Yaw Tracking Performance for a Person-Following Robot

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ABSTRACT – This research focuses on the yaw tracking of a human with an Inertial Measurement Unit (IMU) for the purpose of a person-following robot. Since robot assistance is becoming widely used in the community, it is important that robots could follow a human being for purposes such as to carry items or to maintain security. The yaw tracking was implemented by the following method; the human holds (or wears) the IMU which detects the yaw angle of the human. The yaw angle is then transmitted to the robot wirelessly and the robot uses the yaw angle of the human as reference and adjusts its orientation accordingly. Experiments were done by adjusting the orientation of the human between 0 to 90 degrees at different angles. The results show that, although the yaw rate data is approximated in integers, the tracking was successfully done with average of less than 5 degree of error in the experiments.

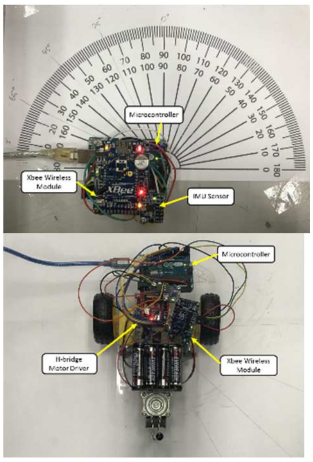
1. INTRODUCTION

The utilization of robots in the industry and community has grown rapidly due to the increase of technology experts and cost-effective solutions in the era of Industrial Revolution 4.0. In the community, a large number of robots have been commercially available, for instance robot vacuums and toy robots that respond to humans [1-2]. While industries may use large stationed robot manipulators, most of the commercially available robots for the community are mobile or walking robots due to its portability and smaller size.

For the purpose of robot assistance, a mobile robot could track and follow a human to carry items or to maintain security, i.e. follow a child in the supermarket. There are many ways for a robot to track and follow the human. Some researchers use range finders (i.e. Laser Range Finders, infrareds or ultrasonic sensors) to track and follow the human [3-4], vision sensors [5], while some researchers use beacons that transmit signals from the human to the robot. The robot then performs the motion required to approach the human or to maintain a distance between the human and the robot. In [6], a vision-based approach was used to detect the pixel area of a specific colour (in HSV format), then the robot decides whether to move forward, to stay still or to reverse if the human/object is too close to it. Our focus in this paper is to ensure that the robot adjusts its orientation according to the human orientation, as to ensure the robot mimics the human motion (orientation). In the future, the steps to come next are the detection of the distance of the human to the robot and generation of forward or reverse motion for the robot.

2. METHODOLOGY

There are two separate modules used in this experimental setup, the yaw detection module for the human and the receiving end at the robot. This is shown in Figure 1 (a) and (b). Figure 1(a) shows the yaw detection module that the human holds and Figure 2(b) shows the robot which will respond to the motion of the human.



(a) (b)

Figure 1 (a) Yaw detection module, (b) mobile robot to respond to human

The MPU6050 IMU sensor held by the human first senses the motion and the microcontroller calculates the yaw orientation of the human. After successfully obtaining the yaw values, the yaw data is sent to the XBee module by serial communication. The XBee module from the sensor sends data wirelessly to the other XBee module on the mobile robot. When the other XBee (on the robot) receives the yaw values, the microcontroller will use the data as a reference or target yaw angle of the mobile robot. The mobile robot then rotates the right and left motors (in differential drive) to obtain the change of heading (or yaw) angle of the mobile robot. This is implemented by comparing the yaw angle obtained from XBee with the robot's own yaw angle from the MPU6050 sensor mounted on the robot. The control law used is a simple method of turning left (at a fixed speed) if the robot angle is less than the human and vice versa. The flowchart of the operation for the human side and the robot side is shown in Figure 2. Both the sensor and robot operate continuously, hence no 'End' block in the flowchart.

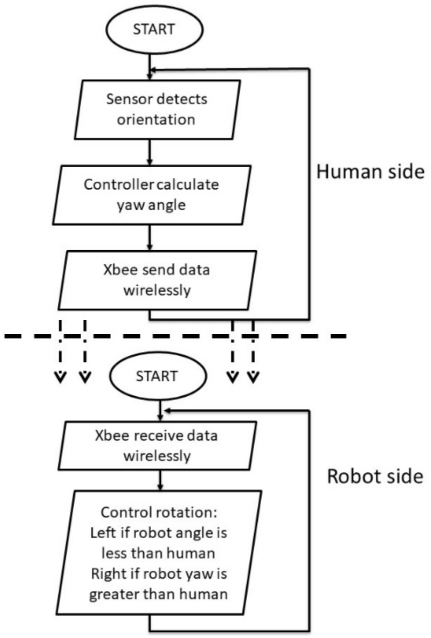


Figure 2. Flowchart of the yaw tracking system

3. RESULTS AND DISCUSSION

The experiment was tested for different angle between 0 and 90 degrees. When the sensor module and microcontroller is turned on, it regards the angle at the start as the initial angle (assumed 0 degrees). Both human robots are adjusted to face toward the same heading at the start. Then the different yaw angle (heading) is changed by rotating the human to different angles. Figure 3 shows the result of the yaw values of the human and the robot.

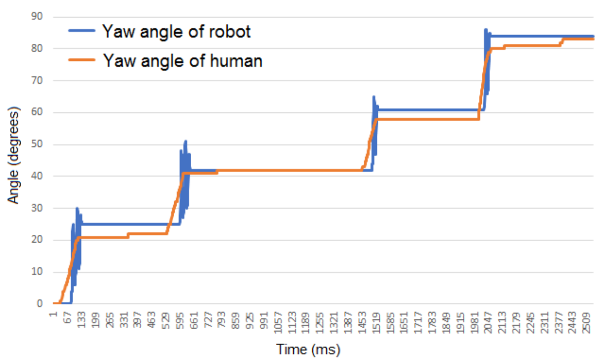


Figure 3. Results of Yaw angle of human and robot

The average error of the experiments is computed as the end of the experiment, as shown in Table 1. Each experiment (1 to 3) rotates the yaw angle of the human between 0 to 90 degrees, namely 0, 25, 45, 65 and 90 degrees.

Table 1 Average error from experiments

Experiment	Average error (degrees)
Experiment 1	5.20052
Experiment 2	4.94447
Experiment 3	2.4644

4. CONCLUSIONS

The paper shows the yaw tracking method of the mobile robot to adjust the heading according to the yaw angle of the human. The experimental results show that the tracking of the yaw rate of the human was successfully done by the mobile robot. In the three experiments done to test different angles of 0, 25, 45, 65 and 90, the average error of less than 6 degrees is acceptable since the yaw angles are approximated as integers instead of floating point numbers.The future direction of this research is to implement distance detection between the robot and the human to allow the robot to approach (decrease), avoid (increase) or maintain its distance from the human. Then the yaw angle (heading) and the distance control will be integrated to accomplish the target of the person-following robot.

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