HUMAN FOLLOWING ROBOT USING KINECT SENSOR

Gregory Cu[1], Alfred George Ang[2], Albert Ranier Ballesteros[3], and John Christopher Rentoy[4]
gregory.cu@delasalle.ph[1]
alfredgeorge_ang@yahoo.com[2]
albertbal18@yahoo.com[3]
jc_rentoy@yahoo.com [4]

Abstract: This study presents a three-wheeled human following robot with a Kinect sensor as its only sensor for following a human target and avoiding collision. It is the goal of the study to eliminate certain limitations for human following robots such as limited operating area and requiring the user to wear intrusive sensors. The robot follows a user by detecting the hip of the user and acquiring the depth data of the hip for steering and maintaining distance. Several tests are made to characterize the robot, these test are: straight path test, varying curve radius test, and collision avoidance test. Though the robot was able to follow the user in a straight path, it was noticed that there is an average deviation of 4 to 8 cm. from the path of the user. In the varying curve test, the safest turning radius is at least 1.5 meters, which enables the robot to not collide with the vertex of the arc made by the user and not lose track of the user. In this test, the robot also tends to undercut the user. For collision avoidance tests conducted, the robot was successful to avoid obstacles but it makes, at most, a 180 cm. of deviation from the path of the user. Although the robot is able to follow a user in a straight path; the robot tends to undercut the user during curved path. There is also a possibility that the robot will follow a different user after losing the user in its field of view during the target reacquisition process.

Keywords: Human Following Robot; Kinect Sensor;

1 INTRODUCTION

For the past years, the development of robot technology had increased significantly due to industrial and military applications. Most robots were used in industrial and military use but intelligent robots for general daily use is yet to be implemented. Human-Following Robot (HFR) is one of the applications that could be implemented under robot technology. Because of its human following capability, HFRs can work as assistants for humans in various situations and it can also acquire or monitor certain information associated with the human subject. One of its applications is to carry loads that are required by people working in hospitals, airports, and other hauling activities. (Morioka, Lee, & Hashimoto, 2004).

HFR's can be implemented using different types of technology applications. Technologies used are infrared sensors, ultrasonic signals or cameras with the use of image processing (Morioka, Lee, & Hashimoto, 2004). Currently there are many researches under HFR's which uses many techniques to locate the human subject with the use of depth sensors and image processing. Most of the studies are limited to an operating environment or require users to wear sensors.

One possible implementation to track humans without area limitation, use of multi-sensor configuration, or intrusive sensors; is to use Microsoft's Kinect sensor. The Kinect sensor has human tracking capabilities from a static position that can provide full-body 3D motion capture. It can also track up to six people but can be used by two active players. The tracking capability allows a user to issue commands via action gestures since it can track twenty skeletal joints (Figure 1) per user with a range limit of 1.2m-3.5m (Pakinkis, 2010). The Kinect sensor sends calculated data from the input sensor to the computer that represents a full body, a hand location, or an array of the pixels in a depth maps. (Pakinkis, 2010)

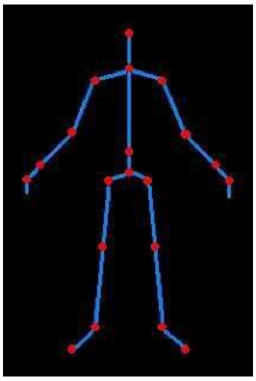

Figure 1 The 20 joints captured by Kinect. (Corellianrouge, 2010)

In this research, the Kinect sensor is mounted on a mobile robot platform to allow human target following without using any sensor on the user and any sensor or marking in the area of operation. The Kinect sensor is also used as the proximity sensor for collision avoidance (objects should be bigger than the robot). The mobile robot follows only one user or target walking at 1 meter per second while maintaining a distance of 1.5 meters.

2 ROBOT PLATFORM

The mobile robot is a three-wheeled robot with a Kinect sensor having an approximate height of 0.5 meters. The rear wheels are connected to a single motor that drives the robot while front wheel is connected to a servo motor that controls steering. For the robot, to be able to monitor the current speed and the current steer angle; odometry and steer sensors are used respectively. The mobile robot can only run on a flat and even path way that is at least wider than the mobile robot of about .75 meters at both sides. This will give the mobile robot enough space to make a turn and move around the path way. The mobile robot is not able to run on a ramp.

3 HUMAN FOLLOWING CONTROL SOFTWARE

The human following control software controls the robot in following a user. It uses the depth image and skeletal joint data from the Kinect sensor to locate a person and detects obstacles in front of the robot.

3.1 Proximity Extraction

Proximity extraction calculates the depth of an image from the Kinect sensor and finds out if there are any obstacles in the current path. This is done by sampling out points from the depth image of 320x240 "pixels". To detect edges of objects in the depth array, sampling points are made that produces a sampling point at every 8 "pixels" that forms a triangle going to the middle of the two-dimensional array as shown in Figure 2. This results to 80 sampling points with 40 points at each diagonal of the triangle. After producing sampling points, the depth data is smoothened to remove undefined values and shadows from the Kinect sensor. This procedure is almost similar to mapping the whole place but it actually takes out only a few points of what the robot is currently seeing or receiving from its camera.

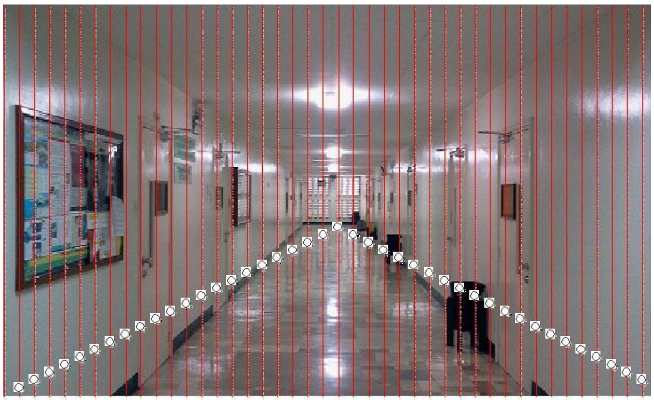

Figure 2.Proximity Sample

3.2 Target Following

Using the depth array taken from the proximity extraction component and the location of the human target from the human target detection component, the robot is able to follow the human target and at the same time check if the distance of the human target is greater than the distance of the obstacle and if the obstacle is closer than 1.7m. If the robot classifies an object as an obstacle, the robot initiates the collision avoidance process. On the other hand, if there is no collision in front of the robot, it proceeds with human following.

The target following algorithm is responsible for following the human target without colliding. The goal of the algorithm is to maintain a 1.5-meter distance from the person while maintaining the person as its center. Target following is done by tracking the hip of the user. The robot is able to detect if the human target is moving nearer to it or farther from it by checking the distance of the human target through the depth image provided by the Kinect sensor. Figure 3 shows the flow of the human following algorithm process.

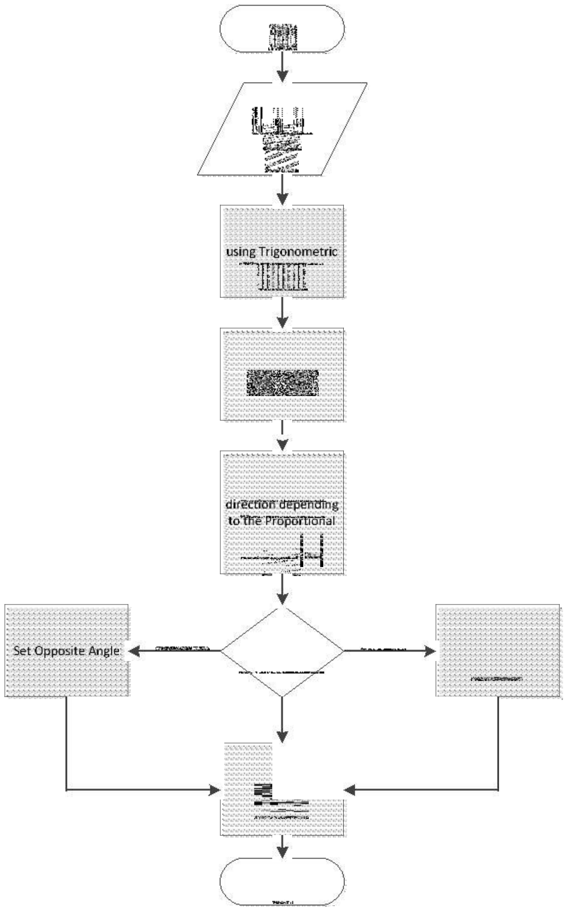

Figure 3.Human Following Algorithm

4 RESULTS

The Cartesian graphs for the straight path test is shown in Figure 4 and Figure 5 shows the behaviour of the robot while following the a person in a straight line at different speeds. The yaxis represents the whole path the user and the robot took while the x-axis represents the deviation of the path of the robot from the path of the user. It is observed that when the user walks at 0.5 meter per second speed, the deviation of the path of the robot from the path of the user is 3 centimeters, but when the user walks at 1 meter per second speed, the deviation of the path of the robot from the user's path increases to 8 centimeters. Overall, there is an average deviation of 4 to 8 centimeters from the path of the user in the straight path test. This is due to the algorithm of trying to place the user as the center of the robot since it does not use any filtering mechanism in pre-processing the center hip data from the Kinect. This affects the robot's steering since a small deviation from the middle makes the robot automatically steer to the left or to the right.

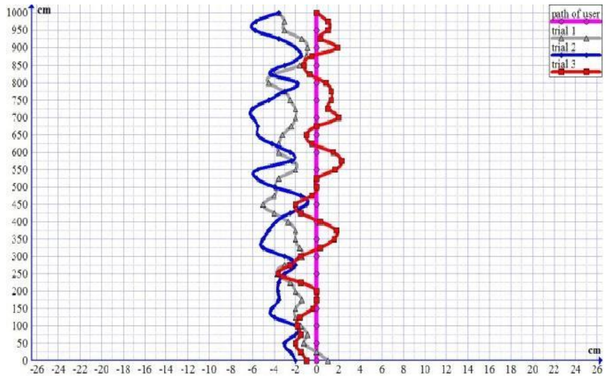

Figure 4.Trials of 1st person walking at speed of 0.5 m/s

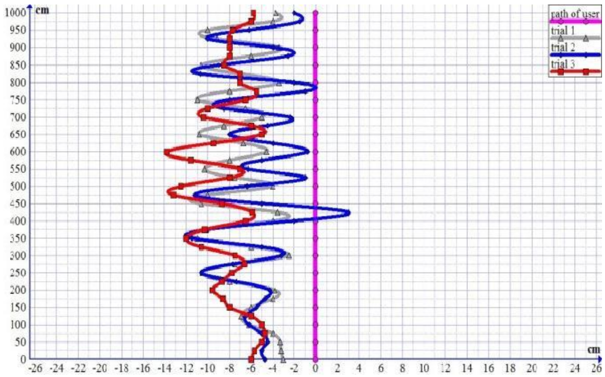

Figure 5.Trials of 1st person walking at speed of 1 m/s

In the curved path test results in Figure 6, the robot was able to follow the user but not the curved path of the user. It can be seen from the graphs that the robot was trying to cut the path of the user. This was caused by the steering and maintaining distance algorithm of the robot. Since the algorithm of the steering was to center the user, it disregards the path taken by the user and instead follows a straight line. It can be seen from the graph that instead of a curved path, the robot is actually traversing a straight path.

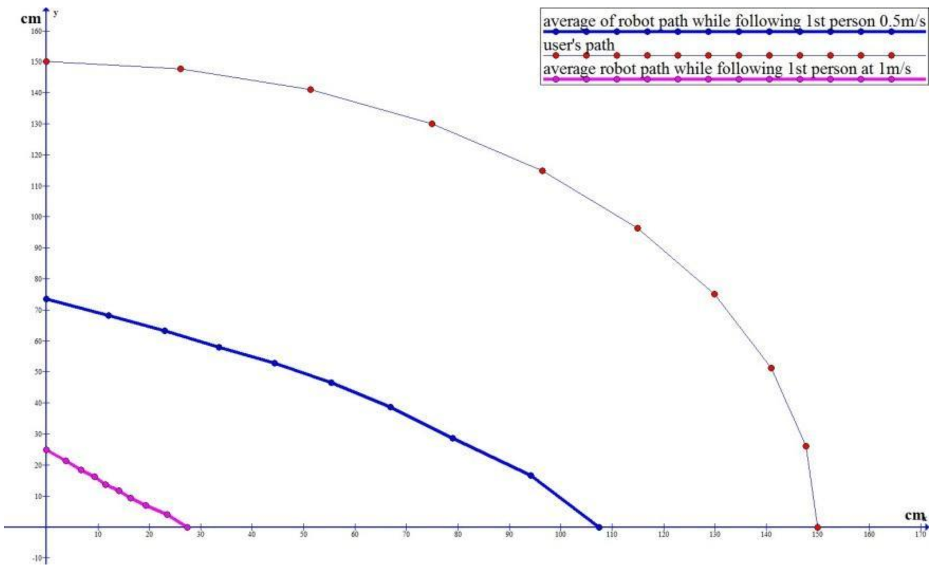

Figure 6. 1.5 m turning radius speed 0.5 m/s and 1 m/s left turn

5 CONCLUSION

The robot is a three-wheeled robot with a Kinect sensor which can follow a human person without the need to wear a special device or clothing. In tracking the user, the robot uses the depth data from the Kinect as an input to the proportional-derivative algorithm to control the speed of the robot while the hip-joint data is used to control the following direction of the robot by centering the robot to the hip of the user. To avoid collision, the robot also uses the depth to check for obstacles that are between the user and the robot.

In testing the robot, it was able to successfully follow the user in a straight path but there are deviations ranging from 4 to 8 centimeters. For the curved paths, the robot was able to follow the user when the turning radius is equal or greater than 1.5 meters since it will not collide with the reference point (which is ‘0,0’ on the Cartesian plane) and not lose track of the user. But when the turning radius is smaller than 1.5 meters, the robot’s undercut problem will lead the robot to collide with the reference point making it either stop or lose sight of the user.

One problem that the robot has when moving along a curved path is the undercut problem; this is shown in Figure 6. This is because of the implementation of the algorithm wherein the robot tries to maintain the distance of 1.5 meters, thereby undercutting the curve.

This caused the robot to "undercut" the path of the user. By undercutting the path of the user, there is a possibility that the robot will collide with an object while it is turning since it has no sensor at its side. One of the solutions currently being investigates is to use trigonometric equations to follow an arc when following a user in a curved path.

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