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Effect of Hand Structure and Mouse Design on Carpal Tunnel Pressure

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Abstract: ***Technological growth boasted the use of computers in almost every field, which keeps on increasing. Today industrial survey, feedback, online teaching, the entrance exam, tutorial became a very common trend. The online preparation for the entrance exam, tutorial and even the competitive exam are also preferred to be done through on line by just clicking the option of the multiple questions. In India most of the exams like PSUs, Bank Job, Railway recruitment board, entrance exams etc are taking the online paper for job. The preparation of such competitive exam needs devoting more time on computers for practicing online sample papers [1]. Hence the frequency of mouse use increases. The software programs for word processing, spreadsheet, database and graphics operations may require computer mouse use for up to two-thirds of the time. The duration of mouse use and the forces applied to the mouse by a computer operator while clicking are two risk factors that may play an important role in the development of musculoskeletal disorders [2]. Local muscle fatigue seems to occur in some light manual activities and could be considered a risk indicator [3]. This increases the need of an ergonomically designed computer mouse so that the performance as well as the safety of human increases. The objective of the study was to compare the effect of computer mouse designs on carpal tunnel pressure and human performance. The flexion of the index finger was measured to identify the carpal tunnel pressure and compared by the use of biometric software and instrument. Statistical analyses for the data was done, the results, showed that the carpal tunnel pressure and time duration to complete the task were dependent on the mouse and hand geometries of subject.***

Keywords: Carpal tunnel pressure, musculoskeletal disorders, flexion angle, extension angle, index finger.

I. INTRODUCTION

The human require an input device for the interaction with the computer system. Among lot of input devices, the most common input device used are the computer mouse and keyboard [4]. Both commercial & non commercial firm take the help of online feedback and survey to know the reality regarding their product or their services by that they can provide better services in the future or rectify their shortcoming so that they can stand the competitive atmosphere. There are lots of online job available based on surveying, data entry, form filling, and data analysis, research studies, problem solution, social awareness, learning etc. Many of the house wife and other people are doing such jobs as their part time or full time job. Apart from these jobs some countries like India is moving towards digital India doing most of form filling, conducting online examination, market surveying, online preparation etc. These all activities involve the clicking of mouse button by index finger [5]. The use of mouse is keep on increasing, the public are unaware of many facts that the continuous clicking of mouse button may lead to musculoskeletal disorders like tangling, tendonitis, tenosynovitis, synovitis, Ulnar nerve entrapment, carpal tunnel syndrome etc [6].

During data input mouse use, extensor muscle loading is more to hold the fingers over the keys. Out of several input interfaces (e.g. keyboard, joysticks, touch pads etc.) the most common input device used today is the computer mouse. Long periods of working at a computer can increase the chance of developing an injury. The sustained, static muscular activation patterns of the finger extensor muscles required to lift the fingers during mouse use [7,8]. During keyboarding, maintaining wrist and elbow postures of wrist for extended period create statistic loading [9].

II. METHODOLOGY

A. Task

The task involved the preparation of questionnaire sheet. The questionnaire sheet contained a number of categories and sub-categories survey questions. Every question had a scaling of 1 to 5 out of which most suited will be selected by the subject by using mouse click button. A screenshot of a page of questionnaire sheet is shown in figure1.

EXAMINATION AND EVALUATION

1)	**Assignment**	5	4	3	2	1
1.1	English Assignments helped me to assess my progress in studies					
1.2	English Assignments covered all the area of English i.e. Reading, Writing, Grammar and Literature					
1.3	Problems that were given in English assignments were appropriate to my ability					
1.4	The number of questions in English assignments were appropriate					
1.5	Questions given in the assignments were easy to understand					
1.6	I was motivated to complete all the assignments during PCP					
1.7	English assignments were evaluated regularly after its submission					
1.8	Feedback related to English assignment was given to me properly after evaluation of the assignment					
1.9	Feedback on the English assignments made me aware of my mistakes in studies					
1.10	English assignments helped me to do well in examination					
2)	**Examination**	5	4	3	2	1
2.1	Availability of on Demand Examination at Secondary Level made the study more convenient					
2.2	The number of questions in English examination papers were appropriate					
2.3	Questions proportionally covered all the area of English i.e. Reading, Writing, Grammar and Literature					

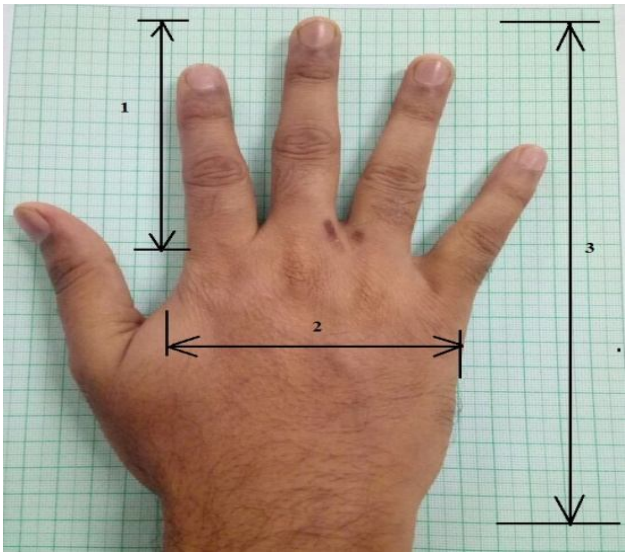
Fig. 1 Screenshot of questions asked during surveying task

B. Dependent Variables

In this study two variables (time & angle) were considered as performance measuring parameters. These were time to complete the task and angular deviation of flexion of the index finger to determine the carpal tunnel pressure. The null hypothesis was that these parameters had no effect on the geometry of the computer mouse and task duration.

C. Subjects

Thirty subjects were selected to perform the task. The mean age of the participants was 25.4 years and range of their age was 22 – 30 years. The population selected was the age group that involved most in human computer interaction activities. All subject reported using their right hand to operate the computer mouse. The sitting posture of subjects and apparatus set was identical. The surface area of subject's hand was measured. Figure 2 shows the hand of the subjects and their hand dimension used in this study.



1. Index Finger, 2. Hand Width, 3. Hand Length

Fig. 2 Hand Geometry

D. Mouse Type

In India scroll mouse is the most popularly used input device, hence this type of mouse is selected for study. Different mouse used in this study are shown in the table 1 below.

TABLE 1
PICTURE AND DIMENSION OF MOUSE SELECTED FOR TASK

Company/Dimensions(l x w x d) mm	Top View	Side View
(A) 98 x 56 x 34		
(B) 100 x 60 x 32		
(C) 117 x 64 x36		
(D) 101 x 52 x 32		
(E) 114 x 62 x 39		
(F) 98 x 56 x 32		

E. Experimental Setup

The subjects were explained about the task before recording started. The Figure 3 show sensor and other accessories used for recording of the index figure activity.

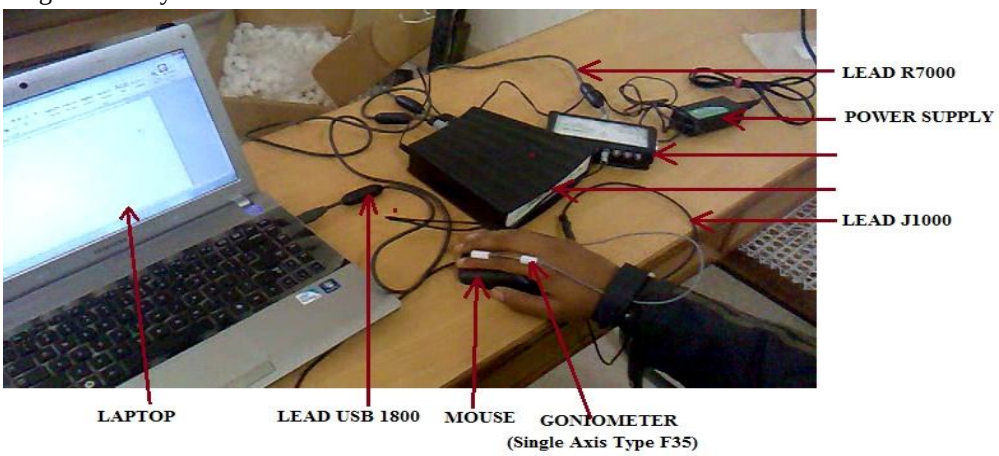


Fig. 3 Experimental Set up

III. PROCEDURE

Each subject performed the given task in sitting posture. Before starting the task, subject's hand geometry was measured. Computer, Computer peripherals, workstation and content, height of the chair, screen and mousing hand was same for all the subjects. Subjects were allowed to adjust their chair according to their comfort level. Subject were provided the oral instruction describing the task and instructed to complete the task quickly and accurately as possible without any given time limit. Each subject performed the same task using each of the six mouses, after a rest period of at least 30 minutes in between two consecutive tasks so that get relaxed. In this experiment, the Data Link software and hardware of M/s Biometric Ltd. (UK) was used to record the muscle activity. The recording was done at the sampling rate of 200/sec using Single axis goniometer sensor (Type: F35; Make: Biometrics Ltd. UK). The signal of goniometer was interfaced on the laptop using 8 channel subject unit of Data Link (DLk900: No. M11138 2009-09: Make) using R7000 Lead (Make Biometrics Ltd. UK) and then transferred to base unit after then to the laptop using connection lead (USB 1800 Make: Biometrics. Ltd. UK).The various component and sensor were attached in a systematic way to record the angle deviation while performing the task. The figure 4 show the layout / connection of the component used in the experimental set up

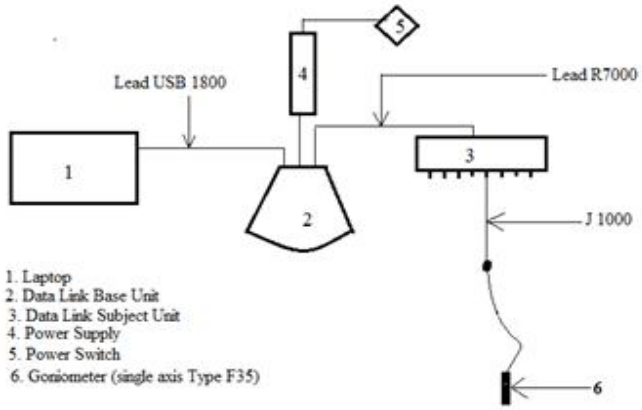


Fig. 4 Layout of the experiment setup

Single axis goniometer Type 35 sensor was attached on the mousing hand index finger of the subject to sense the angle deviation (flexion) pressing down the index finger to click the button and (extension) lifting backs the index finger, while performing the typing task. The other end of the single axis goniometer was attached J 1000 lead. This J 1000 connected the single axis goniometer to the Data Link Subject Unit. The Data Link Subject Unit has the 8 channels; the J 1000 was connecting to any of the 8 channels. This Data Link Subject Unit was connected to the Data link Base Unit by Lead R700. The Data Link Base Unit was further connected by power supply and laptop (USB port), One end of power supply was connected to the base unit while other to the switch. The Laptop and Data Link Base Unit was connected by Lead USB 1800. The Data Link Software was installed in the laptop which read the muscle activity on which sensor was attached. The figure 5 shows the screen shot of the data recording. The index finger angle deviation and time duration to complete the task for each mouse and subject was collected by the Biometrics Data link software. After completion of the task the recorder was stop and saved. The reading was exported by pressing E. Export data file icon was opened, where the data was exported to the desired file format for further analysis.

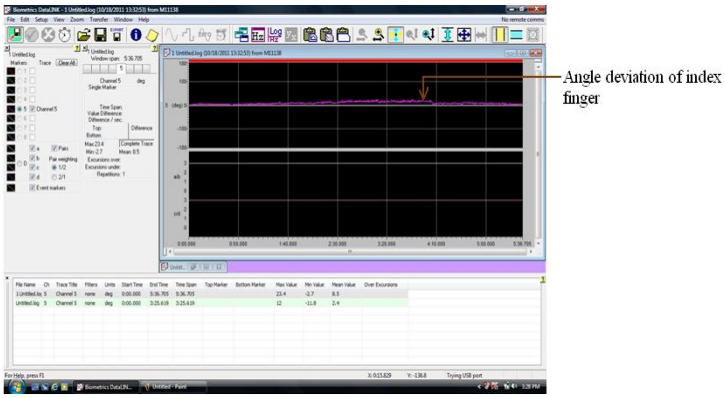


Fig. 5 Screen shot of the data recording

IV. RESULTS

In this study two types of data were collected for the comparison. These are
Duration of time to complete the typing task.
Angle deviation of the index finger while doing the task.

A. Time

The individual subject has taken different time duration to complete the same task by the different mouses. The statistical tool was applied to compare the effectiveness of mouse design on the basis of task completion time. We use the t-test so that each pair of mouse can be compared individually. The table 2 below is the summarized result of the compared data.

TABLE 2
PAIRED T-TEST ON THE DIFFERENT MOUSE PAIR FOR TIME TAKEN TO COMPLETE THE TASK

S.No	Pair	Sample	Mean	Std. deviation	SEM	T	df	P
Pair 1	A	5	5.906	1.21962	0.54543	0.237	4	0.824
	B	5	5.776	1.20981	0.54104			
Pair 2	A	5	5.906	1.21962	0.54543	2.381	4	0.076
	C	5	5.222	0.93588	0.41854			
Pair 3	A	5	5.906	1.21962	0.54543	1.52	4	0.203
	D	5	5.076	1.06627	0.47685			
Pair 4	A	5	5.906	1.21962	0.54543	1.822	4	0.143
	E	5	5.252	1.18113	0.52822			
Pair 5	A	5	5.906	1.21962	0.54543	0.182	4	0.865
	F	5	5.826	0.855	0.38237			
Pair 6	B	5	5.776	1.20981	0.54104	1.925	4	0.126
	C	5	5.222	0.93588	0.41854			
Pair 7	B	5	5.776	1.20981	0.54104	3.042	4	0.038
	D	5	5.076	1.06627	0.47685			
Pair 8	B	5	5.776	1.20981	0.54104	2.459	4	0.07
	E	5	5.252	1.18113	0.52822			
Pair 9	B	5	5.776	1.20981	0.54104	-0.24	4	0.822
	F	5	5.826	0.855	0.38237			
Pair 10	C	5	5.222	0.93588	0.41854	0.472	4	0.662
	D	5	5.076	1.06627	0.47685			
Pair 11	C	5	5.222	0.93588	0.41854	-0.169	4	0.874
	E	5	5.252	1.18113	0.52822			
Pair 12	C	5	5.222	0.93588	0.41854	-3.26	4	0.031
	F	5	5.826	0.855	0.38237			
Pair 13	D	5	5.076	1.06627	0.47685	-0.647	4	0.553
	E	5	5.252	1.18113	0.52822			
Pair 14	D	5	5.076	1.06627	0.47685	-5.307	4	0.006
	F	5	5.826	0.855	0.38237			
Pair 15	E	5	5.252	1.18113	0.52822	-2.796	4	0.049
	F	5	5.826	0.855	0.38237			

The data were analyzed at 95% confidence level. The Pair 7 (B-D), Pair 12 (C-F), Pair 14 (D-F), Pair 15 (E-F) was significant at 95% confidence level. This means that the change in the duration of time taken to complete the task was due to the mouse's geometry profile. While the pair 2 & pair 8 was just above the critical value. The graph between average time and the mouse type show a significant difference in their mean completion task.

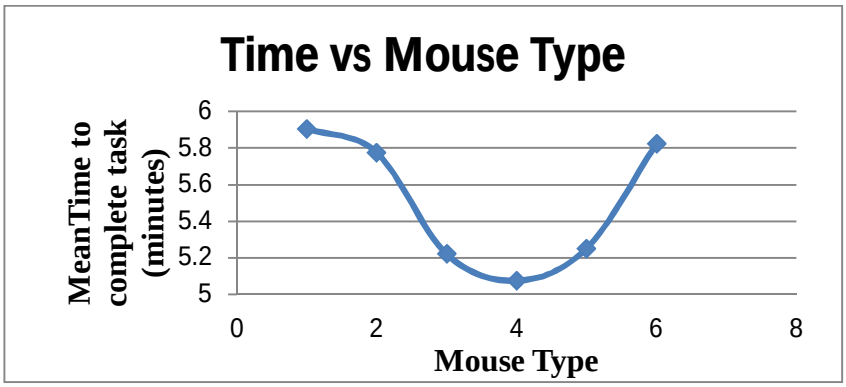


Fig. 6 Meantime of different mouse taken to complete the task.

Figure 6 show, there was difference in the meantime taken to complete the task by the different mouse. The mouse A take the maximum meantime (5.91 minutes) while the mouse D taken the least meantime (5.08 minutes) for task completion, while mouse C and E also have less meantime (close to the mouse D).

B. Finger flexion angle

Angle deviation of the index finger is due to the clicking of mouse button. When we use mouse, the single click is done by pressing down the index finger (flexion) and then lifting it back up (extension of the finger). Extension of index finger very much depend upon the mouse profile, activation force and the subject behavior of lifting the finger to avoid unnecessary activation of the key[10]. The carpal tunnel pressure is very much depended on the flexion angle. The statistical tool was applied to compare the mouse design on the basis of flexion of index finger. We use the t-test so that each pair of mouse can be compared individually. The table 3 below is the summarized result of the compared data.

TABLE 3
COMPARISON OF MOUSE ON FLEXION OF INDEX FINGER

S.No	Pair	Sample	Mean	Std.	SEM	t	df	P
Pair 1	A	207380	-4.3472	3.36669	0.00739	124.677	319543	<.0001
	B	112165	-5.9368	3.57181	0.01066			
Pair 2	A	207380	-4.3472	3.36669	0.00739	27.9445	340981	<.0001
	C	133603	-4.0528	2.3295	0.00637			
Pair 3	A	207380	-4.3472	3.36669	0.00739	224.77	369768	<.0001
	D	162390	-2.2119	2.05926	0.00511			
Pair 4	A	207380	-4.3472	3.36669	0.00739	153.003	348850	<.0001
	E	141472	-6.5001	4.94437	0.01315			
Pair 5	A	207380	-4.3472	3.36669	0.00739	49.6407	345475	<.0001
	F	138097	-4.86	2.26053	0.00608			
Pair 6	B	112165	-5.9368	3.57181	0.01066	157.078	245766	<.0001
	C	133603	-4.0528	2.3295	0.00637			
Pair 7	B	112165	-5.9368	3.57181	0.01066	345.304	274553	<.0001
	D	162390	-2.2119	2.05926	0.00511			
Pair 8	B	112165	-5.9368	3.57181	0.01066	32.0895	253635	<.0001
	E	141472	-6.5001	4.94437	0.01315			
Pair 9	B	112165	-5.9368	3.57181	0.01066	91.6881	250260	<.0001
	F	138097	-4.86	2.26053	0.00608			
Pair 10	C	133603	-4.0528	2.3295	0.00637	228.055	295991	<.0001
	D	162390	-2.2119	2.05926	0.00511			
Pair 11	C	133603	-4.0528	2.3295	0.00637	164.503	275073	<.0001

	E	141472	-6.5001	4.94437	0.01315			
Pair 12	C	133603	-4.0528	2.3295	0.00637	91.6696	271698	<.0001
	F	138097	-4.86	2.26053	0.00608			
Pair 13	D	162390	-2.2119	2.05926	0.00511	319.167	303860	<.0001
	E	141472	-6.5001	4.94437	0.01315			
Pair 14	D	162390	-2.2119	2.05926	0.00511	335.834	300485	<.0001
	F	138097	-4.86	2.26053	0.00608			
Pair 15	E	141472	-6.5001	4.94437	0.01315	112.343	279567	<.0001
	F	138097	-4.86	2.26053	0.00608			

The data were analyzed at 95% confidence level. Since the sample number of the pairs varies, so unpaired t-test was used. The p-value showed the different available design of mouse on which the experiment was performed, had significant main effect on the flexion angle of index finger. This means that the geometry of mouse has very important effect on the flexion angle of the index finger. The flexion angles also depend on the hand geometry of the subject i.e. flexion angle of index finger for different subject was different even for same mouse. The mouse geometry best fit to the hand has the minimum flexion angle. Figure 7 Show the graph between mean angle deviation and type of mouse used for experimental task.

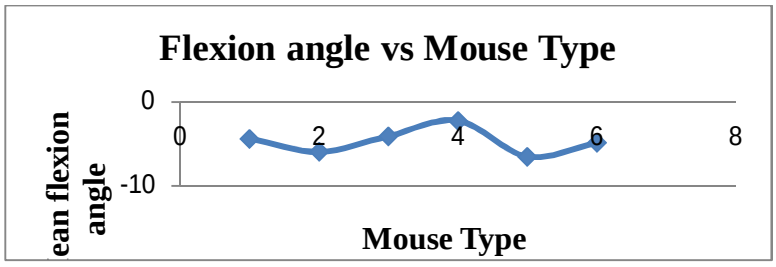


Fig. 7 Mean flexion angle of index finger for different mouse geometry

There were significant main effects of mouse on mean flexion index finger angles. The mean flexion angle of the mouse D was minimum (-2.21^0), while maximum for mouse E (-6.50^0). This difference was due to the design of mouse dimension.

V. DISCUSSION

The Figures 7 showed that the mouse design has significant effect on the flexion angle of index finger. The mean angle was minimum for mouse D, hence the carpal tunnel pressure was minimum while performing the task with it. The maximum carpal tunnel pressure experienced while performing the task with mouse E. Table 3 show there was a significant difference in each pair of mouse. From the above result it was found that the mouse fit to the hand caused less mean marginal angle deviation compared to the mouse which does not fit to the hand. The small size mouse do not fit on hand, result in unnecessary finger extension in order to avoid the unnecessary activation of the mouse button reducing the performance effectively and also develop high carpal tunnel pressure. This result was validated by other researcher. The subject has different hand dimension, but the maximum subject hand fit to the mouse C and D. In combination with extended wrist postures may play a role in the occurrence of forearm and hand/wrist pain during intensive mouse use [11, 12].

TABLE 4 DIMENSION OF MOUSE , MEANTIME AND MARGINAL ANGLE OF MOUSE TO COMPLETE THE TASK

S.No.	Mouse	Meantime	Marginal Angle	l	l 1	d	w	w 1
1	D	5.08	-2.21	101	51	32	52	26
2	C	5.22	-4.05	117	62	36	64	32
3	E	5.25	-6.5	114	39	39	62	31
4	B	5.78	-5.94	100	50	32	60	30
5	F	5.83	-4.86	98	46	32	56	28
6	A	5.91	-4.35	98	49	34	56	28

The task time increases with increase in the activation force of the mouse button. This may be due to the contour and shape of mouse was such that it fit to the hand of the subject (on the basis of subject response). The task completion time was affected by the mouse design (shape, size).

VI. CONCLUSIONS

The uneven extended posture of wrist and index finger may cause injuries, discomfort and reduction in performance of the subject. The mouse should be comfortable to hold and operate, compatible to the hand of varying dimension. Mouse D having less depth (32mm) has least (-2.21^0) mean angle deviation, while mouse E having large depth (39mm) had maximum (among selected mouse) mean angle deviation (-6.5^0). There was no significant effect (except pair 14) between different pair of mouse. But a trend was shown, with decrease in size the time duration to complete the task increases (exception mouse D). The smallest size mouse A had maximum meantime 5.91 minutes to complete the given task. The adjustable mouse (has movable sleeve which can be adjusted according to the hand geometry of the user) can be preferred, so that it should be best fitted on user hand. The design should promote a straight wrist posture, avoiding excess finger flexion (close buttons position) and static loading of the arm and shoulder (low force buttons) results in least carpal tunnel pressure.

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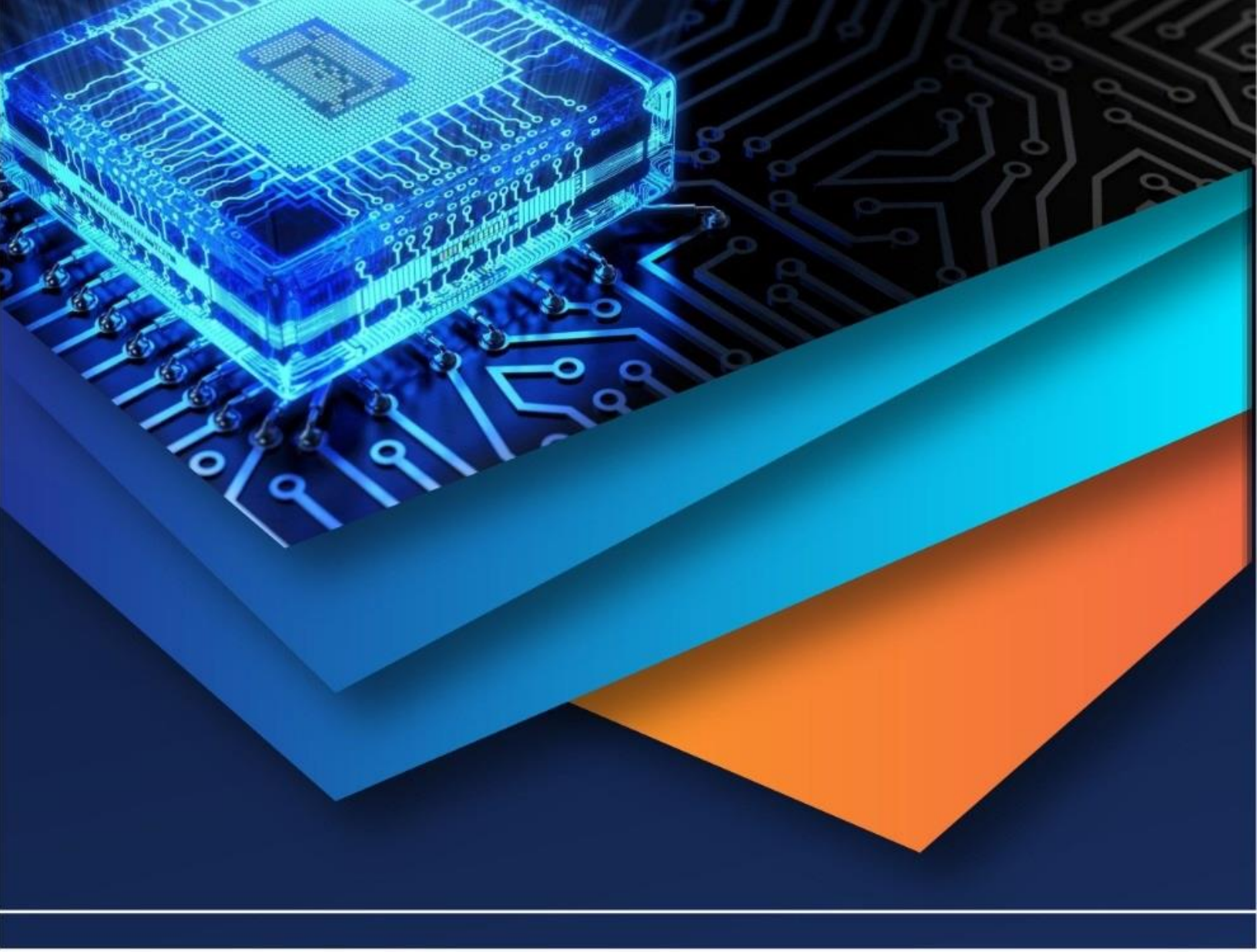

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