, mostly are the components or the parts of robot in the form of Humanoid and robot that can automatically move around for the purpose of cleaning, in which general consumers for this type of robot is the household consumers, therefore, technology development relating to this field of technology should be closely monitored, further, any technologies developments should first consider the patent filed internationally as well. After reviewing the patent descriptions inbound from abroad, most of the Thai national route patents application have been filed through the PCT international filing system which increased the chance and the time to process the patent registration into Thailand, therefore, these patents technology description should be review extensively before making any technologies developments.

4. Analysis on Technologies with adequate potential for further development

From the characteristic of the technology available in Thailand it shows that robot in some characteristics still have a low number of patents in Thailand and no foreign nationality applicant have filed for registration in Thailand such as technology relating to automatic transferring robot, diagnostic robot or robot with the feature of skeletons or artificial organs as in Figure 34 which depicted the example of the inventions related to automatic transferring robot, diagnostic robot and exoskeletons robot, in which these technologies are low in patent applications number in Thailand, therefore making it have a high chances of development and expanding into new technologies branches from these innovations.

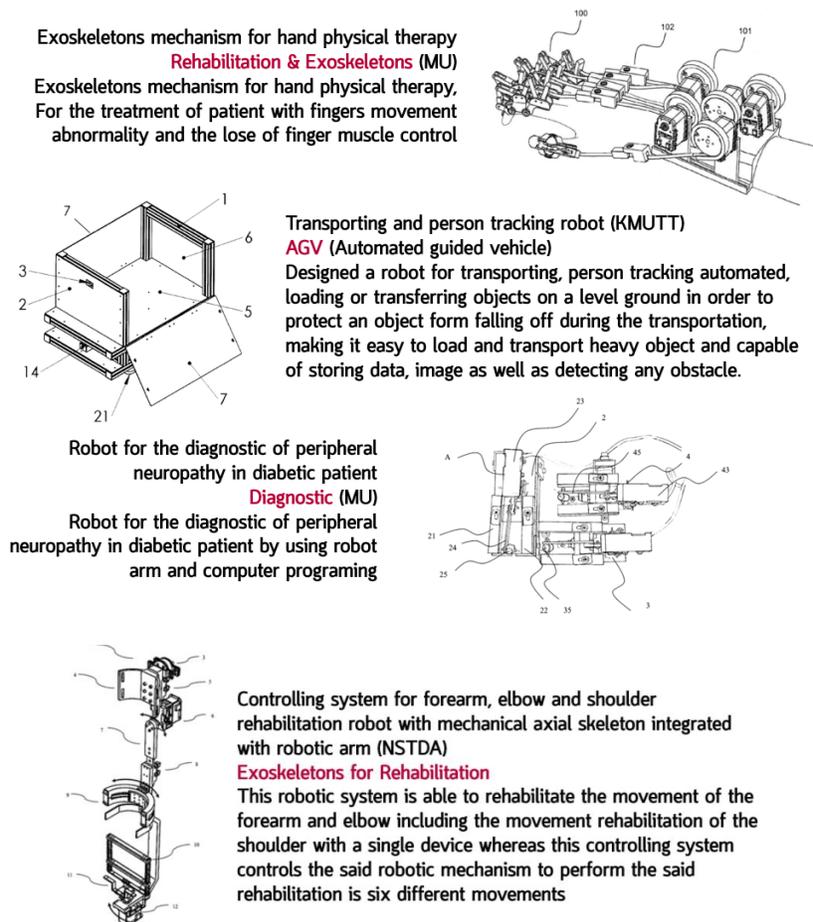


Figure 34 Examples of the invention related to automatic transferring robot, diagnostic robot, and exoskeletons robot

## 5. Suggestion for applying the analysis result

This analysis report shows the overall perspective trend for Robotic for Ageing Society by comparing the Thailand and International patents it could be found that there are very few inventions in Thailand and the growth rate is not certain comparing to the international rate. From this analysis result, it shows the importance of creating intellectual property awareness, especially, awareness regarding to patent protection to each organizations and private companies in order to be able to build an innovation platform equivalent to the international standard.

Patents registered in Thailand is done in the way that the robot characteristic is described in one patent application which make the scope or the flexibility for the exercising of the patent right is low and this might need to improve the strategy or the format of registration to make the patent to be more flexible. Thailand emphasis the development of robotic technology for the use by a professional or an expert but still have a small proportion of robotic technology for the use by a general or household consumers, therefore, this technology is worth looking in to for people who would like to enter the future robotic industry. This report also shows the key competitors in this industry, for the people who would like to enter this industry should conduct a throughout search on relating patents and the inventions information.

In term of technology, it shows that several industrial technologies have a steady increasing rate and it also shows the type of technology that is available in Thailand for the government or the private sector to use the technology information for the robotic development project and research plan in accordance with the patent technology trend by choosing the less patented subject with higher change of development or the technology with a high patent application numbers with high competitive rate. As well as showing type of technologies that are continuously emerging in order of the private sector to have a guidance for the technology development which the private sector is interested in collaboration with the education sector and the government sector further in the future. In addition, the private sector

could get into the researches information and it is easily adapted for the real use in business collaboration with universities or government sectors which needs to develop the technology to be more accessible and making the invention to have less experiment steps or less requirements to obtain the standardized certification.

Lastly, the information as showed in this analysis report has present the applicant, the country or continent that the patents is filed for application, the overall trend and the technology characteristic that typically in most patents, it usually the technical information of each inventions, therefore, these inventions descriptions would be the path way for the public to access and obtain the technical information for each invention in accordance with the objective and the requirement of the public who is interested.

## Data clean-up and Grouping

### Definition of Robotics for ageing society patent

This analysis has selected the patent related to Robotics for ageing society by using the keyword in combination with the International Patent Classification (IPC) Class and the Derwent (DWPI class) as a main filer for searching and data grouping.

The Data Grouping is mainly based on the technological perspective, together with the group of technologies which is the country main interest, in the other word, technology grouping can be done based on the core patent information in which this patent information will be divided into each topic.

The analyzer has divided the industrial group up into a technology groups as follows:

#### **International patent database analysis.**

The international patent database analysis is performed by gathering patents by using the keyword and the International Patent Classification: IPC class relating to robotics or exoskeleton system for elderly, paralysis patient or paresis patient that could be use with elderly and compiling all these patents and categorised into groups as follows:

- 1) Grouping by the characteristics of the Robotics for ageing society.
  - a. the exoskeleton system which comprises of inventions related to exoskeleton to support any parts of the elderly of the patient in order to assist walking and transporting.
  - b. Robotics for supporting mobility which comprises of inventions that is apart from the robotics related to exoskeleton for the elderly and the patient which assist walking or transporting from one destination to the other destination.

- c. Robotic arm which comprises of inventions related to robotic arm or robot having a robotic arm for helping the elderly or patient to do the normal daily routine.
  - d. Caregiving robot comprises of inventions related to robotics which have the system to facilitate and accommodate the elderly or patient such as messaging, shaving, hair blow drying or house cleaning for example.
- 2) Grouping by the performance of the robotics for elderly.
- e. Artificial Intelligence comprises of inventions having the operating and processing system by artificial intelligence.
  - f. Health monitoring system comprises of inventions related to robotic with a health parameter for elderly or patient and medication reminder.
  - g. Motion monitoring comprises of inventions related to robotics with a motion detecting, tracking device and the position locator of the elderly or patient.
  - h. Infotainment system comprises of inventions related to robot with a monitor screen or a stereo as a medium for displaying informative and entertainment.
  - i. Telepresence system comprises of inventions related to robot with a long distance realistic projective display.
  - j. Communication system comprises of inventions related to robot with communication system such as wired communication, wireless communication, Bluetooth, Near Field Communication (NFC), Wifi or emergency calling for example.
  - k. Miscellaneous comprises of inventions related to robotics for elderly, patient or disable person but could not be categorised into the groups mentioned above.

## Thailand Patent database analysis

Analyzing the Thailand patent database, with the few numbers of the patents in Thailand and the limited accessibility of patents information making the patent selection based on the patent descriptions by selecting the patents with the word “ROBOT” or having the invention that comprises of all three components all or equivalent to all three components which are sensing, actuation and cognition by covering the invention in the field of service robot, medical robot, automated system or apparatus, parts or system of a robot or robotic arm which all have a broad claim.

The analyzer has grouped the robot by the core technology which are

- 1) Industrial robotics (these patents having the patent claims of the description that is not specified for industrial adaptation such as the characteristic or the mechanism of the robot)
- 2) Service robot which could be divided into
  - 2.1 Service robot for a skillful person.
  - 2.2 Service robot for general person.

The analyzer has grouped the robot by the uses of the invention into 2 main groups:

- 1) The adaptation uses of the robot.
  - Operation robot.
  - Rehabilitation robot
  - Exoskeleton and artificial organs robot.
  - Monitoring robot.
  - Edutainment robot
  - Caregiving robot.
  - Robot arm.

- Mobility robot.
- Artificial intelligence.
- Communication robot.
- Medicine distributor robot.
- Mobility robot.
- Diagnosis robot.
- Bed.

2) The adaptation of parts or components of robot, systems or mechanism of robot.

- Robotics control.
- Robotics mobility.
- Robot arm.
- Robotics processing form.
- Robotics perception.
- Robotics joints or connecting parts.
- Robotics cover.
- Robotics disassemble system.
- Robot-Robot or Robot-human interaction.
- Circuit.
- Battery or charging for robot.

## **Identification of patent related to robotics for ageing society**

### **International patent database search**

International patent database search by using the keyword in combination with the International Patent Classification (IPC) class and the Derwent (DWPI class) by grouping the IPC class into the technology group that needs to be studied and then search and filter the information.

### **Timeframe for analysis**

#### **International patent database search**

Generating the set of information from the international Patent database by limiting the application date from the past 10 years which is the patent application date starting from year 2007 (B.E. 2550) to year 2018 (B.E.2561), however the patent data from year 2007 (B.E. 2550) to year 2018 (B.E.2561) is not fully published, this making the analyse data to be incomplete.

#### **Thailand patent database search**

Generating the set of information from the Thailand Patent database is not limited by the application date timeframe due the number of patents in Thailand is not high this making it possible to gather all the related patents up to the application date as of August 2018 (B.E. 2561).

### **Data extraction and analysis**

This analysis has arranged the inventions by analysing the metrics by using the patent database as a foundation base and display the result in the form of a table chart, graph or graphic presentation which incorporate the said patent data.

Data management comprises of 4 steps as follows:

1<sup>st</sup> Step: Dividing the technology group in accordance with the International Patent Classification (IPC) of the Derwent World Patent Index (DWPI) Class.

2<sup>nd</sup> Step: Inputting search query by using the relevant description of the IPC or DWPI class.

3<sup>rd</sup> Step: Filtering and cleaning up the data and then gathering the remaining data.

4<sup>th</sup> Step: Analysing the data within the scope of the analysis objective by analysing the data and presented it in a form of a report.

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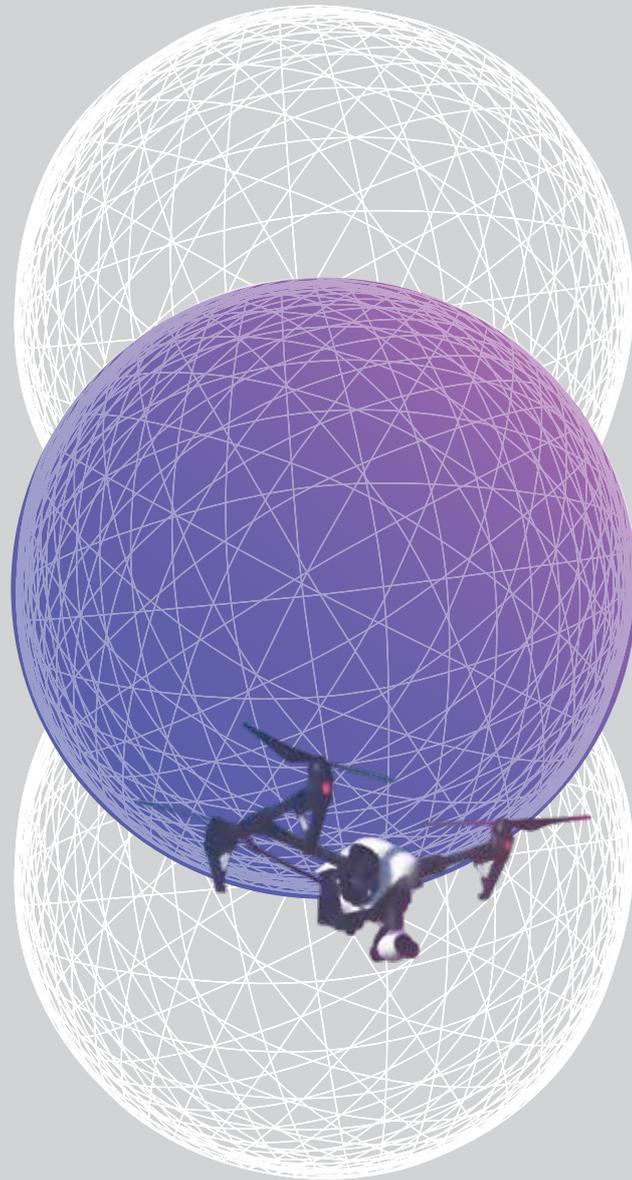
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