Pothole Detection System

Author 1: V. Harsha Vardhan

Author 2: Dr. Uttam Mande

Author 3: K. Vasu

Author 4: P. V S Suraj Puranjay

Department of computer science and Engineering

Centurion University of Technology and Management – Vizianagaram – AP

ABSTRACT

One of the primary issues faced by emerging countries is the maintenance of road condition. Traffic infrastructure for the society is highly significant because majority of road accidents takes place owing to bad condition of road like potholes. Potholes are caused due to poor quality and improperly maintained roadways. The constant movement of the overweight vehicles like trucks is also responsible for these ill roads. These ill quality roads will cause severe damage to the vehicles in terms of tire and most important thing is the accidents which are caused due to this. To track the state of the roads and conduct analyses for upcoming work, an ideal system should be created. We suggest a new technique to stop these dangers by leveraging an advanced sensor system. The sensors will be fitted to vehicles and from vehicles the data's collected from sensors and the location gained by the GPS are communicated to road transport authority through IOT where officials take necessary actions. Using the data's obtained more damaged area can be prioritized and damage control can be reduced.

Keywords: IOT, Sensors, Prioritization, Analysis, Road safety

Introduction

The development of a country is measured with the condition of its roads and their maintenance. Good road conditions offer an ease in transportation and ensures the dynamic nature. But, road accidents, which occur due to a variety of reasons, pose a major problem in smooth operation of transportation system. One such reason which brings hurdles in a hassle-free road transportation is the presence of potholes, which multiplies the risk of such accidents. Hence it implies to the need for an immediate repair of potholes by the authorities. The increase in the number of potholes caused road accidents often leading to fatal injuries, poses a need for an urgent solution to the problem. According to a survey, a total of 3597 deaths occurred due to potholes in the year 2017 and the count is increasing every year. This requires efforts from the government side to be more cautious. Moreover, providing pothole location information to the government officials will help them in repairing the damaged roads which can bring down the count of pothole caused casualties. A lot of research is presently being carried out to estimate the road surface to determine the presence of potholes. To achieve the same, there are two different approaches, which include, the vision-

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 12 | December - 2022 Impact Factor: 7.185 ISSN: 2582-3930

based approach and the vibration-based approach. Out of the two, the vision-based technique revolves around capturing the road images and applying complex image processing algorithms to detect the potholes. The vibration-based approach or the sensor-based approach deploys the usage of sensors to detect the potholes by actually passing through it. This method can also be used to determine the intensity of pothole apart from just detecting them. One advantage of this over the other is, it doesn't require complex algorithmic approach or large processing power. The project's hardware consists of an Arduino-based sensing model working with ultrasonic sensor and accelerometer sensor or g-sensor.

III. Hardware Components and Design

To develop the Pot hole detection the requirements are :

a. Ultrasonic Sensor
b. Accelerometer Sensor
c. Arduino Uno
d. Node MCU
e. GPS Module

HARDWARE SPECIFICATIONS:

The hardware components used to build the above –mentioned prototype, are described below:

Ultrasonic sensor (HCSR04):

It is a distance sensor, used to determining the proximity of an object without any physical contact involved. It consists of two special pins namely 'trig' and 'echo', which send the ultrasound signal and receive (after colliding an obstacle) respectively. The below mentioned basic equation, can be used to determine the distance. Distance = Speed x Time where, speed = speed of sound time = time for which the 'echo' pin is high. Ultrasonic sensor operates at a voltage of 5v, connected to the 5v pin of Arduino UNO and the ground terminal connected to the Arduino ground pin. Practically, it can measure distances ranging from 2cm to 80cm and operates at a frequency of 40kHz.

Accelerometer sensor (ADXL335):

It is an electro-mechanical device, that will measure the accelerometer force. It is the triple-axis accelerometer, with signal conditioned output voltages, to measure the static acceleration of gravity in tilt-sensing applications, resulting from shock or vibrations etc. The resulting X,Y,Z voltages are analog in nature. This sensor operates within a voltage range of 1.8v to 3.6v.

Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328.It contains 14 digital input/output pins in which 6 of them can be used as

PWM output pins, 6 analogue pins, 16MHZ crystal oscillator, a USB connection, a power socket, ICSP pins and a RESET pin. It comes with everything required to support the microcontroller, so all we need to do to get the Arduino working is connect it to a computer using a USB wire. Connecting it to a PC (personal computer), with a USB cable, the code can be dumped in the board and the desired functionality is d

done.

Node MCU

The node MCU is a development board, particularly used for IoT applications and hence also referred to as IoT board. It communicates the data over the internet with the help of an on-board ESP8266 Wi-Fi chip, designed by Espressif systems. It can be programmed by the Arduino IDE, by changing the board configuration to node MCU. In this project, the node MCU directly sends the sensor data to the Blynk cloud.

GPS module

The GPS, sometimes known as the "Global Positioning System," is a radio navigation system based in space that is owned by the US government. A GPS receiver can receive geolocation and time data from the global navigation satellite system from any point on or near the planet where there is an unhindered line of sight to four or more GPS satellites. As a GPS receiver, the NEO-6M module watches the GPS satellites continually and receives NMEA phrases containing location data. The NEO-6M GPS module uses a 5 volt operating voltage and has two distinct pins for transmitting and receiving position information. It is made up of a patch antenna and a UFL connector. A tiny LED present on the module indicates the satellite-fix. The below shown, is the image of it.

SOFTWARE SPECIFICATIONS

To build any particular project, the software plays an equal and important role, as the hardware, since any desired functionality can be performed by the software tools. The two software tools utilized in this project are described below:

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 12 | December - 2022 Impact Factor: 7.185 ISSN: 2582-3930

IV. Software Requirements

f. Arduino IDE
g. Blynk Applications

Existing System

The most common approach for detection of potholes is by using sensors, which detect the abnormalities on roads. As a part of understanding the existing systems, we studied a few related works and came up with the following conclusion that, vibrational technique, in general sense is a cost-effective and simple approach for road-condition monitoring. One such work is which aims at detecting potholes and avoiding road accidents, by using ultrasonic sensor, accelerometer sensor, Arduino UNO, GPS module, GSM module along with an Android smart phone and software requirements like IDE and Android Studio The other related work makes use of single sensor, namely the accelerometer sensor and the Arduino board along with smart phone based user interface, where the data is transferred using Bluetooth. Similarly has an approach based on an android app as a user interface to display the location of potholes detected by the G-sensor, Arduino and Bluetooth-enabled communication. Another related work describes the pothole-detection process by using ultrasonic sensor, PIC microcontroller, IoT board, voice IC, LCD display and speaker to alert the driver about the pothole. Here it is observed that, all related works are clearly aimed at alerting the driver of the vehicle. From the above observation, the common approach followed in the existing techniques, can be explained in three sub-parts:

i) Sensing Subsystem
ii) Centralization
iii) Localization

Proposed System

In the proposed system, advanced sensor system is used to track and update the potholes Apache Hadoop on the road. . Apache Spark uses a UV sensor to distinguish between speed bumps and potholes. The vector quality known as the accelerometer in Apache Hive indicates the direction in which the event is MySql Database occurring. The sensor will identify any odd changes by A vibration sensor is also used in conjunction with this to detect potholes if the vehicle vibrates more than is normal or to predict future events. it. The analysis's next phase is prediction. It serves as a common threshold. To forecast future events, a fixed threshold level is established in advance. It gives a pattern to identify risk Both these sensor values are fed to the Arduino and the opportunities and relationship between variables enables GPS sensor updates of the precise positions where the evaluation and decision are made. There are potholes. Sending this information to the web server Overall, the information from the vehicle, such as vibration through IOT, is important for the road transport officials to take action and determine the accelerometer value and the location of the vehicle. Using this data, the transport authority server is informed on the state of the roads. foreseen, and action is prioritised to take the required According to the information gathered and the actions taken, the officials reply.

Problem Statement

The purpose of this project is to build and create a prototype of an intelligent data gathering system that can be put in any transportation vehicle or car to identify the road or highway conditions. The prototype develops an information gathering system that notifies the authorities about the road conditions. With this information the authorities could take actions to repair the roads which in turn help to avoid accidents caused due to nontechnical

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 12 | December - 2022 Impact Factor: 7.185 ISSN: 2582-3930

humps and thereby minimize the proportion of damaged roads and avoid road accidents.

Objective

The objectives of the proposed work are:

• Design and Development of the Pothole and hump detecting System.

• Help Road maintenance, promoting economic growth.

• Avoidance of accidents by real time alerts through GSM.

• To display the pothole position with latitude and longitude, the link that takes to Google map is also presented in TCP/UDP test tool.

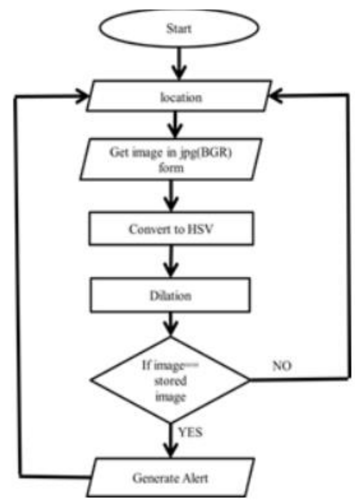
Methodology

Pothole Detection

The location of the car is tracked using Wi-Fi. The camera collects the view of the road continually through Open C V in RGB form. The image is then transformed using an image processing approach from RGB to HSV. It is then enlarged to better see the concentrated area.

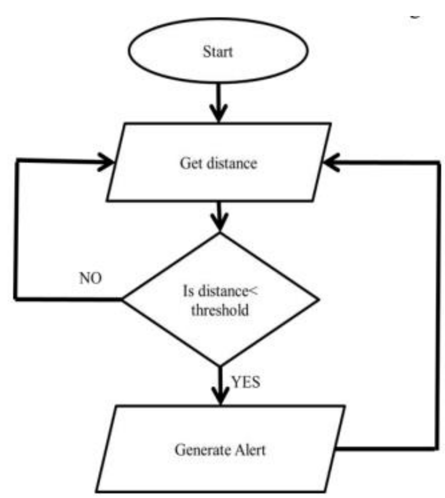
The acquired image is then compared with the recorded pothole reference image in the database. The Raspberry Pi sends the location of the pothole together with the captured image to the municipal officials via email if the captured image and the saved image are identical. The same will be displayed on the TCP/UDP test Tool. The location can also be saved and shared in the test tool. It also generates alarm to the driver through LCD display and sound if a pothole is spotted. It is repeated in this manner.

Flow Chart

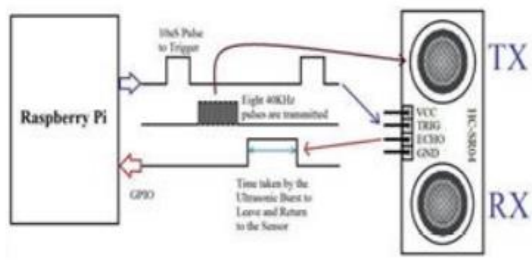


Hump Detection

The ultrasonic sensor regularly monitor the distance between the car and the road. A threshold is established and the distance is compared. The LCD and speaker alert the driver when the distance is below the predetermined threshold.



Working of Ultrasonic Sensor



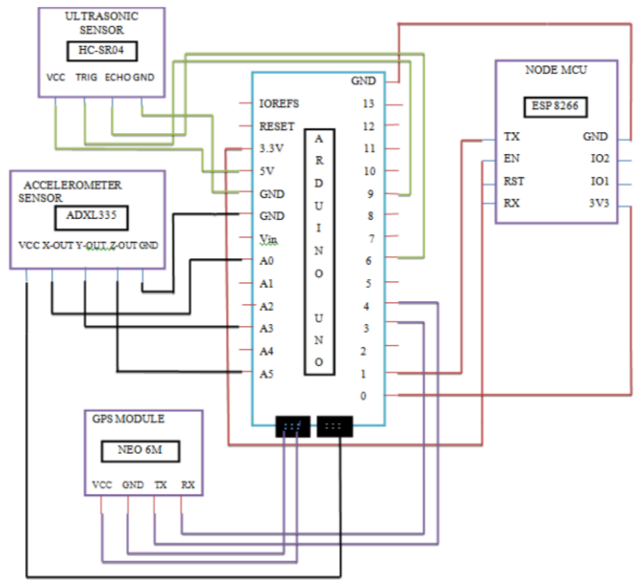
Schematic Circuit Diagram

The schematic circuit diagram above shows how the hardware used in the project is actually connected. I/O pins are the only components of a basic sensor besides the supply and ground. Ultrasonic and accelerometer are connected to 5v and 3.3v, respectively, in accordance with the needed supply voltage. Hardware connections of trigger, echo, X, Y, and Z are also made in accordance with the connections specified in the code. Tx and Rx pins connected per code, GPS module (NEO-6M) connected to 5v supply. The Tx-Rx pins are used for data communication, and the nodeMCU is connected to a 3.3v pins.

PotHole detection Different Methods

There are several techniques for spotting potholes, including vibration detection, 3D reconstruction detection, and vision detection.

Method based on vibration



In this method, an accelerometer is utilised to find potholes. Real-time processing is done via a vibration-based technique, which also uses less storage. This system's preliminary pavement condition assessments make advantage of modern data acquisition technology. The pavement's emptiness imposes impacting forces on the car. Pavement surface conditions can be determined using recorded test vehicle responses. This system has many benefits, including real-time data processing, lower storage needs, and cost-effectiveness. The BusNet sensor network, which is installed on public transportation buses, is used to track environmental pollutants. Readings of acceleration are taken and relayed via BusNet, and Main Station receives them via a central collection point. In the following scenarios, this approach could produce inaccurate results: Even when a pothole is not present, it detects the hinges and joints of the road as such. Second, it is unable to identify potholes in the middle of lanes. Using Android OS-based cellphones, Mednis et al. suggested a mobile sensing system for detecting road inconsistencies. For the testing, a 4.4 km long track with 10 consecutive laps was used. This method demonstrated a 90% true positive rate using real-world data.

3D – Reconstruction

In the 3D reconstruction, a laser scanning device is used for real-time pothole identification. As is well known, the vehicle level uses significantly more sophisticated technology for laser scanning. Three categories can be used to categorise 3D reconstruction.

1. 3D laser technique

Method #2: Stereo Vision

3) The Kinect Sensor technique

3D Laser technique

This technique makes a computer model of the item using the reflected laser pulses. The precise 3D cloud points are captured during canning with the aid of a grid-based processing approach, focusing on distress features. The quantity of materials required to fill the potholes will be precisely determined by this method According to Chang et al., scanning and extraction with a focus on specific distress features were accomplished using precise 3D cloud points and their elevation via a grid-based approach. With the aid of the severity and coverage of distress [the current inspection system, which is used to find distress features like potholes, rutting, and shoving with the aid of 3D transverse scanning techniques, which is a fast technique], the necessary amount of materials can be calculated precisely and automatically. This method makes use of a digital camera and an infrared laser line projector to detect potholes and other problematic features.

Stereo vision method

By using matching feature points, this method reconstructs the pavement surface with a high computational effort. It is useless in a real-time setting. It is crucial to precisely align both cameras since, in the event of vehicle motion vibration, an imperfect alignment will have a negative impact on the conclusion. Two digital cameras are used in the stereo vision approach [6], which covers a paving surface. This process consists of two steps. They start by classifying and identifying cracks in 2D pictures captured by both cameras. After combining the findings from two sources, missing cracks are counted, which improves accuracy. They can create a 3D surface model of the pavement using two photos of the same area. Through geometric modelling, they also discovered longitudinal and intersecting profiles. To recover the 3D properties from a pair of 2D images, a series of procedures called camera calibration, distortion correction, stereo point matching, 3D reconstruction, and profile report should be carried out. A DHDV (Digital Highway Data Vehicle) survey vehicle was used to collect images of the pavement surface using a total of 4 cameras, set up in two pairs. As a preliminary outcome, they present viability after applying stereovision.

Kinect sensor method

This technique makes use of Kinect sensors to get pavement depth images. It is employed to determine a pothole's volume. Using a low-cost Kinect sensor, images of concrete and asphalt roads were gathered. Meshes were created for the goal of improved visualisation. A pothole's area is examined using depth. The volume of the pothole was determined using the trapezoidal method and area depth curves. A low-cost sensor system for locating and analysing potholes is presented by Joubert et al. [16] and uses a Kinect sensor [16] and a high-speed USB camera [16]. There have been several experiments on utilising Kinect to look at potholes.

Vision-based method

Vision-based pothole detection can be classified into two different categories

1) 2D Image-Based Approaches

2) Video-Based Approaches

Image-based approaches

There are two distinct types of vision-based pothole detection.

2) Image-Based Methodologies

2) Video-Based Methodologies

Image-based strategies

In a 2D image-based technique, the image is divided into regions with and without defects. The graphic properties of a faulted terrain can be used to approximate the shape of a pothole. If the composition is found to be coarser and grainier than the region of interest, which is intended to be a pothole, the composition of the region is obtained and compared to the composition of a defective region. A approach based on unsupervised vision is presented by Buzan et al. This procedure eliminates the need for costly equipment, filtering, and training. For locating potholes, they employ clustering and image processing techniques. The process consists of the following three steps:

1. Image segmentation

2. Shape extraction

3. Identification and Extraction Using this method, they get 81% accuracy [21], which can be used as a rough estimation for repairs of a pothole.

Video-based approaches

It explains how to use video recordings to identify potholes, cracks, and repairs [18]. Using the DFS algorithm, video clips are unquestionably segmented into two categories: stressed and distressed frames. The CDDMC algorithm is used to process the distress frames database. The steps in CDDMC include picture enhancement, detection, segmentation, classification, and extraction and quantification of visual attributes. For potholes, cracks, and patches, decision logic takes into account three visual qualities. They are the mean, the circularity, and the average width. The 2D image-based method can identify potholes from a single frame, but it is unable to identify their effects. In order to overcome this drawback of a 2D image-based approach, video-based approaches were introduced. These techniques were used to identify potholes and determine how many there were overall in the series of frames. For the purpose of identifying and measuring potholes, Jog et al. suggested 2D recognition and 3D reconstruction. They are able to locate the pothole and its specifications, including width, number, and depth, with the use of a camera mounted on the vehicle. Koch and Brilakis have suggested a different approach, which is limited to single frames and cannot determine the size of potholes from video-based pavement assessment frames. To identify potholes from all the frames, Koch et al. provide a pothole recognition method with an updated composition signature for perfect pavement regions.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 12 | December - 2022 Impact Factor: 7.185 ISSN: 2582-3930

Conclusion

The suggested system makes use of sensors that are economically less expensive and can be implemented on a large scale, such as shopping malls, baby carriages for safety, sensors that can be mass implemented directly on the government vehicles or at an alluring subsidized scheme on private vehicles to create a mass collection of information on potholes, humps, for which density map can be created to for effective and quick analysis of poorly constructed roads, which further can help the government The sensors' shortcomings include a shorter range, lower precision, and a less direct analysis than image processing approaches. The use of cameras or laser technologies can improve data collection accuracy, but these methods have their own complexity and expense issues. The data on traffic accidents should be used to encourage technical advancements for practical and creative solutions. The precision and recall for the potholes detector employing SSD-Tensor Flow were 73% and 37.5%, respectively, while the mAP was 32.5%. High recall (78%), high precision (84%), and 83.62% mAP were attained with YOLOv3. High recall (81%), high precision (85%), and 85.39% maps were attained using YOLOv4. SSD processing speeds were slow and insufficient for real-time applications. Therefore, our YOLOv4-based pothole detector can be viewed as a reliable, real-time system that can be applied in practical situations. In our upcoming study, a larger dataset, more than 2000 photos, will be used for training. This dataset will have more photographs for potholes from different roads, with a variety of severities, as well as images taken in various lighting and weather situations. Alexey AB and numerous other researchers stressed the importance of employing a sizable dataset with more than 2000 images for training to create a reliable object detector that can function in any situation. Additionally, we'll train our system with manholes in our upcoming work. Given the similarities between manholes and potholes, it is crucial to make this change to our current system in order to distinguish between them pothole.

Summary

This paper comprises of a review of the current pothole detecting methods and the major use of each method with their principal principles. All the methods have their own benefits and cons. Among these, the vision-based method is more accurate and needs fewer equipment, which will minimise the cost of identifying potholes.

Result

Compared findings of YOLOv3 and YOLOv4 can be described in Error! Reference source not found..SDD is not included since SDD displayed worse performance in comparison with YOLO. YOLOv4 demonstrated to be a robust object detection architecture. It can work with real-life settings and at a high speed of processing. The proposed system exhibited high recall 81%, high precision 85%, and 85.39% mAP. Moreover, this pothole detector obtained a processing speed up to 21 FPS using Colab GPU, NVIDIA Tesla P100-PCIE.

References :

[1] Pothole Detection and Notification System, 2018 IJARIIE- Vijaya Shetty, Niveditha, J.Janani, T.Hrishikesh Reddy, Praveen Datt.

[2] Automated Pothole Detection and Pre-Indication System using IoT,2018 IJSRRProf.A.K.Mariappan ,Haridha.S, Haritha.S, Harini.M

[3] Road Condition Detection using Arduino Based depth sensing module & Android smartphone,2017 IJAERD-Omkar Rajmane, Vidya Rane, Aishwarya Bhosale.

[4] Real-time Arduino Based depth sensing for Road Condition Monitoring,2016 IJRITCC- Abhishek Maurya, Avanish Yadav, PraticArote, Amol Baviskar, Jaypal Baviskar

[5] "Road Conditions Detection Using Raspberry Pi Based Sensing Module and Smartphone" Syuan-Yi Chen1, Annie Shih2 and Chun-Yi Hsiao1 1 Department of Electrical Engineering, National Taiwan Normal University, Taiwan 2 Industrial Economics and Knowledge Center, Industry Technology Research Institute, Taiwan978-1-4799-8745- 0/15/$31.00©2015 IEEE.

[6] "Pothole Detection System using Machine Learning on Android" Aniket Kulkarni1, Nitish Mhalgi2, Sagar Gurnani3, Dr. Nupur Giri4 (ISSN 2250- 2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 7, July 2014)

[7] R. Sundar, S. Hebbar, and V. Golla, "Implementing intelligent traffic control system for congestion control, ambulance clearance, and stolen vehicle detection," IEEE Sensors J., vol. 15, no. 2, pp. 1109– 1113, Feb. 2015.

[8] Samyak Kathane, Vaibhav Kambli, Tanil Patel and Rohan Kapadia, "Real Time Potholes Detection and Vehicle Accident Detection and Reporting System and Anti-theft (Wireless)", IJETT, Vol. 21, No. 4, March 2015.

[9] Taehyeong Kim, Seung-Ki Ryu, "A Guideline for Pothole Classification", International Journal of Enginering and Technology (IJET), Vol. 4, No. 10,October 2014.

[10] Gaurav Singal, Anurag Goswami, Suneet Gupta, Tejalal Choudhary "Pit free: Pot-holes detection on Indian Roads using Mobile Sensors",978-1- 5386-6678-4/18/$31.00 c 2018 IEEE.

[11] Ashish Gaikwad, Yashwant Belhekar, Mandar Dangre, Ankit Chaudhary" Path hole Detection System: Using Wireless Sensor Network" International Engineering Research Journal (IERJ).

[12]https://www.mathworks.com/help/visionhdl/ug/pothole-detection.html

[13] https://www.mdpi.com/1424-8220/21/24/8406

[14]https://raiith.iith.ac.in/705/1/EE10M11.pdf

[15]https://ieeexplore.ieee.org/document/9741538

AUTHORS

V. Harsha Vardhan is a second-year student of Computer Science and Engineering, student in CENTURION UNIVERSITY Vizianagaram, India.

Dr. Uttam Mande received the Bachelor of Computer Applications from Andhra University, Visakhapatnam and proceeded to do his Master of Science in Information Science and Master's in technology of Computer Science and Technology department in Andhra University. He has received his PhD degree in Computer Science and Engineering from CSE department of JNT University, Kakinada, India for his work in the field of. Expert Crime Investigation Systems. He is a member of IEEE and IEEE CS and has organized many workshops and was involved in Research Projects. He has also published several international journals about Expert Crime Investigation Systems. He is currently working as HOD, Department of CSE at Centurion University, Vizianagaram.

K. Vasu is a second-year student of Computer Science and Engineering, student in CENTURION UNIVERSITY Vizianagaram, India.

P V S Suraj Puranjay is a second-year student of Computer Science and Engineering, student in CENTURION UNIVERSITY Vizianagaram, India.