The Protection System Using Automatic Human Tracking And Identifying With Kinect 2

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***Abstract*—In this paper, we design a system using Kinect and Arduino to track a human. If the human does not authenticate his or her identity, then the rubber band gun will aim at the detected human and shoot some rubber bands. To meet our requirements precisely, almost all devices is built from material and electronic components in our system.**

Keywords—Kinect; Arduino; human detection; tracking

I. INTRODUCTION

Nowadays, many kinds of technology and application are invented and developed. As the increasing of the ease to get the high tech products, the criminal rate is rising as well. According to the fact, the security has become a big issue, since people always care for their fortune such like things, money and most important, live. Due to this, the development of the security protection becomes more and more important, so we try to propose a system which is used to protect the security. For now, there are many kinds of mechanisms trying to prevent the thief from getting into houses, like fingerprint identification, electronic lock, iron bars with window. However, all these kinds of methods are not enough, that means, too passive, and there will not be able to avoid the thief to get in. So in this paper, we will focus on the indoor protection and introduce a new kind of active, automatic security protection system, which is more robust than the passive system. In practice, we will build a vehicle with a depth camera, some sensors, and an arm which can actually attack the invader. Below will introduce our devices briefly. Our vehicle is hand-made, and this will be more flexible for us to modify and maintain the hardware. The motor controller is *Pololu Qik 2s12v10 Dual Serial Motor*, the Motor is *34: 1 Metal Gearmotor 25 Dx52L mm HP 6V with 48 CPR Encoder*, finally, the platform is 30 cm * 40 cm *balsa wood* box. For the depth camera, we use *Kinect 2*, which is powerful for median distance depth detection, and it also have many tutorials and API that can ease our development of the protection system. For the sensors, we use RFID reader, and we will describe in detail later. For the arm, for safety reason in testing, we use a rubber band gun which can actually aim at a person. Now we will introduce how our system works briefly. At first, the vehicle will stay at a point and wait until detecting a person. After the vehicle detect a person, it will calculate the distance and the angle between the front side and the person. Depends on the distance and the angle, the vehicle can modify the trajectory by controlling the differential and speed, and then get forward to the person directly. When the distance between the vehicle and the person is less than 150 cm, the vehicle will ask the person to show the ID card. If the person show the correct ID card, then the vehicle will sleep for 3 seconds and wait for detecting next person, otherwise, the vehicle will trigger the rubber band gun to attack the person. Compared with the passive defending system, our active defending system has some advantages below.

1. Because the general system is too passive, when the bad guy is trying to destroy the system, it can not counter it. But for our system, it will shoot the bad guy to defend.
2. Our system will run around the full floor, so the bad guy will not know where it is, and this will raise the difficulty for committing crime.

For the reasons above, our system is more powerful and can practically avoid crime. And for the section below, we will introduce our device and methodology separately.

II. METHODOLOGY

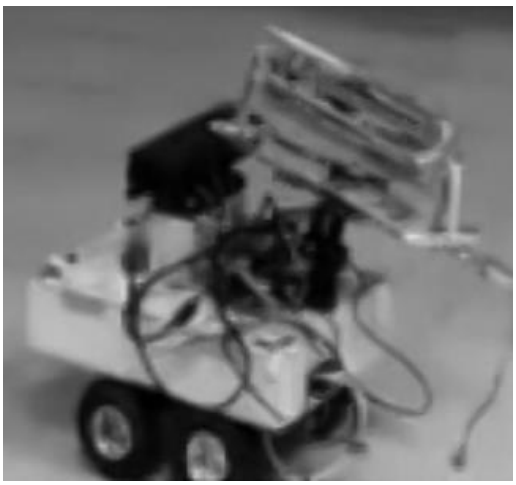

Figure 1 : Overview of the protection system

Figure 1 illustrates the protection system we proposed. Our system can be separated into four parts : Human tracking, vehicle controlling, Rubber band gun, and RFID reader. For vehicle controlling part, rubber band gun part, and RFID reader

part, the main program written in *C++* has to communicate with hardware controlled by Arduino. We write a class *Comm* with function to read from serial port and write to serial port, so *Arduino* can use *Serial.read()* and *Serial.print(val)* to receive command and return result. We will introduce those parts in detail in the following content.

A. Human tracking

The device which we use is *Kinect 2*. *Kinect 2* is a robust video camera for capturing the RGB image and the depth image. Moreover, compared with other kind of video camera like *Realsense*, *Kinect 2* can get the more accurate depth image from a long distance. In addition, because *Kinect 2* is common for many program developer, added with the API and useful function that is provided, many source code can be accessed and referred. For our Human tracking, we use the function for human skeleton detection provided by Kinect 2, and it can detect 25 joints and 6 people simultaneously. We only take the x, y and z coordinate of the middle of the spine. With the coordinate in the 3D space, we can control the vehicle to track the people or direct the rubber band gun to aim at the right direction. For the detail, we will introduce in other parts.

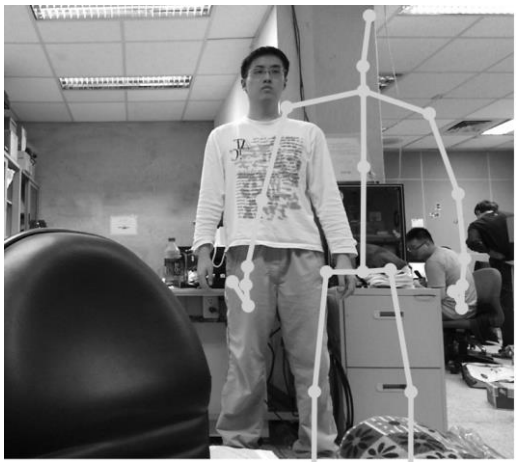

Figure 2 : Use Kinect for human detection

B. Vehicle controlling

With the 3D coordinate of the spine, we calculate the angle between the front of the vehicle and the people. Depends on this angle, we control the vehicle with differential that the speed of the left wheel is *(constant + angle)* and the right wheel is *(constant - angle)*, and modify the + and – to turn left or right.

C. Rubber band gun

As displayed in Figure 3, we use an Arduino to control two 1501MG analog servo motors and the relay in the rubber band gun part. Since Arduino is powered by the laptop in our system, it does not have sufficient current for analog servo motors and the shooting motor, an external connected power supply illustrated in Figure 4 is required. We also use Arduino Sensor Shield to avoid complex wire connection.

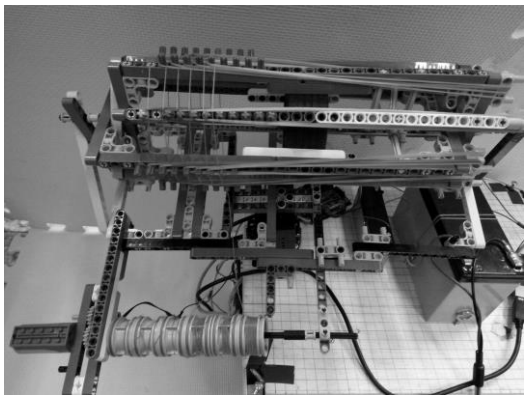

Figure 3 : Overview of the rubber band gun

Figure 4 : External power supplied by a storage battery

Figure 5 displays the analog servo motor, *<servo.h>* is included in the *Arduino* program. *servo.attach(pin, min, max)* is called in the setup function, then we can simply call *servo.write(angle)*, which control rotation degree by pulse width. The shoot motor is switched by a relay shown in Figure 6, when *Arduino* set output pin to high, the electromagnet will make *NO* and *COMM* connected, and thus turn on the shoot motor.

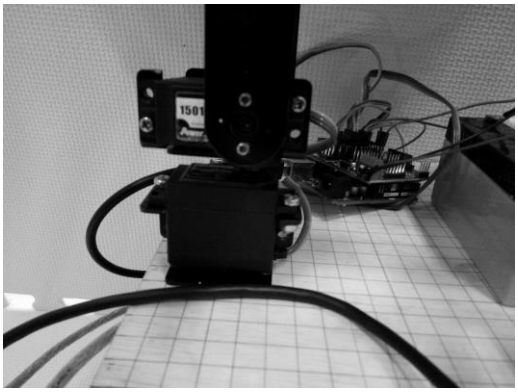

Figure 5 : 1501MG analog servo motor

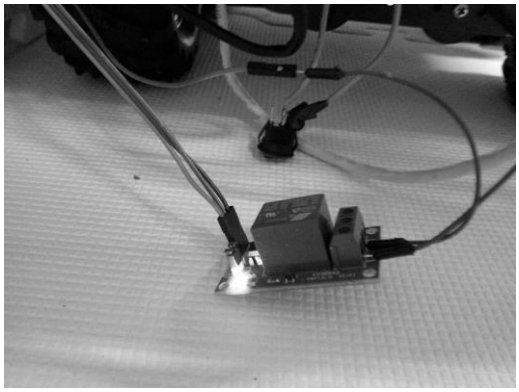

Figure 6 : The relay which controls the shoot motor

The command sent from main program will be in the format

- *" angle_XZ, angle_RY. "* will let two analog servo motors rotate to *angle_XZ* and *angle_RY* degree respectively
- *" H"* will set the output pin for the relay to high to turn on the shooting motor
- *" L"* will set the output pin for the relay to low to turn off the shooting motor

When a human is detected, the main program will calculate angle by atan2 of x, z and r, y and send command to Arduino serial port, so the analog servo motors will aim at the detected human. When a human is judged as an invader, the main program will turn on the shooting motor to shoot some rubber bands, then turn off the motor one second later.

D. RFID reader

As displayed in Figure 7, we use *RC 522* to read UID of the student ID card. <*SPI.h*> and <*MFRC522.h*> are included in the Arduino program. The program check whether there is a new card in the loop by *PICC_IsNewCardPresent()* and *PICC_ReadCardSerial()*. If a new student ID card is detected, it will write the UID to the serial port in the format " *!id* " and delay one second. When the main program read the ' *!* ' character, it will sleep 0.3 second to ensure the entire UID is sent. It will then read the UID from the serial port and check if it is an authenticated UID. To make our system more interactive and interesting, some voice files like "Show me your student ID card !", "Sorry, unknown UID." and " Hello, Wen Chieh ." are generated by *gTTS* package of *Python*. The program can use *PlaySound* function in <*Windows.h*> to play voice files. When the distance to the detected human is small enough, the system will ask him or her to show the student ID card, unknown UID or a waiting time more than 5 seconds will be judged as an invader.

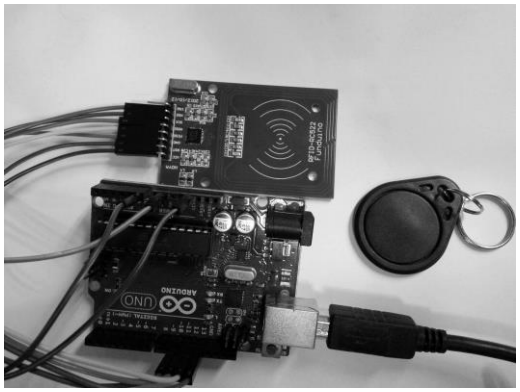

Figure 7 : RFID reader

E. Software and hardware supply

- *OpenCV* : *OpenCV* is an open source library which provide many useful functions for image processing. In our system, we use it to transform the information get from the *Kinect 2* to the appropriate format that we can use in *C++* programming. In addition, we also use the function to display the image so that we can use it to debug.

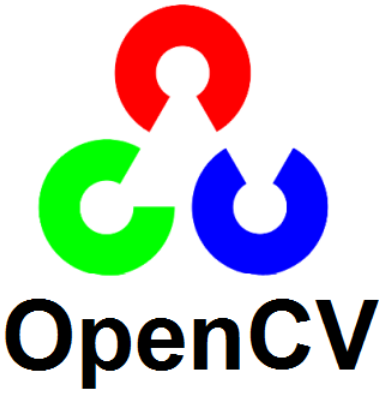

Figure 8 : Logo of OpenCV

- *Visual Studio : Visual Studio* is a developing software which supply many kind of language. In our project, we write our main program using the blank project in the *Visual Studio*. It is very easy to link the open source library and can set the stop point in the program and stop the program at any time you want when the program is running to check the data and parameter is correct or not, and this kind of convenience is the reason attract us to choose it

Figure 9 : Logo of Visual Studio

- *Kinect 2 : Kinect* 2 is a video camera which can get the RGB and depth image simultaneously. The reason why we choose it is because its powerful stability to detect the depth in a long distance, compared with *Realsence*.

In addition, because it is a common hardware for many programmer, not only the API provided by the company but also the open source and tutorial can be found on the website easily, and all these things help us to complete our object more easy.

Figure 10 : Kinect 2

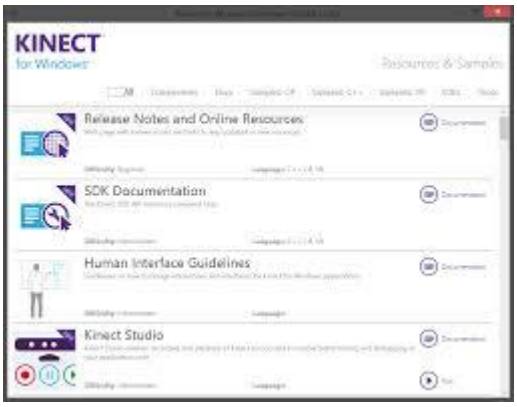

Figure 11 : API for Kinect 2

Figure 12 : Logo of Arduino

- *Arduino* : *Arduino* is an open-source electronics platform based on easy-to-use hardware and software. *Arduino* boards are able to read inputs and turn it into an output. It provides a simple interface for programmer to design a system with hardware to meet various kinds of requirements.

III. Experimental Setup

We test our defender system at the National Taiwan University Computer Science and Information Engineering department. Moreover, we test at night for the situation under the lack of light. For the vehicle part, we use *Pololu Qik 2s12v10 Dual Serial Motor* as the motor controller, and *Metal Gearmotor 25Dx52L mm HP 6V with 78 CPR Encoder* as Motor and using the 30 cm * 40 cm *balsa wood* box as the platform. For the computer, we use a very common one so that it can be exchange to any other laptops. And we also use *Arduino* for communication between the main program executing in computer and the information transported from the sensor. For the video part, we use *Kinect 2* and equip a storage battery for power supply. All these things are attached on the platform.

IV. Results

We have tested our system many times, and it worked well most of the time. Although the system works well, it still have some problem we can solve or can not solve. First, because our vehicle is made by ourselves, so it is a little bit unstable. And for the human tracking, we have found that if the vehicle shakes too dramatically, the tracking of the people will lost. According on this, we have figure out some methods to improve it. For the first thing, we modify the start up speed of the vehicle so that when the vehicle detect a person and is going to start, the vehicle will not shake so dramatically. For the second, we control the differential by the angle between the front of the vehicle and the person so that the vehicle will not turn too much or too less and need to modify back to the right direction. Finally, we place our *Kinect 2* on the vehicle instead of putting on a pillar, and this also improve the stability of the *Kinect 2*. As the result, first, the system will wait until it detect a person. After the system detect a person, the vehicle will go forward to the person and ask for the student ID card. If the person show the correct student ID card, then nothing will happen, the vehicle will wait for the detection of next person. But if the person does not show the student ID card, the system will use rubber bad gun to shoot the person. Depends on the testing, our system can track the people and ask for the student ID card and even shoot the people for about 80 percent accuracy.

We also simulate to track a moving human with real-time obstacle avoidance with C++ and OpenCV. In our simple simulation, we use a static step size and a potential field function inverse proportional to the distance. As displayed in Figure 13, each step has a constant length, and the goal is moving in a random direction. The direction of next step is calculated according to the vector sum of the potential field of obstacles and the goal.

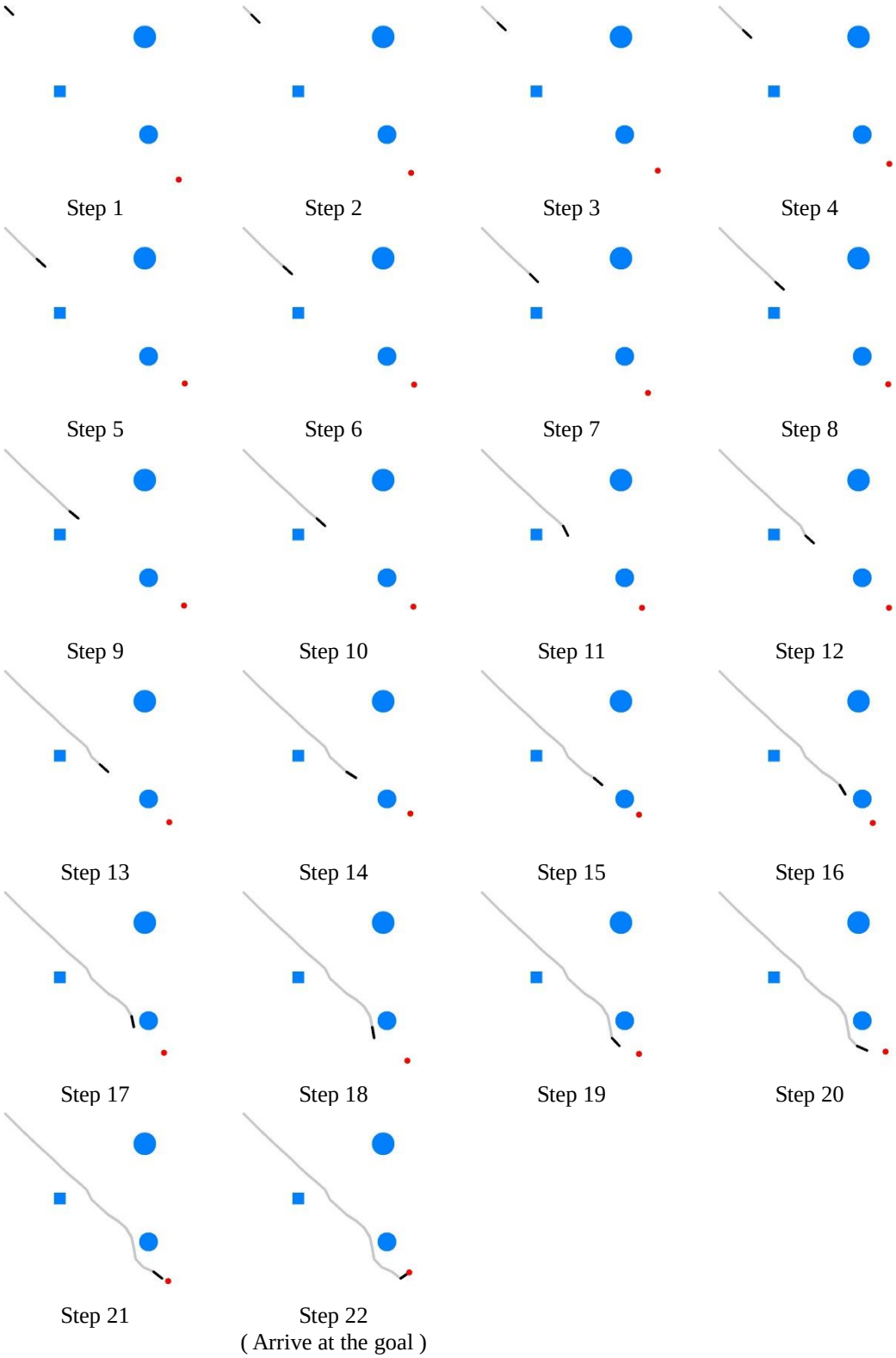

Figure 13 : Simulation using potential field (obstacle : blue, goal : red, path : gray)

V. RELATED WORK

In Chung-Hao Chen, Chang Cheng, David Page, Andreas Koschan and Mongi Abidi's research article [1], they proposed an algorithm to track a moving object with real-time obstacle avoidance. In Abdel-Mehsen Ahmad and Hiba Al Youssef's paper [2], they use Kinect to implement a 3D sensor-based Moving Human Tracking Robot with Obstacle Avoidance. Due to dead weight of our system, we do not put an extra sensor to implement obstacle avoidance in our system. However, their concepts gave us the inspiration of our simulation algorithm.

VI. CONCLUSION

We have completed a system which is a vehicle attached by some sensors and their control board that can track and attack the people who do not show their correct ID card automatically. We use *Kinect 2* for human tracking, and use *Arduino* to control and transport the direction between the sensors and the main function. For the future work, we hope that the system can patrolling around the building even when there is no person detected. Real-time obstacle avoidance is also expected to be implemented.

REFERENCES

[1] Chung-Hao Chen, Chang Cheng, David Page, Andreas Koschan and Mongi Abidi, "Tracking a moving object with real-time obstacle avoidance" Industrial Robot : An International Journal 2006 33:6 , 460-468

[2] Abdel-Mehsen Ahmad and Hiba Al Youssef, "3D sensor-based Moving Human Tracking Robot with Obstacle Avoidance", 2016 IEEE International Multidisciplinary Conference on Engineering Technology (IMCET)