HOME CARE ROBOT FOR ELDERLY

By

LEE LIN JIE

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONS)

Faculty of Information and Communication Technology
(Kampar Campus)

MAY 2019

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DECLARATION OF ORIGINALITY

I declare that this report entitled "HOME CARE ROBOT FOR ELDERLY" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

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I would like to express my sincere thanks and appreciation to my supervisor, Mr. Teoh Shen Khang who has given me this bright opportunity to engage in a home care robot project. It is my first step to establish a career in robotic field. A million thanks to you.

Besides, I must say thanks to my parents and my family for their love, support and continuous encouragement throughout the course and also standing by my side during hard times.

ABSTRACT

This project is to train and control a home care robot for elderly and it is for academic purpose. It is provided with the methodology, concept of training and control of a home care robot. This project is chosen due to the ageing population is rising and many of them are facing the problem which is lack of care. Thus, this brings problems to the elderly for example when they fall down, no one notice or provide help. Researches had been done on the previous works and journals on the topic of home care robot to get ideas and references. This project is using a Turtlebot3 as physical robot. Algorithm had been trained and robot had been controlled so that it can meet the requirements of this project. The project is separated into two parts which are machine learning and robot control. During the machine learning part, python language was used and the algorithm had been trained by using human poses images so that it can recognize the human poses and make detection on the elderly pose. After the algorithm can make pose prediction, the robot will be control using ROS environment so that it can move towards the elderly according to the distance defined and send alert by ringing the alarm. Last but not least, although this project is for academic purpose, it is also developed to help decrease the rate of incidents happened on the elderly.

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LIST OF ABBREVIATIONS

CMOS	Complementary Metal Oxide Semiconductor
ROS	Robot Operatin
SLAM	Simultaneous localization and mapping (SLAM)

Chapter One

Introduction

1.1 Problem statement and motivation

The problem statement for this project is the aging population is increasing nowadays, the seniors may have no child or many of their children are unable to take care of them, this will lead to the increasing of the rate for an elderly to get in risks or dangers. Besides, due to the total amount of elderly is increasing, workloads of care helpers are also growing, so this causes lack of helpers and nursing homes to look after and take care the elderly, the elderly may live alone and probably lead to mental or physical problems. For the elderly who are disable or with health problems, they may need someone to take care on their daily lives, without anyone to help them may let them get into a more trouble situations.

The motivation of this project is to develop a home care robot for elderly so that the problem stated above can be eased. The robot developed in this project is to help people to keep an eye on the elderly daily activities and prevent danger situations from happening.

1.2 Project Scope

This project focus on developing a service robot for personal use which is home care robot and this home care robot is basically being use inside a house, mainly for elderly. The main task of home care robot for this project is to help human in taking care of elderly daily activities to prevent the elderly from getting into danger situations by detecting whether the elders has fallen or not.

First and foremost, this project was developed with a camera attached to the laptop or webcam that used to capture and recorded down the elderly daily live. By the images captured, the home care robot was going to detect and predict the pose whether the elderly has fell down or not. If the elderly has been detected that he/she is falling down, the robot should also be able to move toward according to the distance defined and make alert by ringing the alarm sound.

Hence, in this project, algorithms had been trained about the patterns of human pose like the pose of how a people is falling down. TurtleBot3 and camera were using in this project for the hardware parts. Python, MQTT, ImageAI library, ROS as well as OpenCV library were using for the software parts. Furthermore, for the methodology, prototyping is used for implementing the SDLC cycle of this project.

1.3 Project Objective

The main objective of this project is to implement a home care robot to help in taking care of the elderly and prevent them to get into danger situations . Following are the sub-objectives to support the stated objective:

Sub-objective (1) :

- To monitor the activity of the elderly especially when they are alone in the house.

Sub-objective (2) :

- To detect and predict the pose of the elderly.

Sub-objective (3) :

- To move the robot towards the elderly and ring the alarm when critical happen to them.

1.4 Impact, significant & contribution

The contribution of this project is by making use of technology to implement the home care robot to take care for the elderly, it can solve most of the problems for example lack of helpers to take care the elders and this can prevent the elderly from getting into a danger situation.

1.5 Background information

Recent trend

From birth to childhood, adolescence to adulthood and old age are the stages that cannot be avoided in a human's life. Ageing is a natural and normal process, and that presented all people of the society a big challenge. According to the definition, persons with age of 65 years and above are considered as elderly. The world’s population is ageing everyday: virtually every country in the world is experiencing increment in the amount of elderly in their population.

The amount of elderly whose aged 60 years or over, is estimated to be more than double by year 2050 and to more than triple by year 2100, rising from 962 million globally in year 2017 to 2.1 billion in year 2050 and 3.1 billion in year 2100. Globally, ageing population which aged 60 or over is growing faster than all younger age groups. (World Population Prospects, 2017)

Figure 1.1 and 1.2 show the statistics of estimated ageing population:

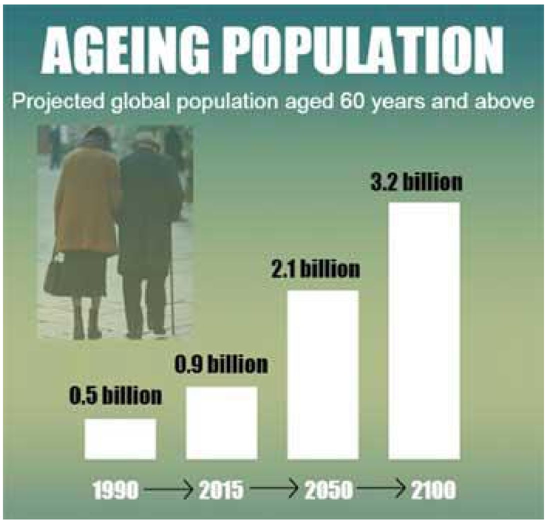

Figure 1.1: Graph of estimated ageing population from year 1990 to year 2100

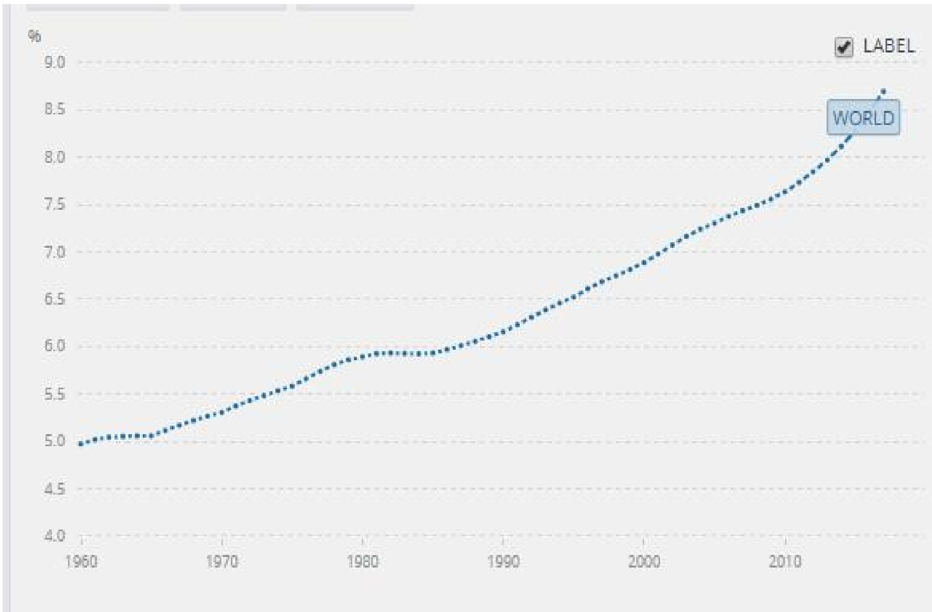

Figure 1.2: Graph of estimated ageing population from year 1960 to year 2017.

For those who are 60 years old and above, they are unlike young people. They need special medical treatment because of the changes in their physiology. An elderly is tends to have a higher leverage of physical disabilities, chronic diseases, mental illnesses and other co-morbidities. The health related problems and health needs of ageing population need to be focused and emphasized. A wide gamut of factors like social concerns, for example: children are not staying together with their parents due to occupation, leaving their parents alone and do not have any physical support in daily life; maltreatment towards ageing population; lack of awareness and knowledge about the risk factors; food and nutritional requirements; psycho-emotional concerns, and etc that cause the medical problems and thus cast a significant impact on the life quality of the ageing population.

Dr. Marc Evans Abat from the Medical City , Center for Healthy Aging, mentioned that the ageing population is require since they may have the symptoms that may be different as those younger people. Besides, he also said that provide special medical attention to the ageing population is very important.

Since the ageing population is keep increasing and recently more and more of their children are moving out from their parent or busy with works, there is no one to take care for the elderly especially the elderly who has health problems. Therefore, home care robot is launched to represent their child to look after and help the elderly to prevent the elderly from happening any incidents.

Service Robot

For the last half-century, research for robotics has evolved as a result of changing human needs. The dominant robotic application areas changed from replacing human operators in factories to more service oriented applications in proximity to humans (Garcia et al,2007) which known as service robot. A robot that works partially or fully autonomously to provide services useful to the well-being of humans and equipment is a service robot. Besides, it excluding the manufacturing operations, and it has the ability to make decisions and acting autonomously in both unpredictable and real environments to complete determined tasks. They are either manipulative or mobile or a combination of both of them. (Karlsson, 2000). Besides, a service robot is also a freely programmable mobile device which can performing services either partially or fully automatically. Services are tasks that providing the services for humans and equipment but not directly serve the industrial manufacture of goods.

Service robots are categorized according to personal or government and corporate use use:

For governmental and corporate use, there are defense, save and rescue as well as the security applications which responsible for the majority of applications. Other examples are field robots (like robot for milking), robot for construction, cleaning, medical, surgery, demolition and others. There is also the mobile robot which is usually for small business and general using.

Whereas robot which performing lawn-mowing and vacuum cleaning, elderly care, tele- and remote-presence, entertainment, medical companions which including hobby system and kit, toy robot, and home training and education robots are the instances for personal service robots. In this project, the personal service robot is focus on elderly care.

In this 21st century, it is getting more and more people using service robot to get help in accomplish tasks.

According to IFR International Federation of Robotics, for the service robots for professional use, sales of the medical robots rank higher than agricultural and logistics robots. Figure 13 show the estimated value of sales for year 2014 and 2015 and estimated value of forecast from year 2016 to year 2019. Blue color bar indicates forecast for year 2016-2019; red bar indicates year 2015 and gray bar indicates year 2014.

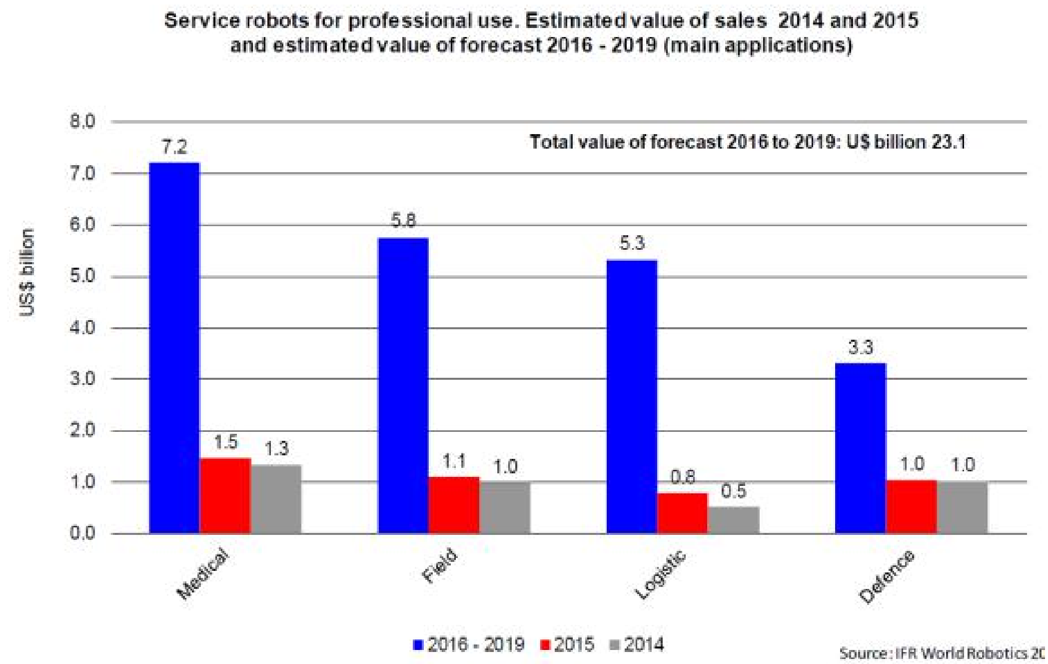

Figure 1.3: Estimated value of sales year 2014, 2015 and forecast for year 2016-2019.

Meanwhile for personal use service robot, Figure 1.4 shows the same years as the statistic in Figure 1.3 which blue bar indicates forecast for year 2016-2019; red bar indicates sales of year 2015 and gray bar indicates sales of year 2014.

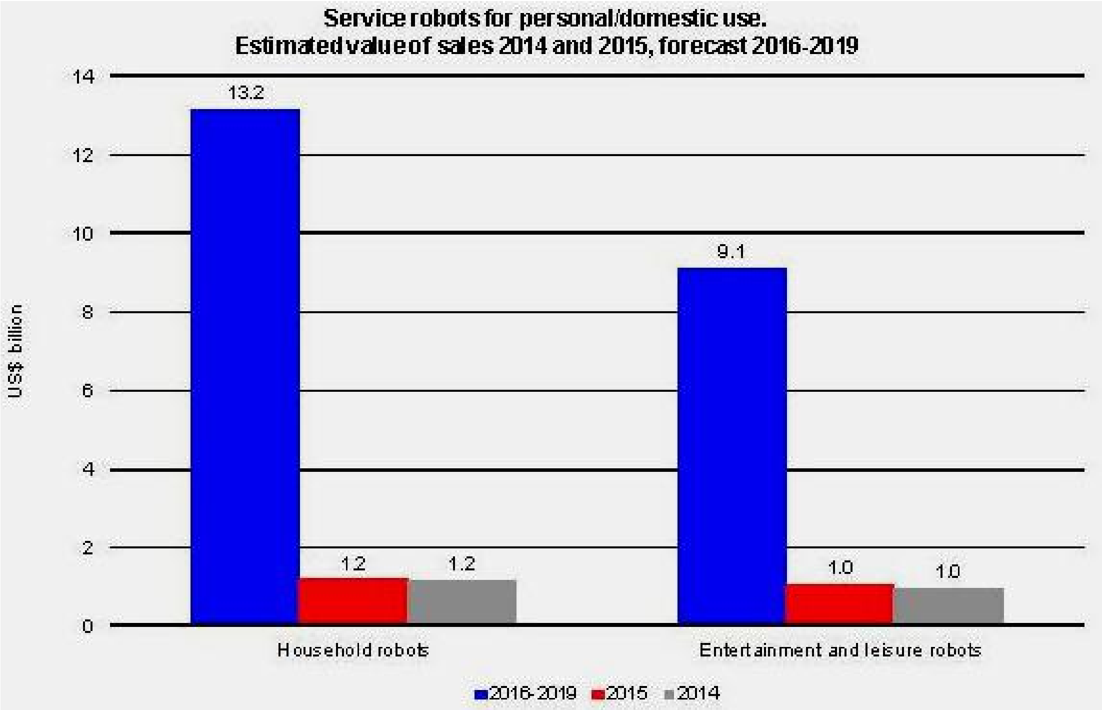

Figure 1.4: Estimated value of sales year 2014, 2015 and forecast for year 2016-2019.

Figure 1.5 portrays the demand of service robots from 2006 through 2021 for worldwide, which rose from 1.5 billion U.S. dollars in 2006 to more than 3.5 million in 2011.

	Demand in million U.S. dollars
2006	1,540
2011	3,560
2016	8,550
2021	17,800

Figure 1.5: The table of demand for service robots from 2006 through 2021 world widely.

<u>Home care robot for elderly</u>

Technical aids enable old people and disabled to live without relying on others in their own homes as long as they wish. In reality, most of the robots that will provide help and support for ageing population who are staying at their house when they might otherwise to be forced to live in nursing homes.

The purpose of home care robot is to make the life of the elderly and handicapped become better. Based on the Federal Statistical Office, the amount of people who are above 60 years old will reach one quarter in ten years time.

Elderly, they need different things like everyone else. Many of them need help and support with the daily activities like bathing, eating, standing up and dressing. A robotic hand can assist them in the daily activities like cooking and the medical management such as going to the doctor's clinics and to hold the elderly when they need accidentally fall down. Meanwhile, loneliness can be relieved and nudge forgetful elders to eat on a regular schedule can be done by robot companion.

The assistive robot's ability have been increased due to the advance in sensors to do mobility assistance tasks, domestic handling and to perform analysis on the individual and environment around them and hence, they can perform monitoring functions.

Robots that assists with health-care delivery inside the house will increase the users' autonomy and also will relieving the burgeoning demands which that ageing populations place on care and health services and caregivers which are informal .

Meanwhile, companion robots are developing to have interaction with users, have social connections with them and also give emotional support and accompany them which is subject to the personal choices.

Personal care robot and other assistive robots are becoming more and more viable ways to accomplish health-care technology trends for instance, mobile applicationa and smart monitoring systems, and this results in increasing the reliance on human care providers..

Nowadays' assistive robots are able to navigate autonomously and perform a wide range of tasks for example providing assistance with mobility, handling, lifting and bathing which can minimizing the workload of caregivers. Besides, they are also having human-robot interaction skills like speech, gestures and movement as well as face recognition. These robots are using more than one digital cameras to retrieve the facial expressions and to record down the environment, and the stereo microphones and speakers are used to communicate and monitor users. Some models are including databases which contains music,photo galleries, as well as brain exercises for the elderly.

In a nutshell, all of the robots are developed to improve the life quality of the ageing population and can let them to live independently without relying others by using Information and Communication Technology (ICT).

Chapter Two

Literature Review

The home care robot in this project is a robot that can capture the activities of elders by a camera. The images of the elderly are been detected whether the pose is fall down or not. If the fall down pose has been detected, the robot will move towards and ring the alarm. Algorithm is given some patterns to learn so that it could detect when an elder is falling down and robot is controlled to move according to the distance defined in the same time ring the alarm.

2.1 Deployment of Service Robot to Help Older People

The paper describe the deployment of the version one of the service robot, which designed for elderly in a retirement village environment. It study about people's reactions to an interaction with an older care robot to get know about which human and robot factors can lead to successful human robot interaction (HRI).

Internationally, the proportion of ageing population is increasing. Taking care the increasing ageing population is a strain on diminishing staff and resources. It has caused problems due to majority elderly need to be taken care. The version one of the service robot is deployed to solve this problem. The robot design and develop in this project is shown in Figure 2.1.

Instead of considering industrial viewpoint, the social and personal viewpoint are considered in ordered to developed a useful service robot. Different from the previous studies, this project is user oriented and not only focus on technical aspects. The long term objective of this project is to design and develop a robotic helper for elderly. An older care robot could carry out a variety of services such as entertainment, vital signs measurement, reminding,falls detection, security, and communication. It could also support care providers by giving scheduling, telepresence, monitoring service and medication management.

In my point of view, the robot deployed is providing more than one functionality, which it can perform more functions in taking care the elderly. Since the target user group was elderly, and the development group has take this as consideration so the robot is having simple user interface. Although the development group is trying to make the robot as low cost as they can, but due to the technology involved, the price of the robot still seems to be to high and no many people can afford it.

Figure 2.1 HealthBot robot for the project above.

2.2 Hobbit, a care robot supporting independent living at home

This paper describe about presenting a robot, Hobbit as shown in Figure 2.2, which provide care to elderly in order of fall prevention or detection. This project combines researches from different fields like robotics, gerontology, and human–robot interaction in order to develop and design a care robot which is able to prevent and detect falls as well as emergency detection and handling. Moreover,other functions such as offering reminders, bringing objects, and entertainment are added to have daily interaction with the robot. User interact with it by using multimodal user interface including text-to-speech, automatic speech recognition, gesture recognition, as well as a graphical touch-based user interface.

Since the aging population is getting more and more, the biggest problem will be the elderly need to be taken care to prevent from happening any accident like falling. Fall down has been verified as the highest risk for elderly of getting serious injured that they cannot stay alone at home like before and have to move to those care centre. The solution proposed by this paper is by developing a robots that can provide help to elderly so that they can stay longer at their houses. They developed Hobbit, a robot which can detect and prevent falls, so that users feel more safe at their own houses..

Hobbit, they developed it different from other service robots for caring of the elderly in the domestic context that have been developed for research purposes so far (e.g. Care-O-Bot, Accompany and many others). For Hobbit, they try constantly altering the environments which they do not know at first and natural interaction from the elderly which is difficult to be predicted and reactions on it are difficult to be pre-programmable. (Fishchinger et al, 2013)

In my opinion, the goal of developing Hobbit is a good idea since if a robot can have emergency detection and handling of fall, most of the elders can stay independently . But instead of this function, it should have a camera which work like CCTV, can synchronously connect the video of the elder's activities to their children. Besides, it should be designed to have a more user friendly interface due to the users are older adult.

Figure 2.2 : The "naked" Hobbit on the left and the Hobbit robot on the right.

2.3 An In-home Advanced Robotic System to Manage Elderly Home-care Patients' Medications

In this article, the safety profile and usability of an integrated advanced robotic device and telecare system had been examined to enhance medication adherence for ageing population home-care patients. It allows individualized patient dosing schedules, patient–provider communications, and on-time, in-home medication delivery to promote adherence. Real time dose-by-dose monitoring and communication with providers if a dose is missed provide oversight generally not seen in home care.

Elderly home-care (HC) patients with complex medication regimens are at high risk of reduced adherence, medication-related problems, and medication errors. The concomitants of aging, such as impaired hearing, vision, cognitive skills, isolation, difficulty communicating with health care professionals, and accessing health services increase these risks. Poor medication adherence may result in unplanned hospitalizations, adverse clinical outcomes, and increased costs. Besides, HC involves multiple steps in the transfer of information and medicines from the prescriber to a patient and subsequent actions by that patient. Each step poses a risk of service lapse and information gaps that can cause errors and can reduce medication adherence.

A well-engineered in-home robotic device and system could improve the coordination of patient communications with care providers. This pilot study was conducted in Finland, where the advanced robotic device and telecare system for managing medications of home-care persons on long-term pharmacotherapy was developed. This robotic device and tele-care system as shown in Figure 2.3 integrate distributing medicines, supporting individualized dosing schedules, providing patient reminders, and communicating with providers (eg, the practical nurse will receive an automatic alert if scheduled doses are not taken. This system is mainly designed to promote medication adherence for persons on long-term medication regimens.(Airaksinen et al, 2017)

From this article, the price of this system needed to be consider, whether it is affordable to majority of the user. Secondly, more functions can be added to it so that it can help to reduce more problems.

Figure 2.3: Evondos E300 Medicine Dispensing Robot with Multidose Sachets (Salo, Finland)

2.4 Robotic Home Assistant Care-O-bot

Technical aids letting people to live alone without relying others and be supported in their own houses as long as they like. Besides, all over the world, the medical expenses are keep on increasing. There are more than 30% of these medical expenses are related to ageing population and the amount of ageing population is increasing. Care-O-bot is thus created and developed to solve the problems stated above.

The Care-O-bot is a type of mobile service robot that have the function of performing fetch and carry and many others supporting tasks in housing environments. It is emphasizing in social integrating and communication based tasks, for instance automatic emergency calls, video telephone, as well as interactive communication. The control system architecture development, the mechanical design and vehicle realisation, , the motion algorithms and navigation implementation and testing are the focus of work performed so far. One of the part for the next development phase will be the sensor guided robotic arm integration.

Moreover, the Care-O-Bot/sup TM/ enable those who needed it to have care and support to live alone in their own house for a longer time. It not only meets their desire for independence and autonomy, it also helps to prevent the expensive costs for the individual treatment.

In my perspective, Care-O-Bot was a better robot as it included many functionalities like household tasks, mobility aid, as well as communication and social integration. The only thing need to be consider on such a powerful robot will be the price of the robot. If Care-O-Bot is selling at a expensive price, no matter how good it is, it won't benefit the society especially for the elderly.

Figure 2.4: Care-O-Bot

2.5 Telepresence Robot for Interpersonal Communication (TRIC) for Older Adults

This paper discuss about the telepresence robot development called Telepresence Robot for Interpersonal Communication (TRIC) for the purpose of interpersonal communication with the ageing population in a housing environment. The main purpose behind this development is to let ageing population to stay in their own housing environments, while their family members and caregivers can maintain a higher level of monitoring and communication than via traditional methods. This project aims to be a low-cost, lightweight robot, which can be implemented in the housing environment easily.

Getting older is associated with an increased risk of isolation. Information and communication technologies have been utilized to assist homecare of older adults. However, in additional for health care purpose to transmit vital sign data , elderly may expect to share their life experiences and feelings by different forms of interactions with their children and family members. Communication tools did facilitate interpersonal communication in terms of real-time verbal communication. Nevertheless, nonverbal communication, such as facial expression and body language, is more powerful and efficient in conveying ideas, thoughts, and emotions.

“TRiCmini+” as shown in Figure 2.5, a interpersonal telepresence robot for which designed and developed in this project, demonstrates extensive capability to provide different care delivery levels to the elderly through vital sign monitoring, interpersonal communication, robotic movements, and social network integration. TRiCmini+ integrates two distinct applications, the “Care Delivery Frame (CDF)” and the telepresence robot. CDF, an App that designed for elderly as an information channel on the tablet PC, which is also the “face” of TRiCmini+. CDF with social network services, and remote caregivers can share messages, photos or video clips with older adults. (Chen et al, 2013)

The advantage of this robot is due to one of the goal is low cost, and among the robot discussed above, this may be the most economical and is affordable by majority of the society since it’s size is not very huge and it’s functionalities focus more on communications. Besides, since it focus more on communication, this robot can prevent the elderly from loneliness and get depressed, thus, they can stay independently under a healthy condition.

Figure 2.5: TRiCmini robot

Comparison of robot from different research

Task/ Robot	Health Bot	Hobbit	Medicine Dispensing Robot	Care-O-Bot	TRiCmini robot
Providing Scheduling	/				
Medication Management	/		/		
Telepresence	/	/		/	/
Monitoring	/	/		/	
Vital Signs Measurement	/				
Reminding	/	/	/		
Entertainment	/	/		/	/
Falls Detection	/	/			
House Hold				/	

Table 2.1 Comparison of robots from different research

2.6 Entertainment robot used in care of Elderly with Severe Dementia

This paper is discussing on the effectiveness of using an entertainment robot instead of animal-assisted therapy in taking care of elderly with Severe Dementia. According to this paper,animal-assisted therapy is a well-known therapy which used to treat patient. The animals in the above therapy are well-trained. Although the animals have been trained, still it has the possibilities that it will cause danger or injury to the patients.

Therefore, this paper is carrying out few experiments to examine the effectiveness of using an entertainment robot instead of real animal to treat the elderly patient who are having Severe Dementia. Besides that, the entertainment robot can also maintain cleanliness.

This study used an entertainment robot AIBO and a toy dog in occupational therapy and compare their effectiveness with demented patients. AIBO is an entertainment robot that its body was made by metal and it can recognized and responded to up to 75 spoken commands whereas the toy dog was a battery-driven toy and it could wag its tail and sit. A group of 13 Severe Dementia participants who average aged 84 years old were involved in the experiment.

Two experiments had been conducted and the result showed that the patients had more reactions toward the toy dog compared with AIBO. The reactions are including watching, talking, clapping hands, touching and caring. But both toy dog and AIBO had effectively increased the elderly patients activities during the therapy session.

The patients known that the toy dog and AIBO were both mimicked a puppy, and the study assumed that the elderly patients remembered past experiences with a pet dog, therefore they will talked and gave response to the toy dog and AIBO.

From this study, it can be concluded that the key element of having a successful occupational therapy program is to choose a correct and suitable toy or robot instead of real animal. It was due to a real animal may bring the risk of allergic, scratches, bites and infection of bacteria to the elderly patients but a toy or robot will not.

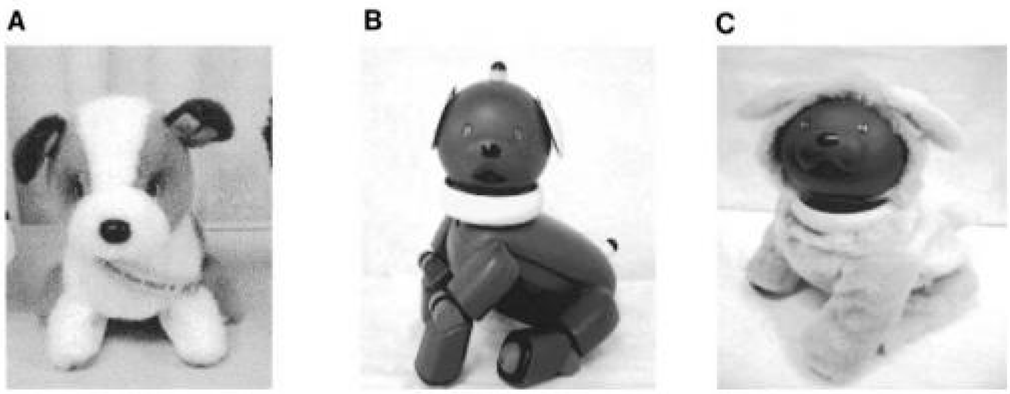

Figure 2.6: Materials: A, motor-driven toy dog; B, AIBO; C, AIBO with clothes.

Chapter Three

3.1 System Design

In the development of home care robot for elderly, the project has been separated into two parts which are: machine learning part and robot control part. Machine learning part had been done in FYP1 and robot control had been done in FYP2. The machine learning part was done in Window while the robot control part was done in Ubuntu due to the use of Robot Operating System (ROS).

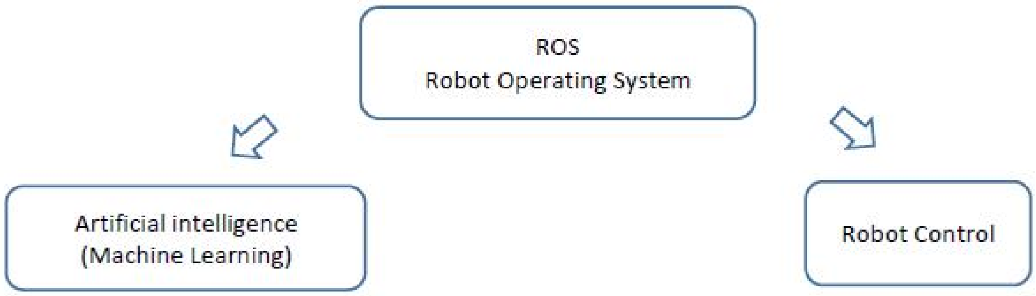

Figure 3.1 System Block Diagram

During the machine learning part which done in FYP1, the algorithm had been trained to recognize the human poses. Three poses were chosen to train the algorithm: sitting, standing and lying down. 500 images per pose taken from different angles and positions were used for training part whereas another 200 images per pose were used for testing part to get the probability of the accuracy. After the algorithm had been trained, it is able to detect the human pose whether it is standing, sitting or lying down when a image is provided to the algorithm.

The language used was Python, and the ide used was Anaconda. Python was chosen due to Python is a very convenient and easier language that can including many different libraries to use in it compared with other programming languages. Anaconda was used due to it is a platform of Python and also it is convenient and easy to compile the Python codes.

After the algorithm had been trained to recognize the human poses and tested by inserting the images manually, it is then proceeded to next step which was reading the real time images from webcam and linking it to the prediction part so that it can read the real time images from webcam and the images can be predicted automatically instead of manually control.

The webcam part was set to get a image for every 10 seconds and a two seconds delay had been inserted before the prediction part so that after the webcam had captured the image, the algorithm will have some time to pass the image to the prediction part.

For both webcam and prediction parts, they had been putting in a while loop and the break condition was the probability for sitting or lying pose was more than 70 percents. While loop was used to make sure the algorithm will keep on running for the purpose of monitoring the elderly activities and will only stop it when it detected the elderly is seems to be falling down. After the algorithm can detected the elderly is seems to be falling down, the next stage which is the robot control part is proceeded.

During the robot control part, the algorithm in robot control node subscribed message published by the pose prediction node. After receiving the message, if the message was lying down or sitting, it triggered the Turtlebot3 to move towards the elderly else it will do nothing. For controlling the Turtlebot3, ROS was used and the process was done in Ubuntu but not Window due to Ubuntu was required for the use of ROS. Therefore, the Python file for the machine learning part also needed to be run in Ubuntu so that the image capture and prediction parts can be done and can triggered the Turtlebot3 to move. Geany had been installed in the Ubuntu to use for writing the Python codes and Arduino had been installed and used as the ide for Turtlebot3.

For the robot control part, subscriber and publisher function had been used. The message published was declared in the Python file (pose predict node) after the prediction part which used to be subscribed by the subscriber in robot control node. To publish and subscribe successfully, a same topic must be used. MQTT and ROS were been used for the communication between nodes. Three nodes were used according to the system block diagram, which are machine learning node, robot control node and a intermediate node (ROS). After receiving the message and has triggered the robot control, the robot will move towards the elderly who had fell down according to the distance defined and an alarm will be ringing as alert purpose. Try and error had been performed to make this project a successful project.

Figure 3.2 is the system flow chart of this project.

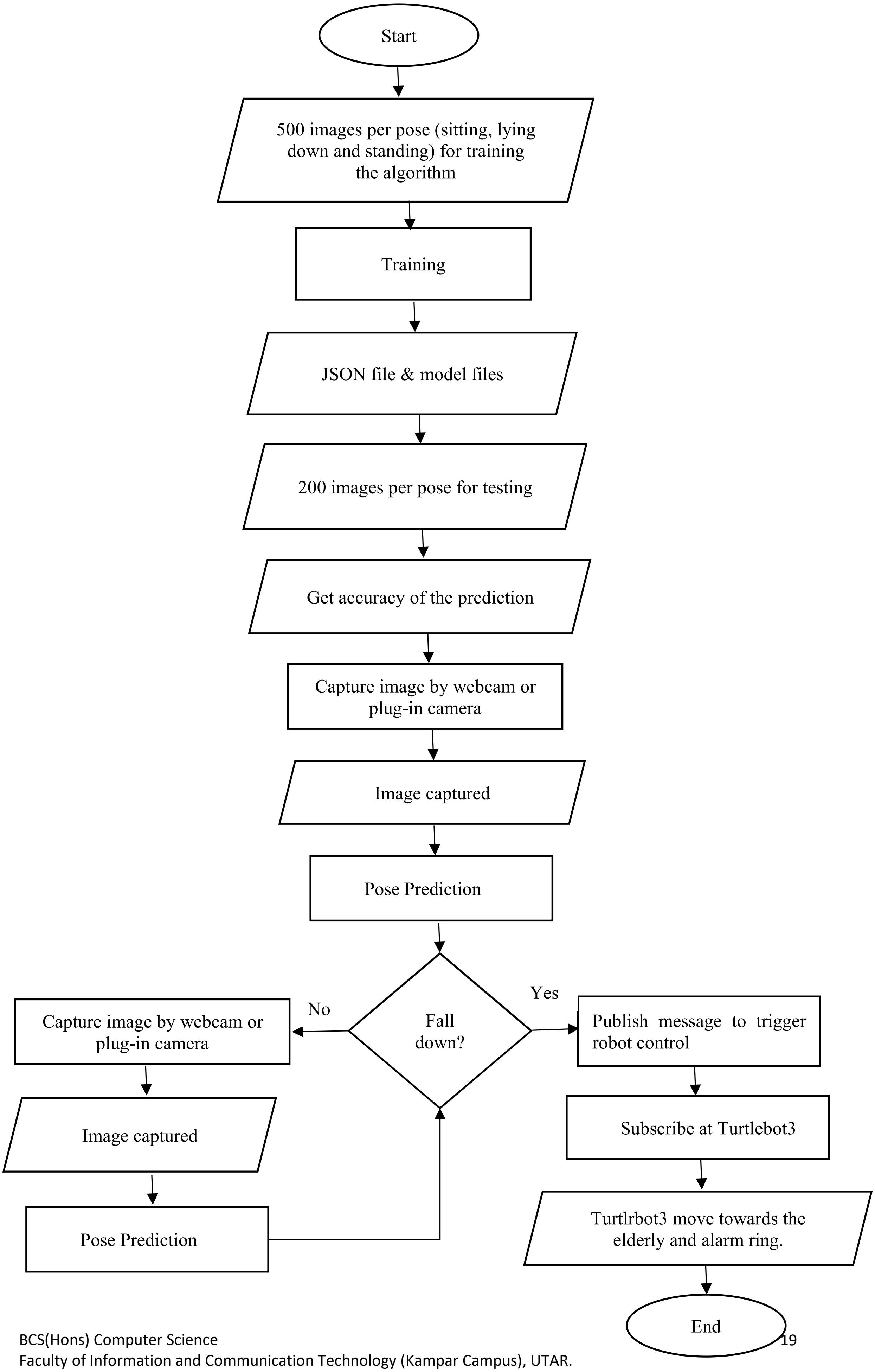
Start
500 images per pose (sitting, lying down and standing) for training the algorithm
Training
JSON file & model files
200 images per pose for testing
Get accuracy of the prediction
Capture image by webcam or plug-in camera
Image captured
Pose Prediction
Fall down?
No
Yes
Capture image by webcam or plug-in camera
Image captured
Pose Prediction
Publish message to trigger robot control
Subscribe at Turtlebot3
Turtlrbot3 move towards the elderly and alarm ring.
End

Figure 3.2 System flow chart

3.2 Hardware

Turtlebot3

Turtlebot3 was used in this project was due to it is a small, programmable and affordable ROS-based mobile robot. Its size of the platform is smaller and the price is lower compared with other robots. It’s optional parts can be used such as the sensor and computer and it’s mechanical parts can be reconstruct.

The second reason that the Turtlebot3 was used because of its core technology: Navigation and Manipulation as well as SLAM. The core technology had made Turtlebot3 become a more suitable and better home care robot. SLAM(simultaneous localization and mapping) is a algorithms that can be run in TurtleBot3 to build a map and can drive around the room. A laptop, Android-based smart phone or joypad can be used to control it remotely. Figure 3.3 show the images of the TurtleBot3 and its component.

The TutleBot3 is divided into four layers: each layer contains different components which performs different functions. Battery and wheels are located at the bottom layer, OpenCR is located at second layer from bottom, Raspberry Pi is located at the third layer from bottom and lastly the 360° LiDAR for SLAM and Navigation located at the top level of the Turtlebot3.

The battery on the bottom level need to be charged when the battery is low and the battery need to be removed to maintain its quality when the robot is using while charging. The robot can be moved by using the two wheels. Whereas for the OpenCR on the another level, it is used for the ROS embedded systems to provide completely open-source hardware and software.

The Raspberry Pi at the second top level was a single board computer. It is first connected to a desktop only for the configuration of getting the IP address and the IP address was then used in the Ubuntu terminal to enable communication between the laptop and the robot by using SSH. Lastly, the 360° LiDAR for SLAM and Navigation is used for navigation purpose.

The turtlebot3 action was depends on the robot control node which had subscribed to the topic published by the pose predict node. If the pose predict node had predicted the pose of the elderly was fallen, it will publish a message to the robot control node to trigger the turtlebot3 to move towards the elderly.

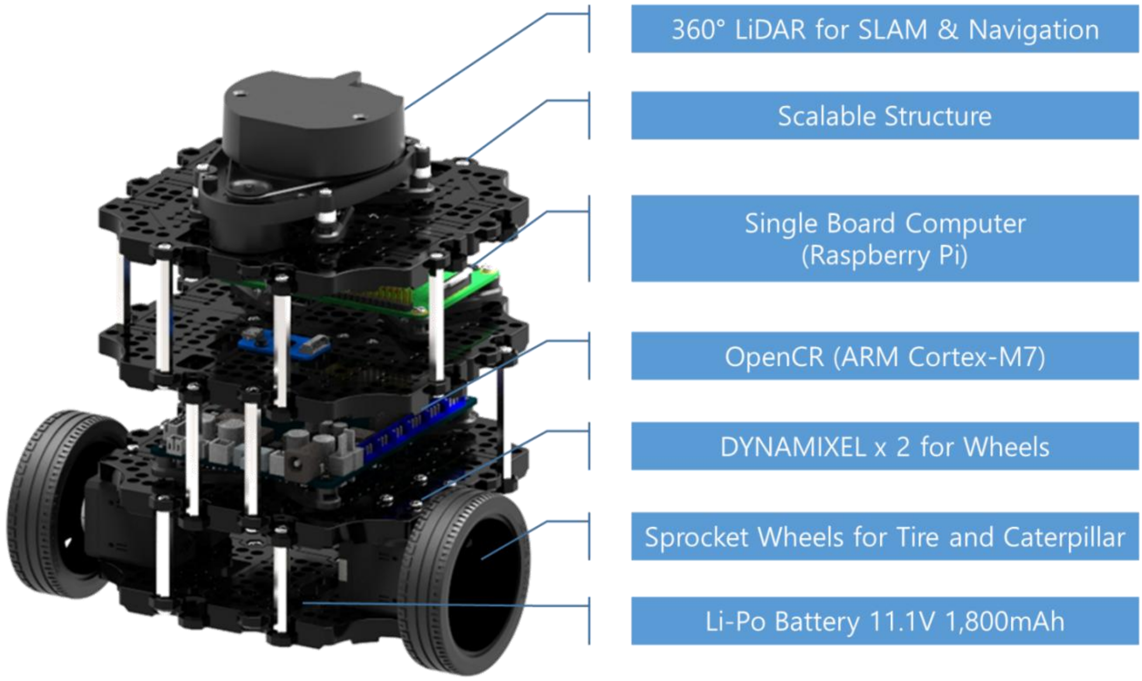

Figure 3.3: Image of Turtlebot3 and its components

3.3 Software

This project involved two operating system which are Window and Ubuntu. Window was used to do the machine learning part to train the algorithm for pose prediction by using Python language in Anaconda whereas Ubuntu was used due to it was required by ROS which used for robot control part. Geany was used as ide in Ubuntu for running the Python files and others functions were proceed using terminal. Besides, Arduino was also used as an ide in the Ubuntu for compiling and uploading the ROS codes to the turtlebot3.

The main language used was Python and the dependencies were imported into Python files to perform some particular functions. The main dependency used in the Python file for machine learning part was ImageAI, whereas for the image capture part, OpenCV was used. For the robot control part, ROS was used and the series of code were used for different purposes for instance: roscore, rosrun, rospy and etc. MQTT was used as a communication platform to enable the communication between the pose prediction node and the robot control node due to the Python versions required by the two different nodes were different. By using MQTT, the pose predict node can publish message to trigger the robot control when the probability of falling down is high.

Figure 3.4: Logo of Geany, ide used to open Python files in Ubuntu

Figure 3.5: Logo of Anaconda, Jupyter Notebook and one of the dependencies used-TensorFlow

Figure 3.6: Logo of Arduino, ide used for compiling and debugging ROS codes

ImageAI

During the machine learning part, two Python files were created, one for Model Training and another one for Image Prediction. Both of these Python files were using ImageAI library. In the ImageAI library, there are four supported deep learning algorithms : InceptionV3, ResNet, SqueezeNet, and DenseNet used to be trained on the image dataset and formed the models for the use of pose prediction.

First of all, Inception V3 is a type of convolution neural network that over million images was trained on it from the database named ImageNet. It contains 48 layers and images can be classified by it into 1000 different object collections due to a wide range of images had been learned by this network.

ResNet, residual neural network is an artificial neural network and which the constructs known from pyramidal cells was built on. ResNet functioned as skipping connections and jumping over layers by using short-cuts. It’s model are constructed with usually double or triple layers skips which the batch normalization and nonlinearities are involved in between. The purpose of the ResNet of skipping the layers is through reusing activations from the previous layer to prevent from vanishing gradients. By skipping the layers, it can simplifies the network and hence will increase the speed of training in the machine learning part.

DenseNet is the extension of the residual neural network (ResNet) and it is found that when the connections between layers are shorter, it can be substantiated more deeper, efficient and accurate when performing the training process. The efficiency of parameter is better and also the gradients as well as the flow of information throughout the network has improved compared with ResNet. As a result, the training process will become more easy.

Besides, SqueezeNet is a deep neural network that designed for computer vision. This network is aimed to use fewer parameters to make a smaller neural network that can fit the computer memory easily and also simplifies the transmission over the computer network.

In the use of the ImageAI library, the image dataset which is the human pose has to be at least two different types of images so that the models trained can recognize more different poses. Therefore, three types of poses were used in training the algorithms : sitting, standing and lying down. An amount of 500 images per pose were used in the training part to achieve the maximum accuracy of the model.

In the ImageAI, a JSON file was generated during the training process and lots of models were created. Processing of the model training and generating the models of this project had taken approximately four to five days times. The models were all come with different accuracy, the model with the highest accuracy was selected to perform the image prediction for the human poses.

Both JSON file and the model file chosen to be used in testing needed to be located in the same folder with the two Python files. The two files were then used in the Image Prediction file to predict the human pose images. Hence, it could be said that ImageAI do really gave a more convenient and easier implementation of the Computer Vision technologies compared with other libraries or dependencies.

Chapter Four

4.1 Methodology

The methodology that used in this project is prototyping. Prototyping was chosen due to this project had no detailed information for input and output requirements. All user requirements were assumed to be not known at the beginning of the project. It was also due to this project does not exist a system and there is no manual process to get the requirements like other large and complex systems. The another reason of using prototyping was due to this project need frequent interaction between the developer and the end users to get the needs for developing the home care robot. A system working model which known as prototype was then presented to the end users to let them try and have some interactions with it.

By using prototyping, the end users were needed to work constantly with the desired system and gave feedback and suggestions about the prototype to ensure the home care robot is usability, functionality and user-friendly. Besides, since the end users were working together with the developer along the development of the project, the end users are having more understanding towards this project. When there is any error or missing parts, it can be found and solved quickly without wasting more times and efforts.

Moreover, if the user is dissatisfied with the prototype no matter at which stage,the prototype can be discarded and can redevelop a new system. Generally, prototype do have different stages as shown in Figure 4.1.

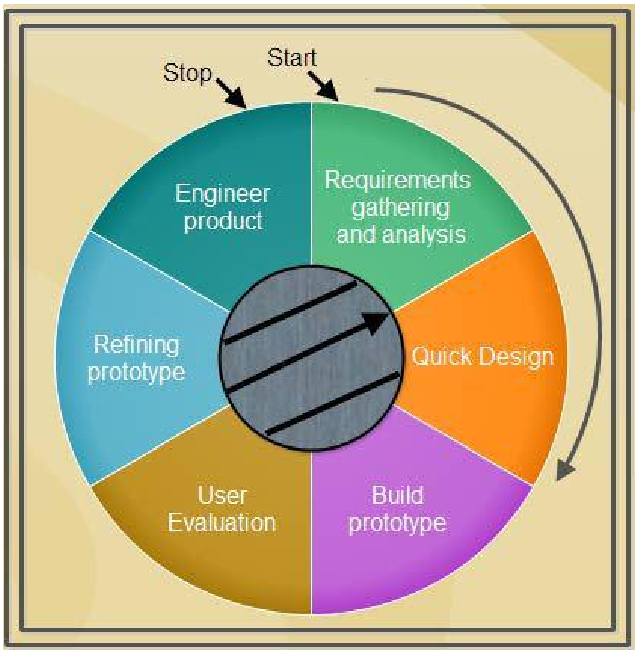

Figure 4.1: Stages in prototyping model.

- **Stage 1- Requirements gathered and analyzed:**

During stage 1 of this project, it was started with the gathering and analyzing of requirements about the home care robot for elderly from the end users. Interviewing, questionnaires or observation had been done to gather the requirements from the end users and the information was then defined in details. After that, the information was analyzed to make the mindset clear and the demands of the end users can be know better.

- **Stage 2- Quick Design(Draft) :**

On stage 2, a draft which was the quick design of this project or the preliminary for the robot was created to show the end users and let them have some understanding towards this project. Only the major parts of the project instead of a complete design was shown to the end user. This aids for the development of the prototype of the home care robot.

- **Stage 3-Prototype Built:**

Comments and feedback were collected from the end user for the quick design. After that, the modification of the current design was done according to the suggestion provided by the end users and the working model which known as first prototype was formed.

- **Stage 4- Evaluation from user:**

During stage 4, the end user had done an evaluation on the prototype of the home care robot to get known with what should be added and removed in the project. Then, feedback from the users are collected again.

- **Stage 5- Prototype refined:**

In this stage, if the feedback that had been collected from the end user was found to have dissatisfaction for the home care robot prototype, the current prototype was then making changes according to the new user requirement. After that, a new prototype was developed based on the new requirements provided by the end user. Evaluation on the new prototype had done like the previous prototype. The process was keep on repeating and stopped when it had met all the user requirements. An ultimate system for the home care robot was developed on the basis of the final prototype when the user was satisfied with the prototype.

- **Stage 6- Product engineering:**

Once the user requirements were fully met which means the ultimate prototype has been accepted by the user , it came to the last stage. The final home care robot for elderly was evaluated thoroughly followed by the maintenance of routine on regular basis to avoid from large-scales failure and to minimize downtime.

4.2 Implement and Testing

Machine Learning phase

At the beginning of this project, Python language and ImageAI library was used for the training and testing of the algorithm to let it learn about the three different human poses which were sitting, standing and lying down. At the machine learning phase, 500 images per pose were used to perform the training and 200 images per pose were used to perform testing. Training and testing were both needed to be performed to get the accuracy of the trained algorithm.

Number of experiment was set to 200 and each experiment had produced one model which included the accuracy result of model. This result helped to know the best performed model that used for image prediction. The training process had took up to five days without shutting down the laptop and kept on running. After training and testing had performed, model "model_ex-040_acc-0.940000.h5" was chosen as it had the highest accuracy value among other models which generated by different experiments. Due to the images in the testing set were predicted using the chosen model and this model can predicted correctly 188 out of 200 images, therefore the accuracy of this model is 188/200*100 = 0.94.

Figure 4.2- Figure 4.5 are the sample sitting pose images that used for training. Figure 4.6- Figure 4.9 are the sample standing pose images that used for training. Figure 4.10 - Figure 4.13 are the sample lying down pose images used for training.

Figure 4.14 - Figure 4.16 are the sample standing pose images used for testing. Figure 4.17 - Figure 4.19 are the sample lying down pose images used for testing. Figure 4.20 - Figure 4.22 are the sample sitting pose images used for testing.

Figure 4.23 is part of the accuracy image for each model of 200 experiments for the training part and the model chosen which with the highest accuracy.

Figure 4.2 - Figure 4.5: Sample sitting pose images used for training.

Figure 4.6 - Figure 4.9: Sample standing pose images used for training.

Figure 4.10 - Figure 4.13: Sample lying down pose images used for training.

Figure 4.14 - Figure 4.16: Sample standing pose images used for testing.

Figure 4.17 - Figure 4.19: Sample lying down pose images used for testing.

Figure 4.20 - Figure 4.22 : Sample sitting pose images used for testing.

```
from imageai.Prediction.Custom import ModelTraining

model_trainer = ModelTraining()
model_trainer.setModelTypeAsResNet()
model_trainer.setDataDirectory("HumanPose")
model_trainer.trainModel(num_objects=3, num_experiments=200, enhance_data=True, batch_size=32, show_network_summary=True)
```

```
Epoch 00038: saving model to HumanPose\models\model_ex-038_acc-0.350000.h5
47/47 [==============================] - 2982s 63s/step - loss: 0.0970 - acc: 0.9661 - val_loss: 4.8336 - val_acc: 0.3500
Epoch 39/200
19/19 [==============================] - 158s 8s/step - loss: 0.6003 - acc: 0.7833

Epoch 00039: saving model to HumanPose\models\model_ex-039_acc-0.783333.h5
47/47 [==============================] - 3078s 65s/step - loss: 0.0954 - acc: 0.9674 - val_loss: 0.6003 - val_acc: 0.7833
Epoch 40/200
19/19 [==============================] - 171s 9s/step - loss: 0.2569 - acc: 0.9400

Epoch 00040: saving model to HumanPose\models\model_ex-040_acc-0.940000.h5
47/47 [==============================] - 3143s 67s/step - loss: 0.0531 - acc: 0.9794 - val_loss: 0.2569 - val_acc: 0.9400
Epoch 41/200
19/19 [==============================] - 166s 9s/step - loss: 0.3155 - acc: 0.9317

Epoch 00041: saving model to HumanPose\models\model_ex-041_acc-0.931667.h5
47/47 [==============================] - 3194s 68s/step - loss: 0.0691 - acc: 0.9727 - val_loss: 0.3155 - val_acc: 0.9317
Epoch 42/200
19/47 [===========>..................] - ETA: 30:52 - loss: 0.0816 - acc: 0.9622
```

Figure 4.23: Part of accuracy for each model of the 200 experiments for the training part and the model chosen with the highest accuracy.

Pose Prediction Phase

After the algorithm had been trained and got the JSON file for the chosen model, pose prediction phase was proceeded. Real time images was captured by using webcam or camera attached to the laptop and was saved to the same folder with the JSON and model file as “frame.jpg”. The image file was keep on overwriting so that it will only has one image with file name “frame.jpg” instead of over million of images. The purposes of keep on overwriting were to save up spaces and also to make sure the image file can be linked to the pose predict algorithm part.

The image capture code was located on top of the pose predict code so that the image was first captured by the camera and then predicted by the algorithm. The two codes were both put in a while loop to keep on capturing images and make prediction until the prediction probability for the lying down or sitting pose is more than 70 percent. It was due to when the probability of these poses are more than 70 percent, the elderly might be fallen. Therefore, the image capture and pose predict should be stopped and triggered the robot control part to move the robot towards the elderly. When the algorithm predicted the pose captured by the camera was not lying down or sitting but standing, it will continue loop for capturing and predicting the elderly pose.

The break conditions for the while loop were set to two different condition which were stand probability more than 70 percent and lying down probability more than 70 percent for testing purpose.

Testing was conducted to test the feasibility of the algorithm above. The test was conducted with the model first standing in front of the camera that attached to the laptop and he had changed to lying down pose after a few seconds. The image captured successfully and the pose predict algorithm had predicted correctly which the pose at first was standing and then changed to lying down. Due to the condition set for stopping the loop was the lying down or sitting probability more than 70 percent, therefore when the pose predicted at first was standing, the algorithm kept on running until the model changed his pose to the lying down pose, then the algorithm stopped.

Some messages were used for debugging purpose for the communication between the publisher and subscriber. When the pose predict algorithm detected that the standing or sitting or lying down pose was each more than 70 percent, it will publish a message “standing” or “sitting” or “lying” to the subscriber.

Figure 4.24 was the image of the model first standing in front the camera and Figure 4.25 was the image that the model had changed his pose to lying down pose. Figure 4.26 was the pose predict result shown that the pose was first standing pose, the algorithm published “standing” message to the subscriber and it kept on running for continuing capturing as well as predicting pose. After that, when the model changed to lying down pose, the pose predict result showed lying down and the algorithm published “lying” message to the subscriber. The algorithm was then stopped looping due to the condition set which the probability of lying down or sitting was more than 70 percent.

Figure 4.24: The model was first standing in front of the camera.

Figure 4.25 : The model had changed his pose to lying down pose after few seconds of standing.

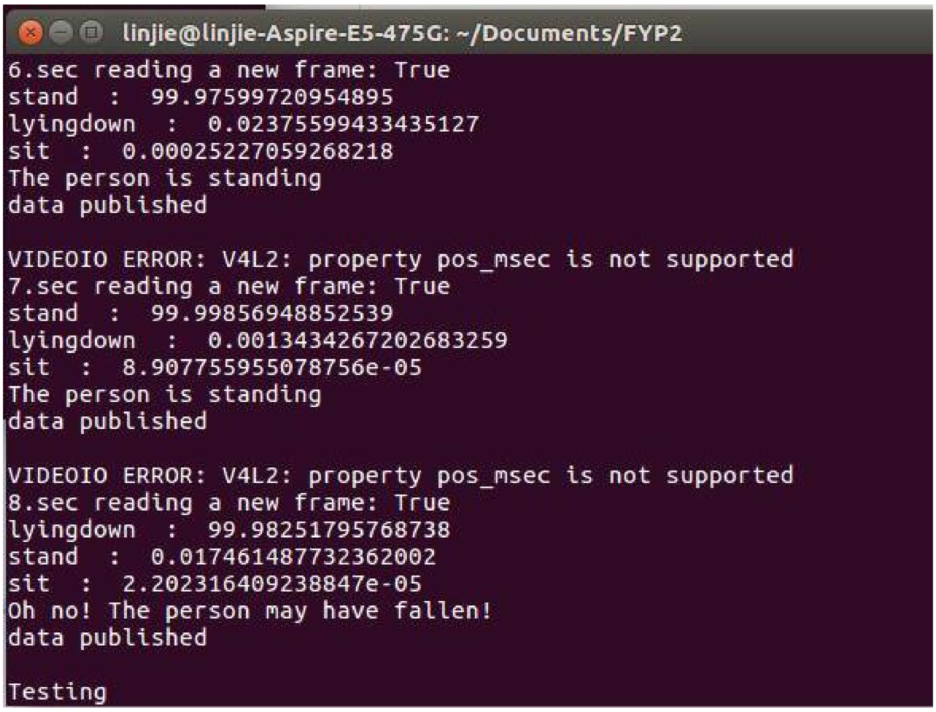

Figure 4.26 : The result showed that the pose predict was first standing, and the algorithm kept on running until the result for the pose predict changed to lying down. The algorithm was publishing message to the subscriber for both predictions.

Robot Control Phase

After the image capture and pose predict phase, the project proceeded to the robot control phase. A “robotmove” variable was declared and set to 0 for the use to trigger the robot to move when the variable changed to 1. When the algorithm had captured the image and predicted the pose, it will publish message to the subscriber which was the robot control node. If the pose predicted was standing, the subscriber will receive the “standing” message and print out “Nothing happen”. Whereas if the pose predicted was lying down or sitting, the subscriber will receive the “lying” or “sitting” message and print out “call robot to move”, then the “robotmove” variable will change to 1. After the “robotmove” variable had changed to 1, it will triggered the robot to move towards the elderly. The robot was set to move to a distance defined which was around 3m. There was an alarm ranging for alarm purpose, it rang in the same time when the robot was moving.

Figure 4.27 showed the subscriber was first printed out “Nothing happen” when it received “standing” message from the publisher and when the publisher had predicted a lying down pose, the subscriber printed out “Call robot to move” and change the "robotmove" variable to 1 to trigger the robot to move when it received "lying" message from the publisher.

Figure 4.28 showed the set up of the camera attached to the laptop that used for image capture and the turtlebot3 placed at the starting point.

Figure 4.29 showed that when the person was lying down, and the algorithm had predicted and triggered the robot control, the robot moved according to the distance defined. A red ballpoint pen was used as the marker for starting point whereas a blue ballpoint pen was used as the marker for intermediate point which shown in Figure 4.30. These markers were used for the purpose to prove that the robot was moving.

Figure 4.31 showed that the robot had moved according the distance defined and had reached in front of the person who was lying down.

Figure 4.32 showed the full screen image for testing environment which set up by attaching the camera to the laptop, the person lying down at the defined distance, and the turtlebot3 was moving from the starting point to the point where the person was lying down.

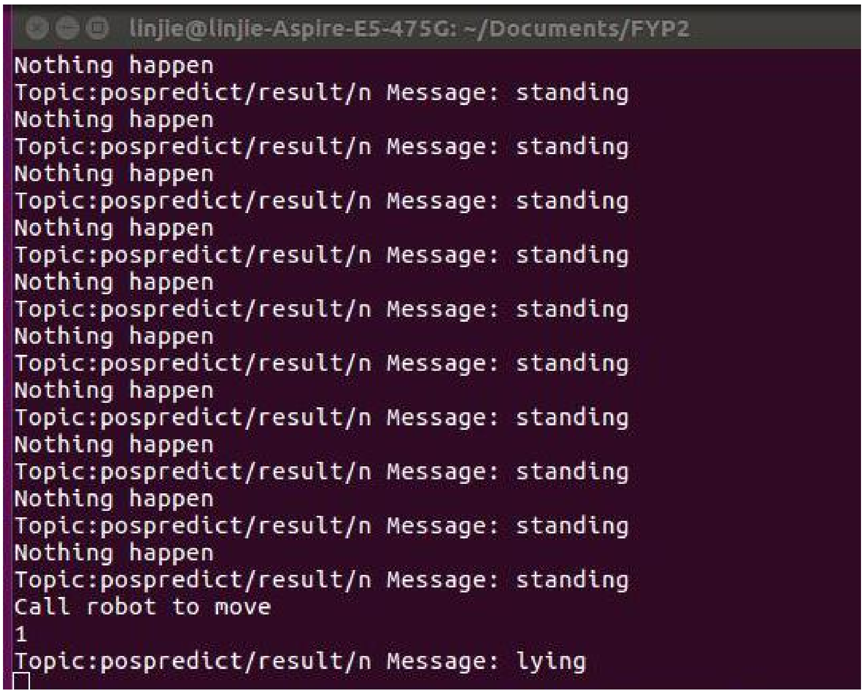

Figure 4.27: The subscriber was first printed out "Nothing happen" when it received "standing" message and then it printed out "Call robot to move" and change the "robotmove" variable to 1 when it received "lying" message.

Figure 4.28: Set up of the camera attached to the laptop that used for image capture and the turtlebot3 placed at the starting point.

Figure 4.29: When the person was lying down, and the algorithm had predicted and triggered the robot control, the robot moved according to the distance defined. A red ballpoint pen was used as the marker for starting point.

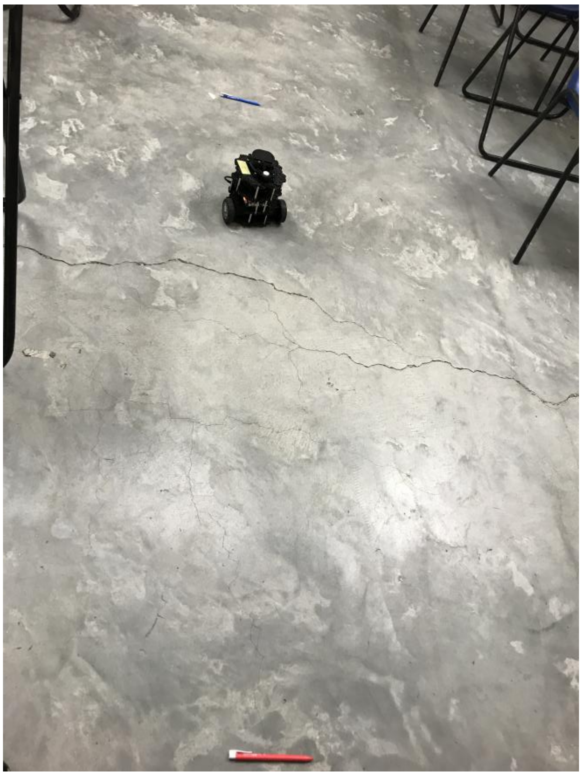

Figure 4.30: A blue ballpoint pen was used as the marker for intermediate point to prove that the robot was moving.

Figure 4.31: The robot rang the alarm and had moved according the distance defined and successfully reached in front of the person who was lying down.

Figure 4.32: The full screen image for testing environment which set up by attaching the camera to the laptop, the person lying down at the defined distance, and the turtlebot3 was moving from the starting point to the point where the person was lying down.

Chapter Five

Discussion

This project was developed to help easing the problem caused by the increasing of ageing group. The main purpose of this project was to developed an algorithm that could capture and predict the daily activities of the elderly. When the algorithm had predicted that there may be some dangers happened to the elderly, it will triggered a small robot to move towards the elderly and rang the alarm.

The project was first used the machine learning to train the algorithm so that it has the ability to predict the pose of the elderly. During the machine learning phase, few friends and siblings were invited to become the model for the human pose images that used as the dataset for training and testing.

At the early stage, only the pose predict part had been done. The image used for debugging the pose predict algorithm was manually linked from the image saved at the same folder with the algorithm file. After ensuring the accuracy is satisfied, the project proceeded to start using webcam to capture the real time image. Then, the image capture code and the pose predict algorithm were put together in a while loop so that the image captured from the real time can directly linked to the pose predict part automatically instead of manually link like previously.

The condition had been set so that when the algorithm detected that the people in the image was lying down or sitting, the image capture and pose predict parts will stop and proceed to robot control part. The lying down and sitting pose were set as the stop condition due to these poses are similar to a fall down pose. When the algorithm detected that the elderly seems to be falling down, it will trigger the robot to move towards it and the alarm rang in the same time.

In this project, there are some limitations that caused the project cannot implement something which can make it better. At the early stage of the project, it was first designed to have a robot arm attached to the turtlebot3 so that the robot can help the elderly to stand up when they fell down. Due to the reason that the cost for the robot arm is expensive and it may not compatible with the turtlebot3 since turtlebot3 is a small robot, therefore the idea for using robot arm had been removed and changed to only move the robot towards the elderly who seems to be fallen and rang an alarm.

Besides, at the stage after pose prediction and before the robot control, the project was originally designed to use a 3D camera to detect the distance between the turtlebot3 and the elderly, so that the robot will move according to the distance detected. But in the middle stage of the development for the project, it was found that the 3D camera provided had the hardware limitation. The 3D camera can only detect the objects in 1 meter range and it is mainly used to detect hand gesture. Therefore, it is not suitable to use in this project due to the camera should be captured the whole person in the project. If the range can only be 1 meter, it may not capture the full human image, therefore, the 3D camera cannot performed the distance detection task for this project. To overcome this limitation, the robot was set to move according to a distance defined which is around 3m instead of the distance detected by real time.

There were also some limitation which caused by the design of the turtlebot3. The turtlebot3 was designed with the battery charging system similar to the laptop charging system, cable was needed to be connected manually for charging purpose, therefore this project was unable to control the robot to move to the battery source and perform auto-charging by itself. Besides, the turtlebot3 is small in size, it does not has the climbing stairs ability, so the robot can just be implemented in single storey house or use it in particular floor only. It also designed without any lighting system, therefore it can only be functioned well during day time or with lights turning on.

Apart from the hardware part, there were also some limitations on the software part. For the algorithm that had been trained for predicting the elderly pose, it is very sensitive to the environment. Due to the algorithm was just only trained for the human pose, therefore when there are other things in the image captured by the camera, the accuracy of the pose predict will be affected. During the testing phase, the experiment was conducted in few different environments to test the accuracy of the pose predict. The experiment resulted that when the environment was having many free space and with less obstacles like tables or chairs, the accuracy of the prediction was higher. Whereas when the experiment conducted in the environment with many other things, the accuracy of the prediction was lower due to the algorithm had predicted wrong pose. Therefore, the project was conducted in an empty classroom to improve the accuracy of the pose prediction.

On the image capture and pose prediction part, there was a limitation that the image used for pose predict needed to be input manually, while in this project the image should be captured in real time and in the same time can be linked to the pose predict part. When the image captured from the webcam or camera attached, it was saved to the folder and named start from “frame0.jpg” to “frameX.jpg”. Works had been done to try linking these image files to the pose predict algorithm by changing the image location to a variable named "image" that used to save the images captured. Due to the variable type was incompatible with the pose predict algorithm, therefore this caused a problem which the image captured in real time cannot directed linked to the pose predict algorithm automatically. The solution that used to overcome this limitation was overwriting the image file so that the images captured was keep on overwriting and saved to only one image file named "frame.jpg". The image location was set to "frame.jpg" at the predict part and as a result, the image capture code and the pose predict algorithm can both run together.

Due to the limitations that had met during the development of the project, it had limited the project from performing more and better tasks. Therefore for future works, many things can be added and improved for this project to make it a better project. A kinetic camera should be used instead of a 3D camera so that the distance between the elderly who seems to be fallen and the robot can be detected so the robot can move towards the elderly according to the distance detected.

Besides, it is also suggested that instead of using robot arm, buttons can be used to replace it on the robot. The buttons can be functioned as a key to send urgent notifications to the family members and the ambulance service. When the pose predict algorithm has predicted the elderly is falling down, the robot will move towards the elderly. When the robot reach the elderly, if nothing happen, the elderly should press a "A" button to notify the robot that it had predicted wrongly; whereas if there is critical happen, if the elderly is still having conscious, he/she should press the "B" button to notify his/her family members and the ambulance service, else if the elderly is without any conscious, the robot should be detected that it had reached the elderly for some time, if the both buttons are not pressed after a certain time, the robot should automatically notify the family members and the ambulance service.

In short, the results of this project had showed that although there were some limitations met in this project, solutions had been found and implemented and these had made this project completed. Future works was also been suggested so that if better resources or facilities have been provided, it will make this project become more better.

Chapter Six
Conclusion

This project is aim to train a robot that can provide some helps to the elderly when they accidentally fall down. This topic is chosen due to the recent trend that the ageing population is keep on increasing but many of them are facing the problem of lacking cares. Elderly are different from others who are still young and have a healthy body, once they accidentally fall down, may lead lots of serious issues to their body health. Furthermore, nowadays, almost all people are busying on their jobs and they do not have the time and ability to look after their parents who are getting older everyday, therefore, this project is to provide a solution to this problem and hope it can help reduce or solve this problem.

On the hardware part, a robot- TurtleBot3 was used in this project. One of the reason that TurtleBot3 was chosen was due to this project is for academic purpose, hence a small size robot was enough rather than a bigger robot because it is more convenient and easy to assemble and use. Whereas for the software part, python language was chosen because machine learning was needed to train the robot to learn the human pose so that it can detect the fall down pose and provide helps to the elderly.

In addition, this project was separate into two parts as the tasks needed to be distributed fairly for two semesters. The first part of this project which conducted on last semester was the machine learning part. In this part, images for 3 poses: standing, sitting, and lying down were used to train the robot so that it could recognize the human pose and can detect the fall down pose. Images was set to be captured through webcam or camera attached to the laptop for real time purpose and the images captured were linked to the pose predict part for predict purpose.

For the second part which had been conducted during current semester was the robot control. On this part, images should be captured in real time and send to the algorithm for prediction, when the prediction result show that the pose is lying down or sitting, the robot will be controlled to move towards the elderly who fell down and ring the alarm for alert purpose. Since there were some limitations and inadequate of resources, some solutions had been implemented to solve these problems to make this project a better project.

In conclusion, existing researches and works had been studied to get more understanding and ideas in working this project. Both machine learning and robot control had been done, results showed that the models trained can correctly predicted the human poses and the robot can move towards the elderly and ring an alarm. The project is completed and had met the project scope and objectives stated in the project. Since the accuracy for the machine learning was still on 94%, therefore, more works can be done in training the models so that higher accuracy can be reached. Besides, other solutions also can be implemented for solving the limitation problems met in this project. Once it can get higher accuracy for the machine learning and the limitations can be solved with better solutions, the performance of this project will definitely be increased. Last but not least, hopefully that this project can bring contribution to the society in helping to reduce and ease the problems faced by the elderly.

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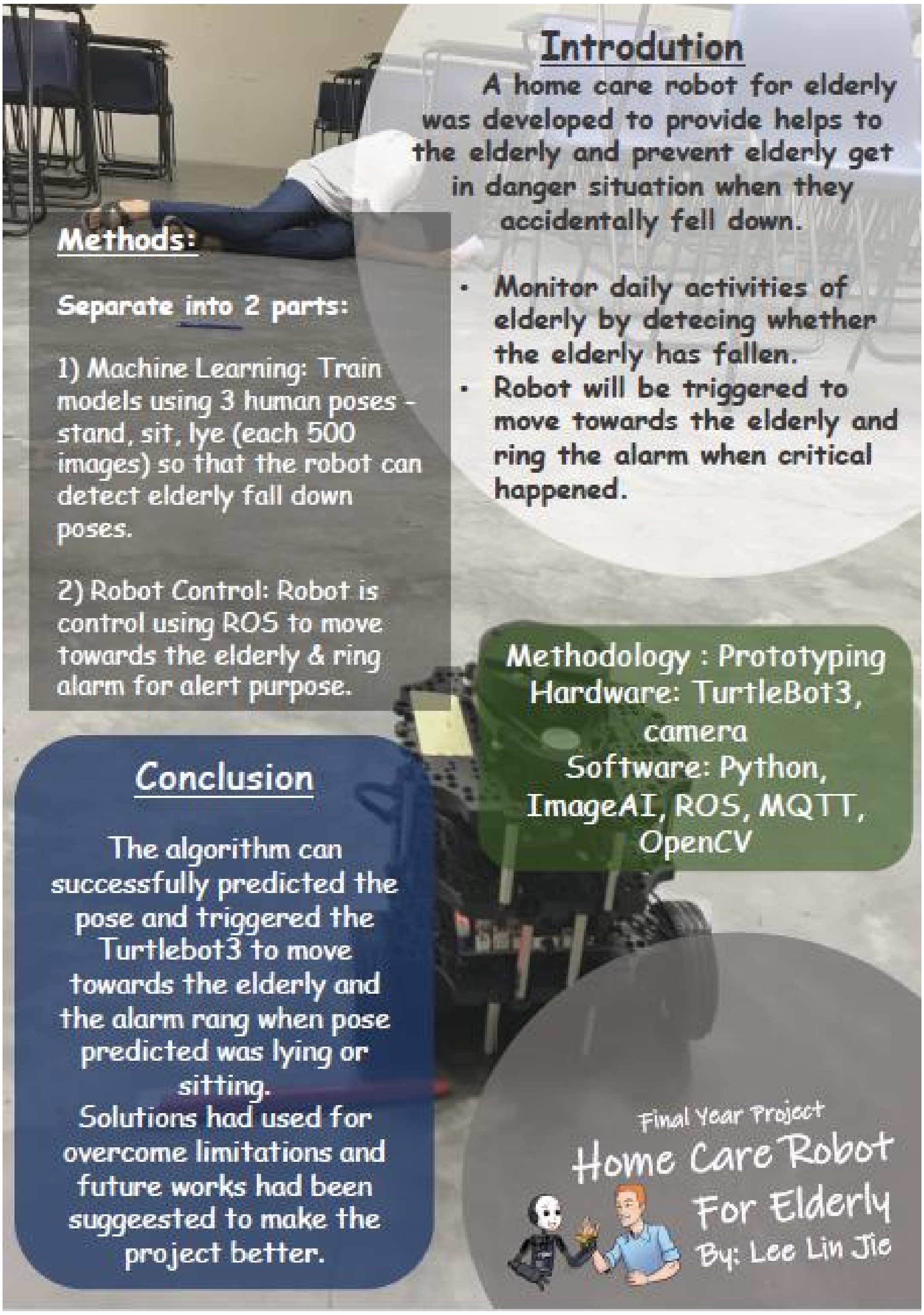
Appendix A- Poster

A.1 Poster



Appendix B- Turinitin Result

B.1 Plagiarism Check Result

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