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Research paper

Gpad and Fuzzy Logic based Assistance System for Disabled People

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Abstract

This paper presents an assistance system for differentially abled people. It consists of Fuzzy logic control system and GpaD hand gesture technique to provide smooth and automatic control of the wheelchair in the presence of obstacles. The ultrasonic sensor is used for detecting obstacles. Actions in forward, reverse, right and left directions are taken care by GpaD which is based on IR sensor. Fuzzy logic controls the breaking power. The breaking power is based on the speed of the wheelchair and the distance between the wheelchair and an obstacle. The main purpose of this paper is to improve the safety of the differentially abled people and can be supervised from long distances without anybody's help.

Keywords: *Fuzzy logic controller, GpaD, differentially abled people*

1. Introduction

Wheelchair using different techniques like hand gesture[Chakraborty, T(2017), Megalingam, R. K(2016)], Eye detection[Al-Haddad .A(2012); Cecotti, H. (2016), Shih, C. H. (2014); Ubeda, A(2011)], Kinect sensor based (Sreejith, M 2015) etc., are helpful for many differentially abled people. The main disadvantage of those techniques are less accuracy and more costly. Doctors are not advising the motor injury people to use the wheelchair with joystick. The above problem is overcomed by hand gesture technique[5] which consists of an IR sensor based GpaD. By using this technique certain operation can be performed without motor action. The main aim is to automate the system.

Fuzzy logic is used to manage the speed of the wheelchair. Fuzzy logic finds its application in different fields like digital signal processing, VLSI design etc., The two inputs to the fuzzy logic are speed of wheelchair and the distance between the obstacle and wheelchair. Thus the breaking power given by the fuzzy logic is given to the motor driver of wheelchair system.

The raspberry pi 3 is used for implementing the system. Ultrasonic sensor is used to calculate the distance between the obstacle and the wheel chair and the optical coupling sensor is used for calculating the speed. The emergency key is provided with differentially abled people which sends the E-mail to care taker.

Different sections in the paper are organized as below. Section 2 contains literature survey. Section 3 gives the methodology of this system.

2. Literature Survey

Different techniques like Eye detection based, tongue detection based and hand gesture based etc., are implemented for different types of disabilities. The eye detection based technique[Al-Haddad .A(2012); Cecotti, H. (2016), Shih, C. H. (2014); Ubeda, A(2011)], is implemented by using IR sensor or camera sensor. The people who are not able to move their body part can use the above technique. But the main disadvantage of this technique is that, the person needs to concentrate more on the action or particular direction. For controlling various devices with the help of software, tongue based technique[Huo, X.(2013)] can be used. The man disadvantage of this technique is that a magnet has to be attached inside the tongue which requires small surgery.

Spinal cord injured people can use hand gesture techniques. Lot of techniques are based on the different types of sensor like IR sensor, Kinect sensor, accelerometer and camera sensor. These techniques are suitable for motor injury or spinal cord injury people by using different algorithm. Kinect sensor based[(Sreejith, M 2015)] and camera based technique detects the movement of the user and matches with stored pattern and gives output. Based on the hand movement accelerometer based technique detects the angular velocity and thus gives the output. IR sensor based technique is based on the light reflection which detects the movement of the user.

3. Implementation and Methodolagy

3.1 GpaD Sensor

Figure 1 shows the Left, right ,forward ,reverse and break control by the GpaD sensor. It consists of 4 IR sensors for 4 action and if there is no hand present on sensor then it actives break.[Megalingam, R. K(2015)].

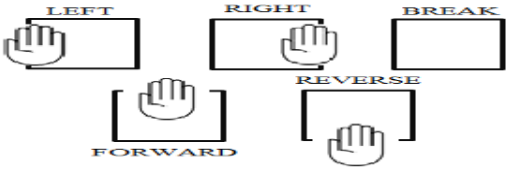

Figure 1: Operation Of GpaD

Raspberry pi directs the motor to move in the particular direction. As only 4 IR sensors are used, power consumption will be less.

3.2 Speed Sensor

It is based on the optical coupling principle. It consists of one light source and photo detector. When gear moves between these two , it produce the output pulse. As a result we can identify the speed of motor.

$$S=P*W \quad (1)$$

$$S(km/hr) = Pi*D(\text{in kilo meter}) * rpm * 60 \quad (2)$$

Where S=speed, P = perimeter of wheel ,D=diameter, W=speed of wheel

3.3 Ultrasonic Sensor

The ultrasonic sensor works on radar principle. When it is transmitting one from trigger pin at 10us,it transmits burst of 8 pulse at 40khz frequency. If any obstacle is present in its path, it reflects back those pulse and set the echo pin. So the distance between the obstacle and wheelchair depends on the time required to transmit and receive back the echo signal.

$$D= (T/2) * V. \quad (3)$$

Where D=Distance, T=travel Time, V=speed of sound

3.4 Fuzzy Inference System

The basic fuzzy inference system consists of fuzzification ,rules and defuzzification. In this system speed and distance are taken as input to the fuzzification and rule set is created based on these inputs[ML Sharma(2011) ;S.Uppalapati(2009)].

3.4.1 Fuzzification

The process of converting crisp input to fuzzy is called as fuzzification. The fuzzy variable also called as linguistic variable. Fuzzification requires membership function to represent the fuzziness.

3.4.2 Membership Function

The membership function is done by an trial and error, by considering the experience of the operator and engineering knowledge. When speed is 50km/hr the membership function is 1 and between the range 40-50 its varied from 0 to 1 based of the assumption. Figure 2 and Figure 3 shows the membership function of speed and distance.

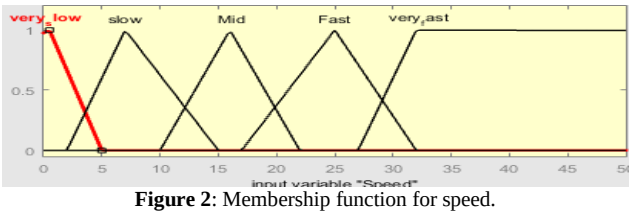

Figure 2: Membership function for speed.

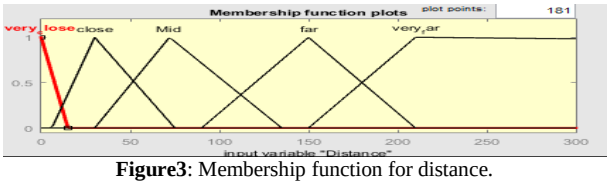

Figure3: Membership function for distance.

3.4.3Rules:

Based on the input i.e. speed and distance the decision is made as output the emergency state is also provided through fuzzy. If emergency key is pressed then its provides high breaking power. Total 30 rules are created for producing braking power. As shown in below table the rules set of system.

Table 1: Rule set

SPEED	DISTANCE	EMERGENCY	BREAKING POWER
Very Slow	Very Close	Low	Light
Slow	Very Close	Low	Heavy
Mid	Very Close	Low	Heavy
High	Very Close	Low	Very Heavy
Very High	Very Close	Low	Very Heavy
Very Slow	Close	Low	Light
Slow	Close	Low	Light
Mid	Close	Low	Heavy
High	Close	Low	Heavy
Very High	Close	Low	Very Heavy
Very Slow	Mid	Low	Very Light
Slow	Mid	Low	Very Light
Mid	Mid	Low	Light
High	Mid	Low	Heavy
Very High	Mid	Low	Heavy
Very Slow	Far	Low	Very Light
Slow	Far	Low	Very Light
Mid	Far	Low	Light
High	Far	Low	Light
Very High	Far	Low	Heavy
Very Slow	Very Far	Low	Very Light
Slow	Very Far	Low	Very Light
Mid	Very Far	Low	Light
High	Very Far	Low	Light
Very High	Very Far	Low	Heavy
Very Slow	none	High	Heavy
Slow	none	High	Heavy
Mid	none	High	Very Heavy
High	none	High	Very Heavy
Very High	none	High	Very Heavy

3.4.4 Defuzzification

It is process of converting fuzzy input into crisp output. The centroid method is used for defuzzification. It based on the average value of membership function.

$$COG = \frac{\int_a^b \mu_A(y)\, y\, dy}{\int_a^b \mu_A(y)\, dy}$$

3.4.5 Architecture & Design

GpaD sensor takes care of the Forward, Reverse, Left and Right actions. The GpaD consists of an array of IR sensor and the output of IR sensors connected to the Raspberry pi 3 to control the action. The speed sensor and distance sensor are also connect to Raspberry pi 3 which producse the braking power based on the fuzzy logic. In case of emergency the location will be shared to the care taker . Figure 4 gives the block diagram of this system.

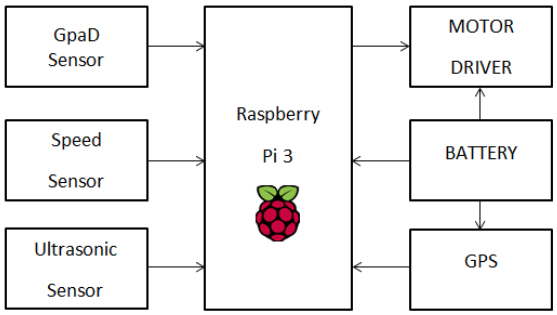

Figure4: Block diagram of the system.

According to the intensity of light, current changes in the IR sensor. The current is converted into voltage and is applied to the comparator(LM358). When the non- inverting voltage is greater than inverting voltage the output will be 1. Thus the reflection distance can be adjusted by applying threshold at inverting pin of comparator. The distance and speed are given to the fuzzy inference system. It will calculate accurate breaking power that is required for controlling wheelchair. The output from the fuzzy inference system is breaking power. The breaking power is applied to motor driver through the PWM to control the speed. The H-bridge motor driver is used for driving motor.

4. RESULT

Output of the hand gesture based GpaD technique is shown in Figure.5

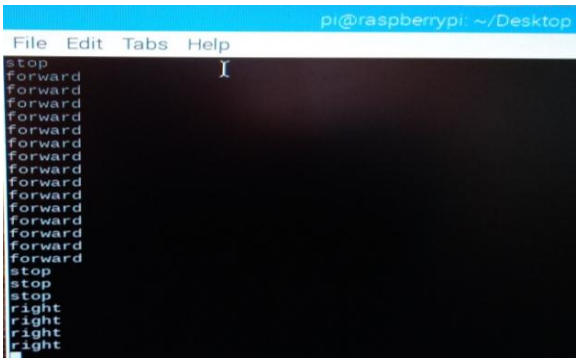

Figure 5: GpaD technique Output

Matlab surface of fuzzy system is shown in Figure.6,7 and 8

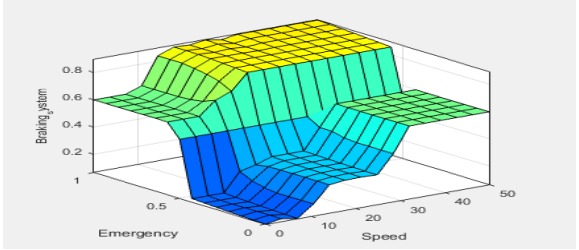

Figure 6: Emergency vs speed

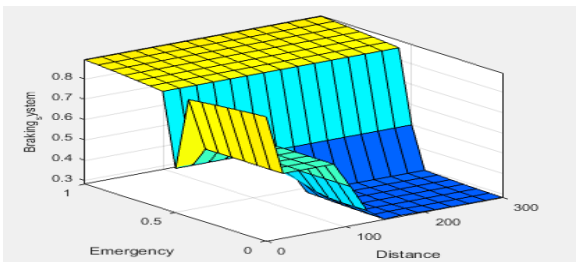

Figure 7: Emergency vs. Distance

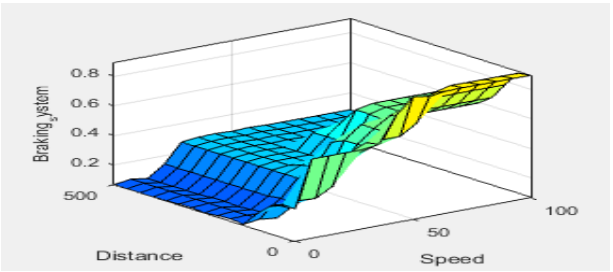

Figure 8: Speed vs. distance

5. Conclusion

This paper describes an automated wheelchair with Gpad and fuzzy logic inference system. The wheelchair provides Handges technique and automatic speed control system. Gpad is used for managing the direction and fuzzy logic is used for controlling breaking power. The fuzzy logic takes decision based on the rule set. Fuzzy system applies 30 rules for providing proper breaking power. The breaking power is based on speed, distance and emergency. The proposed system uses one obstacle sensor. The project can be extended by using 4 obstacle sensors to detect the obstacles present on all the four sides.

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