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Fuzzy Speed Control and Safety Interlocks in Brain Waves Controlled Wheelchair

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ABSTRACT: EEG signals which are low amplitude EMFs generated by the brain because of neuron firing, which can be captured by using electrodes placed on the specific points on the head. The use of processed brain waves signals captured by EEG probes for controlling or actuation is under research on a preliminary stage. This paper intends to give a possible solution for controlling the wheelchair in a better way and making the wheelchair safer for patients. First, the paper describes the signal processing, filtering, and computing method used in a brain-controlled wheelchair. This paper describes a scheme using 2 servo motors on wheels of the wheelchair. The proposed solution will provide a jerk-free speed control and speed retarding mechanism for prevention of over speeding in sloppy surfaces. It also includes a mechanism for the smooth stopping of the chair in case of signal failure or abnormal signal recognition by the controller.

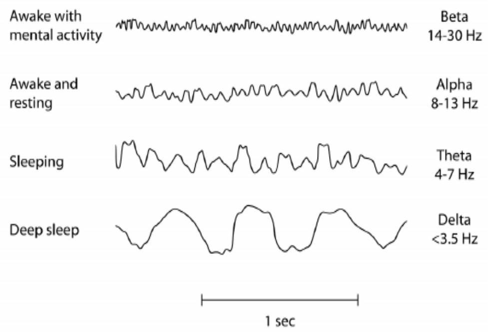
KEYWORDS: EEG, Wheelchair, Servomotors, FFT, Fuzzy logic

I. INTRODUCTION

EEG signals:

EEG signals are captured and processed to extract the information about the state of mind and brain functioning. The frequencies of EEG signals are classified in 5 bands as depicted in the following table:

Band	**Frequency**	**State of mind**
Gamma	>25	Perception involving two senses
Beta	14-30Hz	Active thinking, Focus, High Alert
Alpha	8-13 Hz	Relaxed or Closing the eyes
Theta	4-7 Hz	Drowsiness and idling
Delta	<3.5 Hz	Deep Sleep and inactivity of brain



As the brain waves are in the beta band when the brain is actively thinking and is in focus. Thus the beta band can be used for controlling the speed of the servo motors for locomotion in a wheelchair for a physically handicapped person.

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II. MINDWAVE NEUROSKY

MindwaveNeurosky is a device for sensing and acquiring EEG wave using single electrode. It will give its output to a computing device using wireless communication. The device transmits the information containing raw EEG signals which can be used to extract frequency of the EEG wave. The image of the device is shown here.

Wheelchair and Hardware arrangements

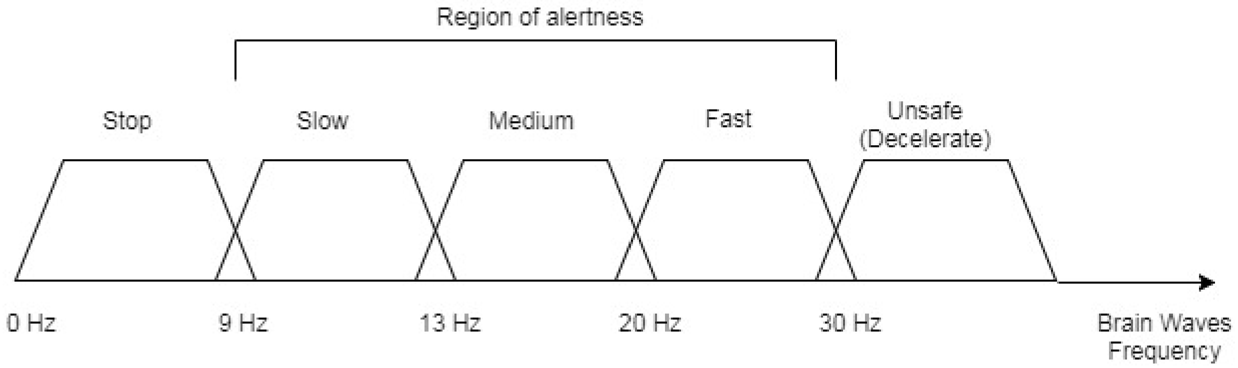
A wheelchair having two driving wheels and two freely rotating wheels need to be assumed for the implementation of the proposed solution. The driving wheels are attached with a drive mechanism which is driven by two DC servomotors. The change in direction of rotation of the servo motors will enable the wheelchair to turn left or right and move forward. The direction of rotation is selected by wired DC relays which are actuated by the computer/microcontroller. The servo motors are driven by a DC battery. The sizing and selection of the servo motors and battery are not included in this text.

III. PROPOSED METHOD

The method which is proposed starts by scanning the brain waves raw signal and extracting the frequency of the wave in 1-second frames by sampling the signal and applying Fast Fourier Transform to the raw signal. The frequency obtained is then passed through the smoothening filter and the resultant wave is subjected to scanning.

As the wheelchair has to be actuated only when the brain waves are such that the mind is in complete awareness and attention, the chair is brought to a halt when the brain waves are outside the working range with a smooth deceleration. The smooth deceleration is achieved by implementing a software deceleration rate limiter.

Frequency spectrum in the range 12 Hz to 35 Hz is then classified using fuzzy rules as shown below:



The fuzzified output of the brain frequency along with the fuzzified feedback of the chair's translational as well as angular velocity is passed through the fuzzy rules to generate a control output for the DC stepper motors. The output will change its state in steps. To prevent jerking of the wheelchair, acceleration rate limiters and motor speed limiters are implemented in logic. The rate limiters will convert the step output change to a ramp signal with the ramp rate tuned as per the acceleration requirement.

Protection:

The chairs rotational and translational motion is sensed and fed back for generating protection commands. Also, an ultrasonic proximity sensor is used for sensing obstacles in the vicinity of the chair. If the chair velocity is out of the range specified in the protection set-points, the deceleration command will get activated and the chair will come to a halt on the deceleration rate selected in the rate limiter.

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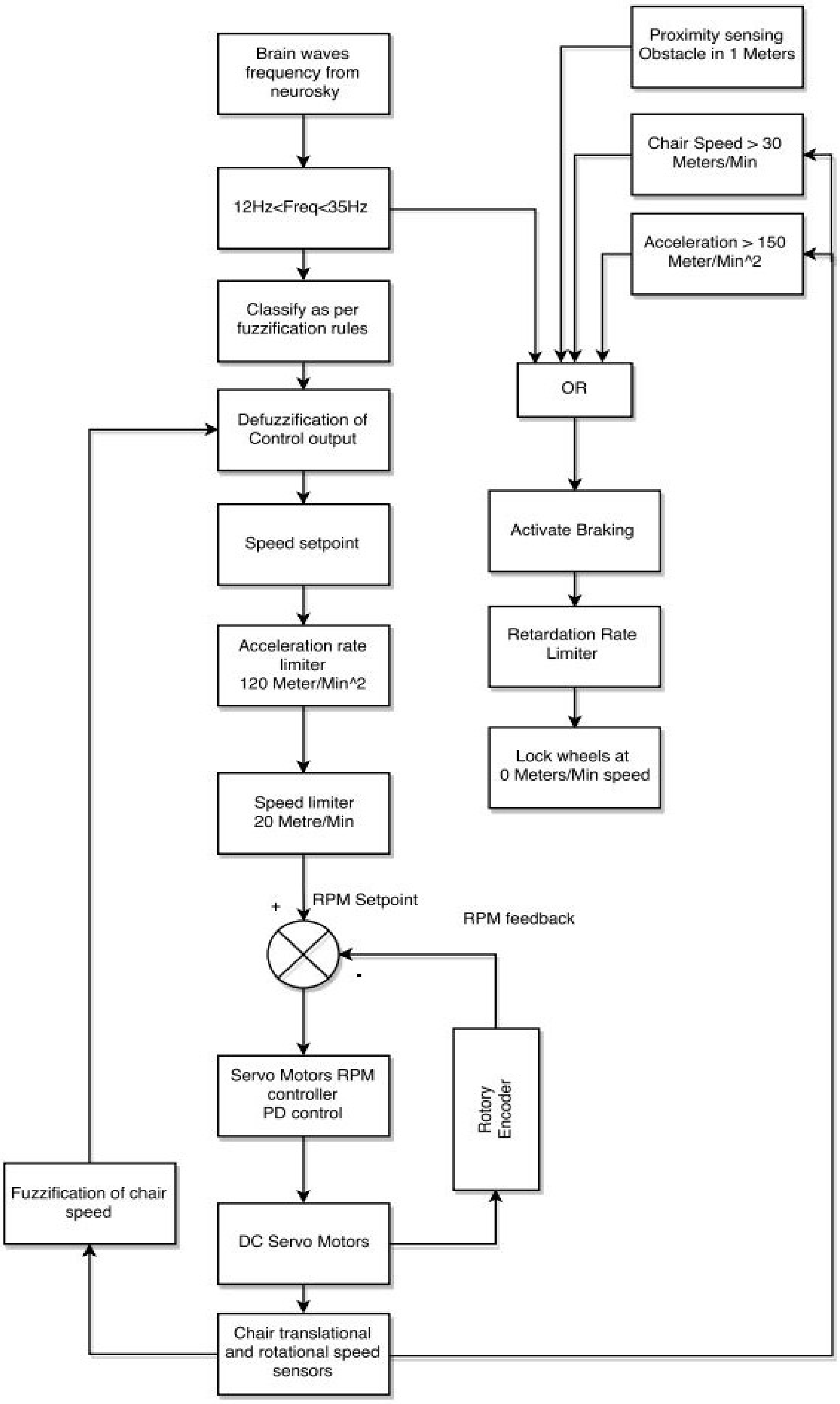
The block diagram for controlling the wheelchair is shown below:



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IV. CONCLUSION

The above proposed solution for controlling an EEG controlled wheelchair using ramp rate limiters and safety braking makes the wheelchair more stable and reliable to use. Also, the use of variable speed control using fuzzy logic gives a speed output based on the level of consciousness.

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