IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 11, Issue 3 Ver. I (May. – Jun. 2016), PP 19-26
www.iosrjournals.org

E-Sense Algorithm Based Wireless Wheelchair Control UsingBrain Waves

Geethu Suresh[1], S.Shanmugaraju[2]
[1] *(Department Of Electronics AndCommunication Engineering, Dr.N.G.P. Institute Of Technology/ Anna University, India)*
[2] *(Department Of Electronics AndCommunication Engineering, Dr.N.G.P. Institute Of Technology/ Anna University, India)*

Abstract*:A Brain Computer Interface (BCI) Is A New Technique Used To Communicate Between The Human Brain And A Digital Signal Processor. The Main Intention Of The Paper Is To Assist The Disabled And Paralyzed People To Move Them Voluntarily Without Any Human Assistance By A Brain Controlled Wireless Wheelchair. An Electroencephalogram(EEG) Based Brain Computer Interface Is Connected With A Virtual Reality System In Order To Control Movement And Direction Of Wheel Chair. It Offers An Excellent Alternative To Natural Communication And Control. Bcis Are Systems That Can Allow Efficient Communication And Control Between The Human Brain And External Devices Through Muscles And Thoughts By Converting Distinct Forms Of Activity Of Brain Into Signal Commands In Real Time. It Is Possible To Achieve Forward/Reverse Movement Of Wheelchair With Respect To The Blink Muscle Contraction And Even Clockwise Rotation By Human Thoughts, With This Proposed System. Hence, Disabled And Paralyzed Persons Can Able To Control The Wheelchair With The Help Of BCI Concept Implemented In The Proposed Wheelchair System.*
Keywords:*Brain Computer Interface (BCI), Brain Wave Sensor, Bluetooth, Electroencephalogram(EEG), Zigbee*

I. Introduction

Even With Fast Technological And Scientific Improvement In Devices For Physically Disabled And Challenged Persons, Only There Has Been Very Little Development In The Design Of Wheelchair Over The Last 200 Years. Many Electric Wheelchairs Having Computer Controlled Mechanism Introduced In The Recent Years Such As “WALKY”, “CALL Smart Chair” And “Tin Man”. There Are Many Distinct Controlling Methods Available Such As Voice [3], Eye Movement, Tongue Movement, Joystick, Hand-Gesture [8] Etc, Which Have Been Deployed For Interacting With A Computer Or Robot Or Wheelchair. The Most Preferred Method For Controlling Movement And Direction Of Wheel Chair Is BCI Technique, Due To It’s High Efficiency, Reliability And Response Time. According To The Placement Of Electrodes, There Are Different BCI Techniques Such As Invasive, Partially Invasive And Non-Invasive Techniques. In Invasive Technique, Electrode Placement Directly On The Brain By Neurosurgery. In Partially Invasive Technique, Electrode Placement On The Skull By Minor Surgery. On The Other Hand, In Non-Invasive Technique, Electrode Placement On The Scalp Without Any Surgery. Among These Techniques, Non-Invasive Is Most Commonly Used In Real Time Applications.

Interface Based Wheelchair Control Systems, Such As P300-Based BCI And Motor-Imagery BCI [5] Require The User’s Active Mental Command To Control Wheelchair. Therefore, The Goal Of This Paper Is To Propose A Cost Effective, Extendable And Easily Hand Able Brain Computer Interface Based Wireless Wheelchair Controlling System For The Handicapped And Paralyzed People To Control Their Wheelchair Themselves Without Any Human Assistance.

Brain Wave Signals Are Considered As Input And Hence They Are First Analyzed. Human Brain Involves Many Interconnected Neurons. The Interaction Patterns Between These Neurons Are Regarded As Thoughts And Emotional States And They Will Be Changing With Respect To Human Thoughts, Which Also Create Distinct Electrical Waves. Even A Muscle Contraction Produces Unique Electrical Wave Signal. Brain Wave Sensor Senses All These Electrical Wave Signals And It Translates Them Into Packets And Transmits Through Bluetooth. Data Processing Unit Receives The Input Brain Waves In The Form Of Packets And Then It Performs Signal Extraction And Processing Using MATLAB And After This, Control Commands Get Transmitted To The Wheelchair Module In The Form Of Interrupt Signals.

In This Paper, Mindwave Mobile Is Used To Capture The EEG Signal And It Contains 3 Main Parts, Which Are Dry Electrodes, Signal Conditioning Module And Inbuilt Radio Frequency Transmitter. Dry Electrodes Are Used To Sense And Collect The Brain Waves, Which Are Usually Analog In Nature. The Purpose Of Signal Conditioning Unit Is To Translate These Analog Signals Into Digital Form For Further Processing. The Inbuilt Radio Frequency Transmitter Translates This Digital Brain Wave Signal Into Data

Packet Which Is Transmitted Through Bluetooth. Then The Received Data Packets Are Extracted And Processed Using Matlab Tool. Thus The Mindwave Mobile Senses And Collects The Brain Signals And Then Sends Them To The MATLAB For Further Process And After Signal Extraction And Processing, Control Command Signals Get Transmitted To Wheelchair In Order To Control It's Movement And Direction.

The Paper Is Ordered As Follows. Section II, Details The Related Works. Section III, Explains Problem Identification. Section IV, Describes The Main Objective And Section V, Explain The Proposed Methodology, Algorithm And Modules. In Section VI, Details The Simulation Results. Finally, Section VII, Concludes The Paper.

II. Related Works

In Wheelchair Applications, There Are Many Different Controlling Methods Available Such As Voice, EOG, EMG, Joystick, Eye Tracking, Breath Etc, As Given In Fig.1, But These Methods Can Be Efficiently Used By Healthy People Only. However, These Methods Are Not Easy To Operate Because Of The Joystick Quick Turn May Lead To More Complexity To Control The Wheelchair For Elderly And Disabled People. In Order To Solve This Problem, BCI Method Has Been Developed. It Eliminates The Conventional Type Of Communication And Provides A Direct Connection Between Human Brain And External Device. The Distinguishing Features Of Brain Controlled Wheelchairs Are That They React To Commands Much Quicker And That Persons Who Are Unable To Speak May Use Them. There Are Many Distinct Ways Available For Make Functioning A Wheelchair For Example, Voice Controlled [3], Using Gestures [8], Using Eye Movement Or Using Joystick Etc, But They Cannot Be Used By Stroke Patients Or Paralyzed Patients.

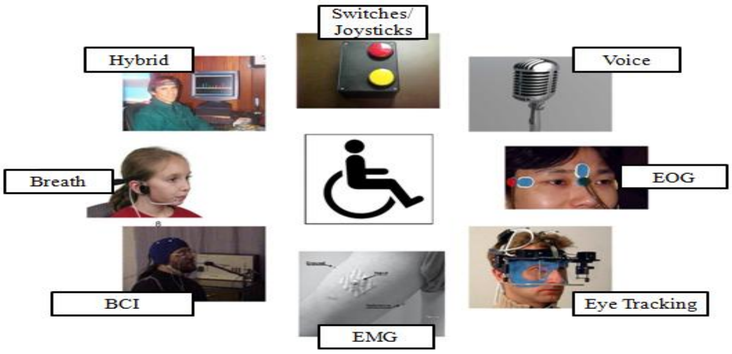

Fig.1 Different Wheelchair Controlling Methods

In The EEG-Based Mobile Robot Control ThroughAn Adaptive Brain–Robot Interface System [7], An Adaptive User-Centric Graphical User Interface Referred To As The Intelligent Adaptive User Interface (Iaui) Based On An Adaptive Shared Control Mechanism Is Used. The Iaui Offers Multiple Degrees-Of-Freedom Control Of A Robotic Device By Providing A Continuously Updated Prioritized List Of All The Options For Selection To The BCI User, Thereby Improving The Information Transfer Rate.

BCW Or Mobile Robot Interface Design Performance Is Often Analyzed In Terms Of Mission Time, Concentration Time, Nominal Time, And Total Cost For Task Completion. These Measures Can Be Made Independent Of The Signal Processing Issues In BCI And Can Quantify The Real Assistance That A User Gets By Way Of Interface Adaptation Approach. The Mission Time Is The Time To Select A Destination Or The Target On The User Interface Plus The Total Traveling Time Needed For Maneuvering The Mobile Robot To Reach The Target. The Concentration Time Is The Mission Time Minus The Relaxation Period, I.E., The Sum Of The Duration Of MI For All Trials. The Nominal Time Is The Minimal Time Required For The Robot To Reach The Destination.

III. Problem Identification

A Handicap Will Generally Depend On Others For The Needs Especially In Wheelchair Movement And Direction Controlling. These Findings Lead To The Activation Of The Smart Wheelchair Which Helps The Handicapped Persons At Least For Not Depending On Others For The Navigation Purpose. There Are Many Systems Used For The Wheelchair Controlling. Although These Systems Have The Advantages, There Are Some Disadvantages From The Sensitively Detecting Ability For The Changeable User Commands And The System Needed To Be Calibrated At The Beginning On Each Day.

Most Of Current BCI Based Wheelchair Controlling Systems Are Very Troublesome Because Bulky And Costly EEG Machines And Personal Computers Are Both Needed For Physiological Signal Acquisition

And Analysis, Which Will Reduce The Flexibility, Portability, And Practicability Of These Systems. However, Most Of The Existing Brain Computer Interface Based Wheelchair Controlling Systems, Such As P300 Based BCI And Motor Imagery Based BCI Requires The User's Active Mental Command To Control The Movement And Direction Of Wheelchair. The Two Main Problems Found In The Existing Systems Are The Following:

- Total Mission Time Is Around 441s.
- Computation Based On Previous Neural Signal Values, Thus Error Possibility Is About 35%.

The Above Mentioned Problems Are The Two Challenging Problems Associated With The Existing Systems. First Problem Related With The Mission Time Which Defines The Total Time Taken To Reach The Target Or Destination, Includes Signal Processing Time And Also The Time Taken For All Activities Of Wheel Chair Movement And Direction Controlling. In The Existing System, The Time Needed For Reaching The Destination ,That Is, The Mission Time Is Approximately 441 Seconds, Which Is High, Which Has To Be Reduced For The Efficient Wheel Chair Movement And Direction Controlling Systems. The Second Problem Related With The Error Possibility Chance Which Defines The Percentage Of Possibility Of Occurring Error, Includes All Types Of Errors Such As System Errors, Manual Errors, Instrument Errors, Environmental Errors Etc. If The Calculation Is Related With Past Brain Signal Values, Then There Is Chance Of Error Possibility, Which Can Be Usually Found In Many Real Time Controlling Systems.

In The Existing System, The Computation Is Based On Past Neural Signal Values, So Error Possibility Chance Is Around 35%, Which Is High And Has To Be Reduced For The Efficient Real Time Wheelchair Movement And Direction Controlling Systems With The Help Of Continuous Monitoring.

IV. Objective

The Objective Of This Paper Is To Develop A Wireless BCI Based Thought Controlled Wheel Chair System With The Following Features Using E-Sense Algorithm.

- Reduced Signal Processing Time.
- Minimal Error Possibility With Continuous Monitoring.

In This Paper, Esense Algorithm Proposed In Which Attention Level Is Used For Making Left/Right Movement And Eye Blink Strength Is Used For Controlling The Start/Stop And Forward/Reverse Operations. This Paper Is Mainly Focusing On The Signal Acquisition And E-Sense Value Computation Through Continuous Monitoring, Which Can Be Achieved By Placing The MindwaveMobile On The Head, Since It Is Fixing On The Area With Minimal Hair, So The Brain Wave Signals Such As Alpha And Beta Waves Associated With Attention And Blink Strength Respectively Can Be Captured More Accurately.

V. Proposed Wireless Wheelchair Controlling System

In The Wireless Wheelchair Controlling System, Wheelchair Is Designed And Controlled Through The Wireless Medium And It Is Accelerated Using The Power Supply Section. The Source For The Entire System Is From The Brain Wave Sensor That Is Used To Sense The Brain Signals. Fig.2 Shows The General Overview Of The Wireless Wheelchair Controlling System.

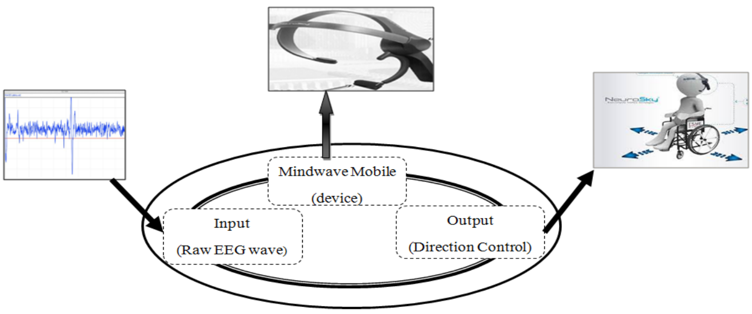

Fig.2 Overview OfWireless Wheelchair Control

In Addition To Brain Wave Sensor, Proposed System Involves Ultrasonic Sensor Which Is Used To Detect The Presence Of The Obstacles. The Wheelchair Functions Based On The Monitoring Section Commands And If It Detects The Presence Of The Obstacle, Then The Direction Of Wheelchair Changes Automatically. The Wireless Transmitter/Receiver Pairs Are Required For Data Communication Between Various Modules Of The Wireless Wheelchair Controlling System.

VI. Methodology

In Wireless Wheelchair Controlling System, A Wireless Physiological Signal Acquisition Module And An Embedded Signal Processing Module Are Also Introduced. Different From Other BCI Systems, Which Are

Usually Bulky And Have To Transmit An EEG Signal To Backend Personal Computer To Process The EEG Signal, Our Proposed Wireless Physiological Signal Acquisition Module And An Embedded Signal Processing Module Contain The Advantages Of Small Volume And Low Power Consumption And Are More Suitable For Practical Application.

Brain Sensor Sense The Brain Signal Of The User. The EEG Signal Of The Human Is The Input For The Sensor, It Is Given To The Bluetooth Transmitter From Which It Is Given To The Bluetooth Receiving Dongle Which Will Be Connected To The Signal Processing Module And Then To Microcontroller. The Overall Block Diagram Of The Proposed System Is Shown In Fig.3. The Wireless Wheelchair Controlling System Has Some Special Features As Given Below:

- Brain Wave Signal Analysis
- Direction Control Using Human Thoughts
- Self Controlled And Operating Facility
- Bluetooth Communication

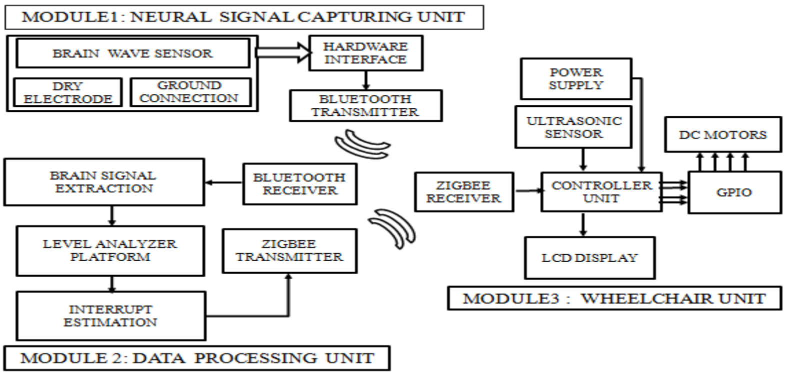

Fig.3 Block Diagram OfWireless Wheelchair Control

The Wireless Wheelchair Controlling System Differs From The Existing Systems By The Above Mentioned Features, Since The Existing Systems Do Not Have Those Features And The Proposed System Can Also Be Used In Other Areas Such As Automobile Application, Industrial Application, Home Applications, Monitoring Device Applications And Remote Control Applications.

5.2 Esense Algorithm

E-Sense Algorithms Provide The Foundation Of A Universe Of Applications That Can Be Built To Improve Brain Health, Education, Alertness And Overall Function. In The Proposed System, E-Sense Algorithm Plays An Important Role In EEG Signal Acquisition And Classification. For All The Available Different Types Of Esenses Such As Attention, Meditation, The Meter Value Is Described On AEsense Scale Of 1 To 100 Given Clearly In Table 1. On This Esense Scale, A Value Between 40 To 60 At Any Given Instant In Time Is Taken As "Neutral", And Is Similar In Concept To "Baselines" That Are Found In Conventional Brain Wave Measurement Techniques. A Value From 60 To 80 Is Taken As "Slightly Elevated", And May Be Explained As Levels Being Approximately Higher Than Normal, Since Levels Of Attention Or Meditation That Can Be Greater Than Normal For Any Individual. Values From 80 To 100 Are Taken To Be "Elevated", And May Be Interpreted As Heightened Levels Of That Esense.

In The Similar Way, On The Other End Of The Scale, A Value From 20 To 40 Is Considered To Be "Reduced" Levels Of The Esense, While A Value From 1 To 20 Is Taken As "Strongly Lowered" Levels Of The Esense, Which May Denote States Of Distraction, Agitation, Or Abnormality. An Esense Meter Value Of 0 Is Some Special Value Denoting The Think Gear Has Some Difficulty To Compute An Esense Level With A Justifiable Amount Of Reliability, Which May Be Due To Excessive Noise.

TABLE I E-SENSE VALUE SPECIFICATION

ESENSE VALUE	STATUS DESCRIPTION
1-20	Indicates "Reduced" Levels Of The Esense.
20-40	Indicates "Strongly Lowered" Levels Of The Esense.
40-60	Considered "Neutral".
60-80	Considered "Slightly Elevated", And May Be Interpreted As Levels Tending To Be Higher Than Normal.

80-100	Considered “Elevated”, Meaning They Are Strongly Indicative Of Heightened Levels Of That Esense.

5.2.1 Attention Metric Method

The Attention Meter Algorithm Denotes The Level Of Mental “Focus” Or “Attention.” The Value Ranges From 0 To 100. The Focus Level Increases Whenever A Person Pays Attention On A Single Thought Or An External Substance, And Decreases Whenever Get Distracted. Users Can Be Able To Identify Their Ability To Concentrate With The Help Of This Algorithm. In Education, Attention To Lesson Plans Can Be Traced Out To Estimate Their Capability In Participating Students. In Gaming, Attention Has Been Used To Make “Push” Control On Virtual Objects Such As Joysticks. In This Paper, Attention Metric Method Is Used For Making Left/Right Movement Of Wheelchair For The Attention Value Greater Than Some Threshold Value.

5.2.3 Blink Detection Method

The Blink Detection Algorithm Indicates User’s Blinks.A Greater Number Means A “Stronger” Blink, While A Lower Number Means A “Weaker” Blink. The Frequency Of Blinking Sometimes May Be Because Of Mental Tiredness. Eye Blinks Are Related With A Standard On/Off Binary System And Therefore Are Important For Controls Which Demand Accurate Responses. For Example, In Communication Purposes, One Blink Indicates No, Two Indicates Yes, Giving People With Special Needs A Simple Communicating Way. In This Paper, Blink Detection Method Is Used To Make The Forward And Backward Movements Of Wheelchair According To User’s Command In The Form Of Eye Blink Strength With Value Greater Than Predefined Threshold Value.

5.3Module Description

The Block Diagram Of Wireless Wheelchair Controlling System Consist Of Three Parts Namely Neural Signal Capturing Module, Data Processing Module And Wheelchair Module. The BCI Consists Of Brain Wave Sensor, Signal Conditioning Unit And Bluetooth For Brain Signal Capturing And Transferring, Which Is Given Below.

5.3.1 Neural Signal Capturing Unit

In The First Module, MindwaveMobile Consists Of A Single-Channel, Dry Sensor Which Is Used To Capture The Attention And Eye Blink Signals, Placed On The Frontal Lobe.The Brain Wave Sensor Senses And Collects The Brain Wave Data And Then Transfers Data Through Bluetooth To Communicate With Your Computer And Mobile Devices.Fig.4 Shows The Pictorial Representation Of Brain Wave Sensor.

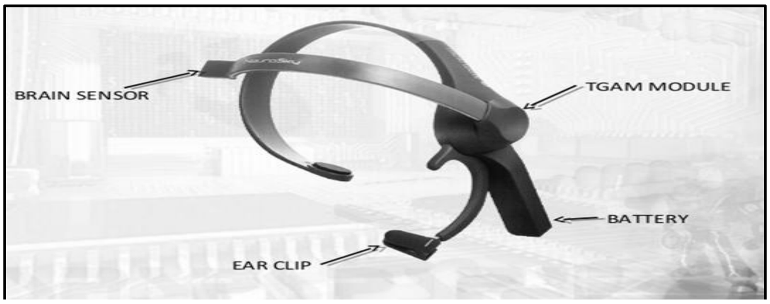

Fig.4 Mind Wave Mobile

Brain Waves Are Produced By Synchronized Electrical Pulses From Masses Of Neurons Communicating With Each Other. Brain Waves Are Detected Using Sensors Placed On The Scalp. They Are Divided Into Bandwidths To Describe Their Functions, Are Best Thought Of As A Continuous Spectrum Of Consciousness. The Specifications Of Brain Wave Sensor Given Below.

- Passive Dry Sensor EEG
- Bluetooth Communication
- Provides EMG Feature
- AAA Battery
- Battery Life : 10 Hours
- Light Weight : 90g
- Bandwidth : 3-100 Hz
- Resolution : 12 Bits

5.3.2 Data Processing Unit

The Artifacts And Noise Developed In The Wireless Wheelchair Controlling System Can Be Removed By Using Fast Fourier Transform Analysis. The Attention And Blink Strength Signal Levels Can Be Classified Separately With The Help Of The Level Analyzer Technique. The Brain Wave Sensor Can Be Interfaced With The Level Analysis Platform By A Bluetooth Which Is Used To Transfer The EEG Signal To The Signal Processor Through It's Transmitter/Receiver Units. In The Signal Processor, There Is A Brainwave Visualizer Software And MATLAB That Can Be Programmed As Per The Baud Rate Of The EEG Signal. The Output Signals Are Transmitted To The Wheelchair.

5.3.3 Wheelchair Unit

ItConsists Of An ARM 7 Microcontroller For Controlling The Movement And Direction Of The Wheelchair With Respect To The Command Received From Data Processing Unit.MATLAB Output Is Given As Input To Wheelchair Module Which Consists Of Dc Motors Which Moves Forward, Left Or Right According To Different Brain Signals. If Blink Signal Strength Is High, Then Wheelchair Starts Forward/Reverse Motion And If Attention Signal Strength Is High, Then Wheel Chair Rotates Clockwise.

VII. Simulation Analysis

The Proposed Wireless Wheelchair Controlling System Consists Of Mind Wave Mobile As A Wireless Signal Acquisition Module. The EEG Signal Is Captured And Transmitted To Signal Processor Unit With The Help Of It .Then The Bluetooth Dongle Which Acts As A Receiver, Will Collect The Signals And Simulation Process Is Carried Out Using MATLAB. A Bluetooth Receiver Is Connected To The Single Processor Where Brain Signals Such As Alpha And Beta Waves Are Extracted And Processing Using MATLAB. M Script /Math Script Is Used To Interface Raw Brain Wave Signals With MATLAB And Produce Output Waveform Based On Time, Through Continuous Monitoring Of Input Brain Wave With The Help Of Inbuilt Brain Sensor In The Mind Wave Mobile.

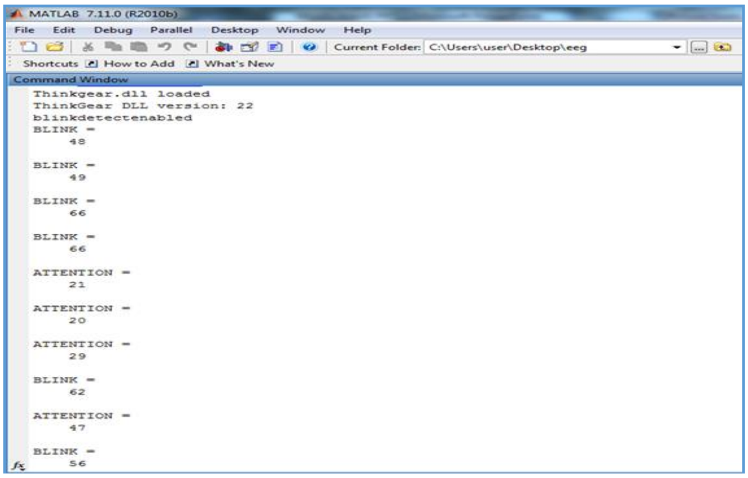

Fig.5 E-Sense Level Computation

The Mat Lab Command Window Shows The Signal Strength Level Of Attention And Blink Signals As Shown In Fig.5. The Output Waveform Indicates The Attention & Blink Signals In X-Axis And Time In Y-Axis As Shown In Fig.6. Whenever Blink Signal Strength Is High, Then Wheelchair Starts Forward/Reverse Motion And If Attention Signal Strength Is High, Then Wheelchair Starts Clockwise Rotation. MATLAB Output Is Given To Wheelchair Module Which Consists Of Dc Motors That Moves Forward, Left Or Right According To Different Brain Signal Commands Received From Signal Processor.

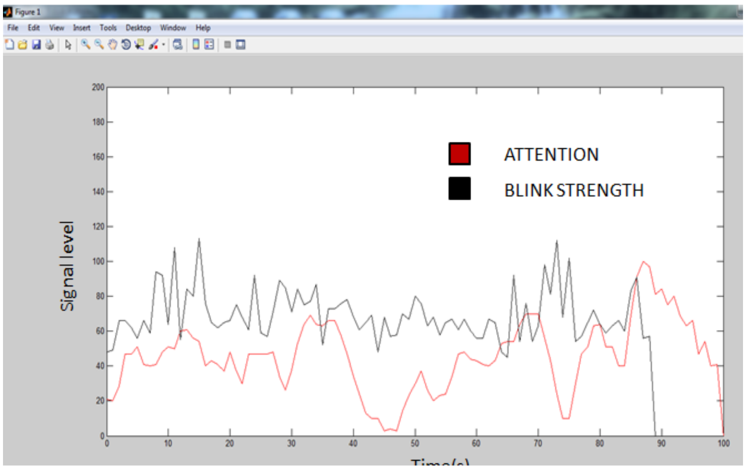

Fig.6 E-Sense Level Graph

With The Help Of The Computed Attention And Blink Strength Values, It Is Possible To Control The Movement And Direction Of The Wheelchair And Hence Easily It Can Be Controlled.

VIII. Conclusion

In This Paper, Wheelchair Can Be Controlled Using Brain Wave Sensor Located On The Frontal Lobe. This Can Be Used For Supporting Disabled And Paralyzed Persons To Move Voluntarily. The Highlighting Merits Of Mind Controlled Wheel Chairs Are That They Respond To Signal Commands Much Faster And That Persons Who Have Lost Their Ability To Speak May Able To Use Them. A BCI Based Wheelchair Is Being Developed For Severely Disabled And Challenged Person To Move Them Independently, Without Any Human Assistance, Even Though There Are Many Number Of Ways For Make Functioning A Wheelchair For Example, Voice Controlled, Using Gestures, Using Eye Movement Or Using Joystick Etc, Since They Cannot Be Used By Stroke Patients Or Paralyzed Patients.AThought Based Wireless Wheelchair Controlling System Is Being Constructed For Paralyzed And Disabled People To Make Their Daily Life, A Problem Free. EsenseAlgorithm Is Proposed In Which Two Methods Are There, Namely, Attention Metric Method And Blink Strength Method. The Attention Signal Is Used For Making Sidewise Movements Of The Wireless Wheelchair Through Clockwise Rotation And Eye Blink Strength Is Used For Achieving Forward And Backward Movements. The Level Analyzer Technique Is Implemented In Signal Processing And The Wheelchair Can Be Controlled By ARM Microcontroller. The Wheel-Chair Controlling System Can Be Further Improved By Removing Artifacts And Noise Level Accurately In Brain Wave Signal Processing And Focus On Additional Improvement Of The Identification Of Irregular Eye Blink So That The Wheelchair Can Be Operated And Controlled Efficiently Without Any Collision.

References

[1] Ang M.H., Rebsamen B., Guan.C, Zhang.H., Wang.C, Teo.CAnd Burdet.E, 'A Brain Controlled Wheelchair To Navigate In Familiar Environments', IEEE Transactions On Neural Systems,Vol. 18, No.6, Pp. 590–598, 2013.

[2] Chin-Teng Lin, Bor-Shyh, Fu-Chang Lin, Che-JuiChang , 'Brain Computer Interface –Based Smart Living Environmental Auto-Adjustment Control System In UpnpHome Networking', IEEE System Journal, Vol. 8, No.2, Pp.228-250, 2014.

[3] Gandhi V., Prasad G., Coyle D., Behera L., 'Quantum Neural Network Based EEG Filtering For A Brain-Computer Interface', IEEE Transactions On Neural Network Learning System, Vol. 25, No.2, Pp.278–288, 2014.

[4] Kanniga E., Selvaramarathnam K., Sundararajan M., 'Embedded Robot Control Using Mems Sensor With Voice Command And CCTV Camera', IEEE Transactions On Mems Systems, Vol. 6, No.6, Pp.4794-4796, 2013.

[5] Kimetal H.K., 'Continuous Shared Control For Stabilizing,ReachingAnd Grasping With Brain-Machine Interfaces', IEEE Transactions On Biomedical Eng, Vol. 53, No.6, Pp.1164-1173, 2013.

[6] Luzheng BiAnd Yili Liu, 'EEG-Based Brain-Controlled Mobile Robots:A Survey', IEEE Transactions On Human-Machine Systems, Vol. 43, No.2, Pp.161-176, 2013.

[7] Vaibhav Gandhi, Girijesh Prasad, Damien Coyle, LaxmidharBehera, Thomas Martin Mcginnity, 'EEG-Based Mobile Robot Control Through An Adaptive Brain–Robot Interface', IEEETransactions On Systems, Man, And Cybernetics, Vol. 9, No.3, Pp.1-9, 2013.

[8] Zhang Yi, Jiao Zhang, Yuan Luo, 'A Novel Intelligent Wheelchair Control System Based On Hand Gesture Recognition', IEEE International Conference On Complex Medical Engineering, Vol. 5, No.1, Pp.12-24, 2012.

[9] B. Obermaier, C. Neuper, C. Guger, And G. Pfurtscheller, "Information Transfer Rate In A Five-Classes Brain-Computer Interface," IEEE Trans.Neural Syst. Rehabil. Eng., Vol. 9, No. 3, Pp. 283–288, Sep. 2001.

[10] J. Kronegg, G. Chanel, S. Voloshynovskiy, And T. Pun, "EEG-Based Synchronized Brain-Computer Interfaces: A Model For Optimizing The Number Of Mental Tasks," IEEE Trans. Neural Syst. Rehabil. Eng., Vol. 15, No. 1, Pp. 50–58, Mar. 2007.

[11] B. Graimann, B. Allison, AndG. Pfurtscheller, "Brain–Computer In-Terfaces: A Gentle Introduction," In Brain-Computer Interface: Revolu-TionizingHuman-Computer Interactions, B. Graimann, B. Allison AndG. Pfurtscheller, Eds. Berlin, Germany: Springer, 2010.
[12] B. RebsamenEt Al., "A Brain Controlled Wheelchair To Navigate In Familiar Environments," IEEE Trans. Neural Syst. Rehabil. Eng., Vol. 18, No. 6, Pp. 590–598, Dec. 2010.
[13] A. R. Satti, D. Coyle, AndG. Prasad, "Self-Paced Brain-Controlled Wheelchair Methodology With Shared And Automated Assistive Control," In Proc. IEEE Symp. Comput. Intell.,Cognitive Algor., Mind, Brain, Apr. 2011, Pp. 1–8.
[14] P. Johan Et Al., "Adaptive Shared Control Of A Brain Actuated Simulated Wheelchair," In Proc. IEEE 10th Int. Conf. Rehabil. Robot.,Jun. 2001, Pp. 408–414.
[15] I. Iturrate, J. M. Antelis, A. Kubler, AndJ. Minguez, "A Noninvasive Brain-Actuated Wheelchair Based On A P300 Neurophysiological Proto-Col And Automated Navigation," IEEE Trans. Robot., Vol. 25, No. 3, Pp. 614–627, Jun. 2009.
[16] V. Gandhi, "Quantum Neural Network-Based EEG Filtering And Adaptive Brain-Robot Interfaces," Ph.D. Dissertation, Intelligent Systems Research Centre, University Of Ulster, Londonderry, U.K., 2012.
[17] B. Gerkey, R. Vaughan, A. Howard, AndN. Koenig. (2013, Oct.). ThePlayer/Stage Project [Online]. Available: Http://Playerstage.Sourceforge.Net
[18] C. Guger, G. Krausz, AndG. Edlinger. (2013, Oct.). Brain–ComputerInterface Control With Dry EEG Electrodes [Online]. Available:Http://Www.Gtec.Ac.At
[19] B. Hjorth, "EEG Analysis Based On Time Domain Properties," Electroen-Cephalogr. Clin. Neurophysiol., Vol. 29, No. 3, Pp. 306–310, Sep. 1970.[14] V. Gandhi. (2013, Dec.). Robot Control Through MotorImagery [Online]. Available: Http://Isrc.Ulster.Ac.Uk/Vgandhi/Video
[20] Luzheng Bi, Xin-An Fan, And Yili Liu, "EEG-Based Brain-Controlled Mobile Robots:A Survey", IEEE Transactions On Human-Machine Systems, Vol.43, No.2, Pp.161-176, 2013.
[21] A. Karnik, "Performance OfTCP Congestion Control With Rate Feedback: TCP/ABR And Rate Adaptive TCP/IP," M. Eng. Thesis, Indian Institute Of Science, Bangalore, India, Jan. 1999.
[22] J. Padhye, V. Firoiu, And D. Towsley, "A Stochastic Model OfTCP Reno Congestion Avoidance And Control," Univ. Of Massachusetts, Amherst, MA, CMPSCI Tech. Rep. 99-02, 1999.
[23] Wireless LAN Medium Access Control (MAC) AndPhysical Layer (PHY) Specification, IEEE Std. 802.11, 1997.