Night Security Guard: Patrol Robot

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***Abstract*— This term paper provides a new design of robot combining Kinect, Pioneer 3DX, and iPhone. The robot can served as a night patrolling guard in schools, institutions or companies. The robot is able to detect and chase intruders in totally darkness, and take counterattack approaches such as flashlight, bomb sound, and calling when is needed.**

Keywords-patrol robot, Kinect, pioneer 3DX, Wi-Fi, iPhone

I. INTRODUCTION

As we all know there're many people serving as security guards for banks, institutions, or companies in Taiwan. We need someone to stay alert and take care of the situation especially during nighttime in order to avoid thievery.

However, humans get tired by nature. There are countless real examples that the guards take naps during their duty time. With the progress of technology, robots can replace humans in such repetitive works. Robots can patrol though an area without rest and are able to react much faster than humans do. Moreover, robots can detect things even in a completely dark scenario. And most importantly, we can save human resources in huge amount by replacing human guards with robot guards.

In this work, we provided a solution combining Kinect sensor, Pioneer 3DX and iPhone. The presented robot have four main features: Autonomous patrol in the assign area, identify unknown objects without light, tracking and attacking the invader, and monitoring and

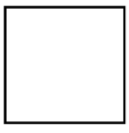
get alarmed via iPhone through Wi-Fi connection.

II. METHODS

A. PIONEER

Assumption：

1. The map is simply as below:



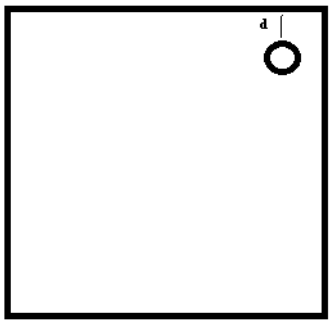
Because of the difficulty of localization, we need to do this assumption, and it greatly simplifies the difficulty of localization so that we can finish the project in semester.

The main tasks of Pioneer 3DX are：

1. Patrol:
   a) Pioneer needs to patrol in a defined trajectory.
   b) To the simply map we can adjust pioneer around the corner

When d <D', we need to turn and adjust the x, y information in the pioneer.

Pioneer provides the obstacle avoidance that makes it wound hit the wall.



2. Get information from Kinect and send message to client:
   a) Pioneer to get the information from Kinect, and if there is a people in sight, pioneer also need to open the weapon.
   b) Pioneer needs to send its position to the client, so that client can show the situation of the whole building.
   c) We use TCP to connect the pioneer and client.
3. Track while finding the target:

When Kinect find a person, pioneer needs to track the people according to the depth message.

a) Get dx, dy form Kinect (dx for displacement of left and right, dy for the distance between Kinect and enemy).

b) Adjust dx, dy relative to pioneer, and get the enemy position.

c) Start tracking by move or rotate.

d) Never rotate for less than 10 degree it cost time and may not catch the enemy.

e) If we lost the target in sight, turn around for 360 degrees, to the direction of the enemy last appear.

f) If we didn't catch the enemy in sight after V, we need to send lost enemy information to client. And then back to nearest landmark , to continue the patrol

g) Use the same method above to adjust the position of robot.

B. KINECT

1. Architecture

The Kinect and the software library interact with our application, as shown in Fig 1.

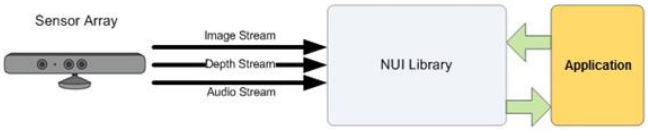
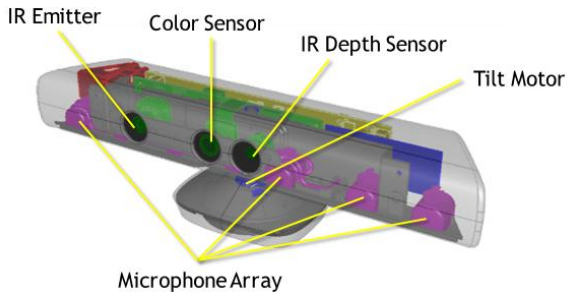


Fig 1. Hardware and Software Interaction with Application

2. Kinect Sensor



Inside the sensor case, a Kinect for Windows sensor contains:

a) An RGB camera that stores three channel data in a 1280x960 resolution. This makes capturing a color image possible.

b) 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.

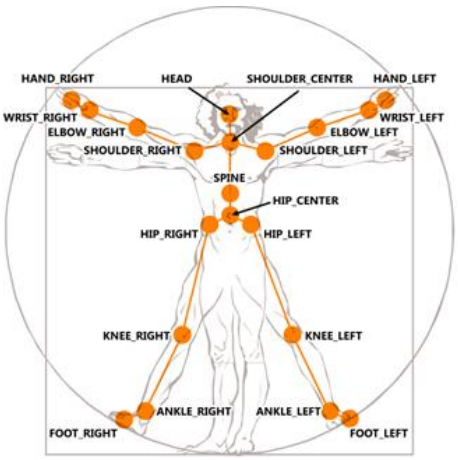
c) A multi-array microphone

d) A 3-axis accelerometer configured for a 2G range, where G is the acceleration due to gravity.

3. Skeleton data

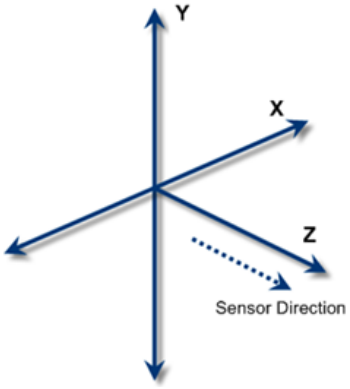
The skeleton data consists of a set of joints. These joints are shown in the diagram below.

We mainly consider the information of HIP_CENTER which is in the center of the human.



4. Coordinate

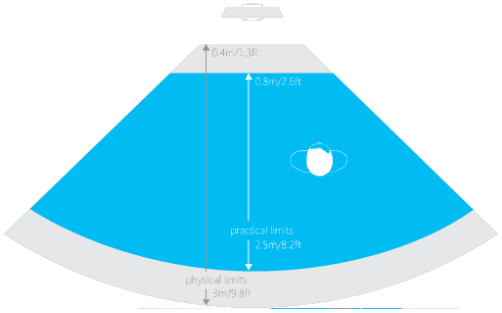
The coordinate system for the skeleton data is a full 3D system with values in meters. It is shown in the following diagram.



5. Range

In default range mode, Kinect can see people standing between 0.8 meters (2.6 feet) and 4.0 meters (13.1 feet) away, In near range mode, Kinect can see people standing between 0.4 meters (1.3 feet) and 3.0 meters (9.8 feet).

Our program can switch between those two modes to track people.



C. iPhone(Warning Part)

In the warning system part, we choose iPhone as our warning platform, for the reasons that it has the functions of emitting flashlight, making a warning sound, and making a emergency call. Further more, iPhone is a compact device compared with other warning platforms such as buzzers, so iPhone has no problem embed on our pioneer platform.

The following will discuss the detail content about iPhone warning system in these respects:

1. Connecting

The warning system has to connect with the main control component to receive the patrolling information. Here we use TCP/IP protocol for the reason of convenience and stability, and its network topology is shown in the Fig.2.

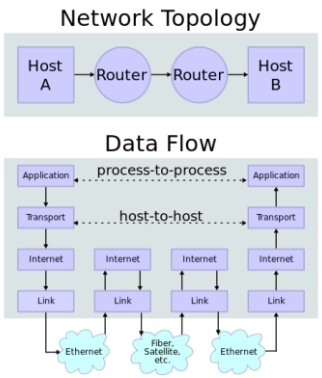


Fig. 2. network topology of TCP/IP

In this kind of connecting method, our warning system has to connect to the same wireless access point with the main control component.

2. Warning mechanism

As shown in Fig.3, through TCP/IP connection, the warning system can receive the detecting data from main control part, when it receive unusual data, the warning mechanism will be triggered and it will emit flash light and make a warning sound as deterrence. The final step in the warning mechanism is that it will make a phone call to the setting number.

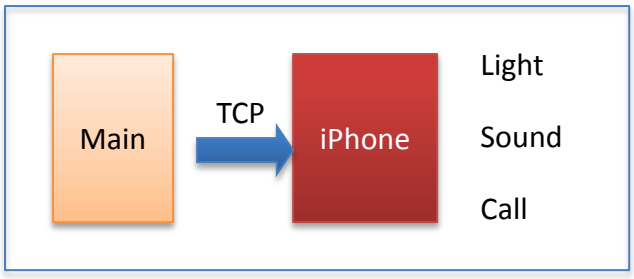


Fig. 3. Structure of warning mechanism.

D. iPhone (Client)

For the client part, its main function is to let user know all the detail information about the patrolling condition. Just like the warning part, we choose iPhone for its compactness.

The following will talk about the details about iPhone client in these respects:

1. Connecting

The client has to show the patrolling situation to the client user, so it has to get information from the main control part. Here, just like the warning part, we choose TCP/IP protocol.

A big difference from warning system is that client part not only receives data but also send command to the main control part, and the connection structure is shown in Fig.4.

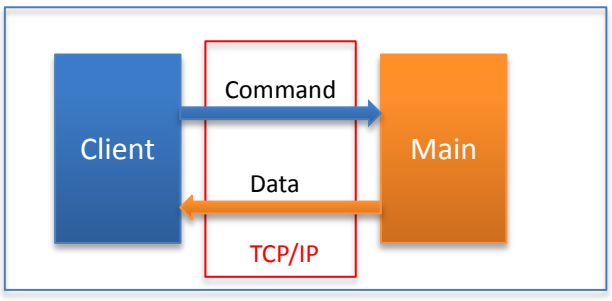


Fig.4. Structure of connection between client and main control part.

2. Client main function

The most important information to show on client part is the position of the patrolling guard and if there is any invader also show its position. To do so, we have to convert the world coordinate to the iPhone display coordinate. We do some experiments to find the linear converting correlation between world coordinate and iPhone coordinate, and the final user interface is shown in Fig 5.

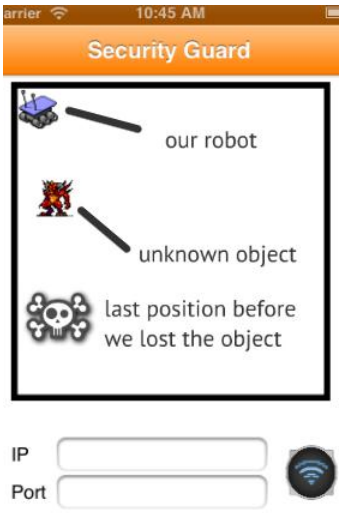


Fig. 5. User interface of client.

Another part in the client is the command sending part. With this mechanism, the users can use their iPhone to control the patrolling robot when to start or stop its patrolling task. This function can be achieved by send some connection sign to the main control part through TCP/IP.

III. RESULTS

A. Overall structure

As shown in Fig.6, the patrol robot is composed of Laptop, Kinect, iPhone, and Pioneer 3DX. We run our main control programs on the laptop, and all parts including the laptop and mobile phones are connected to the same Wi-Fi network.

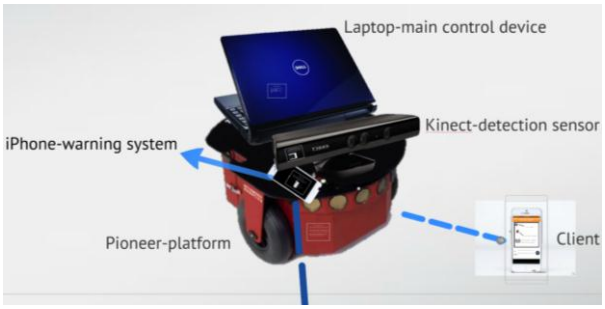


Fig. 6. The whole construction of the patrol robot.

B. Kinect

As shown in Fig.7, the depth (Position X) and lateral deviation (Position Y) information are sent back from the Kinect sensor. The value is read in meters and we take Kinect infrared sensor as the origin. Thus we are able to locate the position of the invader relative to our robot.

In addition, when an intruder appears in sight of the robot, the detection screen will show a human skeleton figure and send messages to the central control program which is ran on the laptop.

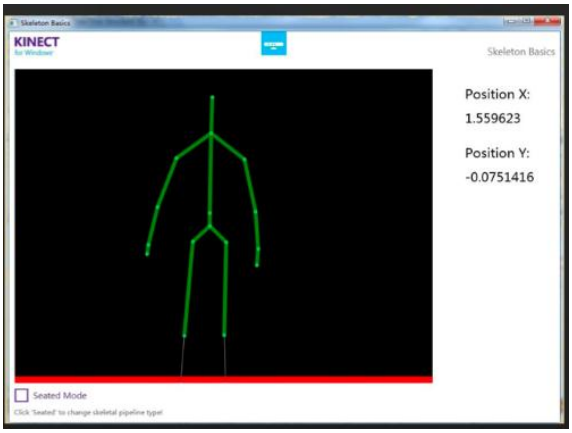


Fig. 7. Human detection using Kinect sensor.

C. Pioneer 3DX

Pioneer can receive signals from Kinect to discriminate whether it should enter patrolling mode or chasing mode. Also, from the x and y position information given by Kinect, Pioneer is able to follow the stranger. After chasing mission is finished, pioneer will go back to the preset checkpoints and continue its patrolling work.

D. iPhone

1) Warning system

The iPhone setup on the front top of the pioneer can take counter approach toward the invasion event. It can turn on its screen light and play the bombing sound to scare the invader. It can also be equipped with any weapon that is controllable by Wi-Fi signal.

When invader is detected, the warning system will also automatically make a phone call to the assigned phone number for cautioning and further support.

2) Client

Once the client set up a connection to the central controlling Wi-Fi network in which the Pioneer is, the client can monitor the real-time position of the robot, invader and the last lost point on the map shown on the phone screen. (See Figure 5.) Additionally, alert windows will jump out when there is an event such as invasion or target disappearing.

IV. CONCLUSION

In this project, we built a night patrolling robot from three sub-systems. The robot can autonomously patrol in the assign area and track the unknown object in the dark scenario. And we believe that this kind of robots would have extensive application in our life.

V. REFERENCES

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