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Obstacle Detection and Wireless Warning System for Forest Railway

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Abstract: ***Indian Railway has connected almost every part of the country. It has made travelling easy at a comparatively cheaper cost. And a part of railway run through deep forest, due to which some animals, specially big animals like elephant get injured or killed and also hamper smooth running of trains due to the damage it face due to collision.***
Our aim in this project is to develop a system which will reduce these mishaps to a great extent and smooth running of railway will be carry on.
Strain gauge load cells can measure weight up to a certain limit. It is used to measure weights of different objects. On the other hand, a transceiver can transmit as well as receive signals wirelessly. nRF24L01 is one of such kind of transceiver. Previously there have been many works using these two separately.
Our target is to incorporate both of these two components in a single system which would contribute largely to one of the lifelines of the country, i.e. the railway.
The purpose of this project is solely devoted to the railway that goes through forests. On successful implementation the system will be able to detect the movements of animals on railway tracks and send warning signals, thus ensuring safety of both the animals as well as the passengers. Consequently, this will decrease the number of accidents and loss of the Indian Railway as well.
Keywords: Railway accidents, load cell, nRF24L01, Asian elephant, wireless communication, warning system

I. INTRODUCTION

The word Dooars means ‘door’ in a few Indian languages. The backdrop of this project is named so because it is considered to be the gateway of the great Himalayas. Dooars is situated in the district of Jalpaiguri of the state of West Bengal, India. It covers about 140 km of the northern Jalpaiguri.

Dooars is famous for its dense forest and rivers like Teesta and Sankosh flowing through it with low hills in the background. Dooars is also known for its famous wildlife sanctuaries like Jaldapara National Park, Gorumara National Park, Chapramari Wildlife Sanctuary, Buxa Tiger Reserve etc. The concerned railway track, the New Jalpaiguri-Alipurduar-Samuktala runs through Dooars. These sanctuaries are home of numerous wild animals and elephant is one of them.

Inevitably, these elephants often get run over by speeding trains while trying to cross the track. A large number of elephants have been killed by speeding trains.

There have been restrictions on the speed of trains, particularly at night, followed by protests by the local population. The ultimate target of our project is to make such an automatic system which would reduce this kind of mishaps.

The North-Frontier Railway has proposed the construction of a new broad gauge railway line from Sevoke in Northern West Bengal to Rongpo in Sikkim through 32.586 ha. (the Gola, Chawa, Andheri and Ruyem blocks) of the Mahananda Wildlife Sanctuary, West Bengal. According to Biswapriya Rahut, Secretary, the Society for Preservation and Awareness of Wildlife and Nature (SPAWN), Jalpaiguri, the proposed track will pass through an important site for Asiatic elephants, leopards, Asiatic black bear, wild dogs, gaur and a near-isolated tiger population.

This project will have a great impact on the environment causing an ecological imbalance because there will be loss of wild lives due to the speeding locomotives.

Till now Indian Railway could not find a concrete solution to this problem, of running locomotives smoothly through forest. Only precautionary measure have been taken, like speed restriction.

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II. MODEL ARCHITECTURE

This project is consisted of two parts:

A. Obstacle Detector and Wireless Warning Signal Transmitter

In transmitter part, four components are used. 1) Load cell, 2) HX711, 3) Arduino Uno and 4) NRF24L01 transceiver.

1) *Load Cell:* One of the most important components of this project is Load Cell. A load cell is a type of transducer, specifically a force transducer. It converts a force as a tension, compression, pressure into a electrical signal that can be measured and standardized.

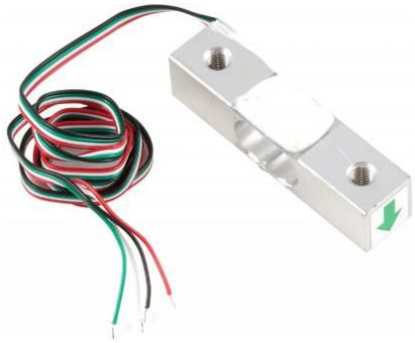

Fig 1: Shear beam and bending beam type load cell

Source: https://www.flipkart.com/robodo-portable-electronic-weight-sensor-load-cell-scale-1-kg-driver-components-hobby-kit/p/itmf9afswyuazezk?pid=EHKF98X7Z32UZYYH&lid=LSTEHKF98X7Z32UZYYHRQGP4T

In this project 3KG Share Beam and Bending Beam Load Cell was used. Generally these load cells have four wires, viz. red, black, white and green. Red indicates the positive (+ve) excitation and black indicates the negative (-ve) excitation. White colour indicates the negative (-ve) output and the green colour indicates the positive (+ve) output from the load cell.

2) *HX711 Load Cell Amplifier:* HX711 is another important part of this project. HX711 is a precision 24-bit Analog to Digital converter (ADC) designed for weight scale and industrial control applications to interface directly with the load cell. It has two sides, one is Analog side and second one is Digital side.

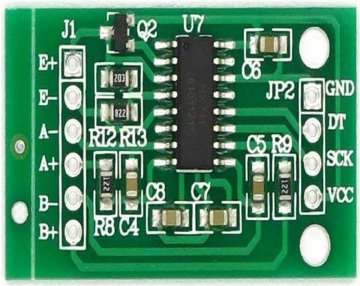

Fig 2: HX711 load cell amplifier

Source: https://robu.in/product/hx711-weighing-sensor-dual-channel-24-bit-precision-ad-weight-pressure-sensor/

In Analog side there are 6 pins: E+: Excitation Positive, E- : Excitation negative, A-: Channel A Negative Input, A+: Channel A positive Input, B-: Channel B Negative Input, B+: Channel B positive Input.
In Digital side there are 4 pins: GND: 0V/ Ground Power Connection, DT: Data 10 Connection., SCK: Serial Clock Input, VCC: Power Input.
The output signal produced by the load cell is in range of milivolts and a microcontroller like Arduino Uno is required to process the output of the load cell. However, Arduino only works in Volt range. So the output of the load cell needs to be amplified from mV to V. For this purpose, we use HX711 amplifier. This amplifier includes an HX711 chip for analog-to-digital conversion. The HX711 amplifier amplifies the low-voltage output of the load cell and sends it to the Arduino so that the Arduino can calculate weight from this data.

3) *NRF24L01 Transceiver:* NRF24L01 transceiver can be used for wireless communication between two Arduino UNOs. Clear from its name, it can work both as a transmitter and a receiver.

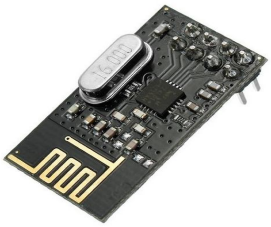

Fig 3: nRF24L01 transceiver with built in antenna

Fig 4: nRF24L01 transceiver with external antenna

Sources: *https://robu.in/product/nf-01-s/?gclid=CjwKCAjw2a32BRBXEiwAUcugiKePx_APs0W1pm02u6SStltg3sKMjBLBMSAjFLFMffjj3gfHd6TrkxoCmSgQAvD_BwE*
https://www.deltakit.net/product/nrf24l01-wireless-2-4ghz-pa-lna-transceiver-module/

It has 8 pins. The pins are – VCC (+3.3 V), CSN (Chip Select Not), MOSI (Master Out Slave In), IRQ (Interrupt) , GND (Ground), CE (Clip Enable), SCK (Serial Clock), MISO (Master in Slave Out), IRQ (Interrupt).

4) *Arduino UNO:* It is the data processor of this project which is used not only in the transmitter part but also in the receiver section. It operates the entire project.

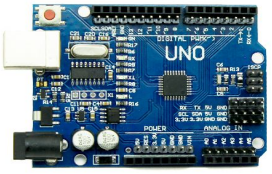

Fig 5: Arduino UNO

Source: *https://robu.in/product/arduino-uno-r3-ch340g-atmega328p-devlopment-board/?gclid=CjwKCAjw2a32BRBXEiwAUcugiLJMXJzYyDP1aA3BBSymHDXTUh_4JJuY39G6TaEeaGAg_Y2NIu5uIhoC1TMQAvD_BwE*

B. Receiver and Warning System

In receiver part following components were used – 1) Arduino Uno, 2) NRF24L01 transceiver, 3) I2C BUS, 4) Piezoelectric Buzzer, 5) LCD

1) *Arduino - NRF24L01:* This connection is similar to the previous connection.
2) *16×2 LCD:* This is a basic 16 character by 2 line alphanumeric display. It shows dark green text on light green background. It utilizes the extremely common HD44780 parallel interface chipset.

Fig 6: 16×2 LCD

Source: *https://www.amazon.in/Silicon-TechnoLabs-Alphanumeric-Display-JHD162A/dp/B00XT53RI0*

3) *I2C BUS:* All the 16 wires coming out of the LCD make the circuit messy. To overcome this problem we used I2C BUS. I2C cuts short 16 to 4 terminals and make it simpler. It has 4 pins. The pins are –VCC, GND, SDA and SCL.

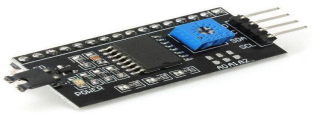

Fig 7: I2C BUS

Source: *https://www.amazon.in/REES52-Display-Interface-Address-Changeable/dp/B01IKT5RVY*

4) *Piezoelectric Buzzer:* It is a type of electronic device that is used to produce a tone, alarm or sound. It is lightweight with a simple construction. Here it is used as a warning alarm.

Fig 8: Piezoelectric Buzzer
Source: https://www.pcboard.ca/minipiezo-buzzer

C. Suggested Model

As the circuit diagrams in the next chapter suggest the systems are completely isolated so whatever has to be done wirelessly. When the sensed weight is above the predetermined value, i.e. 108 grams in this case, it will transmit a signal and if the receiver part is within range it receives the signal and buzzes the buzzer as well as shows a warming message on the LCD screen. If we put 100 grams on the load cell the receiver does not respond. But if we put 108 grams or more then the buzzer buzzes and the LCD shows "WARNING!!! ELEPHANT AHEAD!!"

Range of this wireless system is very wide, depending on the range required; we can use different modules to increase the range because we need at least one kilometer of distance to stop a train. Another type of NRF24L01 transceiver is available with external antenna, having a claimed range of 1.1 km. So for real life implementation this type of transceivers is required.

D. Flow Chart

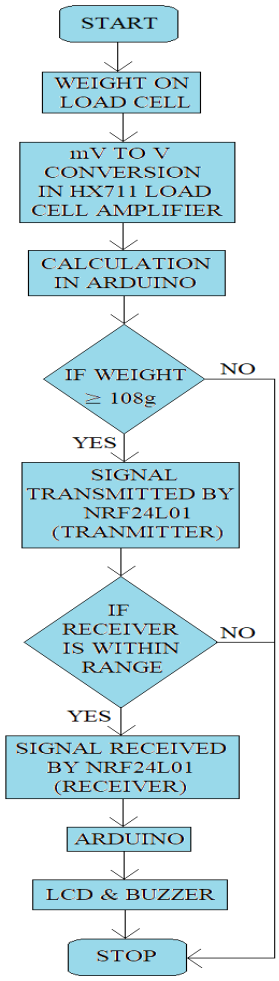

Fig 9: Flow chart

E. Functional Block Diagram

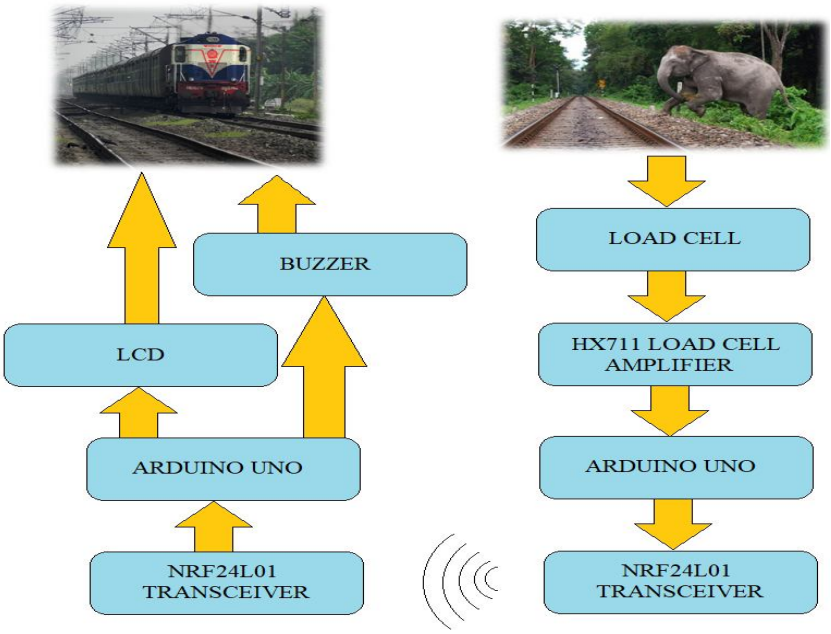

Fig 10: Functional Block Diagram

III.HARDWARE MODEL DESCRIPTION

Now we are ready to learn about the hardware. As mentioned before, fundamentally this project is consisted of two parts: i) obstacle detector and wireless warning signal transmitter, ii) receiver and warning system. However, before using the load cell in the transmitter circuit it needs to be calibrated against a standard weight.

A. Calibration of Load Cell

First, it is required to calibrate the load cell against a standard weight of 100 grams. Necessary program is loaded in the Arduino and connected to the circuit. The serial monitor is turned on. It shows "Weight Measurement", "Calibrating... Please wait..." During this time the Arduino cancels out the weight of the weighing surface mounted on the load cell. Then the serial monitor shows "Put 100 g and wait". A standard weight of 100 grams is placed on the weighing surface. Serial Monitor shows "Please wait..."

After some time it shows the weight as "Measured weight 100 g". Now, the system is calibrated and ready to measure weights of other objects.

For calibration following components were used:

1) 3kg shear beam and bending beam type load cell
2) HX711 load cell amplifier
3) Arduino Uno

Load cell – HX711 amplifier connection is shown in the following table:

TABLE I
LOAD CELL – HX711 CONNECTION

Wire Colour of Load Cell	HX711
Red	E+
Black	E-
White	A-
Green	A+

HX711 – Arduino UNO connection is shown in the following table:

TABLE III
HX711 –ARDUINO UNO CONNECTION

HX711	Arduino UNO
GND	GND
DT	5V
SCK	A1
VCC	A0

B. Obstacle Detector and Wireless Warning Signal Transmitter

In obstacle detection model following components we used:

1) 3kg shear beam and bending beam type load cell
2) HX711 load cell amplifier
3) Arduino Uno
4) NRF24L01

Here, the circuit is same as the previous one, only new inclusion is an NRF24L01 transceiver. Load cell is used for measuring weight and HX711 amplifier amplifies the milivolt to Volt. NRF24L01 is used to connect two Arduino wirelessly. When the load is more than 108 g then NRF24L01 send the signal to the receiver module.

Load cell – HX711 connection and HX711 – Arduino UNO connection are same as Table I and Table II respectively.

Arduino UNO – nRF24L01 transceiver connection is shown in the following table:

TABLE IIIII
ARDUINO UNO – NRF24L01 CONNECTION

Arduino UNO	nRF24L01
VCC	3.3V
GND	GND
CE	PIN 7
CSN	PIN 8
SCK	PIN 13
MOSI	PIN 11
MISO	PIN 12
IRQ	No Connection

C. Receiver and Warning System

In this part following components were used:

1) Arduino UNO
2) nRF24L01 transceiver
3) Piezoelectric buzzer
4) LCD
5) I2C BUS

Positive terminal of the buzzer was connected to PIN 2 of the Arduino UNO and negative terminal was connected to GND.

LCD has 16 pinholes and I2C BUS has 16 pins. I2C BUS is connected on the back of the LCD. Output pins of the I2C are connected to the Arduino UNO. That connection is shown in the following table:

TABLE IV. I2C BUS – ARDUINO UNO CONNECTION

I2C BUS	Arduino UNO
VCC	5V
GND	GND
SDA	A4
SLC	A5

IV. LIMITATIONS AND SOLUTIONS

The problems discussed above are very hard to solve in real life due to their complex nature. Hence, this project cannot be claimed to be flawless. Hence the limitations and corresponding solutions are given below.

A. Limitations

1) *Range:* Range of the NRF24L01 transceiver used is only about 40 – 100 meters in open air. But it requires at least 1 km of distance to stop a train. So the range of the transceiver modules is a big problem.
2) *Curved Track:* As mentioned before, the transceiver can transmit signal properly in open air. But there are numerous occasions where the railway tracks are curved and the vicinity of the curves are covered with dense forest.
3) *Uncertainty:* It can never be 100% guaranteed that the elephants will always try to cross the tracks where the obstacle sensing and signal transmitting unit is installed.
4) *Power Supply:* Both of the systems run on battery, i.e. DC source. It would be a troublesome job to change the battery of the underground unit whenever it runs out.

B. Solutions

1) *Longer Ranged Transceiver:* Long ranged NRF24L01 transceiver is also available. The one with external antenna has a claimed range of about 1.1 km. Neither codes nor the circuits need to be changed to use this one. So at a little higher price the range of this project can be easily increased.
2) *GPS:* The problem with curved track can be solved by GPS tracking. However, this method would be very costly and hectic. It is not going to be an easy task to tag and track all the elephants.
3) *Precise Survey & Installment of More Sensing Unit:* Very precise and continuous survey has to be done to track down all the accident prone areas and those records need to be regularly updated. Based on the recorder data, more sensing units have to be installed to minimize uncertainty.
4) *Solar Powered Rechargeable Battery:* The regular batteries can be replaced with solar powered rechargeable batteries.

V. CONCLUSIONS

In this era of advanced technology we need to upgrade our transportation system too. The growing population needs more trains where safety is the major part. The time has come to safeguard the passengers from railway accidents and provide safety throughout the journey. On the other hand, forest railway in India is the witness to another scenario of tragic man-animal conflict. It is really ironic that the same railway whose official mascot is Bholu, an adorable elephant, is unfortunately turning out to be a terminator of this majestic creature. Measures have to be taken urgently to stop such accidents. Elephants are already endangered because of the poachers who illegally hunt them down for the priceless ivory of their tusks. If both of these perils keep crashing down the elephants from either side, that day is not far away when there will be no elephant left in those forests.

VI. ACKNOWLEDGMENT

The initial idea of this project came from Mr. Souvik Mukherjee, co-author of this paper. Choice of components was made by Mr. Subhradeep Gupta and Mr. Shamik Chakraborty, other two co-authors. Gratitude is due to co-author Mr. Sayan Mondal for his continuous efforts to publish this paper. Two more co-authors, Ms. Sayani Sarkar and Mr. Anupam Chakraborty did their needful to make this paper publishable. Finally, the last co-author, Mr. Basudeb Dey was the guide of this project. Without his guidance this project and paper would never be completed. Eventually, both the project and this paper were results of rigorous and relentless efforts of all the co-authors combined. Finally, we are indebted to Dr. Papun Biswas, Head of the Department of Electrical Engineering, JIS College of Engineering, all the faculty members, all the websites and all whosoever have contributed to provide help to carry out the present work.

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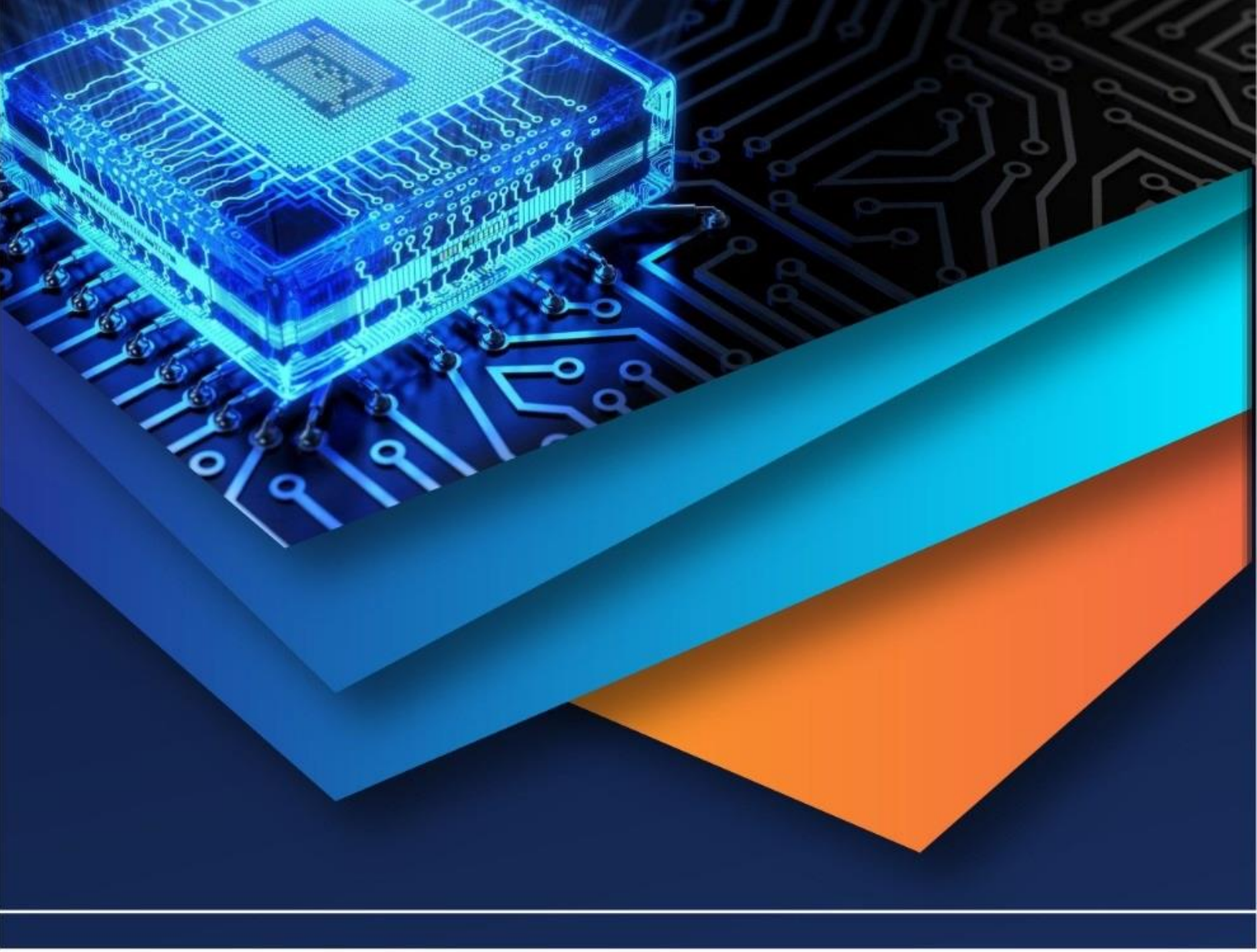

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