Wheeled Robot Design with Brain Wave Headset Control System

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***Abstract*—The development of the world of robotics is inevitable with the rapid development of supporting science and technology. There are various types and classifications of robots, although the basic development is not much different. One type of robot that is in demand and the most widely developed is the wheeled robot. The robot component itself is generally divided into 3 parts, the first sensor, the second processor or component processor and actuator, in this study which behaves as an actuator is a wheel, while that behaves as a sensor, researchers utilize brainwave reader headsets from neurosky, and those that served as a processor component or processor using Arduino Uno R3. The neurosky headset works wirelessly using a Bluetooth connection, and the data sent is in the form of a brain wave power level (blink streght level). Before it can be translated into a telepathic brain command, this signal is first captured and processed using an android handset using an application that is built based on blynk IoT, then after that the command is sent to Arduino as a robot processing component that has previously been fitted with HC-06 bluetooth module hardware. to capture wireless broadcasts from an android device, only after that the signal is processed by Arduino becomes a command to move forward, backward, left, right wheeled robot by the L298N motor driver. The test results in an ideal environment showed an average system success of 85%, while testing in a non-ideal environment (with obstacles of space and distance) showed an average system success of 40% with each test carried out 10 times.**

Keywords*—*Wheeled Robot, Control System, Brain Wave Headset.

I. Introduction

At the beginning of the creation of robots, had the initial purpose to help even replace human tasks, for something that is repetitive or routine, requires high accuracy and can also replace the role of humans when having to deal with dangerous areas, such as its use in the case of Japanese Fukushima, where robot roles are needed to help evacuate and evaluate nuclear reactors that have leaked due to natural disasters. Meanwhile in the world of education, robotics technology is introduced as one of the leading courses, as well as research by lecturers and students to spur its development. In the future, it does not rule out the possibility that robot technology will further develop so that it can move and think like humans based on the programming logic that is entered into it.

In this study, researchers used a neurosky brainwave headset, which was used to represent brainwave measurements into digital signals which were then received by the mindwave mobile application using additional Android smartphone devices. Brainwave headset sensor reading extracts 12 bits of data and translates them into frequency readings in units of Hz, this headset groups them into 7 types of frequencies; including delta, theta, alpha, low beta, midrange beta, high beta and gamma.

Android applications specifically created by neorosky vendors simplify the process of reading these waves, from this can be known perimeter which can be used further for programming and can be converted into a command for robotic motion systems in the form of motion (forward, backward, left and right).

In specific hardware design, it takes at least 5 main devices that work in series, the first (1) brainwave headset, the results of the headset reading are forwarded to (2) android smartphone devices that have been embedded with neurosky mobile software, from here on, using Bluetooth wireless communication, will be received by (3) HC-06 Bluetooth module, from this module the signal is already in digital form and forwarded to the processing device (4) Arduino UNO R3, because it is a processor, this device requires an instruction or command that is typed using Arduino IDE, here also the EEG reading results are processed into a perimeter which will be used as a command or instruction, to govern the actuator device in the form of (5) DC motor driver L298N into a motor movement (CW) or clockwise or (CCW) counterclockwise turn clockwise, or one motor moves and two motors move at once.

This kind of research has also been carried out by Hiaishi [1], using the same equipment, namely the brain wave headset, but for the robotic system he uses a more practical system, namely the NXT mindstrom, the results of 150 experiments the result is 80% accuracy. The second study by Hadi [2] who tried to use a BCI headset (Brain Computer Interface) with the Mindflex connector used to the computer was then simulated using Matlab from 100 experiments with the accuracy of up to 62%. The second research was refined by Nakirekanti [3] who added muscle and brain components as a command stimulus, for visualization using the Matlab application. There are also those who use different basic headsets, especially the P300 ERP EPOC Emotiv, in a study by Nurseitov [4] because there are various types of brain wave headsets on the market, we just need to be observant about reading the available technical specifications, usually more complex, the more expensive the price. Apart from the type of communication based on WiFi (Wireless Fidelity), there is also BCI based on bluetooth [5]. Of course, brain wave reading technology can be developed in other fields [6], especially those that help mankind apart from robotics, such as controlling a wheelchair, helping people with disabilities in hospitals and outpatients, as dev and rahman did [7] . It was also carried out by Salunke [8] and Taksande [9] who focused on BCI research to help people with disabilities. All research shows the good performance of the BCI device, it only needs improvements to the sensitive sensor so that it can stop working 100%, that's what will be done in this research activity.

II. LITERATURE REVIEW

A. Wheeled Robot

Wheeled robots are a type of classification or grouping of robots based on the use of their actuators, many of these types of robots are found, because they are the easiest and most efficient to develop, moreover, their use does not require special specifications, for example, they are only used to cross a flat surface [10]. Today there are many types of wheel drive for robotics needs, such as AWR (Articulated Wheeled Robot), which has a free motion axis, its application depending on the needs or mission of the robot [11]. To be able to run stably, a robot can be designed not to have 4 wheels or more, it can only use 2 wheels, but with the addition of a balancing system like a gyroscope machine [12]. Of course, everything is adjusted to the terrain that will be traversed by the robot, the control system will also adjust it [13].

B. Control system

The essence of a robot is a control system, it can be said that it is a robot's nerves. The control system functions to control the movement and manipulator of the robot. One type of control system that is currently widely used in robotics is Arduino which is a platform consisting of hardware and software components, software is used to create and insert programs into Arduino hardware or hardware [14]. The definition of a robot control system is also explained by Unbehauen in his book [15] entitled "Control Systems, Robotics And Automation". In other reference sources it is also stated that the control system does not have to use an operator, it can also be made automatically or a sensor-based reaction action system [16]. Sensor-based control system is actually inspired by the neural network of living things in which the term sensor itself is an imitation of the five senses of living things [17].

C. Brain Wave Headset

The human brain consists of billions of interconnected neurons, the brain consistently emits neurons when thinking, hearing, walking and speaking. Any interaction between neurons will produce a very small electrical discharge, even though this small amount of electricity can be measured and can be categorized as a wave. This wave pattern is then marked and mapped based on the amplitude and frequency of each resulting condition, for example a wave between 12 and 30 hertz is a beta wave, this wave is generated when a person is concentrating. Then there are also alpha waves, namely waves between 8 and 12 hertz, alpha waves are associated with psychological states of relaxation or mental calm [18].

In practical terms, the brain wave headset will later be used to capture small electromagnetic waves generated by the brain and translate them into digital form. The small electromagnetic signal will be detected by the electrode sensor.

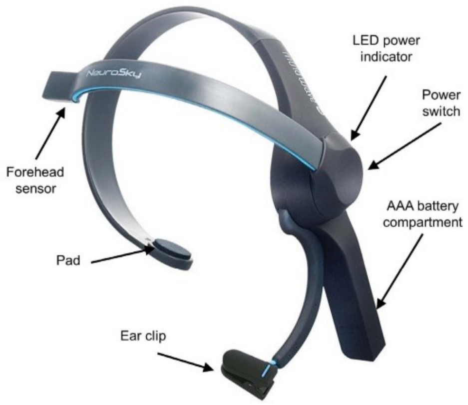
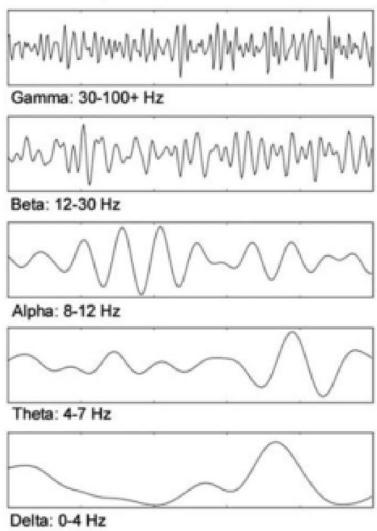


Fig. 1. Neurosky Product Brain Wave Headset (EEG-Headset)

In this brainwave headset, there is an N1 processor which functions to translate analog brainwave signals into digital signals. This processor is capable of reading 20,000 brain signals in 1 second; The following brain signals are captured by a brainwave headser device [19]. This is in line with what Park said in his book [20] entitled "Computer Science and its Applications: Ubiquitous Information Technologies", which is a collection of articles about the 6th seminary of the FTRA or the International Conference on Computer Science and its Application held in Guam, USA. Union. . Still with the same author [21] in his book entitled "Future Information Technology - II" BCI technology and its development, is predicted to become a commonly used technology in many ways. This statement certainly arouses research interest in the field of brain wave reading technology. In line with what Gallo said in his book [22] which predicts that telepathy will become commonplace in the future, of course what is meant by telepathy here is the brain waves themselves.



Fig/ 2. Brain wave frequency

TABLE I. TABLE OF BRAINWAVE FREQUENCIES AND READINGS OF PSYCHOLOGICAL CONDITIONS

Brain Wave Type	Frequency Range	Psychic and mental condition
Delta	0.1 Hz - 3 Hz	sleep well, without dreams, sleep without eye movements, unconscious
Theta	4 Hz - 7 Hz	intuitive, creative, remember, fantasy, imaginary, dream
Alpha	8 Hz - 12 Hz	relaxed, but not sleepy, calm, conscious
Low Beta	12 Hz - 15 Hz	relaxed yet focused, integrated
Midrange Beta	16 Hz - 20 Hz	think, be aware of yourself and the environment
High Beta	21 Hz - 30 Hz	alertness, agitation
Gamma	30 Hz - 100 Hz	cognition, information processing

D. Neurosky Headset EEG (Electroencephalography) Dataset

The neurosky headset product includes a wide range of datasets that developers or researchers can use in research related to the use of EEG reading [23]. Among them:

1) Attention is desired (Att) which is indicated by the output output of 0-100 / sec
2) Meditation abbreviated (Med) is indicated by the output output of 0-100 / sec
3) Abbreviated BandPower (BP) which shows the frequency of brain waves, shown in Hertz (Hz)
4) Eye Blink Detection abbreviated (Blink) which shows the blinking activity of the eye which affects the reading of brain waves, the reading is always below level 0 (always> 0).

The neurosky headset itself, was also introduced by Issa in his book [24], entitled "Smart Technology Applications in Business Environments" especially on page 52, which is also technically clear. In another reference [25] this technology is even predicted to be applied to the control system of unmanned aircraft or drones, which have been commonplace using remote control devices and control boards or control levers, later if this technology is used the control board and control levers are not will again be needed. Besides being able to be combined with the latest technological devices, brain wave headsets can also be combined with simple devices such as the Arduino on a research scale, as described in his book [26].

E. Relevant Previous Research Results

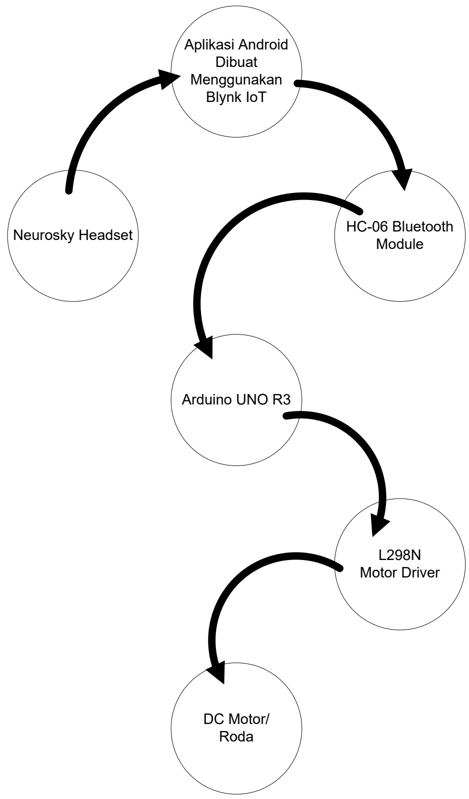
Relevant studies related to research that will be conducted by researchers are:

1) Research M. Nafea, A. Aisha, A.-K. Nurul Ashikin, and F. Harun, (2018). Which uses neurosky brain wave reader (EEG) technology to control home appliances, with a technical design the brain waves captured by the neurosky headset are transmitted wirelessly to an android device and then forwarded to a 0 and 1 signal or On / The off is caught by the arduino HC-05 module [27].
2) Research by S. M. Tiwari, N. Panwar, and S. Tripathi, (2018). Who did a similar research, namely making robots with a brain wave control system [28].
3) Research by F. T. Patiung, A. S. M. L. St, S. R. U. A. Sompie, B. A. S. St, and M. T. (2013). Those who carry out the design of a wheeled robot with voice control, use Arduino UNO as the control system and the easy voice recognition module as a voice recognition sensor that has previously been inputted as a database and the system only needs to match the sound level with the type of command [29].
4) Research X. Gao et al. (2014). The grouping of brain waves into several wave frequencies including delta band (1 Hz), thete band (5 Hz), alpha band (10 Hz) and beta band (20 Hz) each wave shows a variety of brain and nerve activity [30].

III. RESEACH METHODS

A. System Overview in General

Robot control system design using a brainwave headset that will be made is a stage that must be passed in order to get a clear picture of what needs to be prepared, including the preparation of hardware (hardware) and software (software), a general description of the system can be seen in the diagram flow below:



Fig/ 3. System design flow chart

Explanation of the flow chart above:

1) Neurosky EEG headset
It is a portable brainwave reader or EEG without sensor installation procedures inside the head, such as the initial method that still uses the method of implanting sensors in the brain (invasive BCI / brain computer interface).

2) IoT (Internet of Think) Application
Is a liaison software that mediates wireless communication (bluetooth) between the EEG headset device and the HC-06 bluetooth module, here also converted / converted to analog signals into digital signals, which can then be processed into command parameters in programming.

3) HC-06 Bluetooth module
An add-on so that Arduino devices can communicate with other devices wirelessly using a Bluetooth connection.

4) Arduino UNO R3
It is an ATMega328 based microcontroller board that has 14 digital pin I / O and 6 pin analog I / O. This board has a limited ROM storage component and can be programmed using a computer with a USB connection and an Arduino IDE intermediate software, so that it can execute commands according to the input program given.

5) L298N Motor Driver
Is a type of motor driver IC that can control the direction of rotation and speed of a DC motor or stepper motor. IC L298 consists of a transistor logic (TTL) with a NAND gate that makes it easy to determine the direction of rotation of an electric motor.

6) DC Motor / Wheel Actuator
DC comes from the word direct current or direct current, which as the name implies, this type of motor requires a DC data supply as a supply of voltage so that this electric motor can work.

B. Hardware Design

Hardware design here is intended to make it easier for researchers to prepare the needs of any device needed in this study, the following is presented in Figure 4.

C. Software Design

Software design here uses 3 main applications, the first (1) is a carrier application from the neurosky EEG headset device called mindwave mobile, the second (2) is an open source application blynk IoT that functions as an arduino control module, and why is it called IoT because the application This works requires an internet connection, the third (3) is the Arduino IDE application (Integrated Development Environment), which functions as an Arduino module development application, here we embed commands based on the EEG headset reading parameters that have been translated by the mindwave mobile application and blynk IoT.

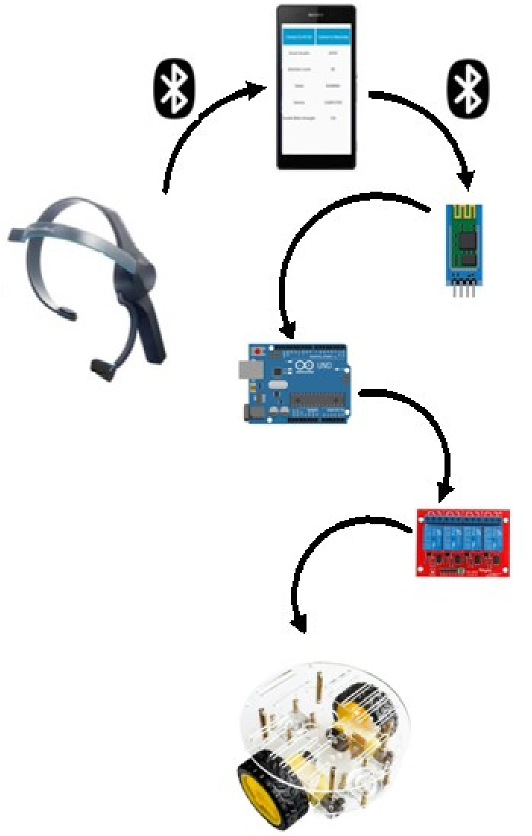


Fig. 4. Hardware Design

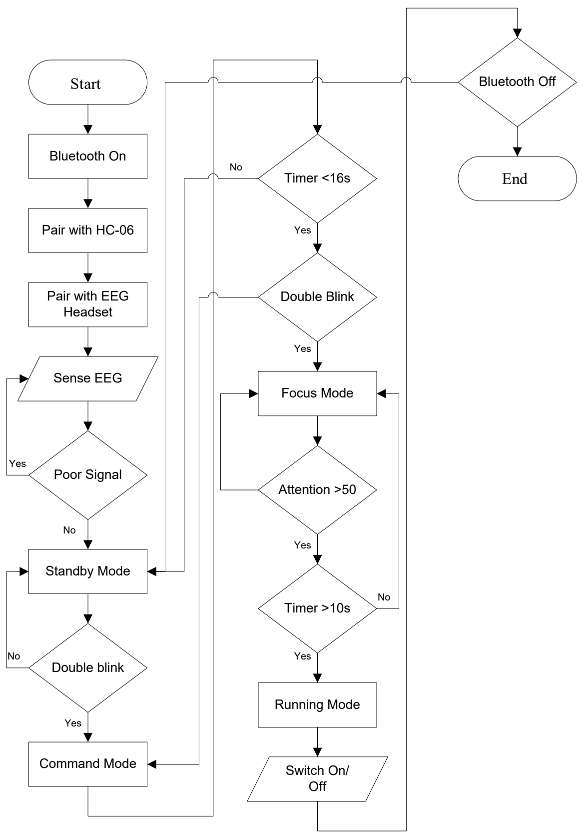


Fig. 5. Flow chart of brainwave headset control system for wheeled robots

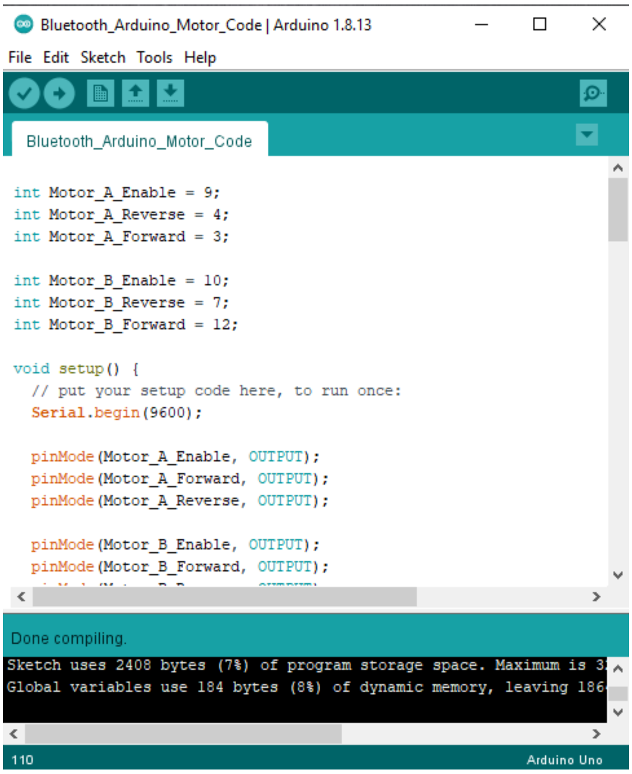


Fig. 6. Programming on the Arduino IDE application

IV. Result and Discussion

A. Testing Learning Loss & Learning Accuracy

Wheeled robot testing with a brainwave headset control system is carried out in ideal conditions without obstacles and non-ideal conditions with obstacles. Ideal conditions testing is carried out on a flat terrain with a maximum distance between the headset and robot devices a maximum of 10 meters without obstacles and testing on non-ideal conditions is done by providing a limit in the form (space and distance) between the robot and the control system. Database testing is done by thinking about the command "forward", "backward", "right", "left" by researchers with recording 10 times per command. To calculate the percentage of success the equation is used.

$$\%error = \frac{total\ number\ of\ commands\ recognized}{total\ number\ of\ orders} x\ 100\%$$

B. Test and Analysis Results

Based on the test results in table 2 and 3, the system solutions issued in environmental conditions are not ideal, in this condition it is positioned in an environment where there is distance and obstruction between the control system or the control of the robot being controlled, when the conditions are ideal or without the help of sufficient distance far and without obstacles the system can run well.

TABLE II. System Performance Test Results With Ideal Environmental Conditions

Command	Number of Tests	Success
Up	10	80%
Back Off	10	90%
Left	10	80%
Right	10	90%

TABLE III. Results of Testing System Performance with Non-Ideal Environmental Conditions

Command	Number of Tests	Success
Up	10	40%
Back Off	10	30%
Left	10	40%
Right	10	50%

V. Conclusion

From the results of the design and testing it can be concluded that the Arduino UNO R3 control system can be used as a processor in the EEG communication wave system to prepare wheeled robot motion. Successful testing of system performance under ideal and not ideal environmental conditions with the difference in successful presentation (success factor) shows that the system can work well, only instruments that increase distance and obstruction, change wireless communication connections using Bluetooth. Summary of test results in an ideal environment shows the average system achieved by 85%, while testing in a non-ideal environment (with space and distance barriers) shows an average system performance of 40% with each test carried out 10 times.

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