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Intelligent Control Systems for Physically Disabled and Elderly People for Indoor Navigation

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Abstract - The needs of many individuals with disabilities can be satisfied with traditional manual or powered wheelchairs, a segment of the disabled community finds it difficult or impossible to use wheelchairs. There is extensive research on computer controlled chairs where sensors and intelligent control algorithms have been used to minimize the level of human intervention. This paper describes a wheelchair for physically disabled people. This paper is to describe an intelligent powered wheelchair for handicapped person using voice signal, touch screen, ultrasonic and infrared sensor system which are interfaced with motors through microcontroller. When we want to change the direction, the touch screen sensor is modelled to direct the user to required destination using direction keys on the screen and that values are given to microcontroller. Depending on the direction selected on the touch screen, microcontroller controls the wheelchair directions. This can be controlled through the voice commands. The speech recognition system is easy to use programmable circuit that to be restored with the words which needs the circuit to be recognized. Possibility of avoiding obstacles by using ultrasonic sensors, downstairs or hole detection by using infrared sensors.

Keywords - Powered Wheelchair, Touch Screen, Infrared and ultrasonic sensor.

I. INTRODUCTION

Intelligent robots are currently developed to help disabled and handicapped people at a high speed, and will be a certain key area in the next 10 years [1]. Since the average age in our society is increasing notably in recent years, the number of people with severe motion impairments is increasing. The expenditure for healthcare and nursing is becoming a big burden for our society. On the other hand, the nursing staff is continuously reduced by the government and health authority in order to cut the cost. Therefore individual healthcare is becoming more expensive than before and people with medium and lower income are unable to afford such service.

Driving a wheelchair in domestic environments is a difficult task even for a normal person and becomes even more difficult for people with arms or hands impairments [2].Fig.1 shows a model of a wheelchair. Some patients who cannot manipulate the direction of the wheelchair with their arms due to a lack of force face major problems such as orientation, mobility etc. Robotic wheelchair is developed to overcome the above problems. Robotic wheelchair extends the capabilities of traditional powered devices by introducing control and navigational intelligence. These devices can ease the lives of many disabled people, particularly those with sever impairments by increasing their range of mobility. This paper aims to resolve the above mentioned issue. In this paper we are going to make a wheelchair which can be controlled automatically as well as manually.

There are different reasons for which people need an artificial means of locomotion such as a wheelchair [3]. The number of people, who need to move around with the help

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of some artificial means, because of an illness or accident, is also continuously increasing. Moreover implementing a controlling system in it enables them to move without the help of another person is very helpful. This means have to be increasingly sophisticated, taking advantage of technology evolution, in order to increase the quality of life for these people and facilitate their integration into their working world. In this way a contribution may be made for facilitating movement and to make this increasingly simple and vigorous, so that it becomes similar to that of people who do not suffer any deficiencies.



Fig.1 Model of Wheelchair

II. BACKGROUND

Improving life style of the physically challenged people to a great extent, in recent times these have been various control systems developing specialization for people with various disorders and disabilities. The systems that are developed are highly competitive in replacing the old traditional systems.

There are many assistive systems using visual aids like smart wheelchair systems, using joystick and much more [4]. These are even systems based on voice recognition too. There are certain drawbacks in these systems. They cannot be used by people of higher disability because they require fine and accurate control which is most of the time not possible.

Automatic wheelchair works on the principle of acceleration, one acceleration sensor, provides two axis, acceleration sensors whose output varies according to acceleration applied to it, by applying simple formula we calculate the amount of tilt and output of tilt will decide to move in which direction sensor gives x-axis and y-axis output independently which is fed to ADC and microcontroller and depending on pulse width it decides to move or not [4]. On chair obstacle sensors will be installed. Total 4 sensors will be installed for detection of wall/obstacle in the forward, backward, left & right direction. Depending on the movement of head, the motor moves in any of four directions. When person tilt his head in forward direction above 20 degree angle chair will move in forward direction like this way when the person tilt his head in any of the directions above 20 degree angle the chair will move in that direction. If person tilt his head at 45 degree forward priority will be given to forward direction. The following are the advantages and disadvantages of using an automatic wheelchair

1. Increased mobility, For disabled people who cannot use their arms to power a manual wheelchair, or for people who do not have the upper body strength to self-propel a manual wheelchair, power wheelchairs offer the ability to be mobile with the use of a joystick or mouthpiece, such as the sip and puff control described by Wheelchair.ca or a tongue-controlled wheelchair.

2. Increased Maneuverability, Power wheelchairs use casters that swivel a full 180 degrees to provide more maneuverability, especially in small areas, according to the Electric Wheelchairs Centre. Maneuverability is one of the key problems associated with wheelchair use. Power wheelchairs allow a disabled individual to get around tight spaces and move through smaller areas, which is especially beneficial at home.

3. Increased Physical Support, A power wheelchair can have the option to allow for more physical support, including adjustable seating such as tilt and recline. Power wheelchair users can also adjust the height of the chair to see their environment more clearly. Some power wheelchairs also have the option of elevation to help a person get to a standing position.

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1. The disadvantage faced by disabled people imposes significant economic and social costs.

2. Although power wheelchairs do have some disadvantages, many of them can be turned into advantages with extra money or additional features. Typically a power wheelchair will not fold up or come apart. Most individuals who need to travel may not have a van or larger vehicle to store the power wheelchair; therefore they will have to make other plans. You may have to purchase an additional manual wheelchair for trips. Another option would be to spend more money on a power wheelchair and purchase one that fold ups or will dis assemble fairly easily. The fold up power wheelchairs is available in most stores; however, they can cost quite a bit more than traditional power wheelchair.

In this paper they made a wheelchair which can be controlled automatically as well as manually [5]. This wheelchair controlled manually through head of the person sitting on it. He/she just need to move his/her hand into the direction it wants to move by using accelerometer. In automatic control user just need to press keys for saved destination. Then the wheelchair will move automatically move into the direction of saved destination by using encoder wheels. This chair also provide the another feature that is it can be operated by speech. The movement of powered wheelchair depends on the motor control and drive system which consists of microcontroller and motor driving. Once the voice recognition system recognizes voice commands in comparison to the stored memory, the respective coded signals would be sent to the microcontroller which then controls the wheelchair accordingly.

Fig.2 shows the block diagram of control system in the wheelchair for navigation with voice recognition. This wheelchair controlled manually through hand of the person sitting on it. The speech is recognised by the HM2007 IC and processed thus giving commands to the microprocessor accordingly and hence to robot accelerometer moves his position thus gives analog signal to microcontroller and convert it to appropriate digital level so as to move the motors of wheelchair. It is the heart of the entire system. HM2007 is a voice recognition chip with on chip analog front end, voice analysis, recognition process and system control functions. The input voice command is analyzed, processed, recognized and then obtained at one of its output port which is then decoded, amplified and given to motors of robot. The chip provides the options of recognizing either forty 0.96 second words or twenty 1.92 second words. This circuit allows the user to choose either the 0.96 second word length or the 1.92 second word length. For memory the circuit uses 8K×8 static RAM. The chip has two operational modes manual mode and CPU mode. This is an attractive approach to speech recognition for computers because the speech recognition chip operates as a co processor to the main CPU.

The jobs of listening and recognition don't occupy any of the computer's CPU time. When the HM2007 recognizes a command it can signal an interrupt to the host CPU and then relay the command code. The manual mode allows one to build a standalone speech recognition board that doesn't require a host computer and may be integrated into other devices to utilize speech control.

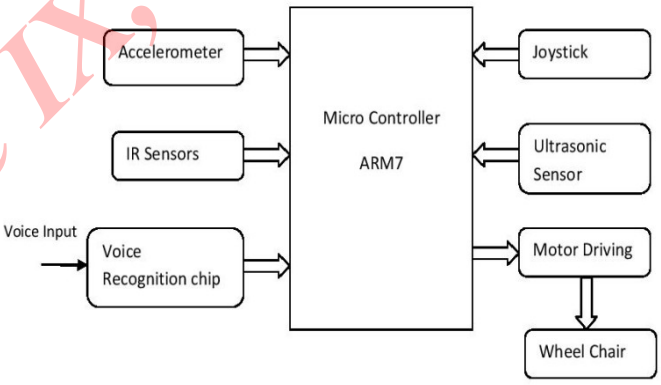


Fig.2 Navigation with Voice Recognition

When accelerometer moves or tilts his position thus gives analog signal to microcontroller and convert it in appropriate digital level so as to move the motors of wheelchair. The ADXL 335 is a small. Thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as

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dynamic acceleration resulting from motion, shock or vibration.

Infrared and ultrasonic sensors are used to detect the obstacle and downstairs. Fig.3 shows HC-SR04 ultrasonic sensor uses sonar to determine distance to an object. It offers excellent range accuracy and stable readings in an easy to use package. It operation is not affected by sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth can be difficult to detect)



Fig.3 Ultrasonic sensor

In this paper voice recognition system is used as interface. First the patient has to be mounting the wheelchair. Then the patient can give voice commands via headphone [3]. These commands are processed in MATLAB software and according signals are sent to microcontroller on board the wheelchair. The wheelchair is operated by 2 DC motors. The microcontroller operates these DC motors and controls the wheelchair accordingly. The other circuitry built into the wheelchair includes the transmitter and receiver circuits and the obstacle detection circuit. It involves two IR signal emitters which emit IR signals continuously when some obstacle appears in front of the wheelchair, these IR signals are obstructed, and reflected back. These reflected signals are then detected by the IR sensor present just at the side of the emitters. As the IR signals are detected, a circuit is connected to the buzzer, and the buzzer beeps. At the same time, signal is transmitted back to the voice recognition system so as to stop the wheelchair.

When the voice is detected, the wheelchair can be controlled to move in that direction by giving commands to the wheelchair. These commands are transferred to the wheelchair using electrical signals which are used the drive the left or right motor of the wheelchair. There are basically two motors connected to the left and right wheels of the wheelchair. The electrical signals are transferred to these motors using some hardware ports, called the communication ports. Generally, the communication port is the parallel port. There are some basic predefined pins of this parallel port which accept the commands given to the wheelchair in the form of electrical signals. For the purpose of demonstration of wheelchair movement using eye motion, a wheelchair model is designed in this project, which works on batteries.

Four wheels are used in the wheelchair for proper balancing. The movement of wheels is controlled by DC motors which are attached to the wheelchair. Two wheels located on left side of the wheelchair are controlled by one motor and similarly the wheels on the right side are controlled by the second motor.

This paper is to describe a wheelchair for handicapped person using voice and touch screen technology [2]. These two are interfaced with motors through microcontroller. When we want to change the directions the touch screen sensor is modelled to direct the user to required destination using direction keys on the screen and that values are given to microcontroller. This controls the wheelchair directions. Wheelchair can be controlled through voice commands using voice controller. The speech recognition circuit is the system to be trained the words the user wants the circuit to recognise.

In the system shown in Fig.4, there are two input devices, speech recognition system and touch screen. In order to select a specific input device we are using a switch that is when the switch=1 voice recognition system is considered and when switch=0 touch screen is considered. The output of the touch screen is analog in nature, to digitize these signals we are using in-built six channel ADC of ATMEGA8 micro controller. On receiving the Signal the microcontroller directs the motors through the control circuit. In this, two DC brushless motors are used for controlling the two wheels of the chair independently.

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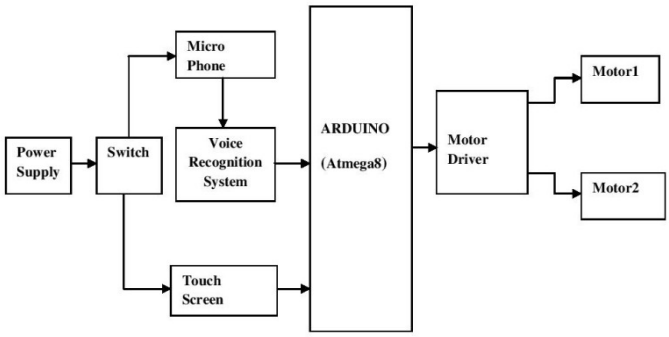


Fig.4 Navigation with Touch Screen

The different directions of motions possible are:

Forward: Both the motors in the forward direction.

Backward: Both the motors in the reverse direction.

Left: Left motor stopped/Right motor in the forward direction.

Right: Right motor stopped/Left motor in the forward direction.

The code is written in arduino such that the speed of the motors is controlled by using PWM output pins of arduino. The motors are controlled with four different speed levels that is with 100% duty cycle, 75% duty cycle, 50%duty cycle, 25% duty cycle.

Touch screen is a 4-wire analog resistive touch screen. That is by touching the screen at one point, resistance between edges is formed for both the x and y axis. As you move your finger across the screen the resistance changes between opposite sides of each axis. By applying voltage across each axis, a change in resistance results in a change in voltage. Thus a simple ADC with a microcontroller can be used to find x and y positions. Add this touch screen to any LCD of requirement. Readings are taken by applying 5V across two of the pins and performing an analog to digital conversion on the other two pins. The full X and Y position can be achieved by using only 4 GPIOs.

In this paper, the controller of intelligent wheelchair adopts the DSP technology, and plays the role of data acquisition and processing of joystick and ultrasonic sensors [1]. 8 ultrasonic sensors are mounted on intelligent wheelchair for safe operation. A DSP device is adopted as the centre processor of the controller, 8 ultrasonic sensors mounted around the intelligent wheelchair for obstacle detection.

As a member of the TMS320C24x generation of TI DSP chips offers high performance processing capabilities and a high level of peripheral integration. The high performance 10-bit analog to digital converter has a fast conversion time of 500ns and offers up to 16 analog input channels. Ultrasonic sensors are widely used in various kinds of mobile robots due to their properties of low cost, simplicity, easy installation and low energy consumption. Intelligent wheelchair is equipped with 8 ultrasonic sensors which are fixed around the wheelchair at a height of 50cm. There are 4 sensors at the front, 2 sensors at the back, each one at the left and right. The space around the wheelchair is divided into 4 modes according to the distance from the wheelchair, which are No-obstacle mode(above 2 cm), Detected mode (1m-2m), Approaching mode(50cm-1m), and Stop mode(0-50cm).

In this paper, the wheelchair has been integrated with dependent user recognition system, ultrasonic and infrared sensor system [6]. Design an electronic system which could be installed in commercially produced electric wheelchairs. Guiding the wheelchair by means of oral commands as well as joystick. Incorporate sensor safety system in wheelchair which would permit obstacles and presence of stairs or holes in ground. Ultrasonic or infrared sensors have been chosen for use as external sensors. Infrared sensor is located in the front part pointed, at a certain angle, towards the floor. The point that justifies the use of infrared sensors for the detection of staircases or pronounced changes in levels is that with ultrasonic sensors, working at frequencies in the range of 50KHZ, it is not possible to make measurements on a floor which is not very rough. With the angle of incidence needed to make the wheelchair stop at a discrete distance in the presence of a staircase or hole.

All the electronic system and the philosophy for functioning have been sufficiently refined to achieve the following performances.

- To respond to the speed requirements for a system of this type(maximum speeds of up to 3m/s)
- To be easily adaptable to any type of commercial wheelchair chassis

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- To facilitate learning to handle the chair and obtaining maximum efficiency
- To make the system easily configurable, on the basis of the needs of the user: activating or deactivating of the various sensors, selection of different voice patterns, selection of different speed margins, human-machine interface which permits up to date information on the state of the wheel chair.
- To make it possible for the same wheel chair to be used by various people without the need for recording the voice patterns each time the wheel chair is to be used.

Fig.5 shows the selection process for each of the driving modes. It can be noticed that selection is necessary among the driving modes before connection to the manual control and voice/autonomous control systems. This choice is made by means of a manual switch. If the chosen mode is voice/autonomous the system comes into the voice control mode. In this mode, every time the work track is pronounced, the mode automatically switches between voice control and autonomous control.

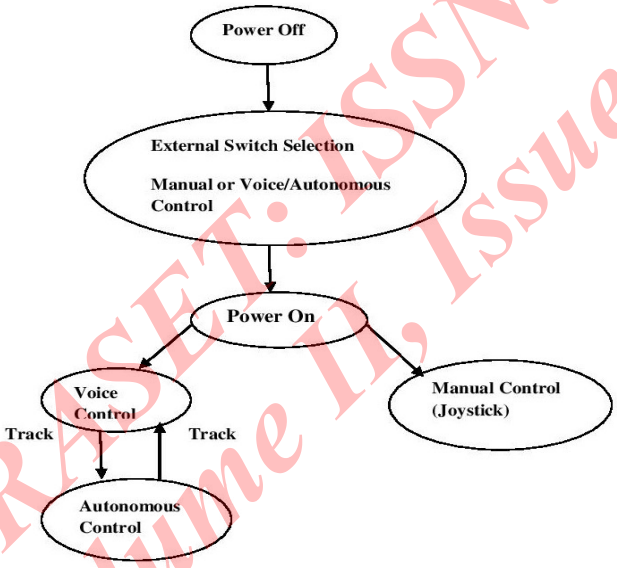


Fig.5 Mode Selection

III. COMPARATIVE STUDY

The automatic wheelchair can be controlled or operating in different modes joystick, voice recognition and touch screen technology. In joystick mode the wheel chair can be controlled manually through hand of the person sitting on it. In voice recognition mode, the wheelchair can be controlled in two different methods. First, the speech is recognised by the HM2007 IC and processed thus giving commands to the microcontroller accordingly and hence to robot. Second, the patient can give voice commands via a headphone. These commands are processed in MATLAB software and accordingly signals are sent to microcontroller on board the wheelchair. In touch screen technology, the touch screen sensor is modelled to direct the user to required destination using direction keys on the screen and that values are given to microcontroller. This controls the wheelchair directions.

In some wheelchairs, the controller of wheelchair adopts the DSP technology and plays the role of data acquisition and processing of joystick and ultrasonic sensors. Automatic wheelchair works on the principle of acceleration sensor provides two axis acceleration sensors whose output varies according to acceleration applied to it, by applying a formula we calculate the amount of tilt and the output of tilt will decide to move in which direction.

The wheelchair is incorporated with sensor safety system that is ultrasonic and infrared sensors. Ultrasonic sensors are used for detection of downstairs or holes in ground and infrared sensors are used to detect obstacles.

In this way some systems uses joystick, touch screen and voice recognition and some uses acceleration sensor with ADC for navigation and all systems must works with the sensor for object detection either by using ultrasonic or infrared sensors.

IV. CONCLUSION AND FUTURE SCOPE

Recent advancements in the technology are making lives easier for everybody. The system was successfully implemented to move the wheelchair left, right, forward, backward or stay in same position. This work is to help the disabled persons by providing alternative methods to control the equipment either by touch screen or through voice, there

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by serving many disabilities. Thus the wheelchair understands the signals coming from control system and reacts accordingly. The efficiency of the voice command control system can be further improved by implementing neural network based algorithms.

In the future work, is to provide a friendly atmosphere for disabled persons that is alerting in case of obstacles and updating the whole indoor environment condition to wheel chair and giving controlling of the devices at wheel chair itself which avoids the problem of approaching the switch.

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Author Biography

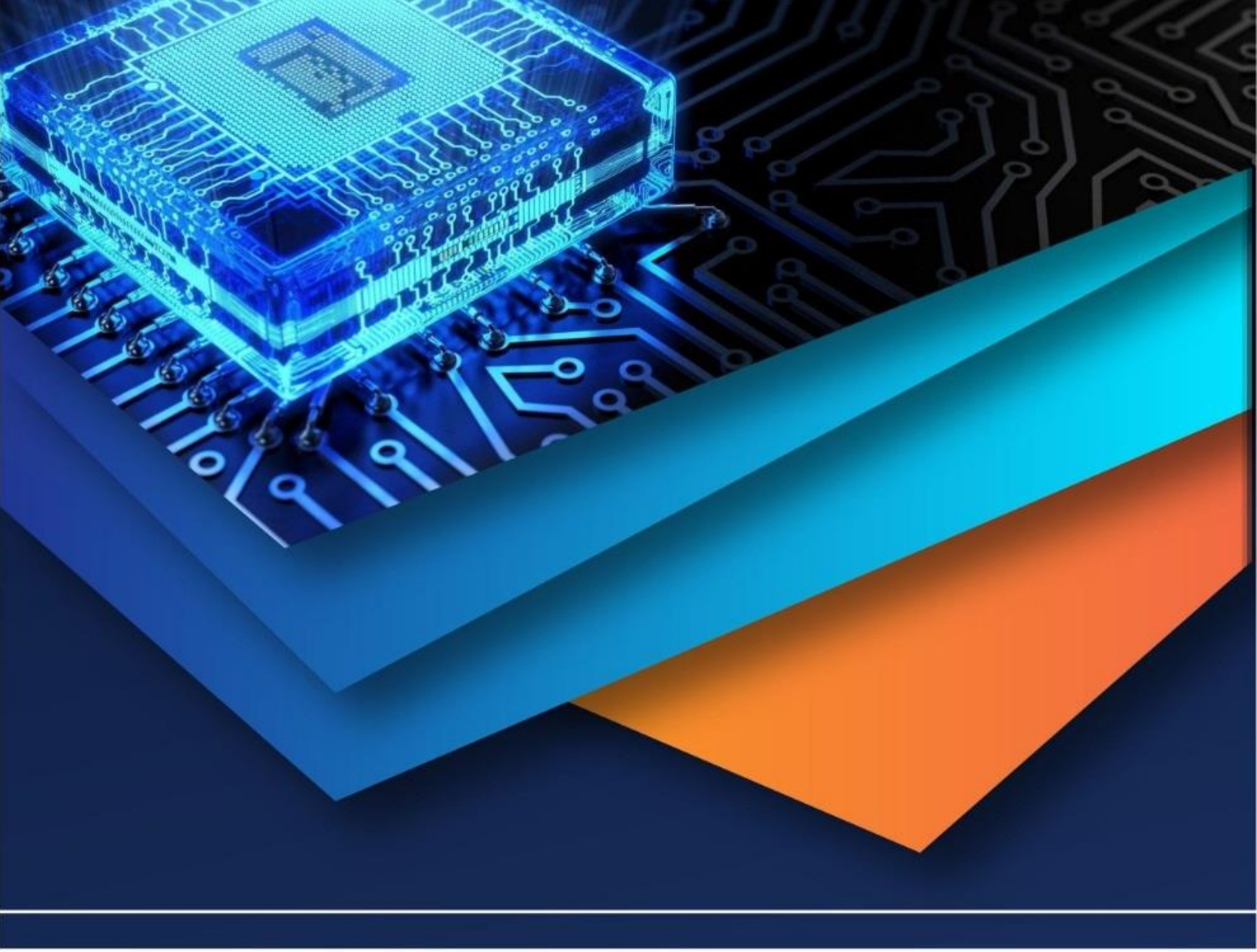


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