

Wheelchair and robotic arm controls using gyro sensor

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ABSTRACT

Someone who could only move his/her head and could not move his/her limbs needs a wheelchair and robotic arms which could be controlled by the head. Gyro sensor is a sensor that could be controlled according to the tilt in the x, y coordinates which then implemented to measure the tilt of the user's head. This paper would explain the head detector application to control wheelchairs and robotic arms. They could be controlled using Arduino microcontroller which uses C programming language. Gyro sensor that is put on the head could control wheelchair to move left, right, forward, and backward according to the tilt of the head. It is the same with controlling robotic arms. It could rotate left, right, and move up and down. The x and y coordinates are used to determine the tilt of the head for controlling the wheelchair as well as robotic arms' movements. It is discovered that wheelchairs and robotic arms could be controlled by the head by the use of gyro sensor.

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1. INTRODUCTION

Someone who has limitations in using his/her limbs so that it is only his/her head which still functioning urges him/her to do everything through head movements. A person who has disabilities but could still move his/her head then needs a device in a form of a wheelchair and robotic arms that could be controlled by the user's head. The control of robotic arms by the head using camera or Kinect has been implemented but it is not simple because eyes always look at a camera [1].

A wheelchair controller which uses brainwaves as an input has been developed by [2, 3]. However, this controller would not work smoothly because if the user is being unfocused [4-6], it would lead to erratic movements. The next development regarding the wheelchair and robotic arms controls would be based on the use of gyro sensor which detects the tilt of the head.

2. RESEARCH METHOD

This paper would explain the methods used in the creation of robotic arms application which uses head detection by gyro sensor.

2.1. Head detection

Gyroscope is a type of sensor which is used to determine the orientation of movement using rapid rotating wheels according to the axes [7]. Gyroscope is used to measure the angular velocity in the unit of deg/s

or rad/s. After the results of the gyroscope's angular velocity calculation are obtained, there are some steps that should be included in the microcontroller software.

example: $V_{cc} = 3.3 \text{ V}$, $n_{bits} = 10$, $V_{static} = 1.5 \text{ V}$

$$\frac{V_{cc}}{2^{n_{bits}}} = \frac{3.3 \text{ V}}{2^{10}} = 0.003223 \frac{\text{mV}}{\text{bit}} = \text{ADC}_{\text{resol}} \quad (1)$$

$$\frac{1g}{1000\text{mV}} = \text{ADC}_{\text{resol}} = 0.003223 \text{g/bit} = \text{Accelerometer}_{\text{resol}} \quad (2)$$

$$\frac{(V_{\text{offset}} * 2^{n_{bits}})}{V_{cc}} = \frac{(2.5 \text{ V} * 1024)}{3.3 \text{ V}} = 776 = \text{Zero}_{\text{offset}} \quad (3)$$

$$(\text{ADC}_{\text{result}} - \text{Zero}_{\text{offset}}) * (\text{Accelerometer}_{\text{resol}}) = A_x \quad (4)$$

$$\sin^{-1} \left(\frac{A_x}{A} \right) = \text{pitch}(\text{radians}) \quad (5)$$

According to Eliezer [7], the function of gyroscope is to measure or determine the orientation of an object relative to the conservation of angular momentum. According to another definition, its function is to determine movements relative to gravity. Gyroscope has a very important role in maintaining the balance of an object, for example in airplanes, which makes it possible to determine the tilt on x, y, and z axes.

2.2. Microcontroller

Microcontroller is a device which has a similar function to a computer, but it is smaller in size [8, 9]. In a microcontroller, there are memory and I/O tool in the chip, e.g., an Arduino microcontroller in Figure 1. Currently, there are many home appliances or office equipment using microcontroller, such as washing machine, microwave, handphone, PDA, home security system, etc.



Figure 1. An Arduino microcontroller

2.3. Wheelchairs and robotic arms application

When the wheelchair and robotic arms are turned on, gyro sensor, which is shaped so that it looks like a hat, is put on the head, and would detect the tilt of the user's head. After the tilt is detected, the information would be delivered to the wheelchair and robotic arms microcontroller through Wi-Fi signals. After the information is acquired, the wheelchair or the robotic arms would move according to the tilt. The flowchart in Figure 2 shows the process of the wheelchair and robotic arms movements, while the flowchart in Figure 3 shows the process of controller (hat).

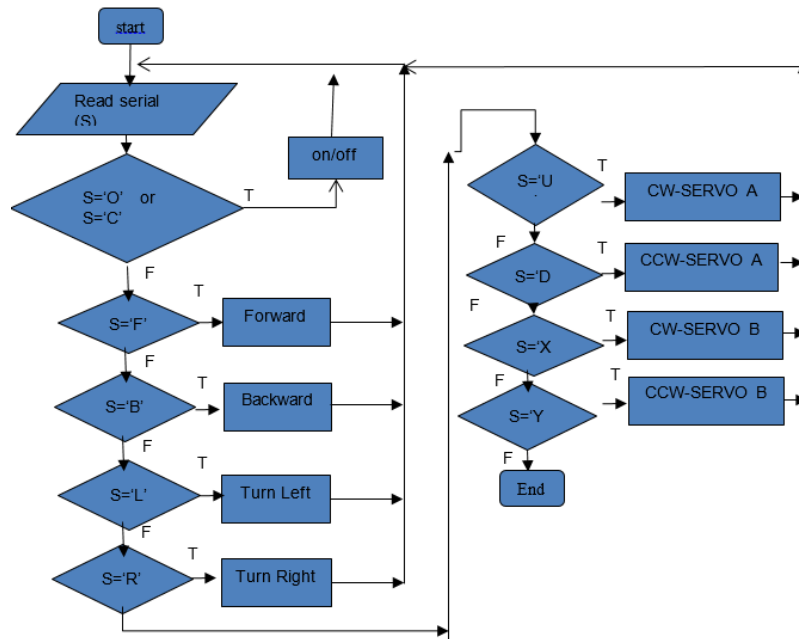


Figure 2. Flowchart command for wheelchair and robot arm

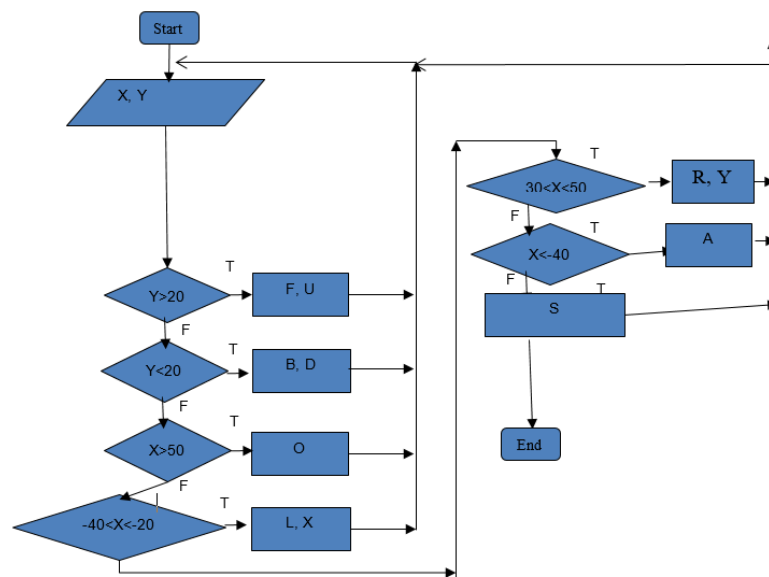


Figure 3. Flowchart of controller (hat)

3. RESULTS AND ANALYSIS

In this part, the results of gyro sensor implementation on wheelchairs and robotic arms would be discussed.

3.1. Wheelchair and robotic arms scheme

The wheelchair and robotic arms scheme have two parts. The first one is the controller that is put on the head and the second one is the wheelchair or robotic arms. In the controller part, there are gyro sensor, Arduino microcontroller and Wi-Fi transmitter. In the wheelchair and robotic arms part, it is equipped with Wi-Fi receiver which would be connected to Arduino microcontroller then wheelchair/robotic arms so that it would move according to the user's will. Figure 4 shows a detailed scheme on the controller and the wheelchair/robotic arms.

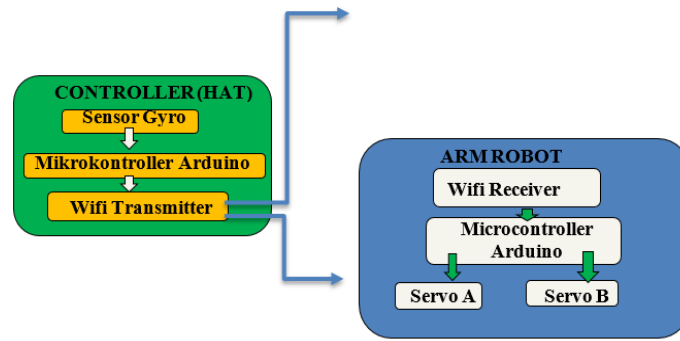


Figure 4. Robotic arms scheme

Robotic arms application is controlled by the user's head equipped with gyro sensor. The sensor detects the tilt of the user's head and send the positional value of aX , aY to the microcontroller attached in the wheelchair/robotic arms. Consequently, after the tilt is determined, the wheelchair/robotic arms would move according to the acquired information on the tilt. Arduino functions as a controller of wheelchair or servomotor (X) and (Y). Table 1 is the specification of the device and software used in the wheelchair/robotic arms application. The wheelchair uses a motor driver to move the motor controlled by Arduino microcontroller, while the robotic arms designed is using acrylic equipped with five servos but it used only two servos. Meanwhile, the list of wheelchair movements based on sent signals delivered through Wi-Fi could be found in Table 2.

Table 1. The specification of the device and software

No	Name of Device	Specification	Amount
1	Wheelchair	-Microcontroller Arduino Uno	1
		-Driver motor DC	2
		-Motor DC	2
		-Chair	1
		-Battery 12 V	1
		-Receiver Wi-Fi APC 220	1
1	Robot Arm	-Microcontroller Arduino Uno	1
		-Servo Motor	5
		-Arm of Acrylic	1
		-Battery 12 V	1
		-Receiver Wi-Fi APC 220	1
2	Controller (Hat)	-Wi-Fi Transceiver APC 220	1
		-Gyro sensor	1
		-Battery LIPO 12V	1
		-Microcontroller Arduino (micro type)	1

Table 2. Wheelchair and robotic arms movements

No	Input Serial	Activity of Wheelchair Robot		Activity of Arm Robot		Description	
		Left Motor	Right Motor	Servo A	Servo B		
1	F	CCW	CW	STOP	STOP	Forward	F,B,L,R for Wheelchair
	U	STOP	STOP	CW	STOP	Up	
2	B	CW	CCW	STOP	STOP	Backward	U,D, X,Y for Robot Arm
	D	STOP	STOP	CCW	STOP	Down	
3	L	CW	CW	STOP	STOP	Turn Left	
	X	STOP	STOP	STOP	CW	Left	
4	R	CCW	CCW	STOP	STOP	Turn Right	
	Y	STOP	STOP	STO	CCW	Right	

Note: CW (Clockwise), CCW (Counterclockwise)

Table 2 is a list of wheelchair and robotic arms movement commands. If the Wi-Fi receiver receives F, B, L, R signal, then the wheelchair would move. For example, if the letter "L" is received then the wheelchair would move to the left while letter "R" would make it move to the right. "F" signal makes it move forward and

“B” signal makes it move Backward. “X” signal would make the robotic arms move to the left while “Y” signal would make it move to the opposite direction. “U” signal would make the robotic arms move to the Up while “D” signal would make it move to the opposite direction. Whether to use the wheelchair or robotic arms depends on the time when the user is given a menu to choose between the two. Choosing “wheelchair” is done by a sharp tilt to the left while choosing “robotic arms” is to tilt to the opposite direction. Experiment results could be found in Table 3. Table 3 shows the result of the experiments and all of them have desirable results. Therefore, the success rate of this is 100%.

Table 3. Experiment results of wheelchair or robotic arms movements

No	Movement of Head	Number of testing	Movement of wheelchair or robot arm	Number of testing	Result (%)
1	Forward	5	Forward	5	100
2	Backward	5	Backward	5	100
3	Left	5	Left	5	100
4	Right	5	Right	5	100
5	Forward	5	Forward	5	100
6	Backward	5	Backward	5	100
7	Left	5	Left	5	100
8	Right	5	Right	5	100
9	Up	5	Up	5	100
10	Y	5	Y	5	100
11	X	5	X	5	100
12	Down	5	Down	5	100

4. CONCLUSION

The experiment results of wheelchair and robotic arms using head detection by gyro sensor is a success. Experiments of five movement's shows a desirable result of 100% success rate.

REFERENCES

- [1] A. Sholahuddin, H. Setiawan, M. Indra, Wheelchair using Kinect, UI-Unpad, 2015.
- [2] S. Hadi, A. Sholahuddin, and L. Rahmawati, “The design and preliminary implementation of low-cost brain-computer interface for enable moving of rolling robot,” in *2016 International Conference on Informatics and Computing (ICIC)*, Mataram, pp. 283-287, 2016.
- [3] Sholahuddin A. Setiawan H. Lany, “Application Brain wave for Wheel Robotic Movement Using Mindflex,” *International Conference IC-STAR*, Lampung, Indonesia, 2015.
- [4] K. Crowley, A. Sliney, I. Pitt, and D. Murphy, “Evaluating a Brain-Computer Interface to Categorise Human Emotional Response,” *2010 10th IEEE International Conference on Advanced Learning Technologies*, Sousse, pp. 276-278, 2010.
- [5] F. Bozkurt, H. Coşkun, and H. Aydoğan, “Effectiveness of Classroom Lighting Colors Toward Students Attention and Meditation Extracted from Brainwaves,” *Journal of Educational and Instructional Studies in the World*, vol. 4, no. 2, pp. 6-12, 2014.
- [6] N. Yildirim and A. Varol, “Developing Educational Game Software Which Measures Attention and Meditation with Brainwaves: Matching Mind Math,” *ICEE ICIT Conference*, pp. 325-332, 2013.
- [7] A. J. Casson, A. V. Galvez, and D. Jarchi, “Gyroscope vs. accelerometer measurements of motion from wrist PPG during physical exercise,” *ICT Express*, vol. 2, no. 4, pp. 175-179, 2016.
- [8] A. G. Smith, “Introduction to Arduino: A piece of Cake!,” 2011. [Online]. Available: <http://www.introtoarduino.com/downloads/IntroArduinoBook.pdf>
- [9] A. Blescia, IthinkUino Project, 2013. [Online]. Available: <https://www.codeproject.com/Articles/567963/ThinkUino-Project>