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Analysis of EMG Signal for Hemiplegia Patients Using Hilbert Transform in Labview

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Abstract— The electromyography (EMG) signals gives more information about different features of the muscle function. These electrical activities which are displayed in the form of signal, the result of neuromuscular activation associated with muscle contraction. The motor unit is the most elementary functional unit of a muscle, when motor unit activate, it generates a motor unit action potential. Continuous activation of motor units generates to form the EMG signals. In conventional method the EMG signals are acquired using surface electrodes. The acquired signals were processed and the feature extraction was performed using RMS filter and median frequency filter for normal people. The mean and median frequency filter has disadvantages of oscillation and aliasing effect. In proposed method, the EMG signals are downloaded from Physionet bank, for the hemiplegia patients and normal healthy persons. Surface electrodes used to acquire the EMG signals from the Tibial arterials and Soleus muscles in the lower limb. The signals are pre processed using Band pass filter and Hilbert Transforms are used. Feature extraction like Zero Crossing, Mean Absolute Value and Integrated EMG, ANN classification are preformed using LabVIEW 10.

Index Terms— Electromyography (EMG), Preprocessing, Hilbert transform, Feature Extraction, ANN Classification, LabVIEW Software.

I. INTRODUCTION

Hemiplegia is the most severe form; it is complete paralysis of half of the body. Hemiplegia can be caused by different medical conditions that include congenital causes, trauma, tumors or stroke. People with Hemiplegia often have difficulties in maintaining their balance due to limb weaknesses leads to an inability in properly shift body weight. This makes more difficult to perform daily activities such as eating, dressing, grabbing objects, or using the bathroom. Hemiplegia is characterized by sided weakness in the leg, arm, and face, is the most commonly diagnosed form of Hemiparesis.

A. Cause of Hemiplegia

If injury to the nerve pathway, that provides control of the muscles may occur on different occasions. Stroke can have different origins, that interruption of irrigation the part of the brain caused by clot that blocks an artery or cerebral hemorrhage. They result in lack of oxygen in a given area, in this cases where the nerve cells die. Hemiplegia is sometimes causes more or less regresses disabling Sequelae. Brutal and Immediate cause of hemiplegia are made by Trauma. Many conditions give rise to hemiplegia such as brain tumors, infections. Generally, the injury to the right side of the brain will affects the left-side of the body while an injury to the left side of the brain will affects the right-side of the body.

B. Hemiplegia Symptoms

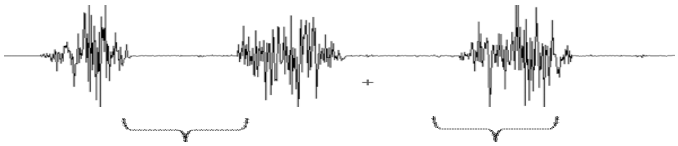
Though Hemiplegia is partial paralysis and it have ability to move the body, because of that there is a decrease in muscle strength and mobility impaired, clumsiness and trouble walking accompanied by a great tiredness and falls of one side. Hemiplegia is accompanied by changes in muscle tone. Right sided Hemiplegia will have trouble in speaking or understanding words said or written. They have slow and careful movement. They also have facial weakness and problem in swallowing.

C. EMG

Electromyography (EMG) is used for record the electrical activity of the muscles in our body. When these cells are activated, an electromyograph detects the electrical activity of muscle cells. The signals can be analyzed to detect the medical abnormalities of muscle, activation level of muscle and analyze of certain various mechanical activities of the human movement [16]. In this present paper, the EMG signals are taken from the muscles of upper limbs. Motor units play an important role in muscle activities. Motor

unit are made up of motor neuron and the skeletal muscle fibers, which is innervated by that motor axonal terminals.

Muscle contains protein filaments of actin and myosin that slide part one another, produce a contraction, it will changes both the length and the shape of the cell. Motor unit action potential are important for the contraction. Acetyl Choline (Ach) is release from the neuron to produce the action potential for contration. The impulses are travels deep into the fiber through the T-tubules and calcium ion get diffused. The diffused ion form a linkage between actin and myosin, myosin pulls actin filament towards. For relaxation, decompose of Acetyl choline (Ach) where the calcium ions transported back to sarcomere and linkage get break to separate the actin and myosin. Continuous activation of motor units, which generates motor unit action potential trains, it superimposed to form the EMG signals.



For various complexities and non-linear problems in signals Artificial Neural Networks (ANNs) has gained lot of interest towards classification. These are massively parallel interconnected networks elements intended to interact with the real world as the same way as of biological nervous system of human body.

D. Artificial Neural Networks

ANN can be used to extract patterns and detects trends that are too complex to be noticed by either humans or other computer techniques with their ability to derive meaning from complicated data. ANN is an information processing system. It has a large number of interconnected parallel processing or neuron elements working in unison to solve different Problems [17]. The other advantages of ANN include

1) *Adaptive learning:* It is an ability to do tasks based on the given data for training.
2) *Self-Organization:* An ANN generates its own organization of the information which are received during the learning time.
3) *Real Time Operation:* ANN computations may be carried out in special hardware devices are being design and manufactured which take an advantage of this capabilities.
4) *Fault Tolerance through Redundant Information Coding:* performance were degradation by the Partial destruction of an network. Some network has the capabilities to retained even with major harm in network.

ANN is an unusual scheme based on the programming and exhibits an higher computational speeds compared to other methods like fuzzy rule based approach.ANN is the number of interconnections nodes, the node characteristics which were classified by the type of nonlinear elements and learning rules employed to use. The ANN has a Processing Elements called neurons, which are arranged in the layers such as input, hidden and output layers. LABVIEW based statistical feature extraction technique to extract the features from each EMG signal corresponding to different body postures.

II. METHODS

A. EMG Signals and Data acquisition

The EMG signals are taken from the physionet bank. The signals are downloaded in the format of .mat for the 10 Hemiplegia patient (age 50) and 15 normal healthy people (age 45).The downloaded signals are taken for 10 sec and converted into .txt format and then used for performance.

The subject were instructed to do the operations like contraction and Relaxation of lower limb,with the help of Surface Electrodes.The data were acquired ,when the subjects were contracting and relaxing their lower limb.

B. Data Processing

The acquired raw EMG signal from the subjects were analysed using LabVIEW 10.which is a graphical user interface(GUI).The LabVIEW applies Efficient and Effective technique on processing of the raw EMG signals.The data were downloaded from physionet bank.The physionet datas are used to read in labview by .txt format. Baseline shift were removed from the downloaded signals, Band pass filter were used to filter the raw EMG signals before applying of HILBERT Transform. Feature Extraction like Integrated EMG,Mean Absolute Value and Zero crossing where made form the filtered signals.

The extracted features are sent to Neural Network for classification. The data's are pre- trained and tested using training method. The trained data from MATLAB are integrated with LABVIEW software for real- time testing.

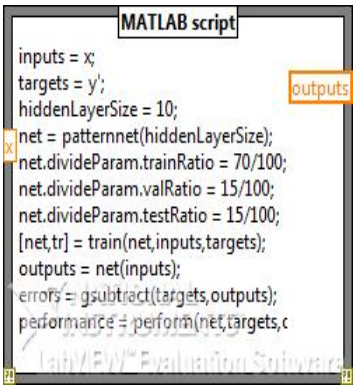


Figure 1.Neural Network in (Matlab script) LabVIEW.Matlab script is used to interface the matlab and labVIEW for make work more easily.

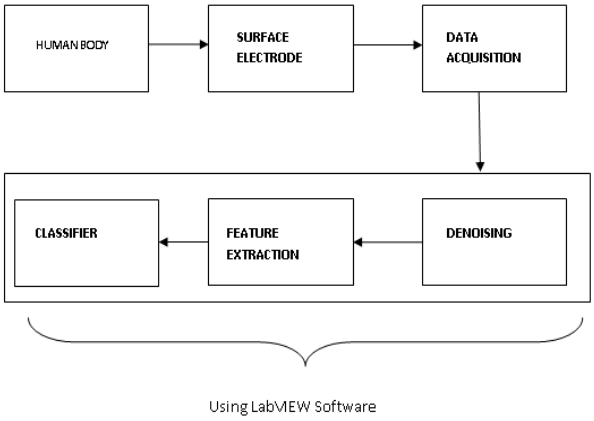


Figure 2.Block Diagram for Acquiring and Analysis of EMG signal

C. Hilbert Transform

The Hilbert transform is an linear operator that takes an function of $u(t)$, and produces a function as, $H(u)(t)$, with the same domain. The Hilbert transform is most important in signal processing. The real signal $u(t)$ are extended into the complex plane such that it will satisfies the Cauchy–Riemann equations. The Hilbert transform is named by David Hilbert, who introduced the operator in order to solve a case of the Riemann–Hilbert problem for the holomorphic functions. The Hilbert transform can be a thought of as the convolution of $u(t)$ with the function as $h(t) = 1/(\pi t)$. Because h(t) is not an integrable, the integrals defining the convolution not to converge. Instead, the Hilbert transform is defined by the Cauchy principal value. Explicitly, the Hilbert transform of a function (or signal) u(t) are given by,

$$H(u)(t) = p.v \int_{-\infty}^{\infty} u(\tau) h(t-\tau) d\tau$$

$$H(u)(t) = p.v \int_{-\infty}^{\infty} \frac{u(\tau)}{t-\tau} d\tau$$

This integral exists as a principal value. Alternatively, by changing variables, the principal value integral can be written explicitly. The Hilbert transform are well-defined, as the improper integral defined, it must be a converge in a suitable sense. However, the

Hilbert transform are well-defined for a broad class of functions, namely those in $L^p(\mathbf{R})$ for $1 < p < \infty$.

$$H(u)(t) = -\frac{1}{\pi}\lim_{\varepsilon \to 0}\int_{-\infty}^{\infty}\frac{u(t-\tau)-u(t-\tau)}{\tau}d\tau$$

D. Feature extraction

1) *Zero Crossing:* A zero crossing is ,where the sign of a mathematical function changes,It represented by an crossing of the axis in the graph of the function.

$$ZC = \sum_{n=1}^{N} f(x_n)$$

2) *Mean Absolute Value:* Absolute value describes the distance of an number on the number line from zero without considering the direction from zero the number lies.

$$MAV = \frac{1}{N}\sum_{n=1}^{N}|x_n|$$

3) *Integrated Emg:* Integrated EMG is defined as the rectified area under the curve of the EMG signal. It is the power of the signal.

$$IEMG = \sum_{n=0}^{N}|x_n|$$

III. APPLICATIONS OF NEURAL NETWORK

A. Neural Network

Feed forward back propagation for neural network is the most common algorithm used for classification and it is called supervised learning algorithm. A Neural Network has consists of three layer like input layer, hidden layer and output layer ,which has it training function respectively .Input layer is used to collect the input data and send to the Hidden layer along with weight. Desired output can be achieved by adjusting the weight of the artificial neural network. Hidden Layer is usually layers of neuron, adding hidden layer to the network increases the network capacities.

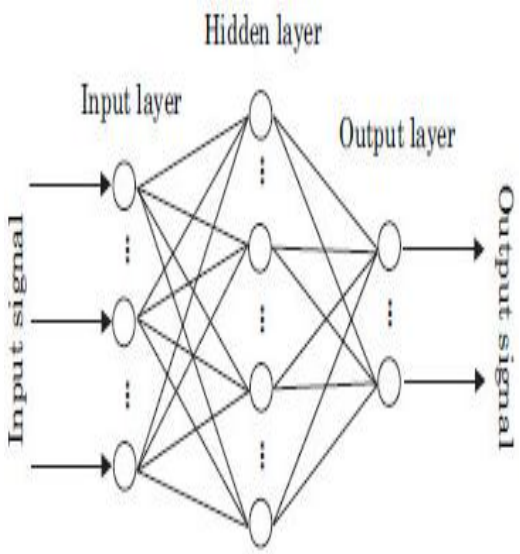


Figure 3.Neural network diagram

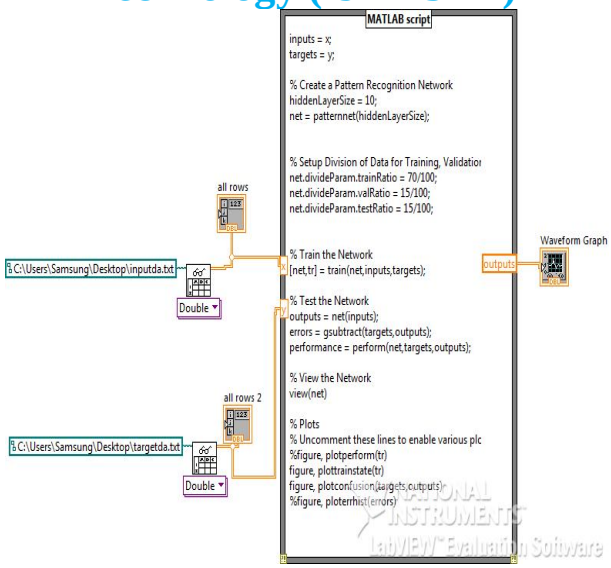


Figure 4.MatLab script

The inputs to the network are the feature extract from the EMG signals. The 50 feature extracted data's has been considered for the training and testing.

B. Training and Testing

There are about three features were taken form 25 persons (where 15 normal healthy persons and 10 hemiplegia patients). In one dataset the input data and correct/expected output together, this dataset are prepared either by humans or by collecting some data in semi-automated way. Testing is to estimate how the model has been trained (it dependent upon the size of your data, the value you predict, input etc). It has 50 of data are used for the training and 75 data were used for the testing.

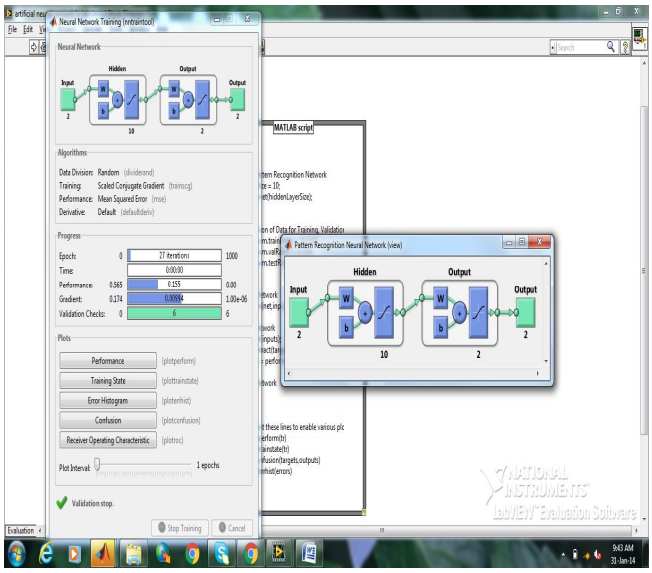


Figure 5.Training and Testing of Data

IV. RESULT

The EMG signals are downloaded from physionet bank for analysis purposes and being processed. The Graph for application of Hilbert Transform and in addition to that, the training, testing and real- time classification results are shown below.

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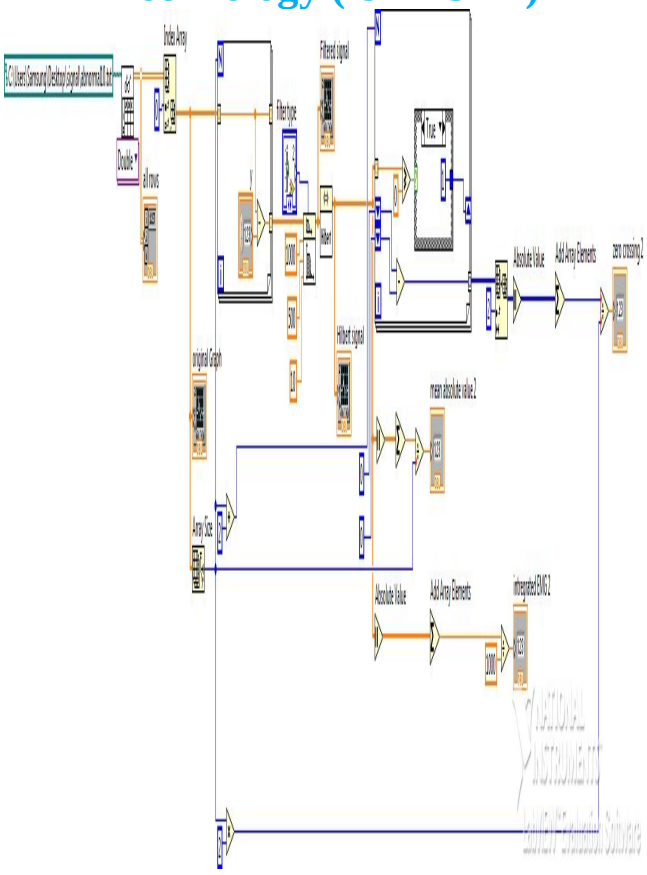


Figure 6.Front panel diagram

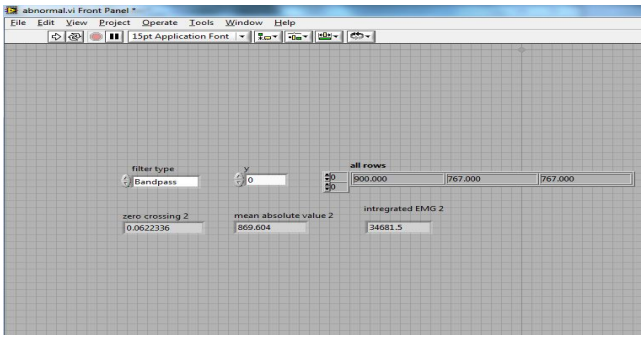
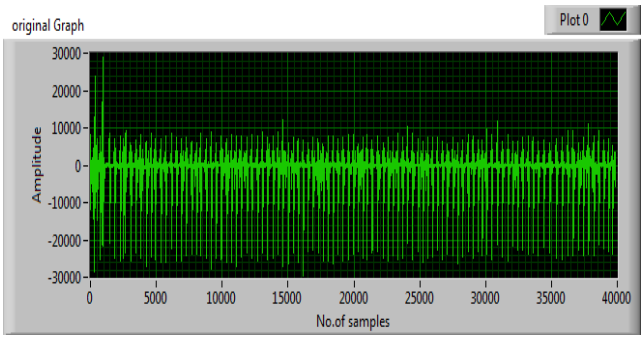


Figure 7.Back panel display



Original EMG signal

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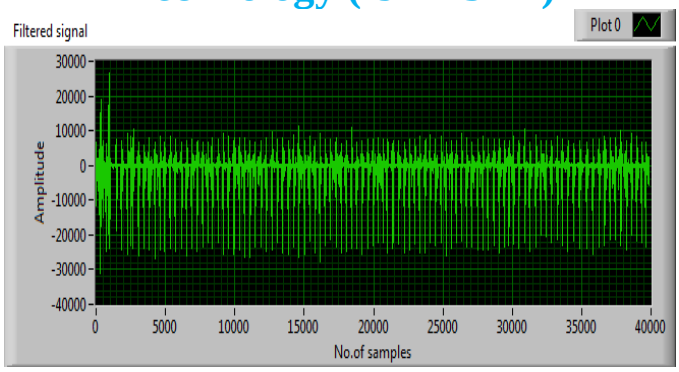
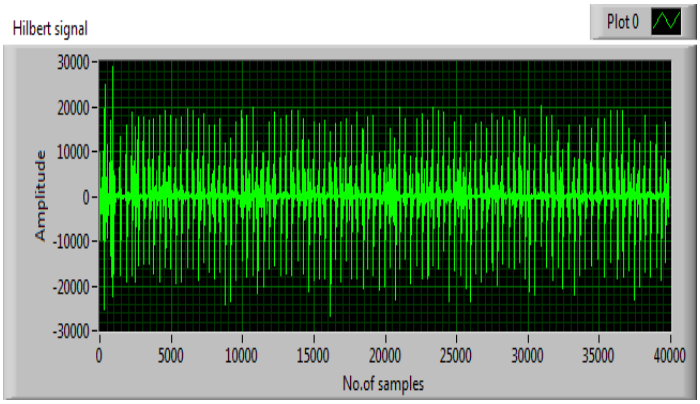


Graph for filtered signal



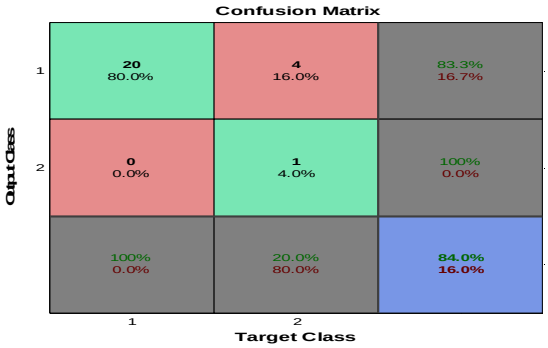
Graph for Hilbert transform

Extracted Using Hilbert Transform

SUBJECTS	ZERO CROSSING	MEAN ABSOLUTE VALUE	INTEGRATED EMG
1	0.00530869	385.871	19625.4
2	0.0053542	384.528	19606.3
3	0.00537424	384.679	19612.5
4	0.00525146	385.509	19600.4
5	0.00527509	381.4	19521.6
6	0.00528286	381.356	19562.8
7	0.00505647	386.823	19660.7
8	0.00501515	367.976	14087.6
9	0.00520885	383.649	19518.2
10	0.00536325	383.086	19499.8
11	0.00526719	384.363	19556.8
12	0.00524971	385.703	19616.9
13	0.0050506	409.496	20837.2
14	0.00536588	382.818	19476.6
15	0.00536504	382.811	19479.4
16	0.0120375	182.818	7312.72
17	0.0101731	596.622	88208.4
18	0.0122375	182.865	7314.6
19	0.0122622	182.365	7294.88

20	0.0120652	183.282	7331.28
21	0.012018	183.755	7362.13
22	0.0122037	183.232	7304.53
23	0.0122236	183.014	7298.98
24	0.0120676	183.813	7349.4
25	0.0122486	183.69	7325.91

Training accuracy met with 15 iterations. The neural network illustrates the transfer function of the features, iterations and performance goal that were achieved during training and confusion plot.



V. CONCLUSION

The EMG signals are downloaded from physionet bank for 25 persons (both normal and hemiplegia people). The signals were pre processed using Band pass filter and Hilbert Transforms were used. Feature extraction like Integrated EMG, Absolute Mean Square, and Zero Crossing were made for the acquired signals in LabVIEW. Systems were designed in LABVIEW software integrating a part of Neural Network from MATLAB software. It has 84.0% of accuracy for classification was achieved using Hilbert Transform.

VI. ACKNOWLEDGMENT

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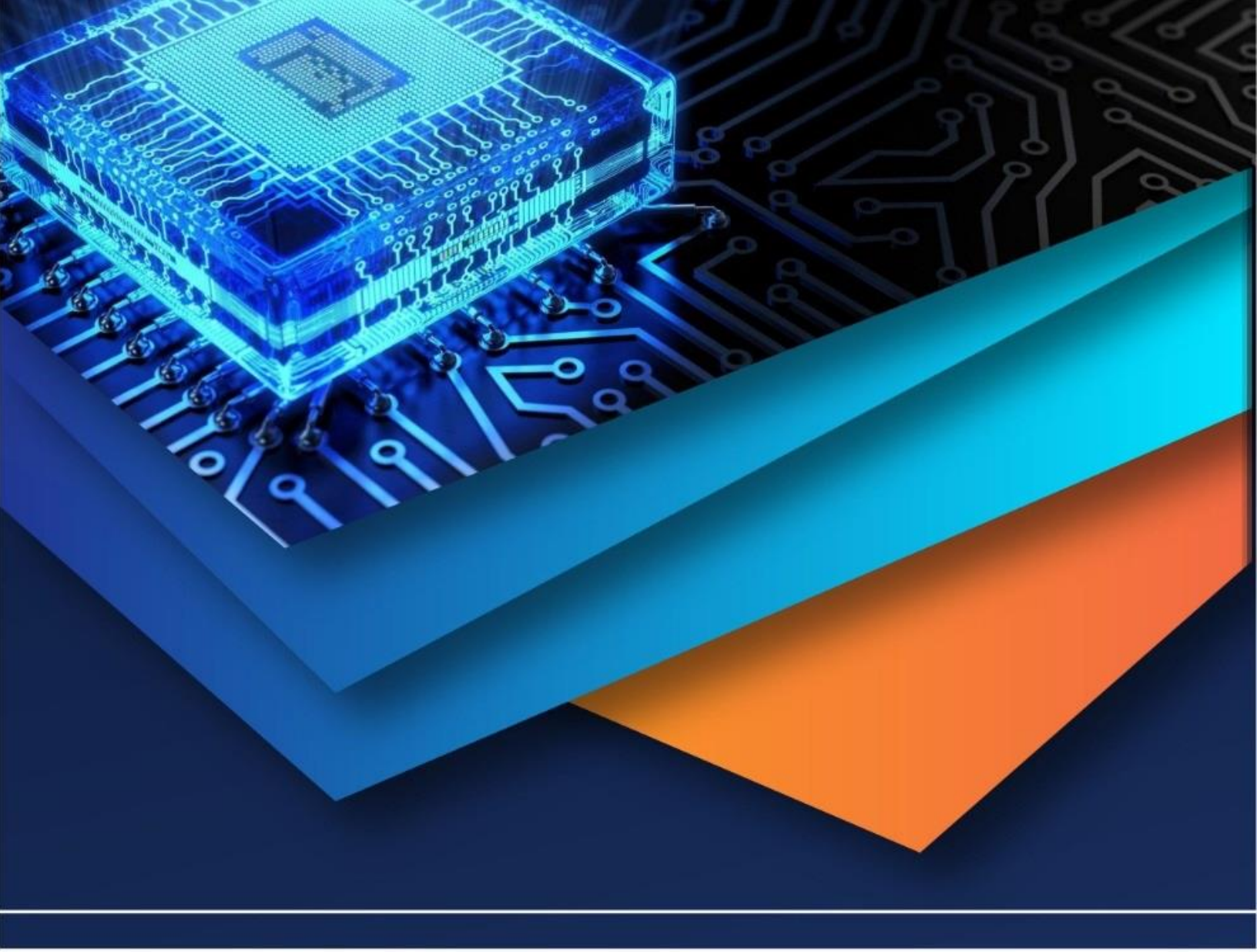

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