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A NURSE FOLLOWING ROBOT WITH HIGH SPEED KINECT SENSOR

B. Ilias, S.A. Abdul Shukor, S. Yaacob, A.H. Adom and M.H. Mohd Razali
School of Mechatronic Engineering University Malaysia Perlis, Malaysia
E-Mail: bukhari@unimap.edu.my

ABSTRACT

This paper highlights on the development of a nurse following robot. A Nurse following robot is a personal robot to help the nurse to do their jobs every day. This robot will follow the nurse from bed to bed while carrying belongings such patients' medical files, medicine and other equipment. The tracking system has been designed using a high speed vision system, which is Kinect sensor for Xbox 360 video games. The Kinect sensor uses the human skeleton tracking method to track the position and distance of the nurse. The human skeleton tracking method has the ability to distinguish a person and other object without confusing it. All the information about the position and distance of the nurse will be synchronized with the whole system of the robot. A laptop is used in this research to process the data from the Kinect sensor and transferred to the microcontroller. The robot has also been equipped with obstacle avoidance system to sense obstacles around it while following the nurse. The robot is able to follow the nurse either in straight or curve part without losing him/her. It is also designed for indoor application due to limitation of Kinect sensor capabilities.

Keyword: kinect sensor, processing.org, high speed vision system, BASIC stamp.

1. INTRODUCTION

A nurse support and help the doctor every day in order to give the best treatment to people. The nurse has their own job or task that must be accomplished. Nursing is a profession which focusing on the care of individual, family, community and others. This is for maintaining the optimal health and quality of life. The current ratio of Malaysian nurse with the overall population is 1:529, which is far from the 1:200 target set by the Ministry of Health, based on the World Health Organization settings [1] [2]. At the moment, nurses waste their energy to push and pull a trolley to carry hospital instruments around. While doing this, it is hard for the nurse to focus with his/her daily routine. Hence, there is a need to find a solution to lessen their work and save their energy for everyday use. To overcome this problem, there are numerous companies such as Aethon, Inc [3] that had created a robot to help nurses and doctors in the hospital, but the robot can only move using an on-board map. The main challenging issue in nurse following robot is how to track the corresponding person when multiple persons are in front of the robot. In this research, we develop a high speed vision for a mobile robot to help the nurse carrying the hospital equipment and at the same time following the nurse wherever he/she goes.

A. Problem Statement

In order to develop the nurse following robot, choosing a suitable tracking method is very important. As the hospital is a dynamic environment, the chosen method must be able to detect the presence and position of a person (in this case, the nurse). The chosen tracking method must be able to distinguish the nurse with any other object. Therefore, this paper will be concentrating on the development of the tracking method.

B. Objective

The purpose of this work is:

- To acquire the reference point of the nurse in the vision system
- To acquire the best tracking method for the nurse following process
- To process the data from Kinect Sensor and interface them to a microcontroller.

2. LITERATURE REVIEW

There are many researchers who use the concept of stereo camera such as tracking people from a moving platform [4] and person following through appearance models and stereo vision using a mobile robot [5]. This method is famous for the human following robot. A human following robot should have the capabilities to differentiate the target object or human from supplementary object and capture it by any method assigned to it. The human following robot needs to obtain and process all information such as position and distance data and continuously follow a target person to ensure that the robot will not be left behind. Nowadays, camera data is frequently utilized to understand the main target. To obtain the information of motion for a person, the stereo system using two or more cameras is needed [6].

T. Sonoura et al and B. Ilias et al have created the Person Following Robot called "ApriAttenda" and "Nurse Following Robot" [7] [8]. These mobile robots find and track an assign person and continuously follow that person everywhere he/she goes. The functions involved with this person following robot are tracking the specified people, following at his/her pace, avoiding obstacles, and looked back for the assign person when the tracking is missed. Yutaka Hiroi, Shei Matsunaka and Akinori Ito from OSAKA Institute Of technology have created a mobile robot system with semi-autonomous navigation using simple and robust person following behavior [9]. This robot, which is called ASAHI, uses a laser range finder (LFR) as the tracking tool. They use the laser range finder because of its capability to give the best performance in

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any lighting condition, plus with the accuracy of the measurement and low computational cost. The laser range finder is installed at a height of 1 meter so that the person's waist can be discovered. Besides that, there is also a project which uses the omnidirectional camera and laser to track a person [10]. Thierry Germa, Frederic Lerasle, Noureddine Ouadah, Vivian Cadenat N Michel Devy have developed a mobile robot, named Rackham, to follow a person [11]. This robot is equipped with one digital camera, one ELO touch screen, a pair of loudspeaker and RFID system. They also make a comparison between their approached with recent approaches such as radio frequency badges worn on clothes.

3. METHODOLOGY

We concentrated on developing the high speed vision system for the nurse following robot. This process has involved the integration of Kinect sensors with processing.org software in the laptop and BASIC Stamp 2 microcontrollers. The nurse following robot has the capability to follow an assigned nurse using two types of human tracking methods, which are the center of mass and human skeleton methods.

In order to find out the best method to track the nurse, several tests have been conducted on both methods. When a person stands in front of the Kinect sensor, the processing.org software will starts to identify and tracks the human. The tracking duration will be recorded in the software. In this experiment, the acceptable tracking duration is set to eight minutes. The tracking duration above eight minutes is considered good and less than eight minutes is considered poor. The test is repeated 10 times for each method.

After getting the test results, the best human detection method would be downloaded to the mobile robot for motion analysis as follows:

a) Forward direction
b) Robot stops
c) Turning to right direction
d) Turning to left direction

Lastly, the solution to improve Kinect vision for outdoor application is also introduced here to minimize ultraviolet (UV) energy from interrupting the IR depth sensor.

A. Kinect Sensor

The Kinect is an input device that can sense the motion. This Kinect sensor (Figure 1) is created by Microsoft for the Xbox 360 video games. It is a physical device that contains cameras, accelerometer and a microphone array that can be used to process color, depth and skeleton data. Basically the Kinect camera knows the depth and distance of every pixel in the frame.

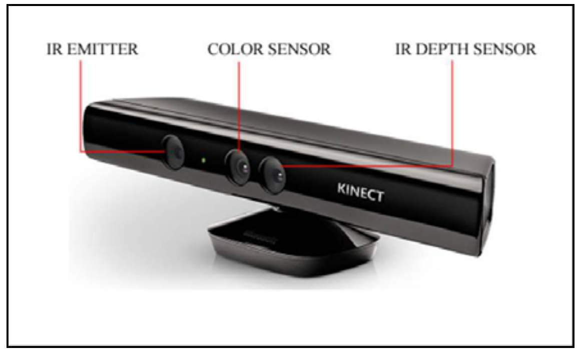

Figure-1. Kinect sensor.

B. BASIC Stamp 2 Microcontroller

BASIC Stamp 2 microcontroller (Figure 2) is chosen to interface the whole system in this research. It has 16 input and output ports. Three units of BASIC Stamp 2 OEM are used for the Kinect sensor, ultrasonic sensor and motor controller.

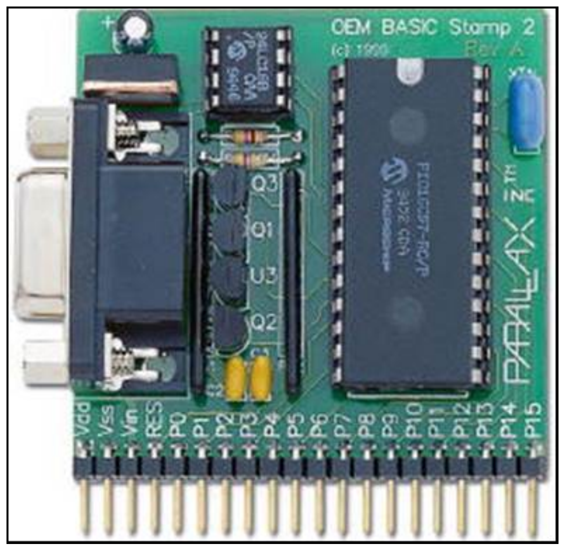

Figure-2. BASIC Stamp OEM.

Every BASIC Stamp microcontroller used in this research has its own function. The BASIC Stamp 2 OEM that used for the Kinect sensor needs to read the x, y and z position from the Kinect sensor.

C. Architecture of the system

The setup process needs to be in the correct way to make sure the system of the nurse following robot function very well, as shown Figure-3. The Kinect sensor is the main part of the system which is used for identifying the nurse. All the data from the Kinect sensor will process by the processing.org software in the personal computer located on the robot.

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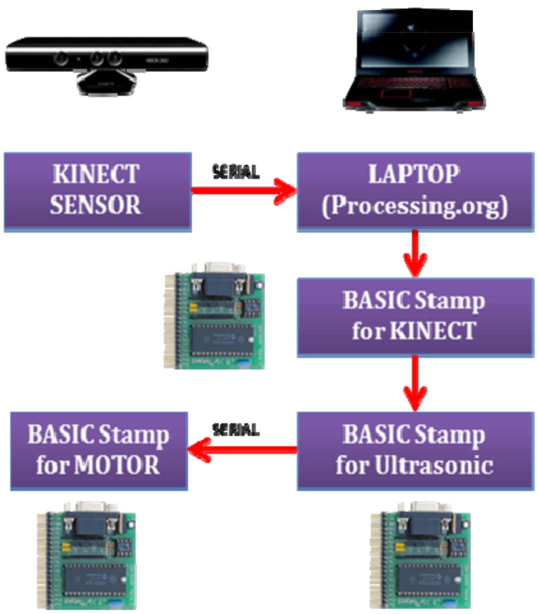

Figure-3. Block diagram of the system.

D. Nurse Tracking Method

In this research, the Processing.org software is used to process all the data captured by the Kinect sensor. The Kinect sensor will transmit the infrared emission in front of it and reflected back to the infrared depth sensor. The human tracking method is used to identify the nurse. When the nurse is detected, a reference point located at the center of her/his body will be created. This reference point is the important target point used by the robot to follow the nurse. The reference point consist of x, y and z coordinate. The coordinate will be sent to the BS2 Kinect to execute the direction of the robot. Before that, the coordinate will go through BS2 ultrasonic to check for the free path. If there is no obstacle detected, BS2 motor will drive the robot to the nurse. This whole process is as summarized in the flowchart shown in Figure 4.

4. RESULTS AND DISCUSSIONS

A. Analysis of Different Human Tracking Method

1) Center of mass method

Center of mass is a center point which the processing.org software created for the targeted person when the person stands in front of the Kinect sensor (Figure 5). The robot will use this point as reference point to follow any targeted person. This reference point consists of x-position, y-position and depth or distance of the person from the Kinect sensor.

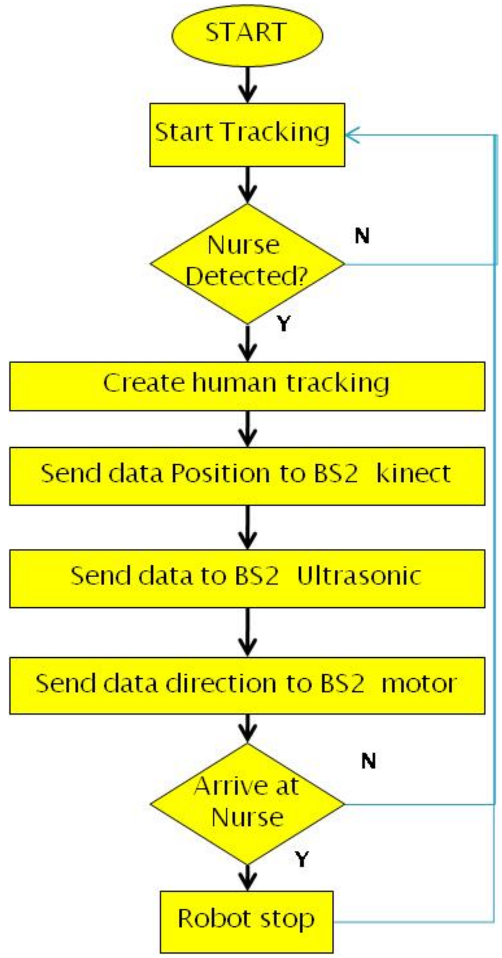

Figure-4. Flowchart of the system.

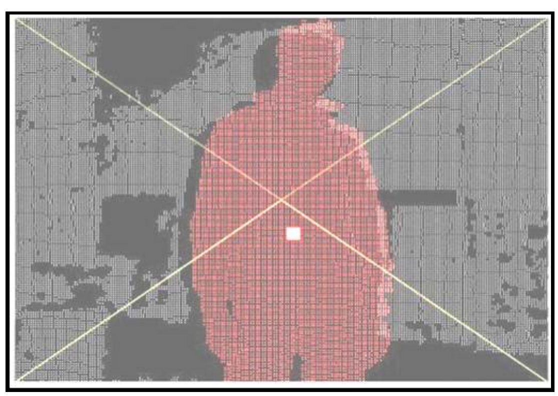

Figure-5. Center of mass method.

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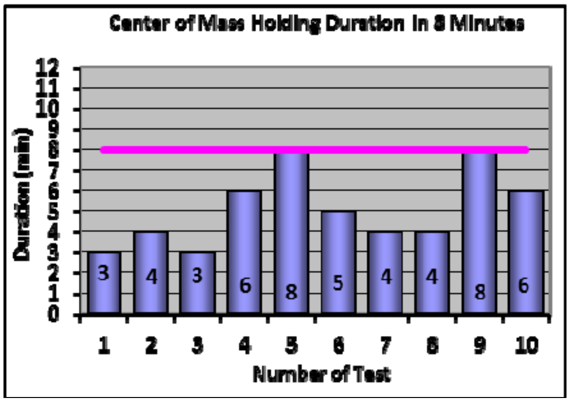

Figure-6. Center of Mass holding duration of reference point.

In this experiment, the time taken for this method is 8 minutes. Based on the Figure 6, there are 2 out of 10 test results achieved the acceptable time, which are tests 5 and 9. The percentage of tests that has achieved the acceptable time is about 20 percent.

2) Human skeleton method

Human skeleton tracking is created when a person stands in front of the Kinect sensor (Figure 7). A person needs to stand in front of the Kinect sensor for a few second with both hands in the air. This process might take 5 second or more, depending on the position of the body. When the calibration is done, Kinect will track the joints and limb's position.

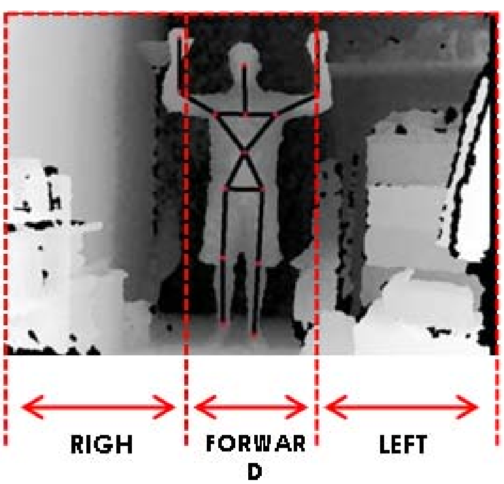

Figure-7. Position of human.

Based on the Figure-8, all 10 tests results have achieved the acceptable time, making the percentage of achievement 100 percent. By using this method, the detection towards human is higher than the center of mass method. The skeleton method is able to distinguish human and object around it. During the following process, the Kinect sensor only detects an assign person as the reference point. For this research, the human skeleton method is used as the tracking method to track a nurse that assigns to the nurse following robot. This tracking method has the capability to track the human during the process of human following.

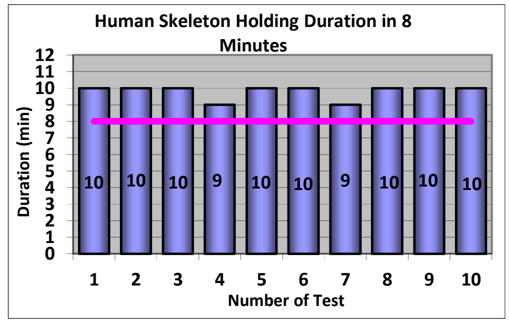

Figure-8. Human Skeleton holding duration of reference point.

B. Analysis of Robot Movement with Human Skeleton Method

Figure 9 shows the code of programming at processing.org for setup the position needed on the screen. The jointPos. x refers to the x-axis while jointPos. z refers to the distance or depth of a person. The distance of a person from the Kinect is set 1000 mm (or 1 meter) as it is a safety distance from the mobile robot.

```
if(jointPos.x > -200 && jointPos.x < 200)
 {
   if(jointPos.z > 1000)
 {
   myPort.write('F');
   println("Forward");
```

Figure-9. Programming code in Processing.org.

The size of the screen is divided into three parts of the position command such Forward, Left and Right as in Figure 7. The Stop command is based on the distance of a person from the Kinect sensor as shown in Table-1.

Table-1. Command for Kinect sensor.

Command	Position
Forward	-200 <JointPos. x< 200
Stop	JointPos. z < 1000
Left	-580 <JointPos. x< -200
Right	200<JointPos. x< 580

1) Forward direction

The nurse following robot will move forward (Figure 10) if the reference point of assigning nurse is between -/+ 200 pixels and the distance of nurse exceeds 1 meter.

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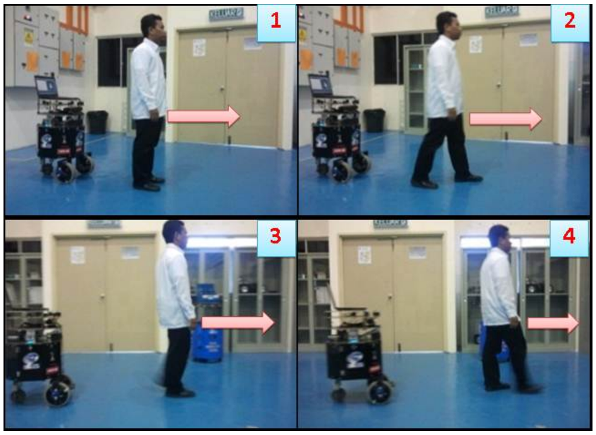

Figure-10. Robot moves forward.

2) Robot stops

Distance to stop the robot is set at 1 meter from the nurse, as shown in Figure-11. The gap will prevent the collision occurred with the nurse.

Figure-11. Distance for robot to stop.

3) Turning to right direction

The nurse following robot will turn to the right when the nurse move to the right as shown in Figure 12. The x-axis position that will execute right command is between 200 and 580 pixels.

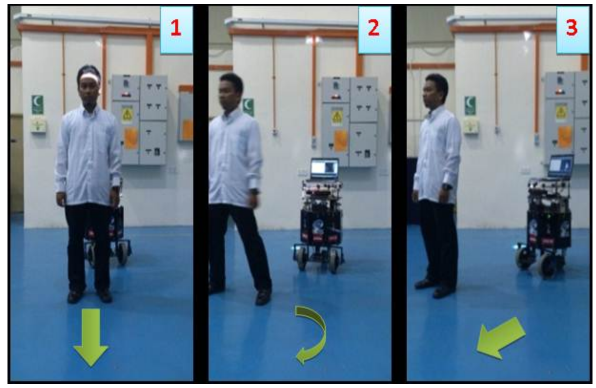

Figure-12. Robot turns to right.

4) Turning to left direction

The nurse following robot will turn to the left when the nurse move to the left as shown in Figure 13. The x-axis position that will execute left command is between -200 and -580 pixels.

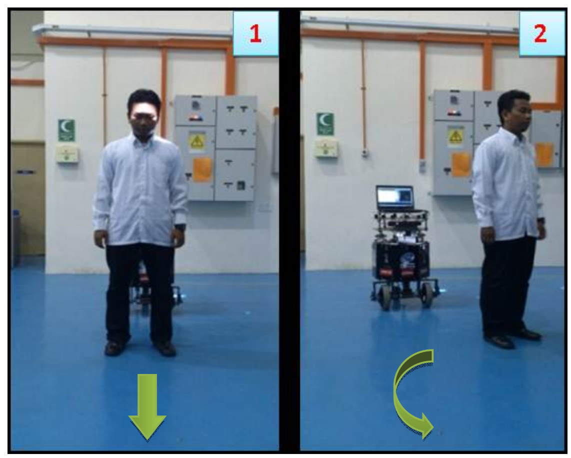

Figure-13. Robot turns to left.

C. Kinect for Outdoor Applications

The Kinect sensor is immune to all indoor ambient light, but not ultraviolet rays. Ultraviolet has shorter wavelength, but higher energy than visible light. The PrimeSense have proclaimed that Kinect sensor is not suitable for the outdoor application [12]. To support the claim, tests have been carried out in the outdoor environment and it is concluded that the Kinect is not reliable for the outdoor application. To overcome this, we have proposed a solution to improve the capability of the Kinect sensor for outdoor application. The solution is by putting the 5% tinted film at the IR depth sensor (Figure 14). Four layers of tinted film attached together in order to block the ultraviolet (UV) energy from entering the IR depth sensor. As a result, the quality of the image becomes brighter and clearer.

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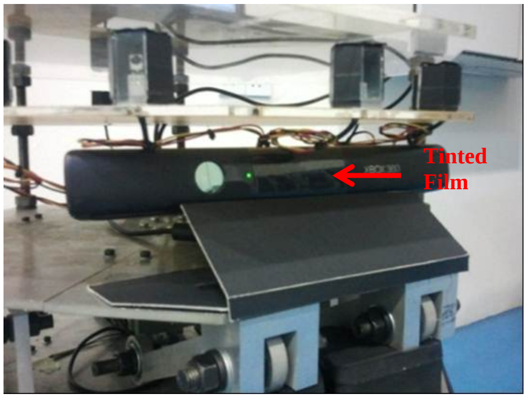

Figure-14. Tinted film at Kinect sensor.

5. CONCLUSIONS

In this research, we have developed a nurse following robot using a high speed vision system. The robot is able to follow a person (i.e. nurse) successfully and at the same time process all the data in 3 microcontrollers from Kinect, obstacle avoidance data and motor control system. The purpose of interfacing a high speed vision system in this nurse following robot is because it resemblance a human's eye and it can mimic human's vision. The vision system is used to identify and continuously track a person. Kinect sensor was selected because it has the capability to detect the position and distance of the person. The method that selected in this tracking system is a human skeleton method. This method is more accurate because it can detect only a human in its field of view and able to hold the reference point of nurse longer than the center of mass method. Apart from the above, in this research the image quality has also been enhanced to be more clearly by attaching four layers of tinted film on the Kinect sensor. This technique will improve the ability of the Kinect sensor to operate in the outdoor environment.

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