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Sensory Profile for Autistic Children by Using EEG Biosignal

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Abstract--- *The neural activities in a brain can be measured in terms of voltages by Electroencephalography (EEG). The neurological problems are diagnosed by EEG because it is capable of being recorded over longer period of time and it is non-invasive. The children suffering from ASD are unable to express their emotions because of lack of proper processing of information in brain. This work is focussed towards building a sensory profile that differentiates among different types of sensory responses by using an EEG biosignal potential. Different states of emotion are identified by EEG signals such as super learning, positive thinking and relaxation of light and lie in between range of 8-12 Hz. This research involved participation of 64 children among which 34 were suffering from ASD whereas 30 were normal. While recoding EEG data, children were provided with visual, vestibular, taste, sound and vestibular sensory simulations. The EEGLAB software and wavelet transform wa used for filtering raw EEG data by using "independent component analysis (ICA)". Later on, sensory profile was built by approximating entropy, standard deviations and means after extracting it from filtered EEG signals.*

Index Terms--- *Electroencephalography (EEG), autistic children, neurological, sensory profile.*

I. INTRODUCTION

A medical professional can help in diagnosing medical conditions of an individual. Physiological signals may undergo variations that may lead to human errors because they are not constant all the time. The problems that children suffering from "autism spectrum disorder (ASD)" face is an additive factor. The early screening, identification and intervention has been highlighted by ministry for this disease. ASD may be diagnosed by questionnaires but it is a difficult task that way. The information is interpret by humans through dedicated pathways such as sending and receiving via synaptic activation and they are known as sensory systems [1][2]. The irregularities in children suffering from ASD are analysed by EEG bio signals. There are two processes of development in children stated by Piaget's theory: (i) Cognitive process and (ii) the movement process obtained with ability. The process of cognitive includes the way a person adjusts with surroundings through accommodation and assimilation. A newly born begins with his sensory system with senses such as hearing, smell, taste and visual by the development of sensory motors. This is how a new born starts adjusting to surroundings. Upon reaching seven months, a baby is able to know about memory related objects. Sensory integration is known as a phenomena in which a systematic organization of human's sensation is done for interpreting. Sensory inputs from receptors are

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utilized by various parts of brain such as cerebral hemispheres, spinal cord and cerebellum. Then different sorts of functions such as body movements, knowledge, perception, awareness, body posture etc. are produced. An instrument for assessing children with or without disabilities is done by sensory profile [3]. The sensory abilities are scored for health occupational discipline in a child. The attention needed by subjects is given by these observations and the score as well. Nowadays, it is widely used by schools for improving the ability of children [4][5].

II. ELECTROENCEPHALOGRAPHY

The neural activities created within the brain are measured by voltage in electroencephalography (EEG). The activity of brain was recorded by a "10-20 International System" for placing electrodes [6]. There are four section in which human head is classified: "the left and right preauricular points, the occipital protuberance, the inion and the nasion". The distance between nasion-inion is measured by placing an electrode in between them and points are marked of this length 10%, 20%, 20%, 20% and 10%. The naming of electrodes in done according to the adjacent parts of brain they are "F (frontal), P (Parietal), O (Occipital), T (Temporal) and C (Central)". A conducting get having ions was used for putting into the head an electrode scalp of a maximum resistance of 10kΩ. There is a pathway between electrode and skin as ions for current. The arrangement of electrodes on various parts of brain is shown in table 1. The activities of brain in children suffering from ASD are recorded by EEG bio signals[7].

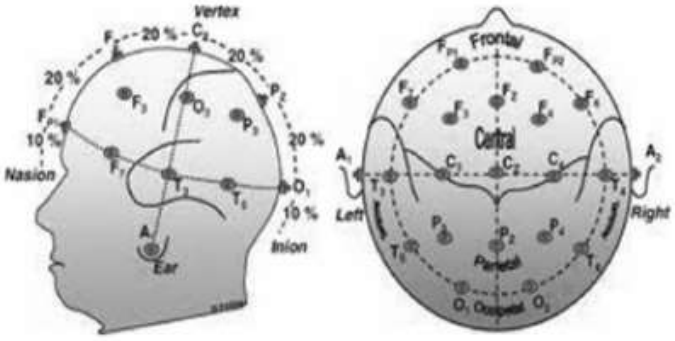

Fig. 1 Placement of electrodes in 10-20 system

A channel in EEG represents potential difference in between two inputs. Division of EEG signal is done into different frequencies [8]. Table 2 depicts the division of EEG bio-signal based on the frequency. The characteristics of EEG bio-signal is non-linear and also non-Gaussian [9]. The useful content of EEG bio signal is discovered by conducting short time Fourier transform because of variations and uncertainties in spectral content. The correct frequency band is verified for extraction of features of sensory response. Another analysis named "Short time Fourier transform (STFT)" is also important for reporting the spectral content or frequency of a signal that moves at time's spots [10]. The implementation of fast Fourier transform (FFT) is done on segment signals having N segments. A spectrogram is used for representing the frequency output in output of time frequency. Morlett introduced wavelet transforms which is used in EEG signal processing. 'Wavelet' is known as a translational of a window function on a sinusoidal Fourier transform. The division of wavelet transforms is done into two types: "continuous wavelet transform (CWT) and discrete wavelet transform (DWT)". The information of synthesis and analysis is presented by DWT along with significant computation time. Then low pass and high pass filters are used for passing the EEG signals which reduces noise. The "alpha, beta, gamma and theta" brain waves are obtained by

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determining cut off frequencies of filters. Hence, the signals at particular frequency bands are extracted by using substitution between frequency and time resolution by the method of wavelet analysis [8].

III. METHODOLOGY

The relationship between sensory response and cognitive ability of children suffering from ASD. The data from EEG is sent to a pre-processing stage after being collected from children. After this, MATLAB is used for further analysing the pre-processed data. Finally, children's sensory profile is presented.

III.I. Collection of Data

The responses of five sensory nerves are involved in data collection which are movement, position, touch, sight, taste and sound. Table 1 shows arrangements of electrodes. The unique activities of children in the age group of 3-7 years were noticed for experiments. The sensory responses include simulation of test such as sweet, sour and salty tastes. The "10-20 International placement of electrodes" was used for collecting data. A standard device used in medicine Neurofax 9200 was used for collecting data of EEG bio signals. A group of 64 children were selected for collecting EEG bio signals, out of which 30 were normal and 34 were suffering from autism. The recording of EEG signals was done for few minutes and sampling at 50 Hz was done for all children. The eyes of participants were closed for avoiding artefacts during every phase of experiment except for the case of visual simulation.

Table 1 Electrode Placement

Sensory	Brain Part	Electrode / Channel
Audio	Temporal and central lobe	T3, T4, T5, T6, C3, C4, CZ
Salt	Central, parietal and temporal	C3, C4, CZ, P3, P4, PZ, T3, T4
Sour	Central, parietal and temporal	C3, C4, CZ, P3, P4, PZ, T3, T4
Sweet	Central, parietal and temporal	C3, C4, CZ, P3, P4, PZ, T3, T4
Touch	Central, parietal and temporal	C3, C4, CZ, P3, P4, PZ, T3, T4
Vestibular	Temporal and central	T3,T4, T5, T6, C3, C4, CZ
Visual	Parietal and occipital	P3, P4, PZ, O1, O2

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Table 2 Division of EEG signal based on frequency

Rhythm	Frequency (Hz)	Mental Activities
Delta	0.1 – 3	Deep sleep, lucid dreaming, increased immune functions, hypnosis
Theta	3 – 8	Deep relaxation, meditation, increased memory, focus, creativity, lucid dreaming, hypnagogic state, consciousness toward drowsiness
Alpha	8 – 12	Relaxing without focus and attention (Light relaxation), "super-learning", positive thinking
Low Beta	12 – 15	Relaxed focus, improved attentive abilities
Midrange Beta	15 – 18	Increase mental ability, focus, alertness, IQ
High Beta	18 – 30	Fully awake, normal state of alertness, stress and anxiety
Gamma	30 – 60	Associated with information rich task processing and high level information processing

III.II. Analysis of Data

The recorded data of raw EEG is transferred to pre-processing stage. The EEGLAB software can be used for analysing noise reduction and removing artefacts is the first stage of EEG signal pre-processing. The participants blink eyes and also show some sort of movement which gives rise to artefacts. The features are extracted at chosen points of electrode by using DWT. The flow diagram of current research is shown in fig.2. The artefacts are removed by selecting large values of distortion and selecting highly undesired signals. An EEG signal's sample before and after filtering are shown in figure 3. The artefact was removed using ICA and EEG signal is filtered and

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fed for further filtration to DWT. The DWT was used for level downing the frequency range which gives rise to waves namely “alpha, beta, gamma and theta”. Also, a filtered signal was used for extracting the features[11].

III.III. Wavelet Transform

A French geophysicist namely, Jean Morlett was the one to propose wavelet transform [12]. A mathematical tool for processing signals by using various EEG signal processing applications was created. It analysed moving signals by an acceptable method, for example EEG signals. The wavelet transform includes signal decomposition, compression, and analysis in time scale. The mother wavelets and its decomposition are comprised in a set of wavelets. The mother function are scaled and translated on time axis for forming this set [13]. The given signal f(t) is decomposed into finer details in DWT for a description of multi resolution according to two sets of primary functions.

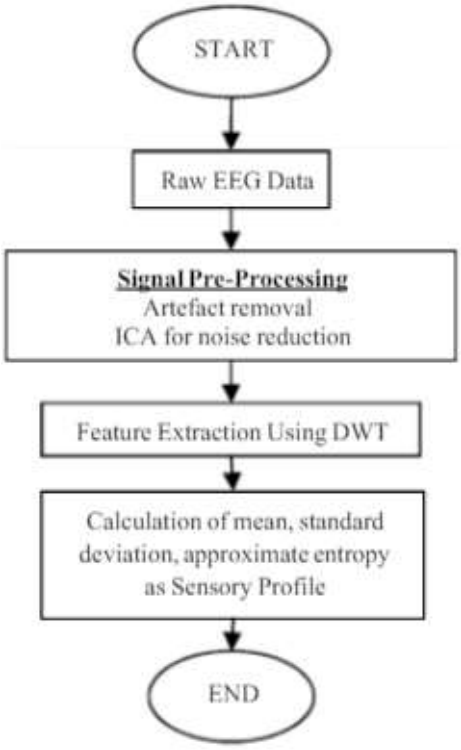
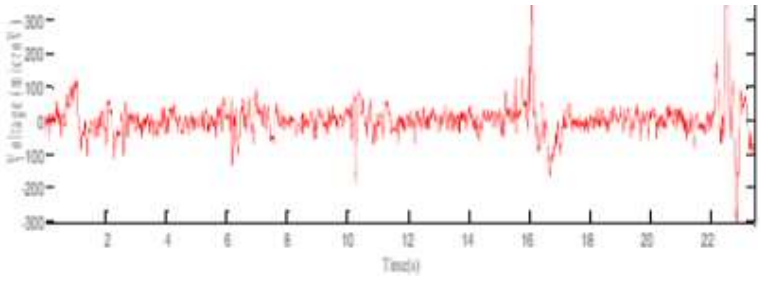


Fig. 2 Flow diagram of current research



(a) Raw Signal

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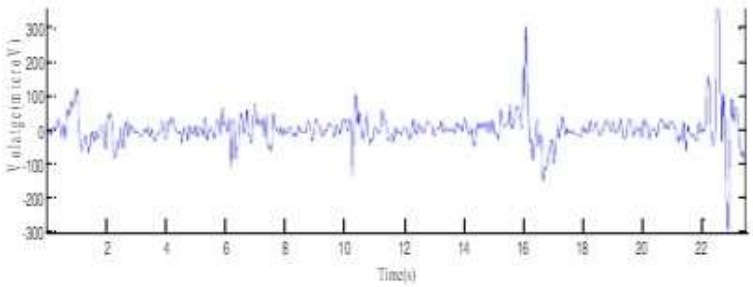

(b) Filtered Signal

Fig. 2 Sample signals of EEG

III.IV. Neural Network

The artificial neurons interconnected together are modelled in a manner of human brain working and form a neural network. The feed forward network is one of the most widely used neural architectures. FFNs are capable of recognizing pattern, and predict and fit into the nonlinear function. 64 patterns are constituted in data set of inputs which represents 30 children who are normal and 34 are suffering from autism[14]. The symbol '0' and '1' are constituted in target set. Thus, the decision rule of neural network activation is:

$$\varphi(i) = \begin{cases} 0, & \text{normal children} \\ 1, & \text{Autistics children} \end{cases}$$

IV. RESULT

For 64 subjects, the alpha frequency lies in between range of 8 to 12 Hz and is shown in figure 4. The experiment resulted that children suffering from ASD had greatest response towards salty taste. The preference of salty food in children suffering from ASD is 27.13μV. The other higher sensory responses were 17.08μV but sight has lower sense at7.72μV due to the lack of attentiveness because of ASD.

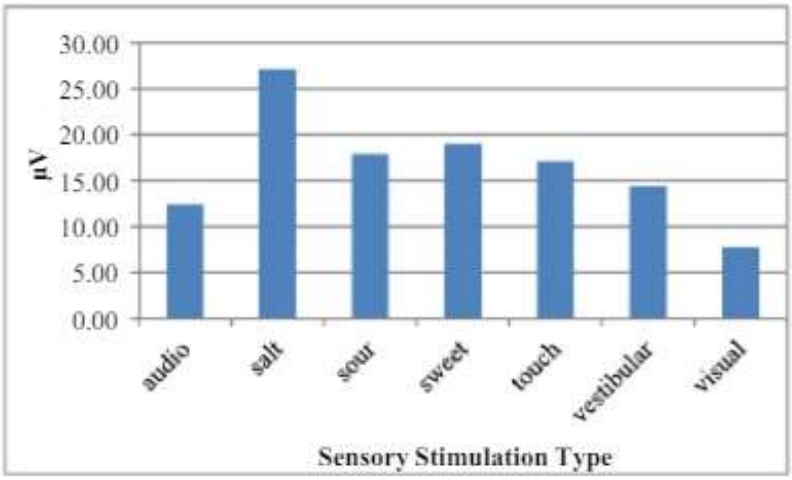

Fig. 4 Sensory simulations in children suffering from ASD

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A computing sensing deviation of all sensory responses was used for recording deviation of EEG data from a given standard value for all the sensory responses. The value of standard deviation was 336.83 μV for salty taste response[15]. The value of standard deviation for lowest sense of sight was 172.84μV. The children suffering from ASD had data point value spread over a big span. The children mood suffering from ASD is variable despite of lower value of mean at sense of sight of an autistic child[14].

V. CONCLUSION

The technique which is non-invasive is recording an EEG signal and it is good for children those who are suffering from autism as the risk factor is low. The sensory responses was compared for acceptance in children suffering from ASD. The signals are decomposed by DWT by using daubechies 4 and level 6. The approximate entropy and mean standard deviation are the features of extraction that are comprised in study. At sense of sight, a mean value was lower for an autistic child, which shows that children mood with ASD is deprived of attentiveness with high variability. An accuracy of 90.6% is observed by training neural networks with settings as displayed in table III. It has value of "mean squared error" at 0.000001156. The reason behind it is the restricted sample number and large quantity of features for a neural network that generalizes the data. The suggestions for finding best feature extraction combination and classifiers are given to the researchers. It is suggested for best performance and accuracy. The EEG classification potential can be maximized reliably for diagnosing autism.

Table III Results of Classification test

No. of hidden Neurons	Dataset Division in (%)			MSE	Accuracy
	Training	Validation	Test		
8	80	10	10	0.128	87.5
	70	20	10	0.038	84
	65	25	10	0.0012	89.1
32	80	10	10	0.00016	87.5
	70	20	10	0.2668	64.1
	65	25	10	0.3568	51.6
64	80	10	10	0.000005	90.6
	70	20	10	0.214	68.8
	65	25	10	0.3804	50
128	80	10	10	0.000001156	87.5
	70	20	10	0.000001679	89.1
	65	25	10	0.226194	70.3

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