A Study of Personal Service Robot FutureMarketing Trend With The Foresight of Technological Innovation A quantitively study

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Abstract

Mobile and immobile manipulator technologies have been significantly used in the industry for more than half a century already. Along with the scientific and technological advancement, robots, nowadays are integrated with functions such as cognition, tactile sensing, thinking, and self-navigating motion, and are capable of interacting with human or other objects thru sensors. By and large, along with these innovations, the dominating industrial adoption of robotic technology is now shifting toward other areas such as Service Robots in domestic and professional usage. Domestic robots then cover applications such as entertainment, education, security, nursing, and house keeping. By reviewing literatures analytically, this study focuses on Service Robots, of its pass and current usage, and determines the key technologies of development of robotics science. Lastly, the study attempts to forecast innovative trend of robots by technical foresight methods.

This study utilized literature review, interviews, and scenario analysis, this study outlines the technology roadmap, and the marketing development strategy and planning of the Service Robots and its future prospect on the market. The study reveals that, Service Robot of future can communicate with its users thru WiMAX and personal digital platform without the boundary of time and distance. And will become an important member of the owner's family by performing care-taking, comforting, house keeping, educating, and entertainment tasks to others under the same roof.

Keywords: *Robots, service robots, technology innovation, technological forecast, digital platform*

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Introduced

Robotic Marketer is a world-first marketing strategy software that is based on artificial intelligence (AI), machine learning and big data that transforms information on your company, your business goals and marketing plan into an actionable marketing strategy.

Three years ago, the founder Mellissah Smith came up with the idea that through AI, machine learning and software robotics, her outsourced marketing consulting agency Marketing Eye would be able to produce over 350 marketing strategies per year at a higher standard, more data-driven and results-orientated than ever before.

As a result, the Marketing Eye's team of marketing consultants would spend more time executing the marketing strategies than the typical 80 to 150-hour time usually wasted on developing marketing strategies. In turn, producing marketing strategies faster, smarter and with greater capacity to be more successful as the technology improved and reduced its reliance on humans.

At the time, there was an uproar in the industry because people are inherently scared of change. The idea that a combination of software robotics, machine learning and artificial intelligence could possibly replace marketing consultants was concerning to those who spent their education and careers in the industry. But what they failed to realise is that change had already begun with email marketing, Google and marketing automation.

Robotic Marketer provided consolation in the fact that that marketing professionals would always be required for relationship building, crafting create marketing plans, having the conversations

and of course, feeding and improving the robots.

A recent U.S. government report—Artificial Intelligence, Automation, and Economy—predicts driverless automated vehicle (AV) technology may eliminate 2.2 to 3.1 million existing U.S. jobs. But any such job losses that occur won't happen immediately or abruptly. They will be spread out over time.

Further, the report concedes that certain types of drivers (e.g., long-haul truckers transporting goods) are more likely to be replaced than others (school bus drivers transporting children, for example). The study also notes, "New jobs will also likely be created, both in existing occupations—cheaper transportation costs will lower prices and increase demand for goods and all the related occupations such as service and fulfillment—and in new occupations not currently foreseeable."

And those projected job losses assume AV technology will become reliable and trusted. Though great progress has been made (driverless vehicles are being tested in several cities beyond San Francisco, Detroit, and Pittsburgh), some of the hardest work remains. As the expression among software developers goes, the first 90 percent of a project takes 90 percent of the time; and the last 10 percent of the project takes the other 90 percent.

AV technology will need to work nearly flawlessly before adoption becomes widespread. Business Insider has reported that lawyers are "salivating" over self-driving cars because they are "going to get a whole host of new defendants," with deep pockets, in the event of any crashes.

Development of AV technology that works dependably regardless of weather, daylight, and other conditions remains challenging. As Gary Marcus, a best-selling author, entrepreneur,

and professor of psychology at NYU, pointed out in TechCrunch regarding AI, “look for example at a driverless car, that’s a form of intelligence, modest intelligence, the average 16-year-old can do it as long as they’re sober, with a couple of months of training. Yet Google has worked on it for seven years and their car still can only drive — as far as I can tell, since they don’t publish the data — like on sunny days, without too much traffic.”

Still, robots and AI already have displaced some workers and will continue to expand into new jobs, particularly those that deal with things rather than people. It will likely be a long time before robots are trusted to care for children, or adults with special needs, but they’ve already been running warehouses for years.

Public policy will need to address those job losses, for example with displacement assistance and retraining programs. But standing in the way of AI and robotic progress would be counterproductive (literally); by increasing productivity, they raise living standards across society. Schemes like a robot tax are a bad idea.

So, Robots Can Weld and They Can Drive—But Can They Market?

Technology has eliminated wide swaths of employment in the past, from telephone operators and electric typewriter repairers, to photo technicians and video rental store cashiers. It’s now threatening various types of clerks, professional drivers, even insurance underwriters and appraisers.

But AI is more likely to change how marketers work than to replace them. It will supplement the efforts of human workers rather than take their jobs. Why?

First, consider one type technology already in wide use:

marketing automation software. Despite the label, these applications don't "automate" marketing; they merely enable marketing professionals to set up sequences of email messages which are then automatically sent out using (human) defined sequences and branches.

There are marketing professionals, agencies, and consultants who specialize in optimizing the use of marketing automation systems. In the words of Marketing Week, marketing automation platforms "don't destroy jobs, they just change what jobs are needed."

Second, there are several distinctly human characteristics essential to marketing that will likely prove vexing to reduce to mimic with silicon.

Interpretation: An AI-based tool like PaveAI can evaluate 16 million possible correlations within Google Analytics then produce a report showing the most significant findings. But it still requires a human to interpret the results.

For example, knowing that the highest conversion rate correlates with visitors who land on your home page on a weekday during business hours is about as unsurprising as any data point could be to a B2B marketer. But discovering the lowest conversion rate associated with a particular section of your website visitors often reach through organic search is far more interesting, and actionable.

Sentiment analysis presents another type of problem. Words like bomb, sick, mad, bad, and beast are generally considered negative terms to associate with your brand; yet all have, within recent memory, had a positive connotation in slang. People get that (hopefully). Machines will likely struggle.

Creativity: Marketing is an almost uniquely left brain and right brain profession. Data analysis, where AI can help, is of course vital.

But emotion plays a significant role in every considered purchase process, impacting both consumer and B2B buying decisions.

The creative side of marketing appeals to our emotions, and that side requires distinctly human creativity. It's difficult to imagine, for example, even the most sophisticated AI systems coming up with something like E*TRADE's invest in vests commercial.

Originality: AI can help marketers optimize current channels, but it won't develop radically new ideas. For example, AI can help optimize and personalize email content—but AI never would have come up with the idea of using email for marketing in the first place (that was Gary Thuerk of Digital Equipment Corporation).

AI may help with optimizing messaging and timing on social networks. But it couldn't have spontaneously computed Oreo's famous dunk-in-the-dark tweet… Or suggested creating a profile for KFC's famous founder on LinkedIn. And it certainly wouldn't have invented a sporting event to support brand content marketing, as Red Bull has done with Crashed Ice.

Perspective: Not every question, in any realm of life, has a clear-cut answer. Even when looking at the same underlying data, reasonable and intelligent people can disagree, based on their beliefs, assumptions, experiences, and definitions—in short, based on their perspective.

For example, is it possible to accurately measure the ROI of

social media marketing efforts? AI could provide an answer—and with the right data sources, even perform the calculations—but it couldn't provide the perspective on the answer that a human thought leader provides.

In marketing content, it's often the perspective that's as interesting as the answer. It's difficult to imagine an AI system weaving a narrative from a unique or interesting perspective. It's even harder to imagine AI writing this post.

Persuasiveness: Great marketing in any form—text, visual, video—combines logic with emotion to move buyers to act. AI has logic literally at its core, but trying to teach AI to understand human emotions has so far been an enormous challenge.

Robots: The New Job Creators?

An analysis by The Economist on the impact of robots and AI on employment suggests not only that the fear of massive job losses is likely overblown, but that in some cases automation may actually increase the number of jobs for humans. A study of the American job market from 1982 to 2012 found that:

"Employment grew significantly faster in occupations (for example, graphic design) that made more use of computers, as automation sped up one aspect of a job, enabling workers to do the other parts better. The net effect was that more computer-intensive jobs within an industry displaced less computer-intensive ones. Computers thus reallocate rather than displace jobs, requiring workers to learn new skills. This is true of a wide range of occupations…

"So far, the same seems to be true of fields where AI is being deployed. For example, the introduction of software capable of analyzing large volumes of legal documents might have been

expected to reduce the number of legal clerks and paralegals, who act as human search engines during the 'discovery' phase of a case; in fact, automation has reduced the cost of discovery and increased demand for it. Judges are more willing to allow discovery now, because it's cheaper and easier… The number of legal clerks in America increased by 1.1% a year between 2000 and 2013."

The analysis also reiterates that almost every new wave of technology in the past has raised the specter of mass unemployment, only to end up creating more jobs than were destroyed. The term "technological unemployment" sounds like a concept Gates or Wozniak may have devised. The phrase was in fact coined by economist John Maynard Keynes in the 1930s. The total U.S. labor force more than doubled in the following five decades.

In marketing, AI will take over routine and data analysis-intensive tasks, but also create new opportunities for human employees—for example, in training and teaching AI systems. AI is already being used in areas like personalizing product recommendations and more granularly targeting advertising.

But AI requires human training, testing, and teaching both during the implementation phase and on an ongoing basis. Both human testing and human judgment are needed up front in terms of preparing AI platforms for the real world and determining when they are ready to go live.

A Harvard Business Review article points out the level at which AI systems are "good enough" varies widely by application; a mistake by Alexa or Siri in understanding speech and ordering the wrong item is annoying. A mistake by a self-driving vehicle may be fatal.

Once live, AI platforms—just like a human graduating from college and entering the workforce—need continued training over time to increase their capabilities and stay current with changing tastes and technology. And that means people, as explained in VentureBeat: "AI's advancement up the value chain is only possible with the aid of human intelligence."

Historically, technological advancements have always ended up creating more jobs than they destroyed. Today may prove to be different, but for now, it appears robots are more likely to be workplace assistants rather than job terminators. As a marketer, you probably don't have to worry

Mobile and immobile manipulator technologies have been significantly used in the industry for more than half a century already. Along with the scientific and technological advancement, robots, nowadays are integrated with functions such as cognition, tactile sensing, thinking, and self-navigating motion, and are capable of interacting with human or other objects thru sensors. By and large, along with these innovations, the dominating industrial adoption of robotic technology is now shifting toward other areas such as Service Robots in domestic and professional usage. Domestic robots then cover applications such as entertainment, education, security, nursing, and house keeping. By reviewing literatures analytically, this study focuses on Service Robots, of its pass and current usage, and determines the key technologies of development of robotics science. Lastly, the study attempts to forecast innovative trend of robots by technical foresight methods.

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1. Introduction

Robots have become quite an issue in the daily life for decades. This study would like to define "robots" or "robotics" more carefully, although both terminologies have already become quite a common science. As well, the study would discuss the chronicle devolvement of robotic technology and its peripherals in depth, while probing into issues of robotics in view of sociology, and scientific development. By their designated applications, this study divides robots into: Industrial Robots, Professional Robots, and Domestic Robots. This research refers to related literatures and produces analytical view on the development of robotic technology, and its latent market opportunities. In discussion of robotic technology in this paper, we would like to present the reciprocal effect between the "market pulling force", and the "technology pushing force". Since long, human's imagination of robots has transferred from the mythological fantasy into practical reality by technological and scientific development. Following the successful utilization of industrial robots, internationally renowned multinational corporations are devoting heavily on the research of service robots, such as Sony, NEC, Philip and etc (Research and production of personal service robotic, 2006). The concept of robots is now adopted from Sci-fi to become scientifically viable technology, as it is commonly agreed among scholars and scientists, that key breakthrough of robotic technology will derived from IT

and its related industries (Angeles, 1997). Yet, what are the key breakthrough technologies that will become the main axis of the development of robot technology? And what are the paces of assorted developments? This study intends to answer these questions by outlining technology roadmap of domestic robots via systematic literature reviews, and in-depth interviews of industry specialists. This study also attempts to outline the future market prospect of domestic robots. At the same time, the forming of necessary systems and related measures for service robots and its potential market are discussed by scenario analysis, and categorized in eleven sub-categories (see Table 1). There are two basic criteria for small and medium enterprises to enter the global market satisfying the customers' future needs, and quality requirement[†] (Ehrlenspie, 1995). Research data indicates that owing to the maturity of products such as domestic robots, the demanded by mass consumers in the next 10 to 20 years will soared, and subsequently, the market will expand rapidly. 38 key factors derived via scenario analysis are detail in Appendix Table 1. Its content asserts that a domestic robot should be based on an "intelligence" broadband digital platform.

Service Robot is not a single-task or unitary function machinery, but a super butler that combines IT technology and a robot. It can organize and perform as, for instance, home multimedia center, home appliance-control center, caring for elderly, home security, domestic chore helping, personal assistant, and etc. Therefore, the user can communicate with the home service robots thru internet via personal digital platform, as well as tracking the

[†] Ehrlenspie (1995) point out Small- and medium-size enterprise (SMEs) can successfully enter the globall market if they can fulfil the customer needs regarding features and quality of products. Custmers are becoming more and more demanding ---all the time. "Customer is the King" is becoming the motto of today.

geographic location of his family member via global satellite positioning system (GPS), so that elderly, underage and family pets can be taken care of (Panzieri et al., 2002). Further, the large-scale database in the robot server center may be accessed remotely by the family members via internet at any time, anywhere. So, a service robot could well be the most effective backup support center of its users.

The second part of this paper focus on reviews of literature, while the third part discusses the associate technologies for robotics. The fourth part probes into the potential market for service robots. The fifth part then consists of prospective technology development for service robots by technical forecast. Lastly, conclusion and recommendation are detail in sixth part.

2. Literature Review for Background of Robotics

2.1 Historic Background for Robots

Concepts akin to today's idea of robots can be traced back to ancient Greek mythology, Cadmus's fable tells how Sown men was made by spreading the teeth of dragons, and Galata's statute beloved by Pygmalion were came to alive, the god of metal Hephaestus created a wisdom mechenical butler, a maid made of gold, and a mobile three-feet table, and etc (Cadmus, 1100-600BCE). The jewish mythology offers similar fantasy, that pottery statute were transferred into legendary personnels by Kbabalistc witch craft, Norway's tale also mentions how pottery giant Mistcalf helped Hrungnir to figh god of thunder Thor (Mistcalf, BCE). A design of a mobile mechnical knight that can stand, sit, wave its arms, and move its head and jaw was found in the Da Vinci's notebooks in 1950s, which could well be the first design of robots in the human history. It is believed that Da Vinci

derived this idea from his anatomy research that was recorded in the Virtuvian Man, although it is unknown whether he had attempted to produce the robot (Leonardo, 1490).

It is said that the word "robot", firstly appear in a play made by Czech drama writer Karel Capek in his piece – R.U.R (Rossum's Universal Robots) (Karel, Čapek. 1890–1938), which derived from the Czech word "robota" that literately means compulsory labor or work. The word implies human beings are long yearning for a durable, tireless, uncomplainingly servant that is always up for serving obediently. And since the First World War, labor work force was in huge demand, and such reality demand stimulated the scientific fantasy that peruse for robotic labor force, particularly in France and Japan (Robotics historical, 2006). Until the present days, the issue of development of robotic technology is still hotly debated, and gagging for. Just like how we have been fascinated by sci-fi novels, comics, and movies that feature robotics. It could be said that, such a fascination had inspired many important robotic scientists since they were small.

An autonomy mobile robot can detect surrounding worlds by sensors, and can position itself by its coordinating system (George, 1946). This study defines the latest robots as follow a robot is a piece of mechanical equipment designated to perform functions to replace manpower, and can detect its surrounding environment via sensors, and resistant to foreign impacts. There is a piece of AI (artificial intelligence) or automatic instrument that can perform specific human functions.

.2 Adoption and Development of Industrial Robots

George Devol patented his general purpose playback device in 1946, and jointly found the world's first commercial robot

company ten year later with Joseph Engelberger (George, 1946). Its first industrial robot, "UNIMATE", was shipped to GM motors' production line in New Jersey in 1961. Its only ccompetitor, Richard Hohnl in Cincinnati Milacron Inc. of Ohio then produced the firstever micro-chip controlled industrial robots called "T3", was named as the "Tool for Tommorow". After that, at least one new company was found each month as the robotic industry was flourshing in the 80s'. No sooner then that, the robotic industry was ready to take bigger challenges humanoid robot. Honda Corporation of Japan started its development of "humanoid" from 1986. The concept of humanoid was to produce mobile robotic machines that can co-exist with, and help human to perform tasks that human cannot, and to increase the welfare for human society. By 1989, mobile robots team of Massachusetts Institute of Technology produced a mobile robot "Genghis" its walking movement was named as "Genghis gait". It was adopted and integrated with sensors that can interact with the surrounding environment, and can speak more than 800 sentences in English, and is capable of talking to another kin machine, the first ever electronic pet "Furbish" was introduced by Tiger Electronics Company in 1998. Following that, Sony launched its robotic dog "AIBO" in 1999, while Honda presented its humanoid "ASIMO" in year 2000 (Robotics historical, 2006).

From the articulated industrial manipulators in early days, until the mobile, self-managed, and self-configuration robots nowadays, it demonstrates human's unchained desire in search of a severing and reliable partner. By the specific functions, design, and the usage of robots today, there are three types of robots: industrial robots, professional service robots, and personal service robots (UNEC, 2006).

2.3 Industrial Robots

Industrial robots are single-task fixture mode that can interact with human or the environment littlely. They are called industrial robots because they are mainly utilized as parts of production automation. They are, in fact, articulated manuplators that perform weilding, varnishig, and quality checking. From late 60s' until 2004, there have been 1.5 million industrial robots being installed, and there are still 0.84 to 1.12 million robots remain operational according to UNEC and UUFR (UNEC, 2006). By the estimation of Japanese Robotic Association (JRA), the amount of robots export raised in 1999, as the production of Japanese robots increased, the total value of production of industrial robots hits its highest in year 2000 at 600 billion Yen. Yet, as the export decreased in 2001, the production value decreased to 400 billion. The fall continues in 2002, at the volume of 391.3 billion Yen (see Figure 1). In 2003, the total value bounced back to 393.2 billion yen, while it was up again in year 2004 at 445.8 billion Yen. By 2003, Japan has been the number one country of production and application of robotic technology in the world, and its adaptation of industrial robots was at the total of 40% of the entire world (JAR, 2005).

2.4 Professional Service Robots

Professional Service Robot is used for repetitive and dangerous works that require degree of high concentration, such as cleaning works in the industrial area, equipment maintenance, data retrieving, medical rehabilitation in nursing field, mending and maintenance, and ratifying. Others include exploration task such "Genie", and "Opportunity" that went to Mars, security checking, safety guard, demolition, and transportation. Also, the military robots that can perform tasks in rescuing, fire-fighting, monitoring, or other robots that are utilized for general public are all

categorized as Professional Service Robots.

General Service Robots have been mass produced and widely spread around the world. According to International Federation of Robotic (IFR), there were 23,000 service robots being adopted for services in year 2003 alone. And there will be 13 million service robots used as personal assistants all over the world. Private usage of service robots will be hugely demanded to replace the old ones, and it is measured as a US$ 670 million market between years 2004 – 2007. For example, the automatic vacuum cleaner robot, introduced in year 2000, has been shipped by a rate of 600 thousands annually. The market for service robots is also expanding at a rate of 400% per year. On top of that, on average, there are 200 companies (70% are newly found companies) that join the field associate to the service robot industry, as the driving force for innovation and high-value added products.

2.5 Personal Service Robots

Robotics Trends (JAR, 2005) defines personal service robots as to provide associated personal services in education, entertainment or domestic assistance. In other words, personal service robots could be marketed in various consumer segments, such as home autonomy/automatic robots (sweeper, security), hobby/education (e.g. Lego's Mindstorms), robotic pets (e.g. Sony's Aibo robot dog), intelligent toy pal (e.g. Hasbro's Fur Real Friends) (http://www.tigertoys.com/), and last but not the least, robotic care-taker for less able, and elderly. By today's technology level, and market potential, personal service robots will be widely spread and hugely demanded in 10 to 20 years. All future domestic chores and personal assisting tasks will be performed by robots. Thus, this study would like to focus on the social circumstance in 2030 when robots will be large service.

3. Discussion in Robotic Technology

As robots are placed to face increasingly complicate environment, and more challenging tasks, technical issues such as robot's functional ability, independence, human interface, interface ability, safety and data providing accessibility should be further explored.

3.1 Human – machine interface ability

The safety of using robots is a basic and typical concern, because the stereo type of intelligent robots, in sci-fi, always implies the impression that they will outrace their human master one day, as they gradually self-taught and become self-aware. Therefore, it is essential to tackle with the safety issues before further into the robots communication ability. Scientist Asimov had made three principles for robots in 1950:

(1) A robot shall cause no harm to human being, by itself, and by its idleness.

(2) A robot shall obey human orders, unless it is violating the first principle aforementioned.

(3) Unless it is violating the first and second principle aforementioned, a robot is self-defensive. (Asimov, 1942)

In addition, the development of robots as a whole tends to orientate around two main themes in mocking humans:

(1) Viable Biological Engineering Model: Scientists attempts to construct a model by integrating sensing systems, motion driver systems, process data from database collected by built-in sensors to perform positioning, and programmable behaviors with a feasible biological engineering system.

(2) Humanoid (Human replica): Humanoid robots act and look like

human beings. Whilst it is a major concern to establish an effective communicating mechanism with human, so that such robots can perform satisfactorily by fully comprehend indication and requirements of human (Azevedo et al., 2004). The design of robots consists of three major technical aspects that determine the successful factors for robots: sensory technology, motion technology and intelligent technology. At the same time, human-robot interface technology covers many technical areas: interface, communication, human-interaction, and etc, each of them are sharing one common objective – to facilitate effective human – machine communication (Chew and Pratt, 2000). (See Figure 1)

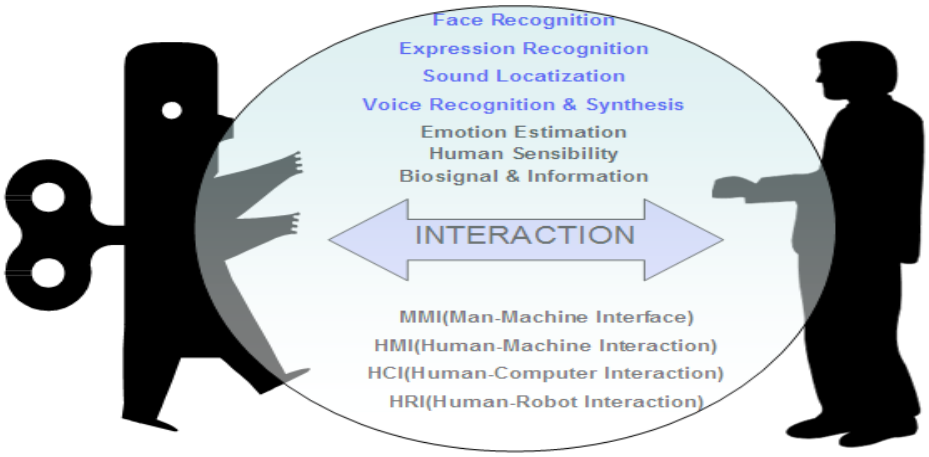

Figure 1 Interfacing between Human-Robot

New robotic technology advancement promises a convenient world for Europe and the world over, as well as demonstrating improved assistance and social tolerance for grey population in the European Commission. Personal service robots will enable independent lifestyle for the largest demographic group there, and reduce the dependence on medical and home-caring resources. Anyhow, these significant social benefits are not diminishing the need for industrial and personal service robots in this country. There will be

a room for developing a huge market and a global supply chain that supports associated robotic products and services in terms of hardware and software upgrading.

3.2 Key Robotic Technologies

Prior to the discussion of the key robotic technologies, it is absolutely essential to understand the market requirement, and the need to shorten the development lead time (Kušar et al., 2004). Key technologies for service robots include:

- *Components for Robots*: Designing and developing a list for key robotic components such as sensors, start-up, mobile and fixture manipulators, effective grabbing and holding mechanisms, mobility system, and the standardized robot interface.
- *Intelligent and Cognition robots*: Performing tasks in the known environment (business and personal use) enabled by human control, instinctive, multi-modular interface. In other words, intelligent and cognition robots of today are made by avant-grade cognition, control, and behavior ability (Luk et al., 2005).
- *Key system engineering issues are*:
  - *Integrated module (Plug-in or Entertaining Robots)*: Advance model design. module and new development, adoptability, function, and plug-and-play service robot system.
  - *Robotic system in the network center*: By embedding an intelligent IT infrastructure to a robotic system that can communicate and synchronize its coordinating position.

In addition to the basic key robotic technologies, research and development for personal service robot technologies must focus on

applications for consistent mobility in the hazardous environment (Luk et al., 2005). This study would like to stress the following points:

- *Extensity – temporary recognition*: study and recognition of objects, analytical comprehension of the location status (Chew 2000, Choe 2005).
  - Face tracing and recognition, and obstacle detecting thru image capture technology.
  - To navigate, measure distance, and coordinate positioning via infra-red or supersonic technology.
- *Decision making*: making choices, forecasting, and planning
  - Make corresponding moves to the integrated process of images, voices, memory, actual situation, and other factors.
  - Making corresponding moves via autonomy management intelligence to its memory or the surrounding environment.
- *Learning*: By retrieving information to acquire novel or advance technology and knowledge (to deduce, infer, and think in regression) endlessly (Francisco and Paul, 1992).
  - Intelligent operation system and functional program language design.
  - By imitating, and demonstrating.
- *Interaction and communication*: Task execution ability, communication and demonstration of its attempt (Ferre, 2005).
  - Voice recognition, and pronouncing correspondent voices.
  - Voice verification.
  - To synthetic language and voices by which to communicate

with human being.

The development of the key robotic technologies for personal service robots is complicate and multilateral with various technical agendas. This study demonstrates these agendas in Figure 2 Associated Technical Network Diagram, and Figure 3 Technical Development Illustrative Forecast. Figure 2 demonstrates the core technical issues for personal service robots are sensor system, monitoring system, display system, interface system, software system, and communication system. The secondary technical issues then are electronic, nanotechnology, biological detecting, material science, human interface, wireless communication, Internet, telecommunication, mathematic models, and etc.

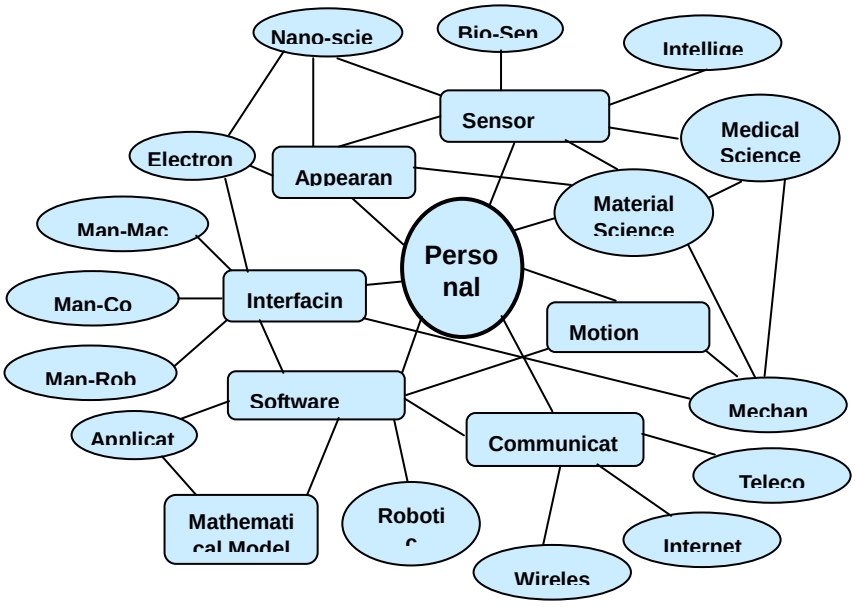

Figure 2 Robotic Technologies and Supply Chain

According to the robotics technology roadmap, the development of computerized robots was already envisioned as early as 1983. Three years later, programming language for driving the robots to execute

tasks was initialed. By 1994, the market for service robots was envisaged. In 1995, the tactile sensors for robots were adopted in the market, and robot automation was introduced to the industry. At the same time, the development of automatic and intelligent mobile robots has been continuously developed. This trend will goes on until Year 2015, for more details please see Figure 3.

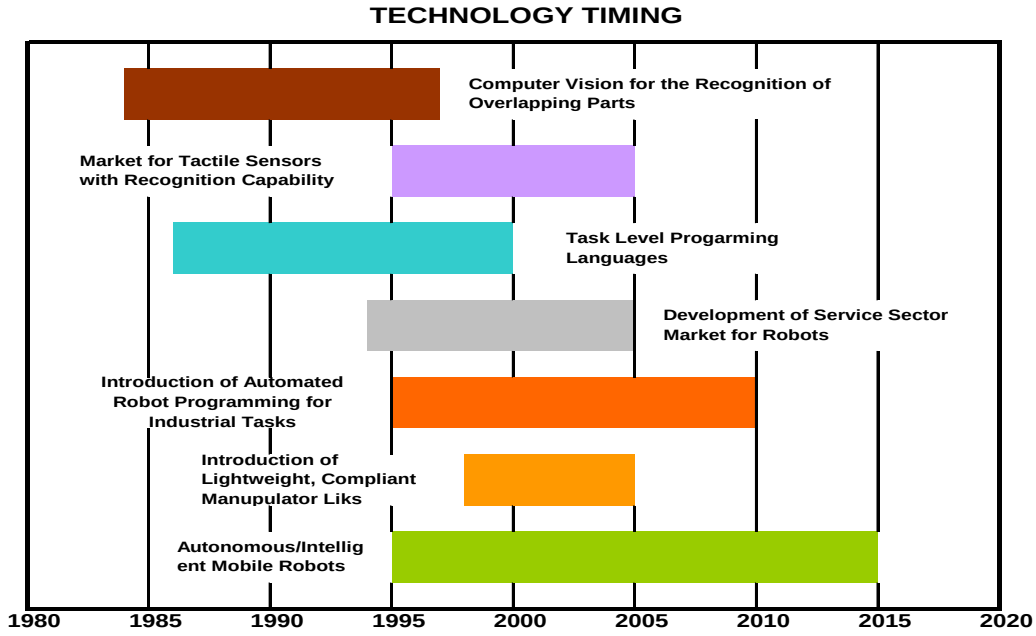

Figure 3 Robotics Technological Roadmap

4. Market for Service Robots

This study's regression analysis of the market for service robots is targeting on Professional Service Robots, and Personal Service Robots. The statistic data are obtain from "World Robotics 2005" a survey by International Robotics Association, and European Commission (Geneva, 2005).

4.1 Professional Service Robots

To the end of Year 2004, a total of 25,000 professional service robots were installed. In which, 5,320 or 21% were used for underwater works such as 14% for cleaning, and laboratory works, 13% for construction, and demolition works, 11% for medical and transportation, and 9% for farmyard usage such as milking, and forest management. The remaining of 5% is adopted for military, rescue, and security works (See Figure 4). The total market worth of professional service robots is about US$ 3.6 billion, and its unit price may vary, from US$ 10K to 300K, according to its specific usage. The most expensive items are those for underwater usage (at a range between US$ 300K to one million), and the medical robots also range around US$ 100K to one million, milking robots are sold at about US$ 200K. Between Year 2005-2008, some 50,000 service robots will be sold, with the biggest sale in humanoid robots, underwater robots, and military robots, rescue and security robots, laboratory robots, and profession cleaning robots, medical robots, and general purpose transportation robots.

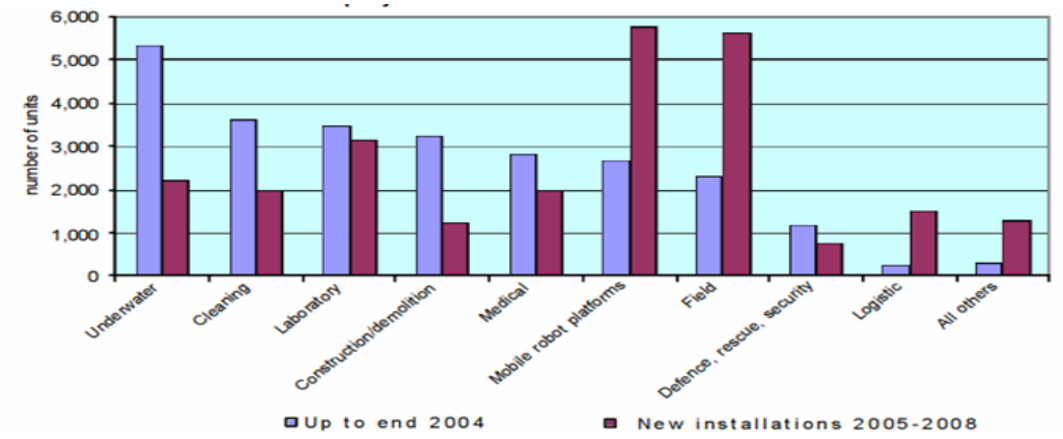

Figure 4 Service robot (unit) for professional use

4.2 Personal Service Robots

By 2004, 1.2 million home-use personal service robots were shipped worldwide. About 900K pieces were use for entertainment and leisure. Domestic robots mainly consists of vacuum cleaner, lawn mower, hobbies, and toys (see figure 5). Lawn Mower Robots are sold well with a total of 46,000 pieces shipped to date, and its sales prospect still remains rosy.

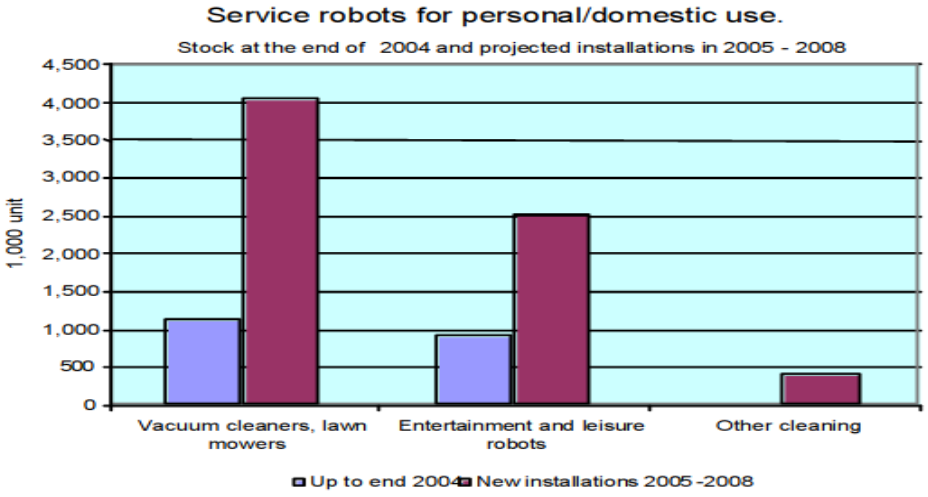

Fig.-5 Service robots (unit) for personal/domestic use

The sales of Vacuum Cleaner Robots were peaked in Year 2002 – 2004, with the potential sales of one million pieces in the foreseeable future. In Year 2004 alone, approximately 550K domestic robots were installed. Seven million personal service robots are estimated to be sold in between 2005 and 2008. The total market worth of 4.5 million domestic robots (such as lawn mower, vacuum cleaner, window cleaner and others) could well top US$ 3 billion (see Figure 6). Whilst other types of robots, such as for leisure, and hobbies, could be sold as much as 2.5 million at the worth of US$ 4.4 billion.

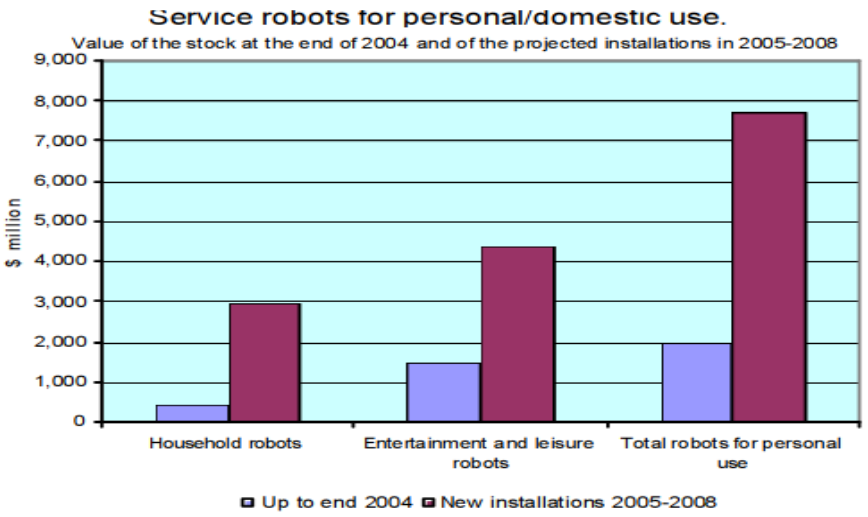

Figure 6 Service robots (value) for personal/domestic use

According to the estimation by JRA, the market for professional and personal service robots will grow from US$ 17.1 billion in 2010 to US$ 51.7 billion in Year 2025 (see Figure 7). The market includes public services, medical service, social welfare, and domestic usage.

Figure 7 Projected growth (value) of personal/professional Service robots

5. Outlining future development of personal service robots by views of technical foresight

This section attempts to outline the prospective technology development, application and market for personal service robots in the future. The outlining timeframe is set for the range between Year 2015 and 2030. The basic structure for the outlining is based on the forecast results in regions of Europe and Korea (Technology and Innovation 2004, Dannemand, 2001) (see Figure 8 and 9).

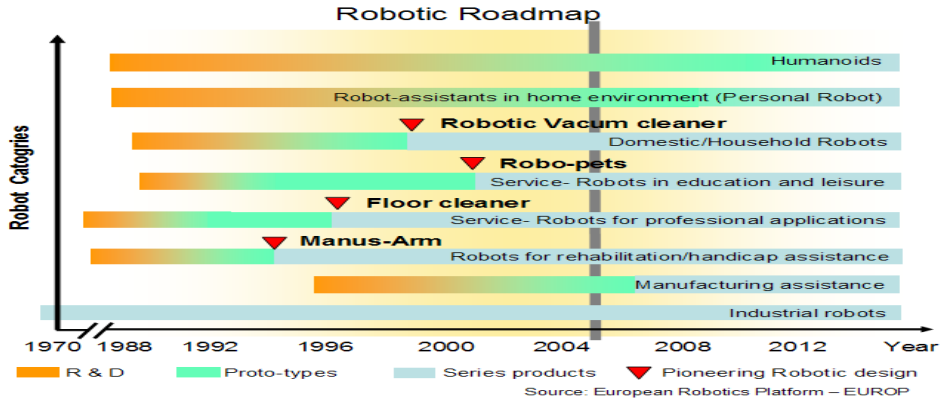

Figure 8 Robotic Roadmap

It is believe that, in these two regions, technologies for all the development between Year 2010 and 2015 are matured for commercial mass production of personal service robots. Meaning, both technology support and the demanding of such products are sustainable for the future, in terms of sales, and application, and production. This then raise the question of how to integrate the product with other peripherals that too have matured technical prospects, so that the robots will be more effectively and widely adopted by humans (Dario, 2001). The study will continue to discuss the technological development, specifically in the IT

(information technology) sector, to outline the personal service robots that will fit for the future technological and marketing condition. The study's research result may provide useful references in technical and marketing strategies for industries that would like to develop personal service robots.

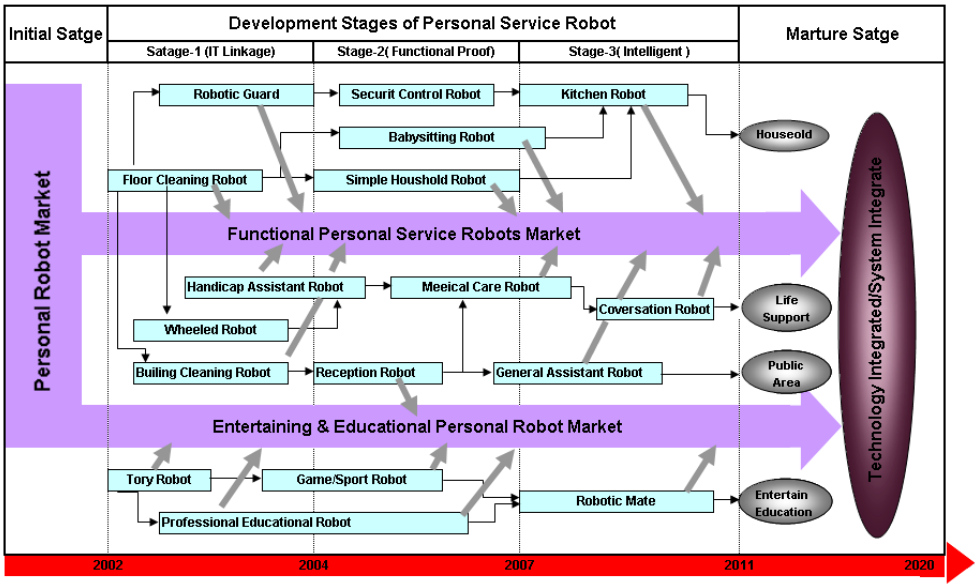

Figure 9 The Roadmap of Personal Service Robot

Source: Derived from Korea Association of Robotics

A forecast research team of this study consists of 12 members, including 3 scholars, 3 industrial experts, and 6 researchers. The research team then divided the works in planning the research procedures, reviewing of literatures in robotics, agenda for discussion, forming of sub-categories, and scenario scripting.

5.1. Planning Procedure

In order to effectively forecast the development of the personal service robots technology and the market trend, the research utilizes the technical forecasting methods to design a research flow chart (see Figure 10) the study's research procedure is as follow:

(1) Confirming the study title

The main theme of the study is orientating around the topic of personal service robots, which then extends to the relevant peripheral technologies, by forecasting technology, application and market trend from the year of 2015 to 2030.

(2) Technological diagram and screening

In order to obtain control over the whole picture of the technical development, and to ensure this study has covered the whole range of relevant technological subjects: firstly, a supply chain chart (see Figure 2) in accordance with the robotics technology is drawn. Then screening these aspects by literature reviewing and seminar discussion to produce 38 effective particulars (see Appendix Table 1), and 11 subsidiary categories through assessing, screening and classifying, definitions for each sub categories can be referred to Figure 1. Through all members' discussions over assessing and classifying these 38 effective particulars and 11 sub categories, 4 scenario elements are constructed by relevant circumstances.

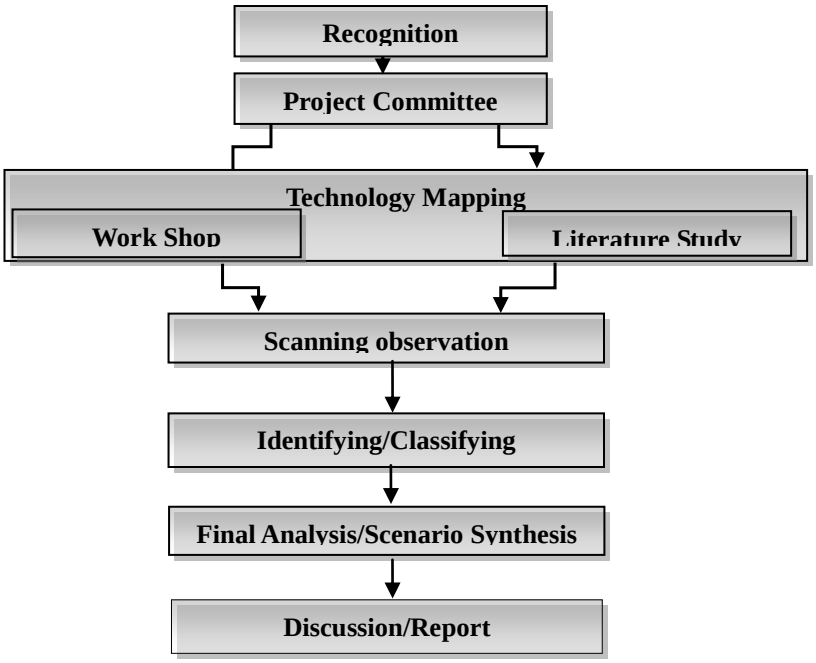

Figure 10 Process Working Flow

5.2 The Function of the Sub Categories

Through the contents of 38 particulars and 11 sub categories, technical assessment and application confirmation are reviewed and verified by the research team. The confirmed results then went on to analyze the function of each and every sub category as follow:

(1) System

The system represents all technologies that enhance functions of robots, so that these functions can further satisfy future human adoption of the robotic technology.

(2) Security

The scope of security is defined as all aspects relate to human

security, including those that are foreseeable and/or unforeseeable environmental threats that are controllable and predictive. At the same time, a person's position data can be charted through GPS system via PMDP (personal mobile digital platform) to the robot at home, so that the location of the child and the elderly can be monitored easily.

(3) Personal Assistance

Personal assistance refers to the process of personal digital information by the assistance of robots. Because of personal digital information has already riffed with daily life, such as memo, to-do list and personal data organizer. Through the connection between PMDP and the servo center robot at home, personal digital device and personal expenditure information can be transferred back, which then acts as a centralized personal accountant and financial administrator from home.

(4) Information

Information represents all sorts of news and information required by each member of the family. Generally, it is a centralized servo center robot in charge of the circulation of information to every member of the family. For instance, E-mail, newsletter message box and family bulletin, etc. At the meantime, it is also archive center to which family members download and store information from the World Wide Web network system.

(5) Interfacing

Interfacing indicates the communication interface design between robots and human. The robot must be able to identify every member of the family through visual and/or sound recognition. As well as being able to perform appropriate responses to the goal discerned. In order to communicate with persons, a

robot's linguistic ability is essential.

(6) Identification

Identification is the permission granted to family members after confirming their identities. It is then permitted to command functions available from the robotic service system. The robot monitors family members constantly (such as the RFID system) through the connection between personal mobile digital platform and the service system with DNA identification device, so as to verify the identity of the family members and to ensure home security.

(7) Domestic Labor (household)

Domestic labor indicates function that is contained within the ability to carry out domestic work and household chores. Domestic labor is an everlasting task that is needed to be attending constantly and carefully, such as house cleaning and kitchen work, which can be tackled with by implementing by domestic personal service robot.

(8) Nursing

This indicates the technology available to regularly monitor health condition of every member of the family. Generally speaking, regularly measuring, analyzing and recording body temperature, blood pressure and heartbeat. Monitor and gathering health information from special-need elderly person, chronic disease, diabetes and high-blood pressure patients, and then send this information to appointed professional medical center.

(9) Entertainment

Entertainment function contains transmission of sound and image, in other words, the so-called multimedia on-demand service.

Music, films, games or television programs are all bundled to the IT network, through which, home entertainment can be accessed. The personal service robots can be connected to household appliances and to the PMDP to provide digital home entertainment on demand.

(10) Education

Education function such as leisure function and distance-learning system can be transferred to the servo center robot at home via local area network, providing the learner a study platform. Different courses are provided in accordance to the corresponding educational level, at the same time the robot can offer interactive learning activities to enable effective learning. As well, the robot can offer home tuition programs to enhance students' study results. The robot can also function as a nanny in looking after preschool infant in absence of adult members.

(11) Communication

Communication indicates the function and technology that provide personal communication channel. Web page, mobile phone system, landline system, message exchange system and web-telephone can be all integrated into a single internet network system. When basic network infrastructure (bandwidth and wireless on-line devices) is well-developed enough to convey the transmission of all message through the internet network, the cell-phone and landline system can be replaced by the network telephone function in the PMDP. And portable computer will be replaced by the terminal mechanism function of the server robot and PMDP.

Table 1 Sub-topics of Future Personal Service Robot Technologies

Sub-topic	Code	Counts
System	SY	10
Security	SE	3
Personal Assistance	PA	3
Information	IM	2
Interfacing	IF	3
Identification	ID	2
Household	HH	4
Health Care	HC	3
Entertainment	ET	3
Education	ED	2
Communication	CM	3

5.3 Scenario Factors and Situational Analysis

Referring to the sub-category functions discussed above, the research group began to critically analyze the human needs of personal service robots for the next 20 years. By brainstorming, scientific compiling and assessing the functions of robots, and association factors between human and robots in real life, the research group has analytically summed up 4 circumstantial stimulations as follows:

Scenario description 1 (relevant circumstances in robotic system): *robots in the future have freedom of movement within the domestic boundary, and the cognitive ability of self-navigation, as well as to provide control interface for other household appliances. It is also self-defensive to external impacts, power shortage and sudden loss of electricity.*

Therefore the service robots of future require powerful computing ability as the servo center that supports the need of family members by providing the function of information access to the family. Personal digital information can be accessed through the PMDP and in combination with individual PDA, portable computer and the robot. The software design for the robot should be virus - proof. In terms of the hardware design aspect, it has to have device to uphold any outward environmental forces, and uninterrupted power mechanism for preventing the loss of electricity, and adoptive measures in case of emergency (Simmonsand and Demi, 2005).

Scenario description 2 (relevant circumstances in security aspect): *the robot in the*

future must have ability of protection for its owner. Taking precautions against threats

from outside environment, pre-warning against danger, and position tracking of the

family members.

Following the implementation of personal mobile digital platform and the basic structure for broadband network, it has made interpersonal communication and information flow in commercial trade more convenient. However transparence of information has implied great threat in preventing the security aspect for protection of personal privacy. Therefore it is to explore the benefits of the personal service robot that can provide protection to human. Such as gate control, hacker prevention, protection for the right of privacy, and domestic security and etc. These are all the security

system aspects that the personal service robot must possess. In addition, such as provides nursing care for toddlers provides care for less-able elderly and provides domestic security when the owners are away from home. These are also security aspects that the personal service robot must take into consideration.

Scenario description 3 (situation in household management): *Since it has become*

a common practice for family earning dual incomes, people have less spare time for

domestic works, such as house cleaning, gardening, cooking and nursing of elderly.

Due to the rise in inflation, increase in family expenditure and numbers of women in employment, double-income-family has become a widespread social trend working women are having less time in doing house works. Thus, there is a need for employing a professional housekeeper in carry out daily domestic chores, such as regularly measuring blood pressure level and blood sugar level for the elderly at home. Because it is not affordable for every family to hire a maid, the benefit of using a domestic robot comes into consideration. Therefore, by connecting the personal mobile digital platform with the broadband network and the robot at home, its owner can make instructions to the robot to carry out household chores remotely.

Scenario description 4 (circumstances in education and entertainment): *Science*

and technology in future living environment has to fulfill the need for knowledge

seeking and leisure activities, the personal service robot has to act as a service center

for offering professional knowledge in lifelong education and in recreational leisure

activity.

With the arrival of knowledge-base economy, the competitiveness of enterprises depends on the density of knowledge of their employees. To utilize the convenience of information technology in their leisure time at home, to substantiate their professional knowledge and to draw in valuable information, at the same time enjoying and taking pleasure of their leisure time, is becoming the vital part of surviving in the futuristic environment. By using WiMAX wireless technology, the personal service robot is able to fulfill the human need in this aspect. Especially, the robot is much capable in compiling and gathering vast information. At the same time, by using the personal mobile digital platform to provide accurate and efficient information service. Furthermore, the robot can offer many kinds of recreational choices to the family, such as multimedia, video-information, family cinema, and etc. It is therefore a valuable resource for everyone's leisure.

5.4 Discussion

Beyond 2005, direction for the future development of the personal service robot is unambiguous, and is not merely the robotic function that we have expected of today. When the personal

robot is gradually accepted by the market, the development of other relevant technology can move forward rapidly and offer other correlated service function. The personal service robot will become a super housekeeper as technology constantly moving forward. In the foreseeable future, the combination of IT technology and robotic technology will enable the personal domestic service robot to become a powerful information servo center at home.

After the basic structure of WiMAX wireless broadband network has been completed, the host who is away from home will be able to make connection with the robot through personal mobile digital platform, and instruct the robot to carry out tasks remotely, such as to undertake domestic work, care for the elderly and children at home, and information retrieving. Therefore, the personal service robot will become an indispensable partner in life, while the robot can only perform tasks on human's command and consensus. Will the robot be able to offer proper consolation to the host, when he is feeling lonely, or he is feeling low emotionally, or he has been wrongly accused by others? Will the robot be able to detect human emotion? It is technically a complex psychological issue that needed further research and development. Nevertheless, there are many interrelated and complex aspects of human psychology which is not simple mathematical equations can easily solved by computers.

As the personal service robot starts to take part in the human's living environment, it raises many issues in psychology and human perceptions. Such as individual psychological adjustability, feeling of mutual trust, human contact, inter-dynamic conversation and proper reception. Although it may not so easy to overcome, it is already an issue on human's agenda. Therefore, how is technology going to grant the soul to the robots? It will be an interesting and

important topic, at the same time it will also determine the commercial viability for the personal service robot.

6. Conclusion and Proposition

Reveal from the proposition of the 38 particulars an interesting and integrated view has emerged for the development of personal service robots. The robot is no longer a mere machine of single task function. It goes one step further to combine future IT technology and robotic function, and become a super housekeeper. From becoming a multimedia center at home, a control center for electrical apparatus, nursing for the elderly, providing domestic security, domestic labor and individual life assistant. It can all be implemented and managed by the personal service robot.

6.1 Conclusion

Communication network in the future will be supporting 100M bandwidth broadband to household and integrated with WiMAX wireless network. Our daily communication transmission will get across via personal service robot through the regional network that links with the Internet network. For example, by the personal mobile digital platform to connect with the internet network and the personal service robot via global position satellite (GPS), and transmit the positioning information back to the servo center that can track the geographical position of the family member at any moment in time.

Family members can store his/her information through the server of the robot to the central storage network. What's more, according to individual need and request, the robot is able to guide through him/her any educational course and subject. Since the robot has been enhanced with mobile ability and intelligence devices, it is predictable to say that the robot will become an important member

of the family. Not only can it offers care for the family but also provide aid, comfort, education and amusement to all members of the family (Chatila, 2005). Thus, we would like to propose several creative topics for discussion in development of new technologies:

. Personal mobile digital platform (PMDP) is a portable terminal of the servo center service robot. It can offer applications such as PDA, portable computer, mobile phone and satellite navigation all-in-one through the server. In addition of sensory systems, for instance: DNA identity recognition system, health monitoring, detective system and other special application systems.

. Home servo service robot: It is similar to the computer system commercially used today, the structural of such system can reduce and replace the numbers of PC in used, by connections to the internet super highway, it provides alternate subsidiary devices PMDP with every possible application software available.

. Individual positioning tracking system: Just as the American automobile security measures, PMDP is linked closely with individual user. Therefore, the geographical position of the person can be tracked through global position systems (GPS) as the data are transmitted to home servo center service robot at any moment in time (Hagele, 2005).

6.2 Research Limitation

There should be a greater perspective for the future technical development of the personal service robot. To define a vivid prospect for the future robots, more thorough and extensive discussion is required. This research only puts forward some feasible applications and developed technology. However, there are more issues entail in the anticipation of the personal service robots

encompass into human society. Such as the psychological aspects: individual human's perception, mutual trust and the emotional expression of a person towards the robots. These aspects have little coverage by the research.

6.3 Recommendation for the future study

The direction for future studies in robotic technology may focus more on the needs of futuristic human society for robotic application as well as the development and adaptation of new science and technology at the same time. New research and development can also begin with preparation for promoting demand, and market development for the robotic technology. In view of making the life of human and robots more harmonious and coherence, researchers should further probe into further discussion and understanding of the human psychological aspects for the joint human-robot society.

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