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BRAIN-WAVE CONTROLLED AUTOMATED WHEELCHAIR

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ABSTRACT

This project attempts to implement an Arduino robot tosimulateabrainwave-controlled wheelchair for paralyzed patients with animproved controlling method. The robot should be able to move freely in anywhere under the control of the user and it is notrequired to predefine any map or path. An accurate and natural controlling method is provided, and the user can stop the robot anytime immediately to avoid risks or danger. This project is using a low-cost brainwave-reading headset, which has only a singlelead electrode (Neurosky mind wave headset) to collect the EEG signal. BCI will be developed by sending the EEG signal to theArduino Mega and control the movement of the robot. This project used the eye blinking as the robot controlling method as theeye blinking will cause a significant pulse in the EEG signal. By using the neural network to classify the blinking signal and thenoise, the user can send the command to control the robot by blinking twice in a short period of time. The robot will be evaluated by driving in different places to test whether it can follow the expected path, avoid the obstacles, and stop on a specific position.

***Keywords*-Braincomputerinterface, Electroencephalogram, Neural network, Neurosky sensor, Wheelchair.**

I. INTRODUCTION

Paralyzed patients face many difficulties in their daily life.It is hard for them to make use of motor neurons to controlmuscle. People suffer from motor disabilities may sometimesbe very stiff and even cannot speak as they want. Theyneed the help from others to perform daily activities. Forexample, fully paralyzed patients may need someone’s helpto control the wheelchair. In the past, many technologieshave grown and become mature for disabled people to interactwith physical devices, such as the electromyogram(EMG) arm, finger gesture recognitionapplication and voicecontrolledwheelchair.[1] However, most of them are relyingon muscles, body movements or speech commands. Obviously,they are not convenient for paralyzed people performthese actions.

Advances in the neural networkand human computer interactiontechnologies have caused concern to brain computerinterface (BCI).[2] By employing BCI technology, humancan use brain wave to interact with physical devices easily.

II. LITERATURE SURVEY

In terms of mobility, this project provided a method thatno any map or path need to be predefined. Although someother systems provided a simple controlling method, the usageof the wheelchair is limited to a specific environmentbecause the system require the predefined paths.[6] If theenvironment changed, a new map is required to load into thesystem. In this project, the robot can move anywhere like areal wheelchair. The user can blink three times or more tostop or start the robot. And blink twice to start turning orstop turning. This is a simple controlling method that allowsrobots to move in any direction and not to rely on any predefinedpath. However, it is important to ensure the Bluetoothconnection between different devices must be establishedand the strength should be stable.In terms of accuracy, this project provided a robot controllingmethod with around 85% accuracy on average, which isan acceptable performance. During the test, we found thatthe accuracy is relatively high in level 1 and level 2. Theaccuracy can reach 100%. However, start from level 4, theaccuracy becomes lower. One possible reason behind is thatwe need to find a good path to hit the obstacle sothat wecan test the obstacle avoidance function. This abnormal motionmay cause some confusion to the robot controller. Andthis situation may not happen in the real life as we will notwant to hit the obstacle by using the wheelchair. Althoughthe accuracy is getting lower from level 4, this method stillprovided 85% accuracy on average.In terms of safety, this project provided an immediate commandto stop the robot to avoid the risk. Also, obstacleavoidance and autonomous terrain detection are included toenhance the safety. Some other similar systems require usersto select a command to stop while the command selectiontime may take up to 7 second. Therefore, compare to othersimilar system, this project has a better performance in termsof safety as it provided an immediate command to stop therobot.[9, 17, 18]

In terms of cost-effective, all the controlling command ofthe robot are in real time. The user does not need to wait be-fore sending any command. Also, all the commands are justsimple blinking which can be sent by the user immediately.

III. IMPLEMENTATION

Thesystem is formed by a Neurosky headset (EEG reader), acomputer included MATLAB, and an Arduino robot car. TheEEG reader contains a TGAM1 chip that can capture thehuman brain signal. TGAM1 also provided the signal filterand signal amplification. After that, the EEG signal willbe digitized and sent to the Bluetooth transmission module(HC-06). Finally, the EEG signal will be transmitted to thecomputer for further analysis.

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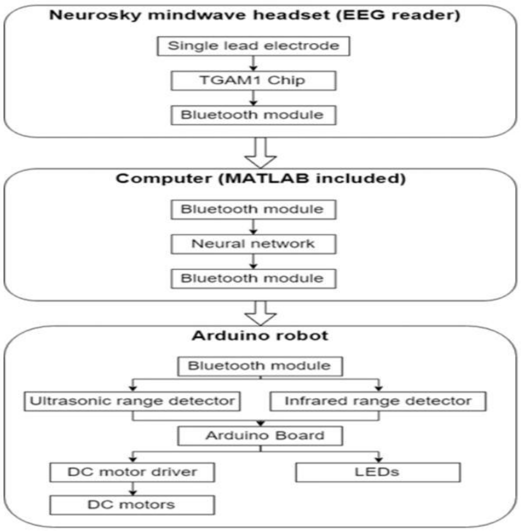

Figure 1. System architecture

MATAB in the computer will be used for noise filtering. Itwill check whether the user is sending a robot controllingcommand, or the blinking are just natural blinking of human.If the blinking is belonging to a robot controlling command,MATLAB will also determine which command does theblinking representing.The Arduino robot car is consisting of 7 components.Theyare Arduino Mega, one Bluetooth HC-05 module, two DCmotors, one L298N DC motor driver,five ultrasonic rangedetectors (SR-04), three infrared range sensors, and oneLEDs board. When the Bluetooth HC-05 module receivedthe controlling command from the computer, the Arduinoboard will consider the data received from the ultrasonicsensor and infrared sensor to make the final decision of thecar movement. The ultrasonic sensors will detect the obstaclesand avoid it automatically. The infrared sensors willdetect the distance between the robot body and the groundto prevent falling from the stair. If the command from eyeblinking is received, the robot will follow this command.Otherwise, maintain the motion in the last time step and runobstacle avoidance. And the LEDs will display the status ofthe controlling command .

Below is the flow chart showing how the system works..

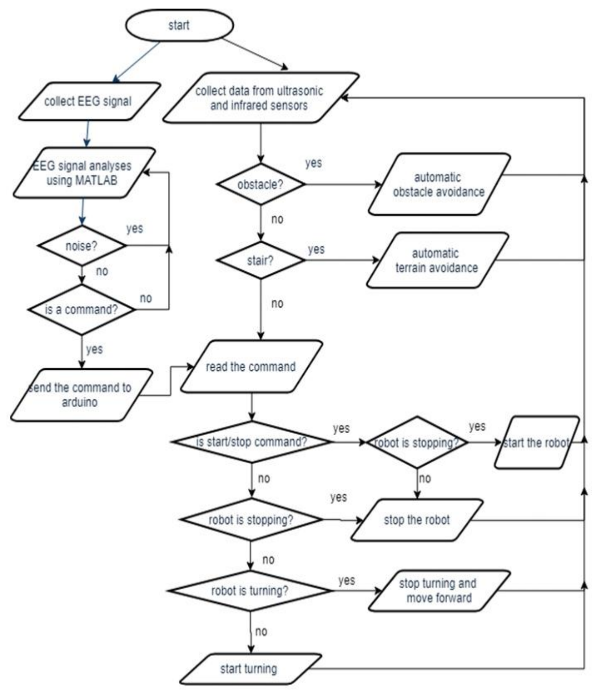

Figure 2. A descriptive flowchart

IV. EXPERIMENTAL RESULTS

Because of the safety issue, 5 ultrasonic sensors and 3 infraredsensors are added in the robot. The ultrasonic sensorsin the front part of the robot will

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detect the obstacles. Eachsensor will echo an ultrasonic wave with a time delay toavoid the wave-conflict problem. The infrared sensors areinstalled at the bottom part of the robot, they are used todetect the distance between the robot body and the ground toprevent falling from the stair (see Figure 3).By including autonomous obstacle avoidance, the motion canbe modified and require less controlling command even theroad has lots of obstacles. If the command from eye blinkingis received, the robot will follow this command. Otherwise,maintain the motion in the last time step and run obstacleavoidance. In terms of performance, the car will becomesmoother in motion.

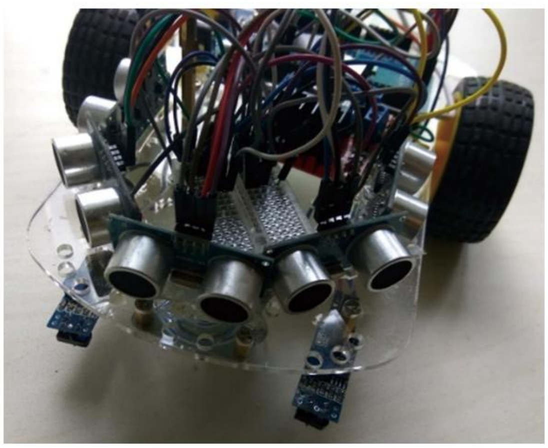

Figure 3. Ultrasonic sensors and infrared sensors

However, there are some limitations when adopting thismethod. First, it is impossible when user wants to get closerto the obstacle. Second, the robot will be totally out ofcontrol if one or more sensor has some unpredictable errors.Therefore, this method has been modified to enhance the performance.If the robot is moving forward, it will include theautonomous obstacle avoidance as mentioned before. However,when the robot is turning left or right, the autonomousobstacle avoidance function will not be used.By adopting the modified method, users are able to get closerto the obstacle as they may want. And users can control therobot by changing the direction even one or more sensorshave an unexpected error. Therefore, both limitations aresolved.

By including autonomous terrain detection, the motion canbe modified and prevent the robot falling from the stair. Ifthe command from eye blinking is received, the robot willfollow this command. Otherwise, maintain the motion in thelast time step and run terrain detection.

The same method will be used as mentioned above. Byadopting the modified method, users are able to get closer tothe stair as they may want. And users can control the robotby changing the direction even one or more sensors have anunexpected error.

Accuracy and safety are the most important part of thisproject. In order to test the accuracy of the robot the followingmethods are used, and each method will be tested forthree rounds.During the test, the number of correct command means themotion of the robot match the command sent by the user; thenumber of the wrong command means either: 1) The motiondoes not match the command. 2) The command is seen asnoise. 3) Noise is seen as a command.The first test is focused on the autonomous terrain detection(see Figure 4).

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During the testing, the robot should detectthe terrain and avoid falling from the stair. The testing criteriaare to count the times of falling from the stair. In this test,a higher-level ground will be used to simulate the stair.

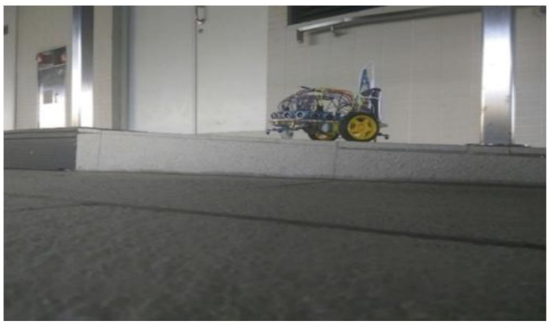

Figure 4. Autonomous terrain detection

The testing results are listed in Table 1.

Round	Number of times trying to fall from the high-level ground	Results	Accuracy
1	2	Both avoided	100%
2	2	Both avoided	100%
3	2	Both avoided	100%

Table 1. Testing results

During the test, the robot can avoid falling from stair successfully.When the sensors detected the distance betweenthe robot body and the ground is too large, it will go backand turn to avoid falling from stairs.The next test is based on a simple rectangular map (see Figure4). During the testing, the robot should follow the rectangledrawn on the floor. The testing criteria are to count the timesof incorrect command received. In this test, 5 checkpointsare labeled on the ground. The robot should reach eachcheckpoint in the order of: red, orange, yellow, green, andfinally stop at blue.

Figure 5. Test on a simple map

V. CONCLUSION

The analysis and development of brain-controlled mobile robots have received an excellent deal of attention as a result of they'll facilitate bring quality back to folks with devastating contractile organ disorders and therefore improve their quality of life. During this paper, they tend to confer a comprehensive up-to-date review of the whole systems, key techniques, and analysis problems with brain-controlled mobile robots.

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