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A Survey on AI Based Fire - Fighting Robotics

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Abstract: ***According to survey India witnesses [1] 25,000 deaths every year due to fire and related accidents. Even though there are a lot of precautions taken for Fire accidents, these natural/man-made disasters do occur now and then. within the event of a hearth breakout, to rescue people and to put out the fireside we are forced to use human resources which are not safe.. There are many fire accidents which fire fighter had to lose their lives in the line of duty each year throughout the world. Detecting the fire and extinguishing it is a dangerous job and that puts fire fighters in risk.***

With the advancement of technology especially in Robotics it is very much possible to replace/support humans with robots for fighting against the fire. This is able to improve the efficiency of fire-fighters and would also prevent them from risking human liveshis would improve the efficiency of fire-fighters and would also prevent them from risking human lives. Robotics in AI contains many advantages to save human hectic life from fire. So, this paper contains many existing system introduction which will be helpful to prevent human life through fire. It also includes some common components used to build fire fighting robot and methods for implementation of fire fighting robots.

Keywords: Robot, Robotics, Sensor, Fire detection, smoke detection, detector, fire, fire department, fire fighting robot, AI, Artificial Intelligence, components, fire fighting

I. INTRODUCTION

There are many methodologies to protect human life from fire. In that one of the best advancement technologies is the robotics. There are so many types of robots implementation using different methods like Autonomous robot, Android application based robots, DTMF based robots, Voice operated robots, etc.

This many robots contain different functionality according to the use [2]. Today many popular ways are there to operate any machine by using smart phones like android. This methods is very easy because mobile phones contain the feature mobility so human is very friendly to operate their machines at any time and from any place in the world. All tasks can be performed at any time anywhere by providing particular human instruction using mobile phones.

Many systems are available to prevent human life using mobile. In many fire fighting applications robots are used and that robots are operated using mobile phone android application. Robot movements, foot-steps, extinguish fire, sensing fire, sensor enable or disable and all other things can be controlled by using android application at remote location. Using Wi-Fi facility (communication) the android phone can control fire fighter robots. Through Wi-Fi communication with other devices, the data can be transferred from application to another robot device [3].

A robot capable of fighting a simulated household fire is getting to be designed and built. It must be able to autonomously navigate through a modelled floor plan while actively scanning for a flame. The robot can even act as a path guider in normal case and as a hearth extinguisher in emergency.. Robots designed to find a fire, before it rages out of control, can one day work with fire-fighters greatly reducing the risk of injury to victims [4].

Many types of Fire fighting robot design based on IOT available in the world. The robot will not only extinguish the fire but can even act as path guider.

The wireless cameras mounted surrounding the robot, to scan surrounding. Many sensors mounted surrounding to detect flame, human casualties and fire extinguishing if the Wateriest turbine connects with the robot [5]. The robot development is consisting of three elements which is that the hardware, electronic, and programming. Various sensors are also interfaced with PIC16F877A as a feedback to the robot like photoelectric sensors, fiber optic sensor and RGB color sensors. LCD display also gives the graphical information of the robot status to the user [6].

This paper includes implementation method for firefighting robot, different sensor types, their uses in robotics, common components used to build fire fighting robots, different fire fighting robots with comparison among different fire fighting system, advantages and disadvantages of robots. So, one can get easy ides about implementation of AI based fire fighting robot.

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II. LITERATURE SURVEY

This section includes information related to different implementation method for fire fighting robots, Robot sensor types and uses of sensors in robotics. It also includes different fire fighting robots with comparison among different fire fighting system and common components used to build fire fighting robots.

A. Implementation Methods For Fire Fighting Robot

Following figure shows Hierarchy of Robot Implementation methods. Then short information on different Robot Implementation methods is provided.

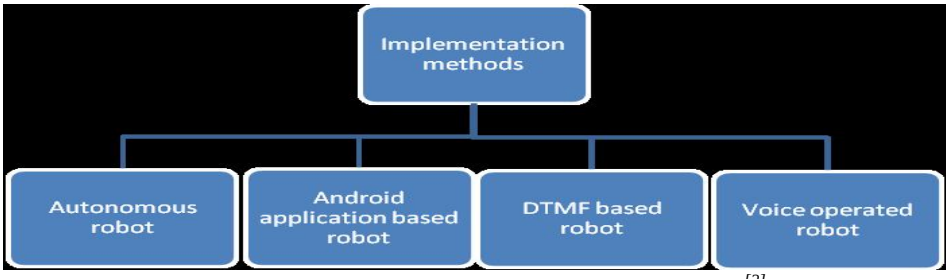

Fig-Hierarchy of Robot Implementation methods [2]

1) *Autonomous Robot:* The robot presented by the authors is an embedded system in real time. The robot is implemented using a variety of hardware and software components built around the C language. There are two modes of operation namely autonomous and manual controlled. The mode of operation is directed to the robot using the computer module making use of HyperTerminal.In the autonomous mode of robot, the robot monitors its surroundings to perceive any fire hazard. IR fire sensors are used on all four sides of the robot and the electrical output of the sensor is amplified by a simple transistor amplifier. The amplified signal is fed to the in pins of the microcontroller PIC18F4550. Metal detectors are placed on the front and back side of the robot which determine the presence of bombs in case of a battlefield. The output of the metal detector is amplified and fed to the microcontroller. The input from the fire sensor has higher priority than any other task. When a fire is detected, the microcontroller directs the motors and activates the actuators. A water tank is mounted on the board, which has a 10 rpm DC pump motor. Depending on the direction of the shot, the robot aligns itself, according to which the motor pump is on. The water reservoir is connected to the pipe whose end is mounted on the head of the robot and the water is sprayed on the fire, thus fight against fire.[2]

a) *Advances and Limitations:* This system is intelligent as it operates in two modes. But in autonomous mode, it will take more time to find the exact location of fire and to reach there and extinguish it due to self alignment system of robot. So accuracy is less.

2) *Android Application Based Robot:* Android is open source software, manufacturers can modify the operating system according to their needs and their respective phones. This becomes a cheap and feasible alternative for the manufacturer. Android OS is Very customizable. It is an open source operating system that is easily modified, hacked, manipulated and molded to fit all the features you had in mind. Found on all platforms for all prices depending on the hardware and software version that interests you. Author had used ARM7LPC2148 microcontroller to control robot. It is shown in fig-4. The Android Bluetooth control application is used as the transmitter. And the receiver is a robot. Wireless commands are sent by Android phone and are received via the Bluetooth module on the robot. It receives the data serially and send it to ARM controller via MAX232 IC for decoding the command .For movement of vehicle DC motors are interfaced to controller.[2]

a) *Advances and Limitations:* In our daily life, the use of Android OS is increasing rapidly. It's a intelligent system controlled by an Android application. More precise results are obtained in this project. There is also no error occurrence in results. The only limitation is the range of the Bluetooth module which is around 50 feet..

3) *DTMF Based Robot:* The author proposed an intelligent robot with a sound activation using DTMF technology with two servomotors for robotic arm, two DC motors for the movement of the robot, two fans to extinguish the fire, ultrasonic sensor, compass sensor, detector flame, thermal network sensor. Tank robot is activated by sound, so it is designed with DTMF (Dual Tone Multi Frequency) transmitter and receiver[2].

a) *Advances and Limitations:* DTMF technology is complex for controlling the robot. It is cost effective. But it require DTMF transmitter and receiver.

4) *Voice Operated Robot:* The design and implementation of a voice-activated fire extinguisher vehicle. The vehicle is controlled by voice input by the operator. The language input allows a user to interact with the robotic vehicle. The speech recognition system is trained in such a way that it recognizes predefined commands and the robot navigates depending on the instruction through the voice commands.[2]

a) *Advances and Limitations:* The advantages of voice-activated robots are rapid data entry and hands-free operation. Speech has difficulty being recognized by an application. Because the speech varies for each speaker. It can be fast, slow or vary in speed. Can also be acute, acute or whispered. Have very different types of environmental noise. The system is affected by surrounding noise and therefore noise interference is a big problem. This leads to an error in the results.

B. Robots Sensors Types

Measure the robot's internal state and they are used to measure its position, velocity and acceleration using the internal sensors. The position of the joint (the degree to which the joint is extended) measure using the position sensors. Consecutive position measurements at known intervals and computes the time rate of change in the position values measure using the velocity or speed sensors. A proximity sensor detects the presence of the objects. There are many sensors uses for different purposes such as the ultrasonic sensors, the capacitive, the photoelectric, the inductive or the magnetic. The proximity sensors contain the track of objects (ultrasonic sensors). For the advanced applications and advancements of technology generally it is using the image sensors (webcams) and the vision software like OpenCV. Image sensors are digital cameras, camera modules and the other imaging devices based on CCD or CMOS technology. [13]

C. Uses Of Sensors In Robotics

The sensors are one of the useful technologies that play the vital role in the field of robotics. Sensors are highly required in the robotics in safety monitoring; inter locking in work cell control. Sensors are used in industrial robotics to monitor dangerous and safety conditions in the layout of robot cells like sensing the fire, motion of objects, pick up the load, measuring load etc... They help in avoiding the physical injuries and other damages caused to the human workers. In the robot work cell, the series of activities of various equipment is controlled using locks. The quality control was carried out with the manual inspection system and the measurement of the resistance of the system.

Now a day, the sensors are used in the inspection process to determine the quality features of the work part automatically. The sensors provide very precise results in all areas such as fireplaces, the medical field, industries and factories, etc. The sensors are used in the collection of object data in the robot work cell to determine the position or other related data on devices, work pieces, equipment, human workers, etc. Apart from sensing the position, It is implemented to find out the other information like the work part's color, the orientation, the size, the shape, etc. Image quality is important in applications that require excellent robotic vision because the identification of things and place using the clear image of that. Algorithm based on the wavelet transform for fusing the images of different spectra and different foci improves the image quality.

Robots can collect more precise information from the resulting improved image. Visual sensors help robots identify the environment and take appropriate action. The tactile sensory signal is useful for identifying external tactile signals for precise operations. Tactile models allow robots to interpret human emotions in interactive applications. The robots uses touch signals to map the profile of the surface in hostile environment such as the water pipe. The robots programming integrated with the sensors. The robots first acquire the random data point. The automated robots require the specific guidance program to reach at place. [14]

D. Common Components Used To Make Fire Fighting Robot

The fire-fighting robot consists of mainly following common components:

1) Flame Sensor Modules[17]
2) EN54-5: Temperature detector[18]
3) EN54-7: Smoke detector[19]
4) DC Motor Driver[20]
5) DC Gear Motor[21]
6) Fire Extinguisher[8]
7) The wheels
8) The motor clamps[22]

9) The jumper cables or wires[23]
10) Screws etc,
The tools required are Soldering Iron [24] , Multi-meter, Arduino[25] ,Sensors[26] ,Wi-Fi, Internet

E. Different Fire Fighting Robots

Many sensors are used to sense the fire like smoke detector[7], gas sensor etc. Fire extinguisher protect to the fire but the people must need to know the idea about how to operate that extinguisher[8]. Fire alarm system provide alert to the human to save their life. That system is much more costly according to that facility. Fire alarm system does not provide first-aid facility to protect with the fire[9]. Sprinkler is one system that provide many facilities that protect through the fire. Sprinkler need more space for installation. The sprinkler pipe installed on the whole ceiling. When fire occur at that time the water will be sprinkled in the whole room to stop fire occurrence at one single corner. Sprinkler will not spray water on specific fire space that's way so many things will be damaged through that fire. So the sprinkler required more space to install and cost of that system is much more according to the facility[10]. When human was not available at the room/shop and door locked from outside and their child or pet animals are inside that room/shop. In this situation if fire occurs in that room/shop then using currently working system we cannot protect that innocent life from the fire. So currently experiencing system cannot provide the first aid facility to protect from the fire.[15]

TABLE 1. Comparisons among Different Fire Fighting System

System/ Feature	Smoke detector[7]	Fire alarm system[9]	Sprinkler[10]	Fire extinguisher[8]
Automatic fire detection	Yes	Yes	Yes	No
Manually Operate	No	No	No	Yes
Automatic Work	Yes	Yes	Yes	No
Alert people	No	Yes	No	No
Automatic fire fighting	No	No	Yes	No
Alert fire Department	No	No	No	No
First-aid work(AI based)	No	No	Yes	No

The fire fighting robots can save a lot of lives someday. Robots can be useful in certain types of incidents where the environment will be very dangerous for the humans such as the hazardous materials, the radioactivity or the prop and tank which can explode. The fire fighting robot will make using fire proof material like EPE [11][12] so they cannot harm any people.

The robots assisting fire fighters are not an often perfect sight. There are many robotic devices available which can already be used for assist the fire-fighting people. When the humans cannot enter that place robot is used to fight the fire. Robot can identify the fire location and it can move automatically towards the fire location. If there are any obstacles then robots turn automatically. Once the robot detects the fire location then it can take many clear pictures of the fire place (according to camera capacity) regularly and it sends it to the central system like fire-department, government safety offices…etc. The artificial intelligence fire fighting robot is movement based robot is also possible to make. It is used to sense the fire and it spreads the water over that direction, we use RF communication to communicate between the robot and the control room that is placed in the remote place.

The fire fighting has two sensors. It moves in all the directions from its position. When the flame or high temperature point is detected by the robot's sensors, the robot will stop automatically and it indicates the fire that has been detected and start the basic activity to extinguish the fire.

The fire fighting has the micro controller that is the most important put of the design. It acts as the brain for the robot. It interfaces all the sensors and the motors. It contains all the code for the robot operations.

The controller is the part of the robot which operates the mechanical arm and it maintains the contacts with its environment. This device is the combination of the hardware and the software which helps it to carry out its assigned tasks.

Most of firefighting robots are controlled remotely. They are tethered by the fire hose which supplies the water. They have infrared and standard cameras that transmit the images back to the operator for saving the humans life.

The firefighting robot helps to detect the exact direction of the fire source using multiple types of sensors. It has the capability of sensing accurately with increased flexibility. Low cost in the long run. It is reliable and economical. By placing the sensors appropriately we can efficiently detect the location of fire.

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III. ADVANTAGES OF ROBOTS

A. Robots can go to the planets. They can be used to explore the space. They can spy on the people in ways the people can't move and from views the humans can't reach.[16]
B. They can give us the information that the humans can't get. Robot can work at any places 24hr in a week without any salary and food. Plus they don't get bored to do all that things regularly basis.
C. Robots can perform the tasks faster than the humans and much more consistently and accurately because the people were very talented and they use their own mind to do all that things. But sometimes human over smart mind create a big problem. They become more common each and every day.
D. The robotic pets and many AI based robots can help the patients with depression and they keep them active. They can entertain us and they can help us in certain tasks like to pick up the things from one place to another, cleaning floor, do some basic activities on regular basis etc....
E. Most of robots are automatic so, you can send them to a dangerous environment such as the deep sea or the war-zones.
F. You can use robots to produce the products in the factories such as assembling the cars, joining the car parts, cleaning some parts there human cannot reach. They can also be used to build the parts for many products such as the plane parts, the car parts & the construction supplies.[16]
G. Robots do anything which human need to be much precise and accuracy.
H. New jobs are created because the people have interested to fix and new interested designs of robot.
I. Robots can work without sleep. So, they can work 24/7/365.
J. They can be used to dig for the fuels from earth. They can be used for mining purposes because in that people need much time to do that thing. They can be harnessed and suffocating for exploring the depths of oceans.
K. They can be used to overcome the limitations that humans have because the every person contain capacity to do the entire thing in many domain related activities.
L. Robots can be used in carrying out time-consuming tasks and repetitive tasks very efficiently.
M. They are used to do dangerous tasks where human cannot reach. They can adjust their feature related parameters like their speed , time, height, direction etc... They can act quickly basis and cannot affect any human.
N. They can work a long time without getting bored or maintenance provided regular basis and they can be more productive than the people work.
O. They have performed medical surgeries like physiotherapy, eye surgeries, suzerains etc… because they can be faster and more precise than the people.
P. Robots are designed to work in very harsh and dangerous environments like in space, without the air, underwater, in the fire and inside the land. They can be used instead of the people when the human safety is more required.
Q. Robot can come in any size according to their work. Robots can do the jobs that the human are unwilling to do.
R. Many robotics probes have been sent throughout the solar system to never return back to Earth. Robot can be stronger than the people. Robots in the warfare and many situation eliminate putting more people at risk.[16]

IV. DISADVANTAGES OF ROBOTS

A. Robots need a power supply to do their work.[16]
B. The people can lose their jobs in factories because the robots take the humans space in factories.
C. The software and the equipment for robots is much more costly. Robots take much money in maintenance and repair.
D. Changing the requirements updated according to robots features that can suit the new requirements.
E. The machines need to be made smarter because the people cannot reach at a time. So the robot is able to take decision according to situation.
F. In case of breakdown and cut off the power supply of robot, the robot lost their data and code so the procedures to restore lost code or data may be time consuming and very costly.
G. Robots can store large amounts of data but the robot does not contain their own brain so storage access and retrieval is not as effective as the human brain.
H. Human can perform repetitive task for long time and they get better experience with time but robot does not contain their own mind so the robot does not contain experience with time.
I. Robots are not able to do any extra task that is different from what they are programmed to do.

J. With the heavy application and advancement of robotics, the humans may become overly dependent on the machines, losing their mental capacities and losing their passions.
K. Robot controlling done by any wrong person then robot may cause the destruction.
L. Robots are not intelligent because they do not contain their own brain.
M. They can never give the results of their jobs outside of their predefined programming.
N. They do not think. They do not have emotions or conscience because the robot does not contain their own brain.
O. Many limits for the robots can help the people and interact with people.
P. Robots can take the place of many humans in factories. So, the people have to find new jobs. They can take the place of the humans in several situations like in factories, medical industries, industries etc... If the robots begin to replace the humans in every field of work then they will lead to unemployment. that is biggest problem in the whole world.
Q. Many Humans contain fear of robots. Robots inspire two types of fear: firstly, that robot might take over people's jobs and secondly, that robots could take over the whole world.
R. Robotics become increasingly present in our everyday or regular life like with household robots, medical field, industrial field on production lines robots, airports, banks, and hotels. So, Robots may be stolen the human species in most of every field. *[16]*

V. CONCLUSION

In this paper, we have discussed many implementation methods of fire fighting Robots. Among which, Android based robot controlled is superior for fighting towards fire. Also provide different uses of robotics for fire fighting. Robots contain many advantages and disadvantages to save people life through fire. There are many different kind of robots are present in the world to extinguish fire. This paper provide different robots information and how to make fire fighting robot for specific purposes like extinguish fire using robot, fire detection using robot, surrounding objects detection and when to avoid use of robot. Common components used to build a fire fighting robot is also illustrated which will be very much useful for beginners to implement working fire fighting robot.

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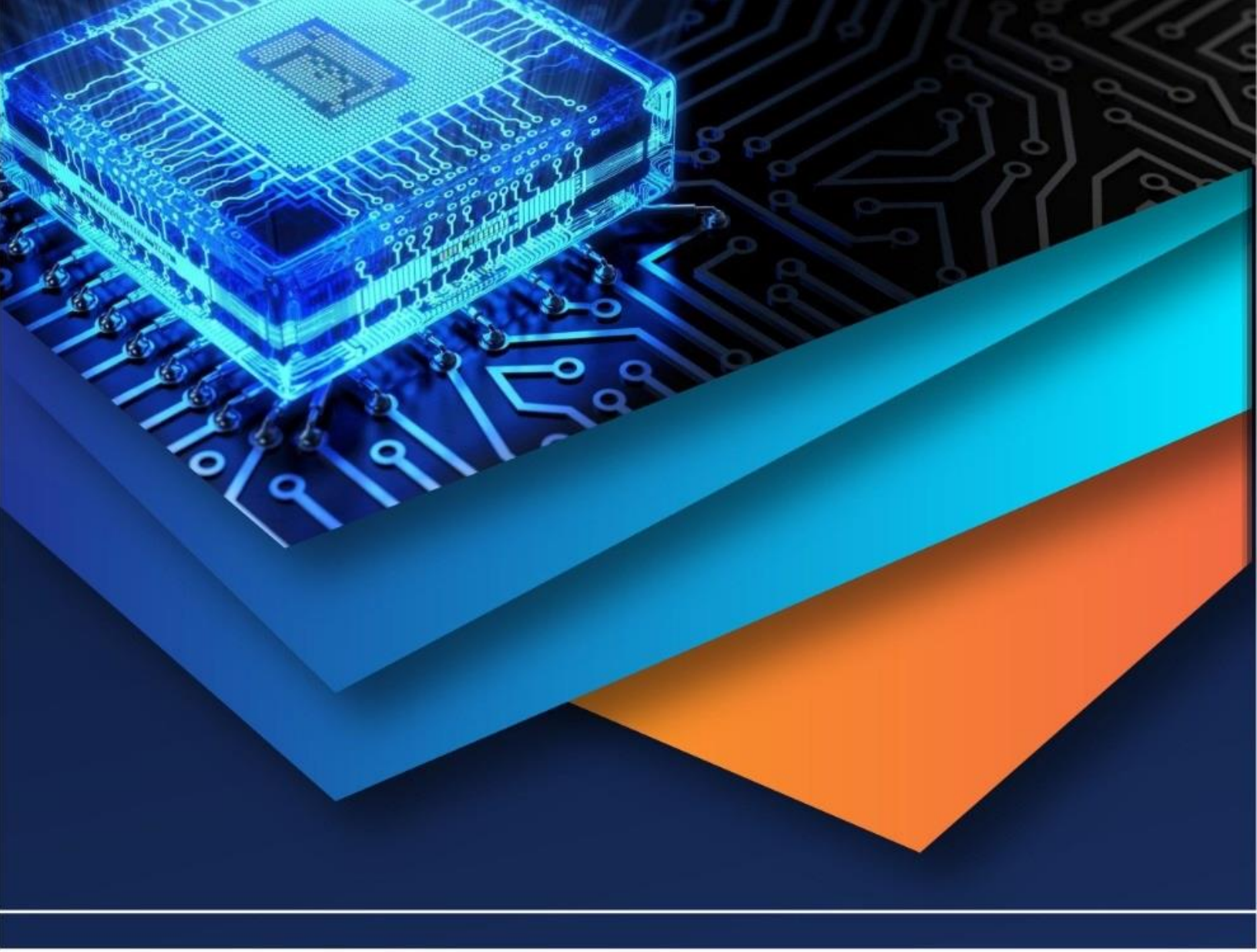

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