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Monitoring and Evaluation of Vocal Pitch in Music

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***Abstract*: This paper describes the methodology of monitoring and evaluating the musical note (vocal) using computer as a music learning tool. Every musical note (vocal) has its pitch and frequency which can be identified using a pitch detection algorithm. After the detection of the frequency and pitch of the musical note (vocal), the vocal pitch can be evaluated to check its accuracy and precision using Standard Deviation and Normal Distribution. The evaluation of the musical note is very important for the music learners in their music practice as it can help them to know how accurately and precisely they are singing the musical notes and can tune them accordingly.**

***Keywords*: Pitch, Frequency, Musical Note, Vocal Pitch, Monitoring Vocal Pitch, Evaluation of Vocal Pitch.**

I. INTRODUCTION

A series of regular vibrations in a medium such as air generates musical sound. The frequency of the musical sound determines the pitch. Therefore, pitch classifies a musical sound as relatively high or low. The human ear can hear infinitely different sounds distinguished by frequency. However, as per Indian Classical Music, the human ear can differentiate between twenty two different frequencies within a specified range of frequencies. These twenty two frequencies are known as Shrutis (Microtones) and the specified range of these frequencies is known as Saptak (Octave). Thus, it is inferred that in a Saptak human ear can determine twenty two different Shrutis through fine auditory perception attained with knowledge of music and practice [1]. Although a Saptak consists of twenty two Shrutis, but only twelve of these are predominant, out of which seven are known as Shudh Swaras (main notes) and five as Vikrit Swaras (Variant Notes). In Indian Classical Music the seven Shudh Swaras form a Saptak whereas in Western Music the eight Shudh Swaras form the Octave. The eighth note of an octave is basically with double the frequency of the first main note of the octave. A Saptak is characterised by the frequency of its first Shudh Swara . The frequency of rest of the Swaras are defined as the fixed ratio with respect to first Shudh Swara of the Saptak. Thus, the frequencies of the twelve Swaras (Shudh and Vikrit) in Saptak are characterised by its first Shudh Swara. The twelve Swaras defined in Indian Classical Music are as given in Table 1 where Sa, Re, Ga, Ma, Pa, Dha, Ni, SA are the Shudh Swaras and Re(K), Ga(K), Ma(T), Dha(K), Ni(K) are the Vikrit Swaras:

TABLE I
12 MUSICAL NOTES (NAMES, SYMBOLS, RATIO TO STARTING NOTE)

S No	Indian Musical Note (Name)	Indian Musical Note (Symbol)	Western Musical Note (Symbol)	Ratio to Starting note (i.e. Sa) [11], [12]	Musical Note Frequencies Based on Ratios (if Sa=240 Hz)
1	Shadaja	Sa	C	1:1	240 x (1/1) = 240 Hz
2	Komal Rishabh	Re (K)	C# , D^b	16/15	240 x (16/15)=256 Hz
3	Shuddha Rishabh	Re	D	9:8	240 x (9/8) = 270 Hz
4	Komal Gandhar	Ga (K)	D# , E^b	6:5	240 x (6/5) = 288 Hz
5	Shuddh Gandhar	Ga	E	5:4	240 x (5/4) = 300 Hz
6	Shuddh Madhyam	Ma	F	4:3	240 x (4/3) = 320 Hz
7	Teevra Madhyam	Ma (T)	F# , G^b	35/32	240 x (45/32) = 337.5 Hz
8	Pancham	Pa	G	3:2	240 x (3/2) = 360 Hz
9	Komal Dhaivat	Dha (K)	G#, A^b	8:5	240 x (8/5) = 384 Hz
10	Shuddh Dhaivat	Dha	A	5:3	240 x (5/3) = 400 Hz
11	Komal Nishaad	Ni (K)	A# , B^b	9:5	240 x (9/5) = 432 Hz
12	Shuddha Nishaad	Ni	B	15:8	240 x (15/8) = 450 Hz
13	Shadaja	SA	C	2:1	240 x (2/1) = 480 Hz

According to Table 1, the frequency value ratios related all the twelve *Swaras* to each other. If the *Swara Sa* is assigned some frequency value in hertz, the rest of the *Swaras* are spread around *Sa* as per the ratio governing them [2].

Music is an interaction of melody, harmony, and rhythm. There are certain features every music tradition has, which can be used to identify, classify and differentiate from others [7]. But whether its Western or Indian Music, practise (*Riyaz*) is very important to gain good control over ones vocal chords while singing. For any singer it is very important to have control over the musical notes and while learning music, the vocal pitch has to be evaluated to check its accuracy and precision. For the beginners in music, it may be the case, that they won't be able to sing or control the musical notes perfectly. But with patience and regular practise (*Riyaz*) of musical notes, one can overcome this and master it. For example, just playing the note, say *Sa* on Keyboard or Harmonium, singing and matching the vocal frequency with it repeatedly, is the musical exercise that can assist to tune the note (vocal) accordingly.

This paper describes the influence and usefulness of technology in music learning. It also discusses about the different computer aided instruction tools commercially available for vocal pitch monitoring along with their merits and demerits. The methodology for evaluation of accuracy and precision of the single musical note (vocal) using statistical methods has also been described.

II. TECHNOLOGY AIDED MUSICAL LEARNING

Modern Technology is increasingly present in modern music education from the elementary school to the university level. Electric instruments are present in the most well equipped music classrooms. Computers and the use of the Internet broaden the field of the music education even further. Many different computer programs and software developed lately make music making, composition and accompaniment, practise and improvisation easier and more meaningful [9]. Technology has influenced all aspects of society, schools, and music throughout history. Today's digital technologies are no exception. They are facilitating new ways of learning and being musical. Utilising these technologies in music education doesn't mean we have to eliminate valued traditional classes, ensembles, teaching and learning approaches. Current and developing internet technology holds the promise of a more musical culture and society, allowing everyone to learn and be active musical participants throughout their lives. For this to happen it will require the leadership of technologically proficient music teachers, educators, and students who thoughtfully consider the role of technology in traditional and emerging ways of musical participation and expression [8].

Learning music is not possible without Guru or trainer, who is always there to guide and correct the shishya or student, whenever and wherever required. In India, Guru Shishya Parampara is a perfect example of a close relationship between master and pupil to continue the oral music tradition. However, given the situation that in most contemporary learning situation in India and abroad there are constraints on availability and time, there is a need to look more critically at the great institution of guru shishya parampara [3].Therefore, it is important to develop and accept certain approaches to teaching music in the hectic, contemporary life. There has been a growing need for structures of music education that are more time-efficient (through a more analytical approach, or by using technical aids) [3] along with guru shishya parampara.

Technology has been a major influence in music for hundreds of years, and is extremely useful in the education of music. The printing press was perhaps the largest reason for widespread music education and now new technology can be used to assist in teaching music as note recognition, pitch perfection, rhythm, etc.

III. COMPUTER BASED TECHNOLOGY AND MUSIC LEARNING TOOLS

Computers in music teaching, in general, focus on specific tasks related to typical musical activities in an attempt to minimise uncertainties from such an open ended domains [4]. Techniques from Computer Assisted Instructions (CAI) and Intelligent Tutoring System (ITS) are widely used in music education applications. CAI had limited teaching strategy because they have no explicit representation of knowledge to be taught. CAI cannot differentiate between different students. ITS consists of an instructional environment containing three kinds of knowledge, expert knowledge, student domain knowledge, and circular knowledge [4, 5].

This paper is about vocal pitch monitoring and evaluation in music, so let's discuss some of the computer based music education tools for monitoring pitch.

A. Vocal Pitch Monitor

This is an android application which can very well monitor the pitch of the input musical note but cannot evaluate it. This tool also does not provide accuracy and precision report. No suggestions for improvement are provided.

B. CANTA

Learn to sing in tune. When you sing, in real time, Canta analyses and measures the frequency of your voice. It shows you the pitch of the note that you are singing in the form of a curve on the screen. Your pitch curve is superposed to the notes of the melody. You then see if you sing in tune, or if you are below or above the note you want to reach [6]. This doesn't provide report of accuracy and precision along with the suggestions for improvement, if required.

IV. SONNETA VOICE MONITOR

It is an application for pitch and sound level measurement. It is designed specifically for measuring the human voice — talking, singing, shouting, and humming [6]. A real-time meter display and moving chart provide you with feedback for singing or speech therapy exercises [7]. Though this tool provides the statistical views of the recorded samples but no suggestions for improvement are provided.

After studying various tools for voice monitoring, it was commonly observed that they all lacked in providing report containing either the statistical data for accuracy and precision or the suggestions for improvement.

V. METHODOLOGY FOR VOCAL PITCH MONITORING AND EVALUATION

It is very important for the music learners to control and tune their musical notes which is only possible through music practise (Riyaz). Here, we will discuss about the methodology for monitoring the single note in the real time scenario and its evaluation to get the accuracy and precision of the input frequencies (vocal). After detecting the vocal pitch, it is needed to be monitored and evaluated so as to provide the result and feedback accordingly. There are various statistical methods for evaluating the accuracy and precision of the vocal pitch.

The term "accuracy" is used to describe the closeness of a measurement to the true value. Trueness is the closeness of the mean of a set of measurement results to the actual (true) value and precision is the closeness of agreement among a set of results.[10]

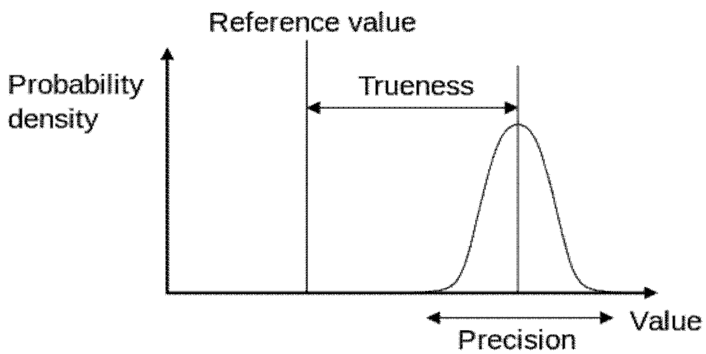
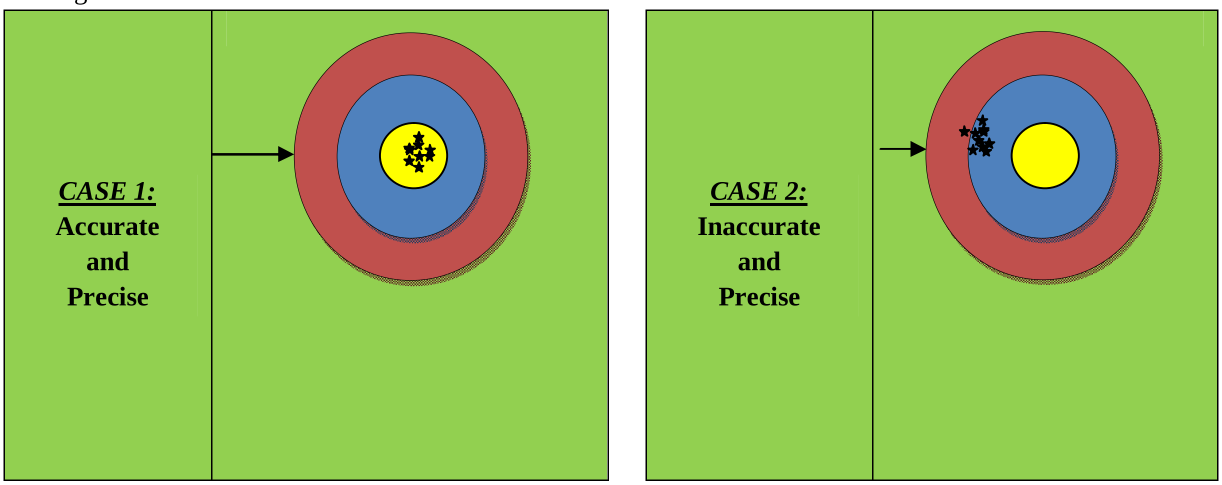


Fig. 1 Accuracy and Precision, According to ISO 5725-1

Thus, accuracy is determined by how close a measurement comes to an existing value that has been measure, i.e. mean value of all the measurements of the same measurand and precision is how close a measurement comes to another measurement and it can be determined using one of the statistical methods known as Standard Deviation.



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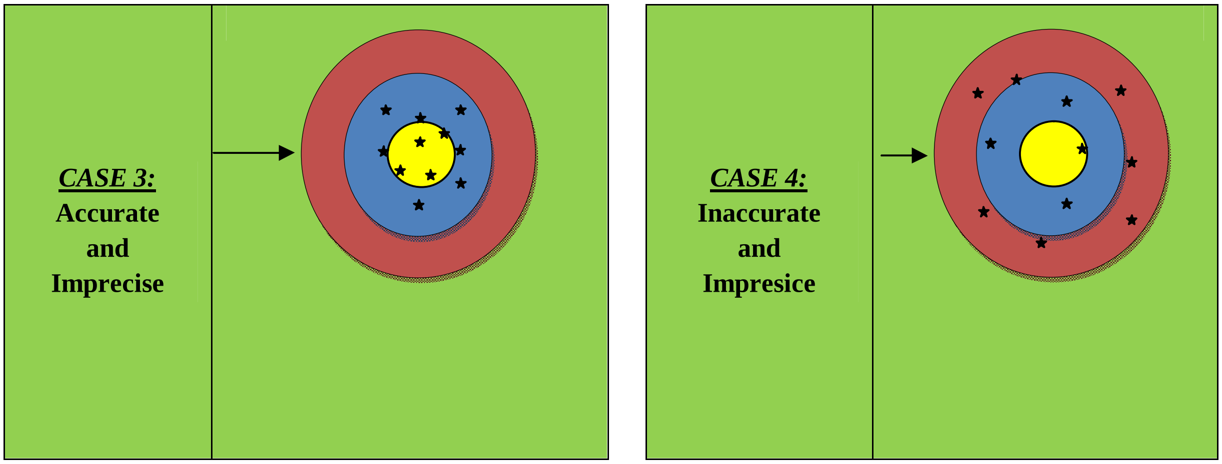

Fig. 2 Different Cases of Accuracy and Precision Combination

Thus, accuracy is the degree of correctness, while precision is how strict that correctness is or not (i.e. the reproducibility of the result). Now, taking the musical note as Sa, which is the midi note 60 here and its frequency is 261.63 Hz, let us consider all the above four cases of accuracy and precision for evaluating the vocal pitch where the measurand is the vocal input for any single musical note.

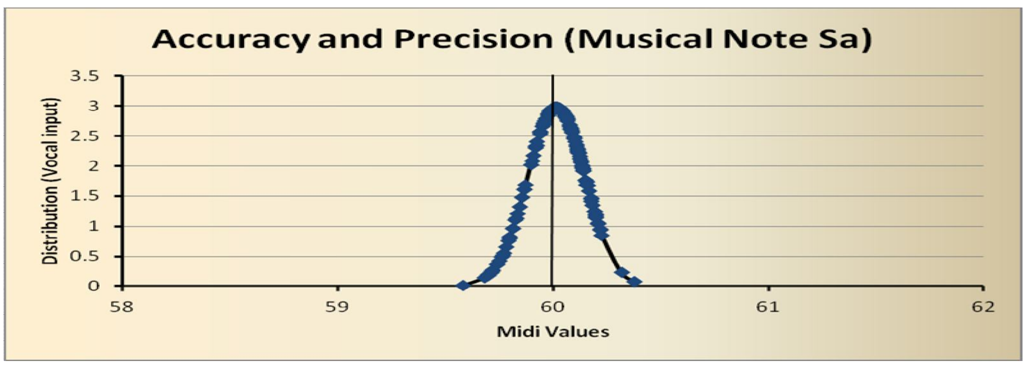

Fig. 3 Case 1: Accurate and Precise

For any singer, while performing their music practise (Riyaz), case 1 (Accurate and precise) is the most appropriate state. This is the case when the singer is singing any musical note (here, Sa) correctly as well as consistently.

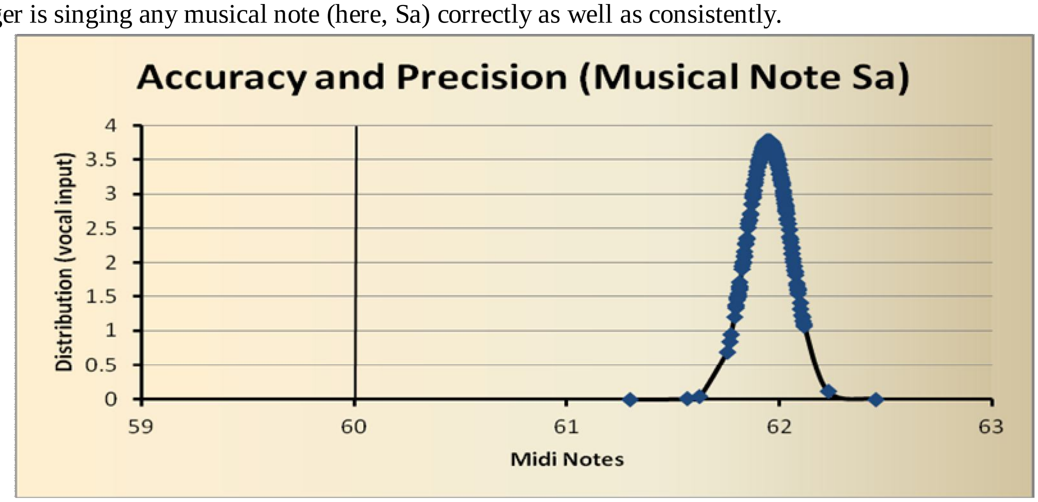

Fig. 4 Case 2: Inaccurate and Precise

Here, in Case 2 (Inaccurate and Precise), the singer while practising for any musical note (in this case, ***Sa***) is maintaining the consistency but is not singing the musical note correctly. As is it clear from the fig.4, the singer is consistently singing the musical note around the midi value 62, which is the musical note Shudh Re, where as he was suppose to sing the midi note 60, i.e. ***Sa***.

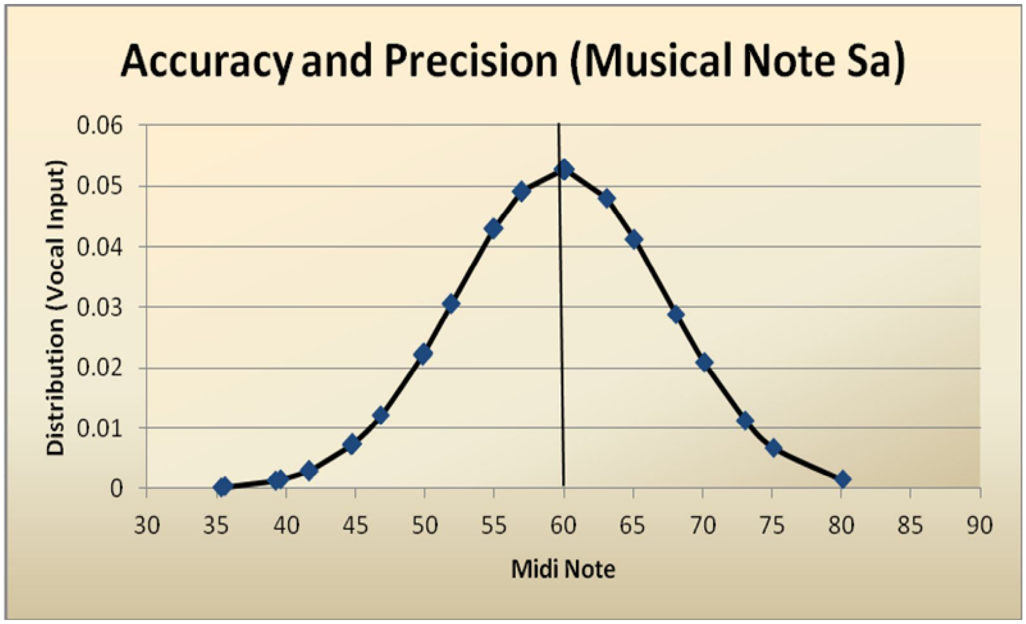

Fig. 5 Case 3: Accurate and Imprecise

In Case 3 (Accurate and Imprecise), the singer is practising the musical note (in this case, ***Sa***) near to accuracy but is not maintaining the consistency. From the fig.5, it is clear that the singer is not at all singing the desired musical note (here, ***Sa***) consistently. In this case, the vocal input for the desired musical note sometimes seems to be correct and sometimes incorrect. The input vocal frequencies keep on flickering continuously but somewhere around the desired frequency.

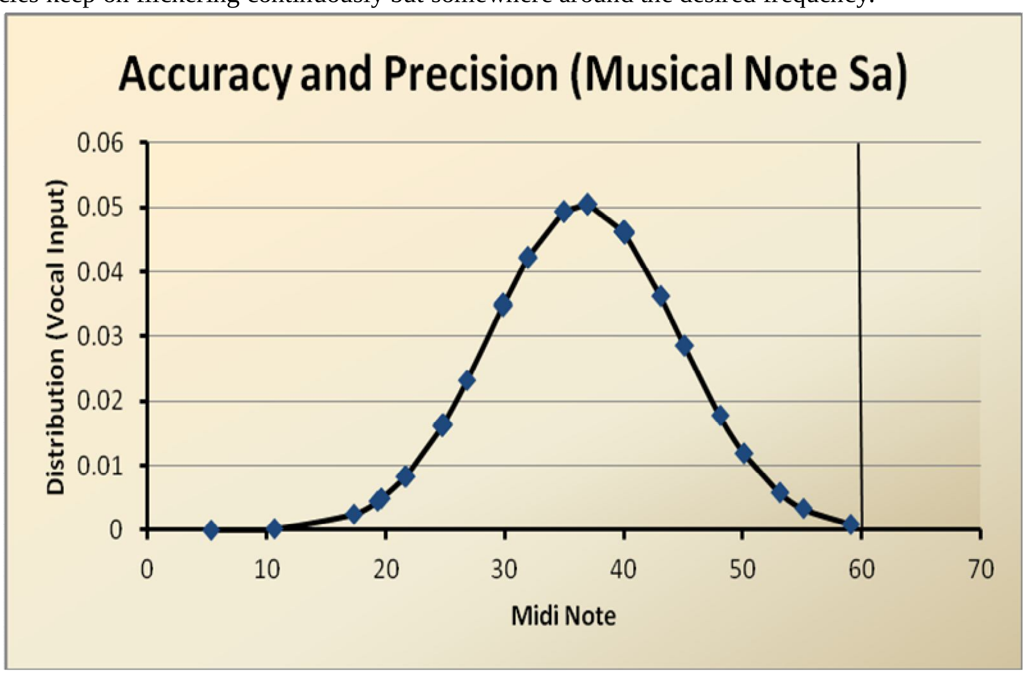

Fig. 6 Case 4: Inaccurate and Imprecise

In the above case, i.e. Case 4 (Inaccurate and Imprecise), the singer is neither practising the musical note (here, ***Sa***) correctly nor he is maintaining the consistency. From the fig.6, it is clear that the singer was suppose to sing the musical note ***Sa***, but he is nowhere singing around the desired frequency as well as not maintain the consistency. Thus, this is the most inappropriate state of singing for any singer where the maximum improvement is required.

Thus, Case 1 is where the singer is singing the desired musical note accurately as well as precisely and therefore no improvement is required. Whereas, in case 2, 3 and 4, the singer is required to improve his singing. So while monitoring and evaluating the vocal pitch (for single musical note as input) only considering the accuracy doesn't provide the correct result (as in case 3: Accurate and Imprecise). Both accuracy and precision should be considered and reported with the appropriate feedback and suggestions for improvements accordingly.

VI. CONCLUSION

Music learning is not possible without any guru or trainer, but due to the constraints like availability and time, technology can be very helpful in music learning. In this paper, the methodology of monitoring and evaluating the vocal pitch (for single musical note) is discussed. For any singer it is very important to sing the musical notes correctly as well as consistently which is possible through regular music practise (Riyaz). While practising music practise (Riyaz), the singer may sing the musical note accurately as well as consistently, or may not. Accuracy is the agreement between the input value with the desired value. It does not reflect on the quality of the singing. Therefore, both accuracy (mean or average of the input values) and precision (evaluated using standard deviation) shall be taken into consideration while the evaluation of the vocal pitch. Thus, based on the methodology given, the music learner can get assistance in improvement towards at the better accuracy and precision.

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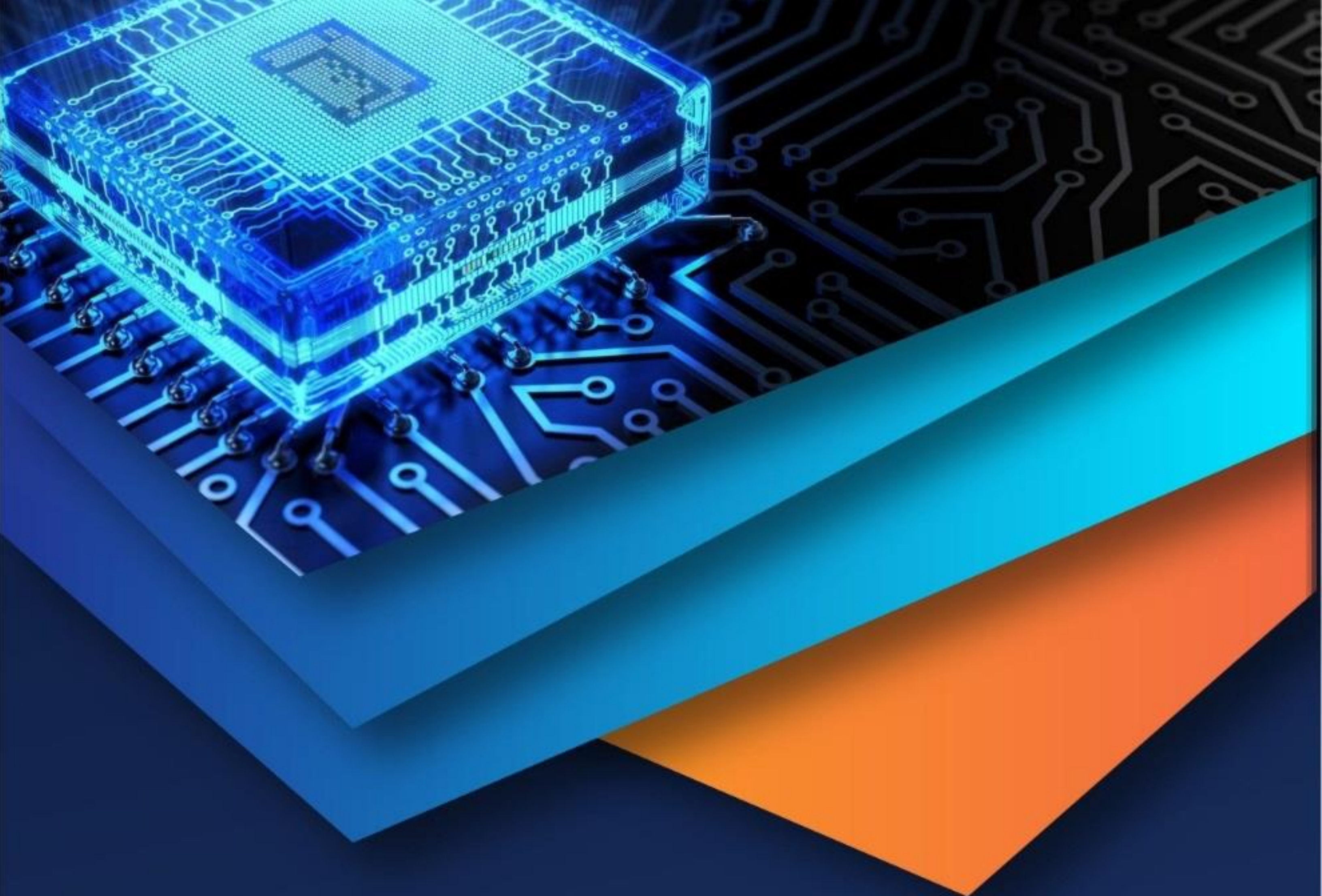

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