TROLLEY FOLLOWERS FOR HYPERMARKETS

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ABSTRACT

Shopping trolley is a necessary tool for shopping in supermarkets or grocery stores. On the other hand, it is inconvenient and time wasting for customers who are in rush to search for desired products in a supermarket. The trolley is implemented in such a way that it will automatically move in accordance to the movement of the human. The shopping trolley is equipped with a Kinect sensor, computer system, Arduino UNO Microcontroller, Motor Driver L293D and a servo motor. The Kinect provides a skeletal data as well as depth data. The depth data contain the distance information in form of binary bits. This depth data is used to maintain the distance between the human and the trolley. The data is processed by MATLAB and will rise the interrupt to the Arduino is based on the skeletal data and depth data. Based on the interrupts generated in the Arduino UNO and motor driver will move the trolley.

Keyword: -*Kinect sensor, Depth data, Skeletal data, MATLAB, trolley, Arduino.*

1. INTRODUCTION

The Kinect sensor is a motion sensing device by Microsoft. It was originally designed for video gaming. Microsoft released a version of the Kinect sensor especially for windows. The sensor contains two cameras (one RGB camera and one IR camera), a microphone array, and a tilt motor as well as a software package that processes color, depth, and skeleton data. Thus, users are able to create interactive applications that based on the recognition of natural movements, gestures, and voice commands. An RGB camera that stores three channel data in a 1280x960 resolution. This makes capturing a color image possible. An infrared (IR) emitter and an IR depth sensor. The emitter emits infrared light beams and the depth sensor reads the IR beams reflected back to the sensor. The reflected beams are converted into depth information measuring the distance between an object and the sensor. This makes capturing a depth image possible. A multi array microphone, which contains four microphones for capturing sound. A Kinect streams out color, depth, and skeleton data one frame at a time. Each frame of the depth data stream is made up of pixels that contain the distance (in millimeters) from the camera plane to the nearest object as shown in the figure 3.1. An application can use depth data to track a person's motion or identify background objects to ignore**.** The depth data is the distance, in millimeters, to the nearest object at that particular (x, y) coordinate in the depth sensor's field of view. The depth image is available in 3 different resolutions 640x480 (the default), 320x240, and 80x60. Each pixel is represented by one 16-bit value. The 13 high-order bits contain the depth value the 3 low-order bits contain the human index. Any depth value outside the reliable range is replaced with a special value to indicate that it was too near, too far, or unknown.

1.1 Distance Calculation

The Kinect sensor returns 16-bit raw depth frame data. The first three bits are used to represent the identified players and the remaining 13 bits gives the measured distance in millimeters. The upper 13 bits, which represent the actual distance of the pixel value from the sensor. From the available 16-bit data, the upper 13 bits gives the distance. Perform a bitwise shift operation to move the bits to their correct position. Figure 1.1 will represent the packet format of depth data.

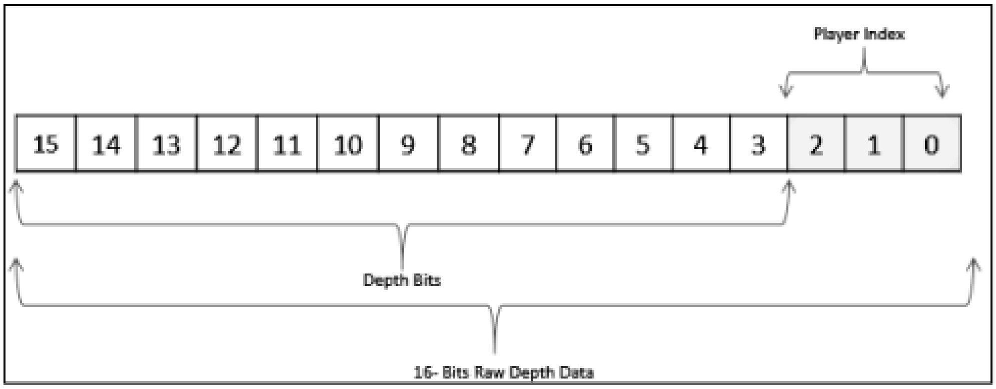

Figure 1.1: Packet format of depth data

2. PROPOSED SYSTEM

The Kinect sensor will be placed over the handle of the trolley in order to get the fully tracked skeletal data. The depth sensor will receive the reflected IR rays from the human and then process it into the computer system with the help of MATLAB software. Kinect sensor will assign different skeleton id for tracked skeleton. The middle person standing infront of the Kinect will be assigned as the primary user. Based on the skeleton id of the primary user trolley follow the user. Skeleton ID is used to differentiate between the primary user and human .By obtaining the depth data of the primary user, distance between the trolley and primary user can be determined. There are totally three interrupt is designed to move trolley according to state of the user. Interrupt a for forward direction and interrupt b for turning right and interrupt c for turning left. Based on the interrupt generated in the Arduino it will process the motor driver to rotate. The distance between the trolley and primary user is 1 meter. If distance primary user exceeds 1 meter. The interrupt A is generated and trolley will be moved forward.

When turning the system on, the Kinect sensor, which is the main part in the system, starts capturing the depth image of the whole scene in front of it. The information captured by the Kinect must then be transferred to the computer where the processing is running. The processing will analyze the depth image and once it detects a user, it will determine his/ her center of mass which is the main point in tracking him/her and it has also to detect the obstacles between that user and the robot. Based on the analyzed data, the processing will send commands (like: left, right, forward, stop, etc…) to the Arduino serially via the computer, these commands will be already defined between processing and Arduino. Finally, the Arduino which will be connected to the car motors will receive the commands coming from computer, analyse them and order the robot to move in the right way. The overall setup of our trolley follower is shown in the figure 2.1 as follows.

3. IMPROVE DETECTION ACCURACY

When the program finds a targeted person, it is not sufficient to tell if it is a human. According to experiments, false detections like mistreating a door, wall or a chair as a human. In Figure 4.1, in case like target person is too near, and only part of the body is detected, skeleton pattern is very disordered. In this situation, it is not confident to tell the exact position of the user. Then program should not execute. For each joint, there are 3 statuses to illustrate the confidence level.

- Tracked -it is confident to tell the joint is found
- Inferred - it is not confident to tell the joint is found (may or may not exist)
- Not tracked - the joint is not found

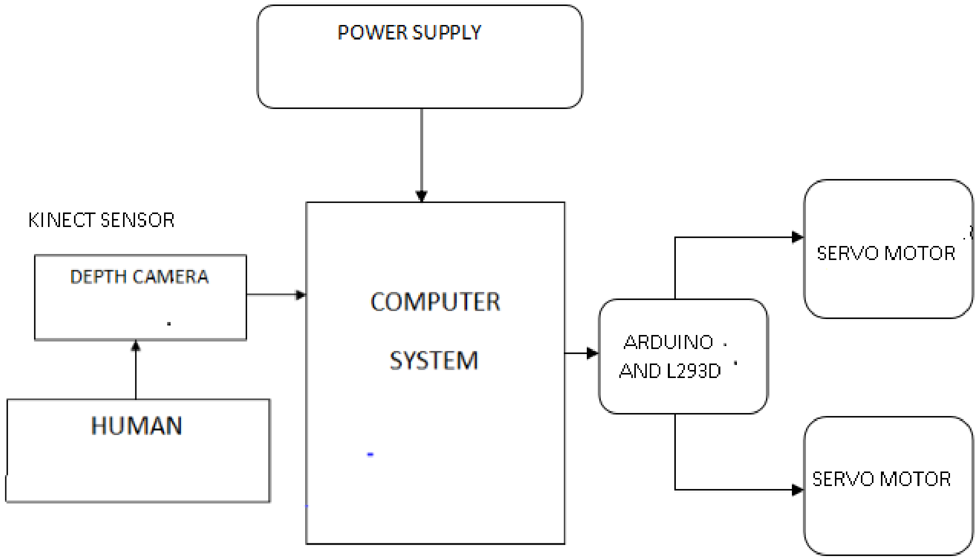

Figure 2.1 Block diagram

3. IMPROVE DETECTION ACCURACY

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Figure 3.1 When user is too near, skeleton disordered

Count the number of tracked joints to represent the confident level. The higher number, the more confident it is. There is another condition that the algorithm can be further improved. As when the user is close to the Kinect, joints of lower body is usually unable to be captured, which causes the confident level low. But in this case, the user does exist and program should execute. Thus count the number of upper body joints will be more accurate. Joints 14- 20 of the whole body will be omitted.

3.1 Noise Rejection

As there is always noise and disturbance when detecting skeleton, the following example occurs frequently.

Number of confident upper body joints

14,14,14,14,14,14,14,14,14,7,14,14,14,14,14

As it is seen, when a sudden noise as circled occurs, it will tell the program that the user is lost.The robot companion stops immediately and speeds up again right after. This will cause an unsmooth action and do harm to motors. To solve this problem, the author developed an algorithm to get rid of this noise.

- Take 22 data sample (data in roughly 1 second).
- Set threshold (below threshold meaning user is lost)
- Count the number of data below threshold.
- Only consider user is lost if the number of data below threshold appears more than 4 times in 22 n data sample.
- Otherwise, consider the user is still tracked.

Number of confident upper body joints

14,14,5,14,14,8,14,14,7,14,14,14,14,14,14,14,14,14,14,14,14,14

In this case above, set threshold as 12. There are less than 4 times lost detections within one sample range. It is considered as user in track.

3.2 False Detection Rejection

In the case shown on Figure 3.2, the Kinect mistreats a chair as a user and its skeleton confidence is still quite high. Therefore, algorithm discussed above is not sufficient to reject this false detection.

Figure 3.2 Kinect mistreats a chair as a user.

A new algorithm is developed to reject false detection. Since within a very short period of time, the user hardly moves body too much, the joint position in such short period is changing very little According to experiment data, when false detection happens, for example Kinect mistreats a chair as a user with the joint position is jumping unreasonably. Therefore, variance of position is a good parameter to judge the joint moving fluctuation. It is derived in equation 3.1 as follows

$$Sn^2 = \frac{1}{N}\sum_{i=1}^{N}[(xi - xave)^2 + (yi - yave)^2 + (zi - zave)^2] \qquad 3.1$$

The axis if the joint is set based on Kinect as shown in Figure 3.3. Take the average of x, y, z axis respectively and compute the variance according to the formula above.

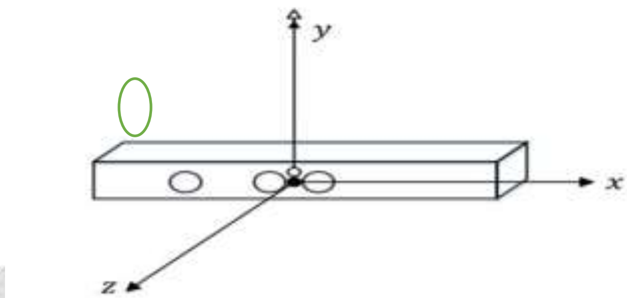

Figure 3.3 Axis position in Kinect.

If the variance is above threshold, it means big data violation. It is considered as false detection. In this case, the trolley should not follow. By doing so, it is able to reject situations like mistreating some obstacles as a human.

4. CONCLUSION

In our module, a portable robot is built based on Kinect sensor. The Kinect sensor is used for collision avoidance and to maintain an equal distance between the user and trolley. With effort of Kinect detection accuracy improvement, the robot system is able to intelligently follow the user. 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 centring 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. 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. The false detection rejection is more accurate because it can detect only a human in its field of view and able to hold the reference point of user.

9. FUTURE ENHANCEMENT

The future of ad- hoc networks is really appealing, giving the vision of anytime, anywhere and cheap communications.

Before those imagined scenarios come true, huge amount of work is to be done in both research and implementation. At present, the general trend in MANET is toward mesh architecture and large scale. Improvement in bandwidth and capacity is required, which implies the need for a higher frequency and better spatial spectral reuse. Propagation, spectral reuse, and energy issues support a shift away from a single long wireless link (as in cellular) to a mesh of short links (as in ad- hoc networks). Large scale ad hoc networks are another challenging issue in the near future which can be already foreseen. As the involvement goes on, especially the need of dense deployment such as battlefield and sensor networks, the nodes in ad-hoc networks will be smaller, cheaper, more capable, and come in all forms. In all, although the widespread deployment of ad- hoc networks is still year away, the research in this field will continue being very active and imaginative.

5. REFERENCES

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