Autonomous sumo robot, helped by gesture control

Ivan Danielov Ivanov
American college of Sofia , Sofia, 10th grade

Tutor
Vladimir Velinov
Software Engineer in SAP Labs Bulgaria

Abstract

With the advancing of technology, more and more dreams from the past become real. One of these dreams is remote control. The following science article presents one such example - control based on hand gestures. The article focuses on a simple and convenient way to establish the remote control. A device is presented, consisting of a glove and an accelerometer. Aside the glove, a mobile application for Android is implemented which serves as a device for gesture control. Gesture control is discussed in the syllabus of the sumo battles between robots where a player helps otherwise autonomic robot. That gesture control is very simple and requires very small resources so its applications are numerous. The most common one of them in the real world is in the sorting robots. They can be controlled using exactly the glove, or the Android application.

Key words: wireless control, hand gestures, easy and convenient way, accelerometer, sumo robot, Android, sorting robots.

Contents

1 Introduction **3**

2 Way for recognition **4**
2.1 Sumo battle 4
2.2 Glove with accelerometer 4

3 Other ways for hand gesture recognition **7**

4 Applications **7**

5 Conclusion **8**
5.1 Ideas for future development 8

1 Introduction

After the creation of the computer, people started searching for easier ways to communicate with it. Here is the gradation of the discoveries up to the moment: From the initial accumulation of cables and buttons, everything is transformed into a keyboard and a mouse. The touchscreen is invented, or the also called communication with touch. Google creates their own voice recognition software. All these developments try to simplify the communication between machine and human to a communication between humans. The next step in this gradation is the replacement of the "hard" monitor with a visual one. And here the following problem appears: how would a person work with this monitor? The mouse, the keyboard, and the voice commands would not change, however the lack of screen from hard matter would eliminate the communication with touch.Or not? If the computer can distinguish between our body and our hands and can locate them? Then the communication with touch will be again an option and will even be more handy, because the visual monitor can have a big size and in this way the mouse and keyboard can prove inefficient. The possibility for voice recognition also is neglected because there are still problems to be solved within it. Even the voice communication between two people can prove ineffective. In many conversations people use gestures and intonations in order to understand everything. In that moment the visual screen becomes the most effective device, but in order it to be accomplished another simpler problem must be solved - hand gestures recognition. It will be even easier if that device for gesture control is found in a glove which should be just put in order the communication to start. And also an Android app would be useful because many people in our world use Android.

The following article discusses a problem in this sphere - controlling a robot with gestures. The demonstration consists of the following: autonomous sumo robot with independent algorithm for control is helped by specified hand gestures from the player. The device for gesture control is found in a glove. Also an alternative of its is presented - an Android app - an application for the massive user.

2 Way for recognition

2.1 Sumo battle

The rules of the battles are the following: First, the players in the battle power on their robots and place them in the arena. The robots should not start fighting immediately, they should wait a particular amount of time, equal for every player, after they are turned on. The arena is colored in two contrasting colors, for example black and white, when one of them is the color of the border, while the other one fills the arena inside. The idea behind these two colors is that the robots can distinguish whether they are inside or on the border of the arena. Second, in the process of fighting, the robots try to push one another out of the arena. The robot that loses is that one which exits the arena first.

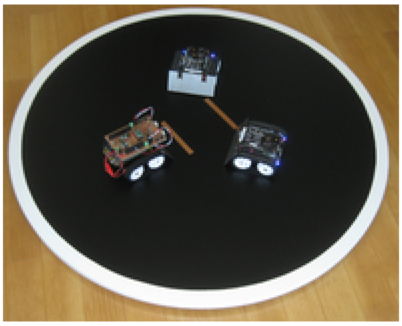

Figure 1: A fight between 3 robots on the arena

The current research is based on the idea that a player can help his or hers robot in the sumo fights, using hand gestures, but at the same time the robot should keep its autonomy, which means that when there is no help from the player, the robot should play on itself.

2.2 Glove with accelerometer

The accelerometer is built in the glove. The glove has a simple look and should be worn as normal glove. It consists of an accelerometer, which works using the yaw, pitch, and roll principle of the gyroscope, see Figure 2, and is from the series MPU-6050. This accelerometer should be connected to a device which should make the connection between the glove and the robot. It would be best if that device is a microcontroller with a wireless module in order to not use a second Arduino board for powering the accelerometer and the device for communication.

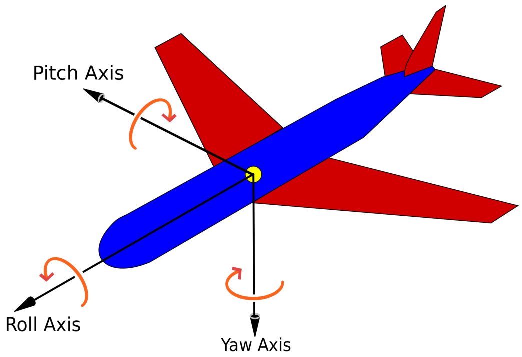

Figure 2: Yaw, Pitch and Roll

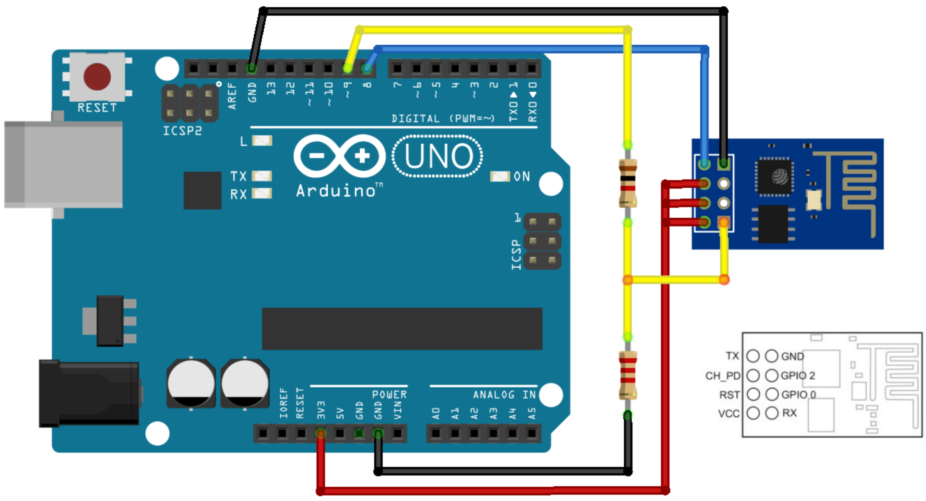

Figure 3: The wireless module ESP8266 connected to a microcontroller Arduino UNO

For our project we would use a microcontroller Wemos D1 Mini based on the ESP8266 processor which has its own Wi-Fi module. The technical characteristics of this device are better than the ones of Arduino. ESP8266 has small small dimensions which means that it can easily be fit on our robot. In addition, ESP8266 has its own GPIO pins which makes it very handy for the wireless communication between the glove and the robot, see Figure 3. GPIO or General-purpose input/output is called a pin which can be used either as an input or as an output. The microcontroller Arduino has GPIO pins, too. In the case with Arduino, these pins divide in analog and digital, but for them will be talked in a later moment of the research. The Arduino UNO, which commands the sumo robot, has no wireless module, so another device with such module should be added to the sumo robot in order it to communicate with the glove. We will use another Wemos D1 Mini with processor ESP8266. It will receive the packets from the glove and transmit them to the sumo robot. Because of its small work, it will also host a Wi-Fi network with name "SumoRobot" secured by WPA2 with password "ZumoShield." With this wireless network, other devices such as an Android phone, or the glove can connect to the sumo robot. The password is used as security in order only these people who should control the robot to be able to control it. The wireless module gives dynamic IP addresses using DHCP and the module itself has its own static IP address, which the connected to it devices know and thus communicate with it.

The most important part of the communication is based on the protocol of communication. The realization shows that this determines the whole work of the robot. Initially the synchronous protocol TCP was used. It is commonly used while serving web pages. or checking our email. It is characterized with the fact that after each sent byte it waits for a response from the receiver that everything arrived. This guarantees the sender that all packets arrived in the proper order and that each of them arrived successfully. However, on the other side, this waiting for an answer slows the communication a little bit. That can be neglected in devices with a big computing power such as laptops and desktop computers. However, with the ESP8266 TCP slows down the whole connection with around 5-6 seconds which is bad. The reason why it is bad is because when the robot accepts the gesture and starts doing it, amount of time would have passed and this gesture may become helpless and even can cause the robot's defeat. This means that we should use another protocol. The protocol we use is UDP. It is very similar to TCP, but it is asynchronous and does not wait for a response that everything has arrived. This protocol is commonly used while watching movies and listening to music from the Internet because our eyes and ears are not sensitive enough to detect a missed packet. The lack of confirmation makes UDP very fast and ideal for our project. The fact that some packets may be lost or mixed places is not a problem because many commands are sent from the glove in order the glove to detect every small movement of the player.

3 Other ways for hand gesture recognition

Another device which captures hand gestures is Leap Motion, Figure 4. This is a device which connects to the computer via USB cable and presents a real picture of the hands of the person. The principle in which it works are three infrared lights situated at the both ends and at the middle. Leap Motion works with precision around a millimeter and the computer program is easily accessible. This is a great advantage of Leap Motion over the presented glove because it gives a full picture of the person's two hands.

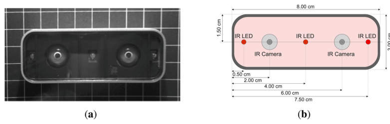

Figure 4: Principle how the Leap Motion device works

However, Leap Motion has its drawbacks. One drawback, is the fact that the device works in a very small area. This means that watching the sumo robot, the player may distract and move his/hers hands away from the Leap Motion's perimeter. Thus the use of Leap Motion is inconvenient because the robot is constantly moving and the player moves his/her hands as a result. Another drawback is that Leap Motion uses a much more electricity than the suggested accelerometer. Thus we encounter in a much bigger phase the problem with the batteries described above.

4 Applications

The presented way for hand gesture recognition has a wide application because it offers a wireless connection as a control for a robot. This type of control can be used in the factories where instead of a human to work with plain hands, this human can wirelessly control a robot to do that. This way the chances the worker to be harmed are very low. This way the hand gestures recognition appears to be useful not only when using a computer, but also in the production of goods. Examples where the current research may be useful: processing dangerous waste, radioactive products, and etc.

The Android application also has big applications because the Android system becomes more popular and is available to almost everyone, even to children, and the easy use of the application makes everyone able to use the wireless gesture control.

5 Conclusion

In the current research a way for hand gestures recognition was presented. The demonstration of the research is a sumo robot which is helped by hand gestures from the player. The device for the gesture control is presented in a low-budget glove with a price around 20 BGN. This not only makes the sumo fights more interesting, but presents the sumo robot as a multi-functional robot. The Android application also shows that the research is multifunctional, and the algorithm is not applied only on ESP8266 and on a sumo robot.

5.1 Ideas for future development

In the current research, the hand gestures recognition is presented by a sumo robot and the gestures were limited to a particular ones.

Here is how some elements of this project may become better and more interesting

- development of an IOS application: I find it useful in order to compare how the virtual machines on Android would compare with the IOS software built only for Apple devices
- implementing a secure communication using a lightweight cryptography between client and server in order this project to be more applicable in industrial places.
- Centering commands more on the sumo fights. This means that if the hand is tilted more, the robot will move with higher speed. And if tilted less, the robot will move with lower speed.

References

[1] *Kaghyan, Sahak,* and *Hakob Sarukhanyan.* "Activity recognition using K-nearest neighbor algorithm on smartphone with Tri-axial accelerometer." International Journal of Informatics Models and Analysis (IJIMA), ITHEA International Scientific Society, Bulgaria 1 (2012): 146-156.

[2] *Kela, Juha,* et al. "Accelerometer-based gesture control for a design environment." Personal and Ubiquitous Computing 10.5 (2006): 285-299.

[3] *Lam, Patrick Pak-kit,* and *Soung C. Liew.* "UDP-Liter: an improved UDP protocol for real-time multimedia applications over wireless links." Wireless Communication Systems, 2004, 1st International Symposium on. IEEE, 2004.

[4] *Liu, Jiming, Chow Kwong,* and *Hui Ka Keung.* "Learning coordinated maneuvers in complex environments: a sumo experiment." Evolutionary Computation, 1999. CEC 99. Proceedings of the 1999 Congress on. Vol. 1. IEEE, 1999.

[5] *Patel, Krupal Kachhia, Jignesh Patoliya,* and *Hitesh Patel.* "Low Cost Home Automation with ESP8266 and Lightweight protocol MQTT."

[6] *Prathyusha, M., K. S. Roy,* and *Mahaboob Ali Shaik.* "Voice and touch screen based direction and speed control of wheel chair for physically challenged using arduino." International Journal of Engineering Trends and Technology (IJETT) 4.4 (2013).

[7] *Seyssaud, Jeremy*, et al. "Robotic D&D: Smart Robots–15093."

[8] *Solanki, Utpal V.,* and *Nilesh H. Desai.* "Hand gesture based remote control for home appliances: Handmote." Information and Communication Technologies (WICT), 2011 World Congress on. IEEE, 2011.

[9] *Tirian, Gelu-Ovidiu, Anne-Marie Nitescu,* and *Cristian Chioncel.* "The design and construction of an autonomous mobile mini-sumo robot." ACTA TECHNICA CORVINIENSIS–Bulletin of Engineering 8 (2015).

[10] *Wachs, Juan Pablo,* et al. "Vision-based hand-gesture applications." Communications of the ACM 54.2 (2011): 60-71.

[11] *Weichert, Frank,* et al. "Analysis of the accuracy and robustness of the leap motion controller." Sensors 13.5 (2013): 6380-6393.