AN AI BASED REAL-TIME ROAD ANALYSIS SYSTEM USING MEMS DATA WITH IOT APPLICATION

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project report **“AN AI BASED REAL-TIME ROAD ANALYSIS SYSTEM USING MEMS DATA WITH IOT APPLICATION”**is the bonafide work of “**ARAVINTH.K(814720106008),KOVENDAN.S(814720106044),KRISHNARAJ.R (814720106045) ”** who carried out the project work under my supervision.

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DECLARATION

We hereby declare that the work entitle "**AN AI BASED REAL-TIME ROAD ANALYSIS SYSTEM USING MEMS DATA WITH IOT APPLICATION"** is submitted in partial fulfilment for the degree in B.E, Anna university of Chennai, is a record of the own work carried out by us during the academic year 2023-2024 under the supervision and guidance of, **Mr.M.VIJAY**, Assistant Professor, Department of Electronics and Communication Engineering, SRM TRP Engineering College, Trichy621105. The extended sources of information are derived from the existing literature and have been indicated through the dissertation at the appropriate places. The matter embodied in this work is original and has not been submitted for the award of any other degree or diploma, either in this or any other University.

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ABSTRACT

Asphalt pavement problems are the main worry of both emerging and established countries for the efficient functioning of everyday commutes. The identification of potholes, which might result in an accident and endanger cars and people, has been the subject of several research. This work aims to explore the possibilities of deep learning models and use three outstanding deep learning models for edge device pothole detection. This article proposes a low cost real-time pavement surface condition detecting system for roads. The MEMS signals given by on-car sensors are processed in the time frequency domain to gain information on the condition of the road surface. High categorization rates show how well the suggested approach recognises the kind and level of annoyance. The experimental results show that the proposed system is effective at detecting the presence and the type of distress with high classification rates.

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LIST OF ABBREVIATIONS

MEMS	Micro-Electromechanical System
IOT	Internet Of Things
GPS	Global Positioning System
CNN	Convolutional neural network
PSU	Power Supply Unit
USB	Universal Serial Bus
VR	Virtual Reality
AR	Augmented Reality
LCD	Liquid-Crystal Display
AC	Alternating Current
DC	Direct Current
SDG	Sustainable Development Goal

INTRODUCTION

A pothole is a type of failure in an asphalt pavement, caused by the presence of water in the underlying soil structure and the presence of traffic passing over the affected area. Introduction of water to the underlying soil structure first weakens the supporting soil. Traffic then fatigues and breaks the poorly supported asphalt surface in the affected area. Continued traffic action ejects both asphalt and the underlying soil material to create a hole in the pavement.

1.1 FORMATION OF PATHOLE

Figure 1.1: A deep pothole with a nearby patched area.

Figure 1.1 depicts a deep pothole on a road surface, surrounded by worn-out asphalt. Adjacent to it lies a patched area, suggesting attempted repair. This visual highlights the persistence of road degradation despite maintenance efforts.

Road markings are an important indicator for traffic network information that can separate road areas and provide guidance for drivers and pedestrians. They play an important role in traffic safety[1]

According to a U.S. Army Corps of Engineers publication, Pothole primer— A public administrators guide to understanding and managing the pothole problem, (Eaton, et al.), pothole formation requires two factors to be present at the same time: water and traffic. Water weakens the soil beneath the pavement; traffic applies the loads that stress the pavement past the breaking point. Potholes form progressively, first from fatigue of the road surface, which can lead to a precursor failure pattern known as crocodile cracking. Finally, chunks of pavement between the fatigue cracks gradually work loose, and may eventually be plucked or forced out of the surface by continued wheel loads to create a pothole.

The development of an automotive surface recognition system is an important and yet unsolved task. In the current study we are considering a novel approach to surface classification based on the analysis of the real road surface images obtained using the 79 GHz imaging radar and demonstrate the advantage of millimeter wave radar for surface discrimination for automotive sensing.[2], In areas subject to freezing and thawing, frost heaving can damage a pavement and create openings for water to enter. Spring thaw of pavements accelerates this process when thawing of upper portions of the soil structure in a pavement cannot drain past still-frozen lower layers, thus saturating the supporting soil and weakening it.

Potholes can grow to several feet in width, though they usually only develop to depths of a few inches. If they become large enough, damage to tires, wheels, and vehicle suspensions is liable to occur. Serious road accidents can occur as a direct result, especially on those roads where vehicle speeds are greater.

According to Eaton, et al., potholes may result from four main causes:

- Insufficient pavement thickness to support traffic during freeze/thaw periods without localized failures.
- Insufficient drainage.
- Failures at utility trenches and castings (manhole and drain casings).
- Miscellaneous pavement defects and cracks left unmaintained and

unsealed so as to admit moisture and compromise the structural integrity of the pavement.[4]

India, the second most populous Country in the World and a fast growing economy, is known to have a gigantic network of roads. Roads are the dominant means of transportation in India today. They carry almost 90 percent of country's passenger traffic and 65 percent of its freight. However, most of the roads in India are narrow and congested with poor surface quality and road maintenance needs are not satisfactorily met. No matter where you are in India, driving is a breath-holding, multi-mirror involving, potentially life threatening affair.

Over the last two decades, there has been a tremendous increase in the vehicle population. This proliferation of vehicles has led to problems such as traffic congestion and increase in the number of road accidents.[3] Pathetic condition of roads is a boosting factor for traffic congestion and accidents. Researchers are working in the area of traffic congestion control, an integral part of vehicular area networks, which is the need of the hour today.

Speed breakers on Indian highways are a double-edged sword, dispersed unevenly and frequently built to non-scientific heights. Although their purpose is to regulate automobile speeds and maybe avert collisions, their haphazard placement and uneven proportions sometimes result in unexpected outcomes. Although drivers must exercise caution when navigating these obstacles, the unexpected bumps and abrupt speed changes can also cause pain, wear and tear on the vehicle, and even accidents, especially for those who are unaware of them or are unable to respond quickly.

To make matters worse, the absence of uniform laws governing the building of speed breakers in various areas aggravates the issue and jeopardizes road efficiency and safety even more. In order to guarantee that speed breakers fulfill their intended purpose without causing any problems, addressing these concerns requires a complete strategy that includes appropriate planning, technical standards, and routine maintenance. Roads in India normally have speed breakers so that the vehicle's speed can be controlled to avoid accidents.[5] However, these speed breakers are unevenly distributed with uneven and unscientific heights.

Figure 1.2 Condition of roads with potholes.

Figure 1.2 illustrates a section of road marred by numerous potholes, indicative of infrastructure decay and potential hazards to motorists. This depiction underscores the pressing need for comprehensive road maintenance and repair initiatives

Potholes, formed due to heavy rains and movement of heavy vehicles, also become a major reason for traumatic accidents and loss of human lives. According to the survey report " Road Accidents in India, 2011", by the ministry of road transport and highways, a total of 1,42,485 people had lost their lives due to fatal road accidents. Of these, nearly 1.5 per cent or nearly 2,200 fatalities were due to poor condition of roads. Figure 1.1 portrays the condition of roads with killer potholes.[4] To address the above mentioned problems, a cost effective solution is needed that collects the information about the severity of potholes and humps and also helps drivers to drive safely. With the proposed system an attempt has been made to endorse drivers to ward off the accidents caused due to potholes and raised humps.

Furthermore, fostering public awareness campaigns on safe driving practices and the importance of road maintenance can encourage a collective effort towards creating safer road environments for all users. Collaboration between government agencies, civil society, and technology providers is essential to achieve lasting improvements in road safety nationwide.

1.2 ASPIRATIONS

- Real-time Monitoring: Develop a system capable of continuously monitoring road conditions in real-time using MEMS sensors.
- Data Integration: Integrate data from MEMS sensors with IoT platforms to create a comprehensive and unified dataset for analysis.
- Traffic Analysis: Analyze the collected data to provide insights into traffic patterns, congestion, and vehicle behaviour on roads.
- Safety Enhancement: Identify potential safety hazards such as potholes, slippery road surfaces, or sharp turns, and provide timely alerts to drivers or authorities.
- Infrastructure Optimization: Use the gathered data to optimize road infrastructure planning and maintenance schedules based on actual usage patterns and wear and tear.
- Decision Support: Provide decision-makers with actionable insights derived from real-time road analysis to improve traffic management and transportation planning.

- User Engagement: Develop user-friendly interfaces and applications to enable both authorities and the general public to access and interact with the road analysis data.
- Scalability and Reliability: Ensure that the proposed system is scalable to accommodate a large number of sensors and capable of operating reliably under varying environmental conditions and traffic loads.
- Cost-effectiveness: Explore cost-effective deployment strategies for MEMS sensors and IoT infrastructure to make the system feasible for widespread implementation.
- Validation and Case Studies: Validate the effectiveness of the proposed system through real-world case studies and comparative analysis with existing methods of road condition monitoring.

These objectives aim to address key challenges in the domain of real-time road analysis using MEMS data with IoT applications, with the ultimate goal of improving road safety, efficiency, and infrastructure management.

1.3 ROAD ANALYSIS

Asphalt pavement constitutes a fundamental component of transportation infrastructure, providing essential attributes such as smoothness, traction, load-bearing capacity, and minimal noise generation. However, the continuous exposure to vehicular traffic, weather elements, and other environmental factors subjects these surfaces to wear and deterioration, necessitating regular maintenance to uphold their functionality and structural integrity. The challenge of preserving high-quality road surfaces is a universal concern for governments globally, as deteriorating pavements pose various risks, including increased accident rates, degraded driving experiences, and heightened environmental noise levels.

The detrimental impacts of poor road conditions extend beyond immediate safety concerns to encompass broader societal and economic implications. For instance, traffic noise has been identified as a significant public health issue by organizations such as the World Health Organization, highlighting the need for effective pavement management strategies. Moreover, the presence of distresses such as potholes, rutting, cracking, and patching not only compromises road safety but also imposes financial burdens on governments and individuals through increased vehicle maintenance costs and potential legal liabilities. To address these challenges, there is a growing recognition of the importance of
proactive monitoring and maintenance practices. The Department of Transportation Pavement Management Information System Rater's Manual categorizes asphalt pavement distresses into eight primary types, including rutting, patching, block, alligator cracking, longitudinal and transverse cracking, ravelling, and potholes.

These distresses necessitate tailored maintenance approaches to mitigate their impacts and extend the service life of roadways. In this context, leveraging advanced monitoring techniques such as deep learning models holds promise for enhancing pavement management practices. By enabling real-time detection and classification of distresses, these technologies empower transportation agencies to prioritize maintenance activities, allocate resources efficiently, and ultimately enhance road safety and longevity. Through collaborative research and innovation, stakeholders can collectively address the multifaceted challenges associated with maintaining high-quality road surfaces, thereby fostering safer, more sustainable transportation networks.

1.4 INTERNET OF THINGS (IOT)

Pavement management systems that use Internet of Things (IoT) technology are a paradigm change in the way we monitor and maintain road infrastructure. The conventional method of managing pavements mostly depends on manual data gathering and recurring inspections, which frequently causes ineffective resource allocation and a delay in responding to new problems. However, IoT provides real-time pavement condition monitoring, supporting proactive maintenance methods and boosting overall system resilience by integrating sensors and communication devices into road surfaces, vehicles, and infrastructure elements. There are a number of clear benefits to pavement management systems that come with IoT integration. First of all, it makes it possible to remotely and continuously monitor important variables like temperature, moisture content, and structural integrity. This gives transportation organizations a thorough understanding of how well their road networks are doing. With the use of this real-time data, possible distresses may be identified early and promptly addressed to stop further degradation and reduce safety concerns.

IoT-enabled pavement management systems can also support predictive maintenance strategies by using machine learning algorithms to estimate future pavement conditions based on analysis of past data. Transportation authorities can maximize the lifespan of road infrastructure assets, manage maintenance schedules, and prioritize expenditures by recognizing patterns and trends in pavement deterioration. Moreover, improved connection and interoperability provided by IoT technologies allow for easy integration with other smart city systems and transportation networks. Urban mobility solutions become more comprehensive and effective as a result of the synergies that are fostered across various infrastructure components, including public transportation networks, traffic management systems, and environmental monitoring platforms.

We examine how IoT may transform pavement management techniques in this research study, emphasizing how real-time monitoring, predictive maintenance, and system integration can benefit from its use. We intend to show the effectiveness of IoT-enabled pavement management systems in improving traffic safety, maximizing resource allocation, and fostering sustainable urban growth through case studies, experimental validation, and real world demonstrations.

1.5 IOT IN ROAD ANALYSIS

The Internet of Things' (IoT) applications in road infrastructure have drawn emphasis due to its rapid advancement. The long-term real-time monitoring of pavements is hampered by issues with front-end sensor durability, sensor embedding causing harm to the pavement, and the redundancy of a large volume of real- time data. These issues are present when using IoT to road infrastructure monitoring. In order to overcome these obstacles, our research created an IoT-based self-powered distributed intelligent pavement monitoring system that includes a communication network, sensor network, cloud platform, and power supply system[6].

An integrated paving technique was developed that integrates embedded sensors with pavement material structures, taking into account the unique properties of slipform paving for cement concrete pavements. In order to provide data support for pavement design, maintenance, and vehicle-road synergy applications, the system actively gathers and analyzes a variety of data types through on-site engineering monitoring, including system energy consumption, temperature and humidity, environmental noise, wind speed and direction, and pavement structural vibrations. The use of IoT technology in traffic safety, digital road maintenance, and optimum pavement material structure design will all be promoted in the future.

CHAPTER 2

LITERATURE SURVEY

2.1 YOLOX-RDD: A Method of Anchor-Free Road Damage Detection for Front-View Images

Author : Jie Li, Zhong Qu,et al. Year : 2024

Description:

Road damage detection based on front-view images of roads is more in line with practical application scenarios and is suitable for automatic road damage detection systems. The road damage objects in the front-view images have the characteristics of complex background, multi-scale and large aspect ratio, which greatly increase the difficulty of detection. We propose an anchor-free road damage detection model YOLOX-RDD for front-view images. YOLOX is used as the basic network and three optimization strategies are implemented according to the characteristics of road damage objects. The refined switchable atrous convolution is used to adaptively adjust the receptive field according to the size of the object, which can satisfy the requirements of the detection of the damages of multi-scale and large aspect ratio. For unobvious road damage detection in complex background, four feature enhancement attention modules are added to the network to extract more salient information and enhance the fusion effect. Two-level adaptive spatial feature fusion is performed by fusing dark2 with the three output feature maps of neck respectively, and the optimal fusion weights are learned through training to further improve the detection capability of multiscale objects. The experiments on CNRDD, RDD2020 and USRDD datasets demonstrate the effectiveness and high generalization of our method. Compared with the baseline model, the mAP@0.5 can be improved by up to 2.78%, and F1-Score can be improved by up to 2.55%.The FPS can reach up to 90, achieving a balance between detection accuracy and speed.

2.2 Real-Time Road Damage Detection and Infrastructure Evaluation Leveraging Unmanned Aerial Vehicles and Tiny Machine Learning

Author : Muhammad Waseem Khan,et al. **Year : 2024**

Description

Road damage detection (RDD) through computer vision and deep learning techniques can ensure the safety of vehicles and humans on the roads. Integrating unmanned aerial vehicles (UAVs) in RDD and infrastructure evaluation (IE) has also emerged as a key enabler, contributing significantly to data acquisition and real-time monitoring of road damages such as potholes, cracks, and surface anomalies, facilitating proactive maintenance and improved road conditions. These UAVs are low-powered and resource-constrained devices that work autonomously to perform pattern detection and decision-making leveraging tiny machine learning (Tiny ML) algorithms. These Tiny ML algorithms are designed to run on edge devices, IoT devices, UAVs, etc. In this study, the RDD2022 dataset collected using UAVs and dashboard cameras of vehicles was utilized to train pure and mixed models that exhibit class instance imbalance in certain classes which is addressed by implementing data augmentation as a regularization technique. State-of-the-art two-stage detectors; Faster R-CNN ResNet101 and one-stage detectors; SSD MobileNet V1 FPN, YOLOv5, and Efficient D1 are employed. The results indicate that the two-stage detector achieved an impressive mAP of 88.49% overall and 96.62% for focused classes. Notably, the state-ofthe-art Efficient D1 approach achieved a competitive mAP of 86.47% overall and 95.12% for focused classes, with significantly lower computational cost. These findings highlight the potential of advanced object detection techniques, particularly Efficient D1, to enhance the accuracy and efficiency of RDD systems, thereby improving passenger safety and overall performance.

2.3 Promoting Automatic Detection of Road Damage: A High-Resolution Dataset, a New Approach, and a New Evaluation Criterion

Author : Tianxiang Yin, Wei Zhang; Jinqiao Kou,et al. Year : 2024

Description

This paper presents a novel approach to road damage detection utilizing deep learning, aimed at enhancing road maintenance effectiveness. We introduce the Asphalt Road Surface Disease Dataset (ARSDD), a high-resolution collection of 2297 images derived from a real-world project, annotated with precise labels and damage types in collaboration with road maintenance authorities. Unlike conventional anchor-based models which suffer from limitations due to predefined anchors, we propose an adaptive training sample selection strategy tailored for road damage detection, reducing the need for manual anchor settings. Additionally, we address the challenge of information loss in downsampling by designing a cross-layer attention feature pyramid network to mitigate spatial dimension degradation for slight road damages.

Recognizing the inadequacy of general object detection evaluation criteria for road damage detection, we devise a new post-processing method and introduce a diagonal-based evaluation criterion, aligning with the specific characteristics of road damage. Through extensive testing on both the ARSDD and the 2018 Road Damage Dataset, our model demonstrates superior performance in road damage detection. Practitioners in pavement inspection systems can leverage our released dataset and method to develop more effective automated inspection systems. Future research directions include exploring refined inspection schemes and evaluation metrics, such as meshing road surface images for quality evaluation based on individual mesh inspection results.

2.4 Integrating GAN and Texture Synthesis for Enhanced Road Damage Detection

Author : Tengyang Chen; Jiangtao Ren,et al. Year : 2024

Description

In the domain of traffic safety and road maintenance, precise detection of road damage is crucial for ensuring safe driving and prolonging road durability. However, current methods often fall short due to limited data. Prior attempts have used Generative Adversarial Networks to generate damage with diverse shapes and manually integrate it into appropriate positions. However, the problem has not been well explored and is faced with two challenges. First, they only enrich the location and shape of damage while neglect the diversity of severity levels, and the realism still needs further improvement. Second, they require a significant amount of manual effort. To address these challenges, we propose an innovative approach. In addition to using GAN to generate damage with various shapes, we further employ texture synthesis techniques to extract road textures. These two elements are then mixed with different weights, allowing us to control the severity of the synthesized damage, which are then embedded back into the original images via Poisson blending. Our method ensures both richness of damage severity and a better alignment with the background. To save labour costs, we leverage structural similarity for automated sample selection during embedding. Each augmented data of an original image contains versions with varying severity levels. We implement a straightforward screening strategy to mitigate distribution drift. Experiments are conducted on a public road damage dataset. The proposed method not only eliminates the need for manual labor but also achieves remarkable enhancements, improving the mAP by 4.1% and the F1-score by 4.5%.

2.5 Road Surface Pits and Speed Bumps Recognition Based on Acceleration Sensor

Author : Yunfei Yin; Wanli Fu; Xianyong Ma,et al. **Year :** 2024

Description

Road potholes pose dangers to traffic safety, damaging vehicles, and increasing accident risks, especially during low visibility conditions. Traditional detection methods are costly, inefficient, and inaccurate. Leveraging advancements in smartphone sensor capabilities, this article presents a novel approach for road pothole and speed bump detection using smartphone acceleration and GPS sensors, along with extract data features filter (EDFF) technology.

The method involves preprocessing acceleration data using Euler point, least squares, and wavelet techniques to enhance accuracy by reducing noise. The genetic algorithm is then employed to identify car model parameters. In addition, EDFF is established based on data features to differentiate between speed bumps and grooves and determine groove properties. Experimental results using real data from Harbin show pit recognition accuracy of over 75% and 100% accuracy for speed bumps. This demonstrates the proposal’s effectiveness in detecting pits and speed bumps accurately, making it useful for practical engineering applications.

2.6 An Intelligent Road Damage Detection Method Based on YOLOv7-Tiny Framework

Author : Huyiping Zhou; Si Chen,et al. **Year :** 2023

Description

Road health condition heavily relies on daily road maintenance work. Intelligent road damage detection method is considered one of promising techniques. The current road damage detection (RDD) methods face challenges such as high computational complexity, slow detection speed, low detection rate, and difficulty in meeting the requirements of real-time detection on mobile devices. To address these issues, this paper proposes an intelligent road damage detection system based on the You Only Look Once version seven-tiny (YOLOv7-tiny). We collect a road damage dataset named RDD and trained it using YOLOv7tiny and other similar object detection networks. YOLOv7-tiny achieved a 55% improvement in mAP@0.5 compared to Retinanet, and a 51% improvement in F1 score compared to Faster-RCNN. The experimental results show that our proposed RDD based on YOLOv7-tiny exhibits better performance and is more suitable for deployment on lightweight edge devices for road damage detection.

2.7 YOLOv5s-BSS: A Novel Deep Neural Network for Crack Detection of Road Damage

Author : Conghua Wei; Qianjun Zhang,et al. **Year :** 2023

Description

Cracks are one of the most common and significant types of road surface damage, posing a threat to the safety of pedestrians and vehicles. If left untreated, cracks can lead to severe consequences such as road and bridge collapse. Therefore, it is essential to develop an efficient road crack detection method. Traditional crack identification methods have the problem of being largely affected by the environment and having low recognition accuracy. In this paper, we propose a road crack detection model based on an improved You Only Look Once version 5 (YOLOv5) model that addresses the limitations of existing stateof-the-art crack detection methods in terms of accuracy and detection speed. First, we replace the intersection over union (IoU) loss function with the SCYLLA-IoU (SIoU) loss function for better accuracy. Second, to enhance detection performance, we replace the feature pyramid network (FPN) with a bidirectional feature pyramid network (BiFPN). Finally, to better extract spatial feature information of different sizes, we modify the original Spatial Pyramid Pooling Fast (SPPF) module of YOLOv5 by using Spatial Pyramid Pooling Cross-StagePartial Connections (SPPCSPC). We evaluated our YOLOv5sBiFPNSPPCSPCSIoU (YOLOv5s-BSS) method on the dataset from the IEEE 2020 Global Road Damage Detection Challenge (GRDDC) and achieved promising results on road damage datasets from China, Japan, and the United States. The mAP@0.5 of different cracks in three datasets reached 84.9%, 54.6%, and 71%. Our method outperforms related methods, with an increase of 0.7%, 0.7%, and 2.8% over YOLOv5s.

2.8 A Comparison of Road Damage Detection Based on YOLOv8

Author : Zhipeng Tang; Rapeeporn Chamchong,et al. **Year :** 2023

Description

With the rapid development of computer technology, the intelligent driving of automobiles has become a popular research field. Road damage detection is critical in intelligent automobile driving and has been developed for a long time. The early detection method is to detect by embedding several sensors in the car. In recent years, deep learning methods have also been gradually applied in the research of pavement damage detection. This paper mainly takes road damage detection based on the YOLOv8 by comparing it to YOLOv5 and multiple pretrain models of YOLOv8. This paper describes the solution using YOLO to detect the various types of road damage in the Crowdsensing-based Road Damage Detection Challenge (CRDDC'2022). The dataset is separated into training, validation, and test sets. The medium and large pre-train models of YOLOv8 have the highest mAP and F1-score at 0.62 and 0.61, respectively. YOLOv8 of the small and medium pre-train model provides better performance than YOLOv5. For comparing YOLOv8, the performance of the large pre-train model is better than the others, but it is not much different from the medium pretrain model. For this reason, the medium pre-train model may be suitable for the real-time problem as it does not take time for training.

2.9 Detection and Classification of Road Damage Using Deep Learning Approach with Smartphone Images

Author : Sharmin Shila; Fahima Taher Bayshakhy,et al. Year : 2023

Description

In cities, road surface monitoring is mostly done by hand which is a timeconsuming and labour-intensive procedure. One of the most critical responsibilities is infrastructure maintenance work for traffic safety. To keep the road network safe, it must be assessed on a regular basis to identify potential threats and risks. We work on detecting and classifying road damage using deep learning approach in this research, which is a low-cost intelligence system. The goal of this work is to investigate the detection and categorization of road damage from road surface photographs using deep learning concept. This study used different transfer learning algorithms to categorize road damage in order to determine which algorithm performed better at detecting and classifying road damage. We divide damages into four groups: potholes, cracks, and revealing and rutting. For this research, we used a smartphone camera to collect data from the streets of Dhaka and processed with it. Our work uses various transfer learning deep neural network algorithms including VGG16, VGG19, ResNet50, MobileNetV2, EfficientNetV2 for classifying road damages, as well as for detection, and it outperforms earlier research. We got the highest 97.15% accuracy for ResNet50 and lowest accuracy 94.88% for MobileNetV2 and EfficientNetV2, 94.31% accuracy for VGG16 and 93.18% for VGG19.

2.10 Performance Evaluation of Detection Model for Road Surface Damage using YOLO

Author : Tomoya Fujii; Rie Jinki; Yuukou Horita,et al. **Year :** 2023

Description

The social infrastructure, including roads and bridges built during Japan's period of rapid economic growth, is rapidly deteriorating, and there is a need to strategically maintain and renew the social infrastructure that is aging all at once. On the other hand, in road maintenance and management in rural areas, it is not realistic to increase the number of road management patrol cars or the number of specialized engineers engaged in road maintenance and management, and the reduction of management budgets and the shortage of engineers due to the declining birthrate and aging population are serious problems. In addition, in rural areas, it is difficult to conduct all road inspections by visual inspection, which is performed by expert road maintenance technicians, and an inexpensive, highprecision system that can automatically detect road surface damage through image analysis or other means is required. In this study, we construct a road surface damage detection model using YOLOv5, a machine learning algorithm capable of real-time.

2.11 Implementing intelligent traffic control system for congestion control, ambulance clearance, and stolen vehicle detection

Author: R. Sundar ,et al. **Year:** 2015

Description

This paper presents an intelligent traffic control system to pass emergency vehicles smoothly. Each individual vehicle is equipped with special radio frequency identification (RFID) tag (placed at a strategic location), which makes it impossible to remove or destroy. We use RFID reader, NSK EDK-125-TTL, and PIC16F877A system-on-chip to read the RFID tags attached to the vehicle. It counts number of vehicles that passes on a particular path during a specified duration. It also determines the network congestion, and hence the green light duration for that path. If the RFID-tag-read belongs to the stolen vehicle, then a message is sent using GSM SIM300 to the police control room. In addition, when an ambulance is approaching the junction, it will communicate to the traffic controller in the junction to turn ON the green light. This module uses ZigBee modules on CC2500 and PIC16F877A system-on-chip for wireless communications between the ambulance and traffic controller. The prototype was tested under different combinations of inputs in our wireless communication laboratory and experimental results were found as expected.

2.12 Metrology and visualization of potholes using the Microsoft Kinect sensor

Author: I. Moazzam,et al. **Year:** 2013

Pavement distress and wear detection is of prime importance in transportation engineering. Due to degradation, potholes and different types of cracks are formed and they have to be detected and repaired in due course. Estimating the amount of filler material that is needed to fill a pothole is of great interest to prevent any shortage or excess, thereby wastage, of filler material that usually has to be transported from a different location. Metrological and visualization properties of a pothole play an important role in this regard. Using a low-cost Kinect sensor, the pavement depth images are collected from concrete and asphalt roads. Meshes are generated for better visualization of potholes. Area of pothole is analyzed with respect to depth. The approximate volume of pothole is calculated using trapezoidal rule on area-depth curves through pavement image analysis. In addition pothole area, length, and width are estimated. The paper also proposes a methodology to characterize potholes.

2.13 Pothole detection and warning system: Infrastructure support and system design

Author: S.S.Rode,et al, **Year:** 2009

Description

Many on-going projects in the field of vehicular networks are working in the direction of providing driver with relevant information about roads and traffic movements. In this paper, we propose a novel Wi-Fi based architecture for Pothole Detection and Warning System which assists the driver in avoiding potholes on the roads by giving prior warnings. The system consists of access points placed on the roadsides for broadcasting data, which can be received byte Wi-Fi enabled vehicles as they enter the area covered by the influence of the access points. The mobile nodes can also broadcast their response as feedback which when received by access point can beutilized for backend server processing. The pothole detection application proposed in this paper enables the driver to receive information of the potholes on the roads in the vicinity of the moving vehicle. The application can be integrated in the vehicle so as to alarm the driver in the form of a visual signal, audio signal or even trigger the braking system. Simulations demonstrate the advantages of using our approach for constructing pothole detection systems. Many such similar applications can be deployed over the framework provided by the system to assist navigation on roads.

2.14 A research of pavement potholes detection based on three-dimensional projection transformation

Author: H. Youquan,et al. **Year:** 2011

Description

In order to detect the three-dimensional cross-section of pavement pothole more effectively, this paper proposes a method which employs optical imaging principle of three-dimensional projection transformation to obtain pictorial information of pothole's cross-section in pothole detection. Multiple digital image processing technologies, including: image preprocessing, binarization, thinning, three-dimensional reconstruction, error analysis and compensation are conducted in the series of image analysis and processing. Experimental results indicate that the method is markedly superior to traditional methods in many aspects.

2.15 Potholes detection based on SVM in the pavement distress image

Author: J. Lin,et al. **Year:** 2010

Description

There are much more researches on the recognition of the cracks on the distress pavement, but the research on the potholes is relatively less. In this paper, Texture measure based on the histogram is extracted as the features of the image region, and the non-linear support vector machine is built up to identify whether a target region is a pothole. Based on this, an algorithm for recognizing the potholes of the pavement is proposed. The experimental results show that the algorithm can achieve a high recognition rate.

CHAPTER 3

EXISTING SYSTEM

Figure 1.1 depicts the Existing pothole-maintenance system with a pothole detector that uses a black-box camera and audio frequencies(noise). Pothole information, such as size, location and appearance, is collected by the potholedetection system using the camera. The collected data is stored in the pothole database, and the pothole-maintenance server uses it for smart pothole maintenance. We developed new software for the pothole-maintenance server based on our previous pothole database system, as shown on the right in Figure 1.1. This software provides various pieces of information about potholes such as their video clips, images, regions, road authorities, route number of a road, driving direction, lane number of the road, type of road, latitude, longitude, collectors, collected date, type of pavement, location, shape, size, and comments. The pothole's location is visualized on a digital map using the collected GPS data. Thus, users can easily see the distribution of potholes. Furthermore, the software accurately estimates the costs of pothole maintenance in the selected area. This way, transportation officials can easily and accurately develop roadmaintenance policies and strategies with the software. Potholes can then be repaired smartly using the pothole-maintenance system such as our intelligent asphalt repair systems, and pothole information can be extended to other users and services via external connections and Open API. Figure 1.1. potholemaintenance system.

Insofar as the Existing pothole-detection system uses a single black-box camera. A number of survey vehicles for pothole detection can be developed inexpensively, and data can be acquired quickly over a wide area. In fact, the Korean government cannot accurately budget annual road-repair costs, because existing pothole-maintenance systems do not provide accurate pothole information[8].

In countries like India, the probability of encountering irregularities on the road is more since the road conditions are prone to changes .The purpose of this project is to detect and monitor road conditions and bring awareness of the irregularities on the road.

- The existing systems is road surfaces based on going in the direction of detection using cameras with smartphone cameras.
- Use a mobile Android device to perform real-time detection of anomalies, e.g., potholes and cracks.
- Close Proximity method (CPX) is the name of a methodology based on test-tyre rolling on the road with measuring microphones located close to the tyre surface.
- Tyre-road noise is mainly due to the combination of airborne noise and structure-borne noise.
- However, this methodology has some drawbacks,
- Influence of bad weather, shadow, and light variations on the results.
- That it requires a very complicated hardware and software setup with low final performance.
- Many studies are available about the correlation between road surface quality and tyre-road noise.

3.1 TECHNOLOGIES INVOLVED IN EXISTING METHODS :

- **AI Algorithms**: These could include machine learning models for tasks such as traffic prediction, anomaly detection, road condition monitoring, and even autonomous vehicle navigation.

- **IoT (Internet of Things) Infrastructure**: IoT devices could be used to gather data from MEMS sensors in real-time and transmit it to a central processing system. This system could be cloud-based or located onpremises.
- **Data Processing and Analysis**: The collected data would need to be processed and analyzed using AI algorithms to derive meaningful insights. This could involve tasks like data cleaning, feature extraction, and applying machine learning models to make predictions or detect patterns.
- **Real-Time Monitoring and Reporting**: The system would likely include features for real-time monitoring of road conditions, traffic flow, and other relevant factors. Reports and alerts could be generated for stakeholders such as transportation agencies, drivers, or maintenance crews.
- **Integration with Existing Infrastructure**: Depending on the application, the system might need to integrate with existing transportation infrastructure, such as traffic management systems or smart city initiatives.

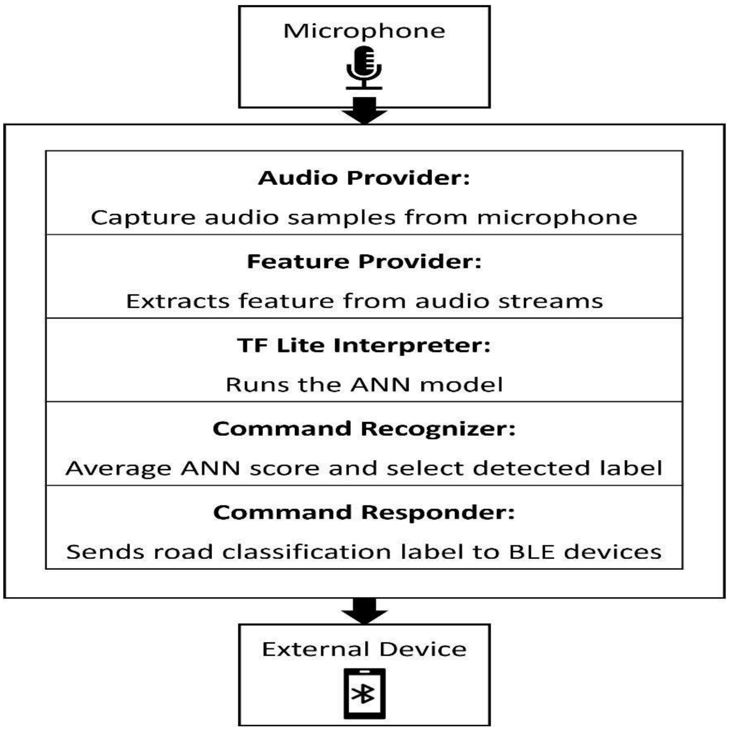

Figure 3.1 Flowchart

Figure 3.1 shows how microphone, board and external devices are related. The audio provider that has the task of allowing the communication between the device's mic hardware and the microcontroller. Then, raw audio data are elaborated by the feature provider that converts the data into spectrograms. These represent the inputs of the classifier that was already trained on a computer.

The required dataset to train the artificial neural network model was created in two phases. Firstly, several recordings were collected. In particular, the road surfaces considered are: good quality, bad quality, such as cracks or high roughness streets, potholes, dirty and covered in grass. Then, these acoustic data were processed with the intention of obtaining a balanced set.

The acquisition of the signals took place in Pisa province. To achieve this, it was employed a proto-board based on the components listed below:

- CUI Devices cma-4544pf-w electret microphone placed inside the tyre cavity that was modified for measuring higher sound pressure values;
- Raspberry Pi 3 model B attached to the tyre rim that samples and locally stores the data.

This methods detects the pathole using audio frequ. While using a acoustic data. It is difficult to find the accurate location of the pathole. It also detects the sounds of the engine,tyre and other devices in the vehicle.

So we come up with the method using MEMS sensor and limit switch. It will detects the correct location of the pathole, rutting etc.

CHAPTER 4

PROPOSED METHOD

The aim of this work is to develop a road classifier system capable of providing a real-time assessment of the infrastructure. The focus of this project is the development of innovative artificial intelligence techniques able of autonomously learning from the vision and MEMS data acquired through an integrated system. The algorithm is deployed on an electronic board mounted on the dashboard or on board unit of a vehicle, linked to a sensors and camera that is installed inside the suspension cavity and equipped with components for WiFi or IoT data transmission.

An important proposal of this project is the creation of a new dataset containing the inertial data due to the interaction between wheel and road surfaces. The set of data is mainly acquired with several measurement campaigns and partly generated by data augmentation. The files are related to road surface typologies such as: good quality, roads covered in grass, dirty roads, potholes, and bad quality, e.g., cracks or high roughness roadways. The main contributions of this paper are summarized as following:

- A new low-cost device based on CNN for real-time road defects classification based on acoustic signals;
- A modified condensed microphone sensor placed inside tyre cavity achieving a perfect insulation from external noise and weather condition;
- A design of different CNN architectures taking into account the memory footprint and execution constraints required by the embedded system.

When any vehicle travels over the damaged potholes vibrations are produced. These vibrations can be sensed by the accelerometer to detect the severity of the pothole also captured by the computer vision process. Here use MPU6030 accelerometer which can easily detect the rate of change of momentum in x, y and z direction. The intensity of vibration is recorded along with the current location which is then sent to common server. The GPS monitors the coordinates of the potholes and map the index of pothole on a digital map on the user's application[9].

- The system comprises of an Accelerometer, GPS Receiver, Arduino Board, a server and a custom made mapping application.
- The accelerometer will produce values of X, Y, Z axes (coordinates).
- The GPS receiver provides the latitude and longitude coordinates.
- The Arduino Board is used as a communicating interface between the GPS and the accelerometer and a server which is used to receive the data and send it to the server for classification and storage.
- The server, on receiving the coordinates of the irregularity, classifies them based on the severity and stores them in the database.
- The mapping application, which is custom made, is designed to accept the source and the destination and shows the presence of any irregularities on the path.
- The cheapest systems for the estimation of road surfaces are based on inertial sensors like MEMS.
- The aim of this work is to develop a road classifier system capable of providing a real-time assessment of the infrastructure.
- A new low-cost device based on AI for real-time road defects classification based on MEMS signals and detect the location using GPS.
  • Design of AI Embedded architectures taking into account the memory in the IoT and execution constraints required by the embedded system

4.1 BLOCK DIAGRAM

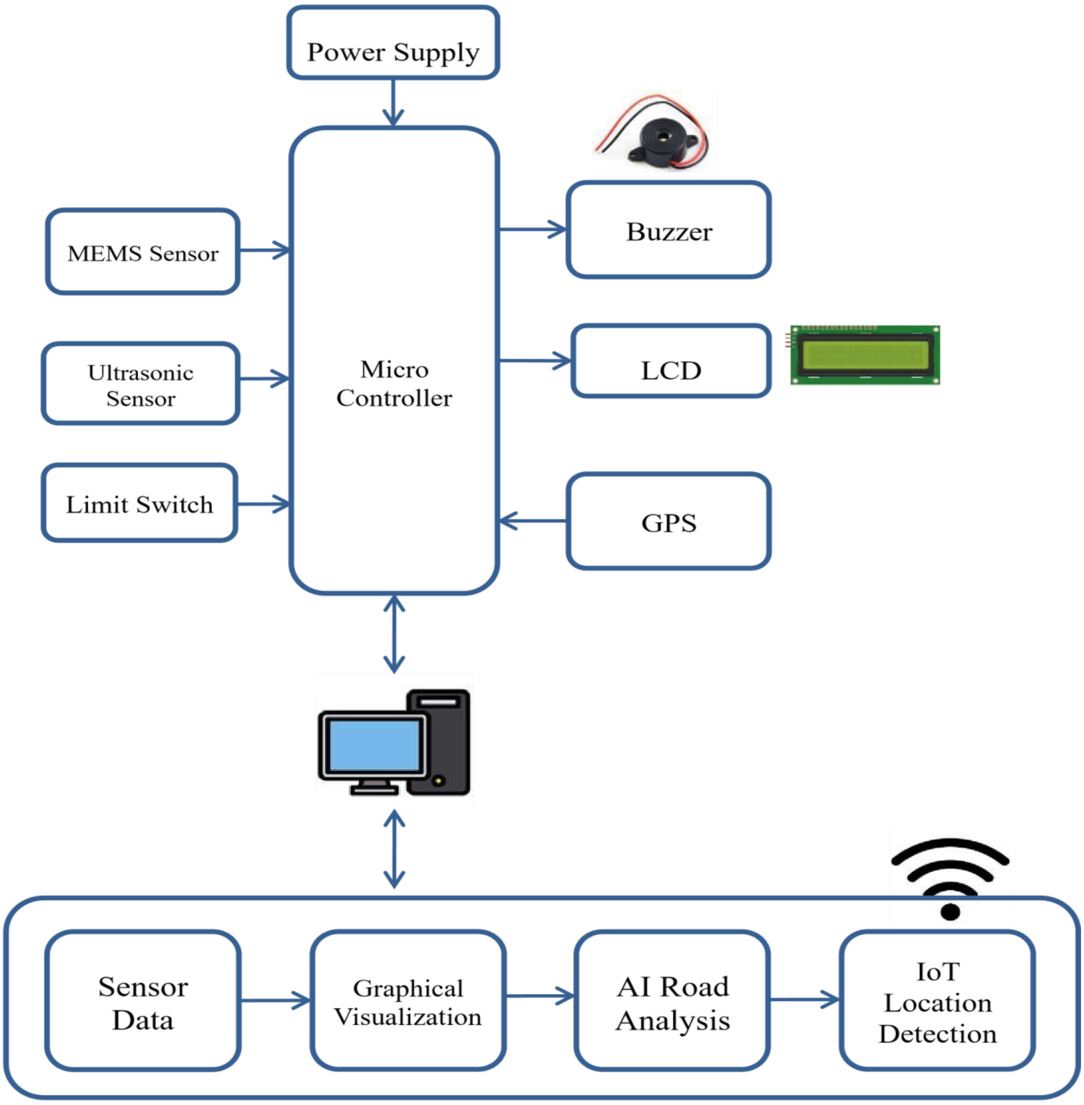

Figure 4.1 Block Diagram

4.1.1 ULTRASONIC SENSOR DATA:

The HC-SR04 is an active ultrasonic sensor and contains a transmitter and a receiver. It is used to measure distance at which, objects are placed in front of it. The ultrasonic sensor transmits high frequency sound waves and waits for the reflected wave to hit the receiver. The distance is calculated based on the time taken by the ultrasonic pulse to travel a particular distance. The working principle of this device is shown in figure 4.1. There are different types of ultrasonic sensors with different transmission ranges and angles of detection. The HC-SR04 sensor work at frequency of 40 KHz and can measure distances of the objects in the range 2 to 400 cm with a 15° angle of detection.

- The cheapest systems for the estimation of road surfaces are based oninertial sensors like MEMS.
- The aim of this work is to develop a road classifier system capable of providing a real-time assessment of the infrastructure.
- A new low-cost device based on AI for real-time road defects classification based on MEMS signals and detect the location using GPS.
- Design of AI Embedded architectures taking into account the memory in the IoT and execution constraints required by the embedded system.

4.1.2 MEMS SENSOR DATA :

A MEMS (Micro-Electro-Mechanical Systems) sensor is a type of device that integrates mechanical and electrical components on a microscopic scale. These sensors are typically fabricated using semiconductor manufacturing techniques, allowing for miniaturization and mass production at a relatively low cost.

MEMS sensors can detect various environmental parameters such as acceleration, pressure, temperature, humidity, and magnetic fields, among others. They find applications in a wide range of industries including automotive, consumer electronics, healthcare, aerospace, and industrial automation.

In our project we use MEMS accelerometer. A MEMS accelerometer is a type of sensor that measures acceleration forces. It utilizes Micro-ElectroMechanical Systems (MEMS) technology to detect changes in acceleration, which can include changes in speed or direction. These sensors are commonly used in various applications such as automotive systems, smartphones, wearable devices, industrial machinery monitoring, and aerospace.

4.1.3 LIMIT SWITCH :

A limit switch is a type of electromechanical device that is used to detect the presence or absence of an object, or to monitor the position of a moving part within a machine or system. It operates by physically contacting the object or part being monitored, and then triggering a response when a certain limit or threshold is reached.

4.2 ADVANTAGES

- This has the main advantages of reducing costs and facilitating the spreading of the technology.
- An advantage respect to the use of cameras is that the data obtained with inertial sensors have a smaller size and are easier to be stored.
- It assures higher speed, lower power consumption and safeguards from data.
- Other benefits are related to the fact that the sensor signals recorded inside the tyre suspension are not influenced by external environmental
- The measurements can take place in every light condition.

- Enhanced Safety immediate detection of hazards for timely warnings or automatic interventions.
- Improved Traffic Management real-time insights optimize traffic flow, signal timings, and suggest alternative routes.

- Predictive Maintenance identifies maintenance needs before critical issues arise, reducing disruptions.
- Cost Efficiency allocates resources efficiently and extends infrastructure lifespan, reducing long-term costs.
- Environmental Benefits minimizes fuel consumption, emissions, and addresses pollution hotspots.
- Customized User Experience provides personalized navigation, alerts, and services tailored to drivers.
- Scalability and Flexibility easily adapts to expanding networks and changing conditions.
- Data-driven Decision Making offers insights for informed infrastructure investments and traffic management strategies.

CHAPTER 5

HARDWARE AND SOFTWARE REQUIREMENTS

5.1 HARDWARE REQUIREMENTS :

- Arduino NANO
- Power supply
- LCD
- Accelerometer
- Ultrasonic Sensor
- Limit Switch
- USB Interface Cable

5.2 SOFTWARE REQUIREMENTS

- Arduino IDE
- Proteus 8 Professional

5.3 HARDWARE DESCRIPTION :

5.3.1 Power supply

A power supply (sometimes known as a power supply unit or PSU) is a device or system that supplies electrical or other types of energy to an output load or group of loads. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

This circuit is a small +5V power supply, which is useful when experimenting with digital electronics. Small inexpensive wall transformers with variable output voltage are available from any electronics shop and supermarket. Those transformers are easily available, but usually their voltage regulation is very poor, which makes then not very usable for digital circuit experimenter unless a better regulation can be achieved in some way. The following circuit is the answer to the problem.

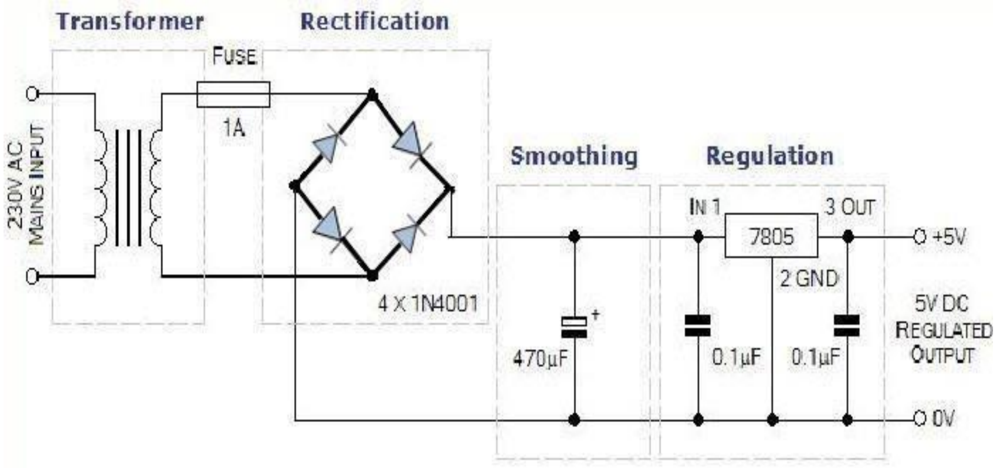

Figure 5.1 5V Power Supply

Figure 5.1 Displayed is a compact 5V power supply unit, featuring robust design and efficient voltage regulation, crucial for powering various electronic devices. This depiction highlights the reliability and versatility of modern power supply technology in meeting diverse energy demands.

5.3.2 Transformer

A transformer is a device that transfers electrical energy from one circuit to another through inductively coupled wires. A changing current in the first circuit (the primary) creates a changing magnetic field; in turn, this magnetic field induces a changing voltage in the second circuit (the secondary). By adding a load to the secondary circuit, one can make current flow in the transformer, thus transferring energy from one circuit to the other. The secondary induced voltage V_S is scaled from the primary V_P by a factor ideally equal to the ratio of the number of turns of wire in their respective windings:

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

By appropriate selection of the numbers of turns, a transformer thus allows an alternating voltage to be stepped up — by making N_S more than N_P or stepped down, by making it less.

A key application of transformers is to reduce the current before transmitting electrical energy over long distances through wires. Most wires have resistance and so dissipate electrical energy at a rate proportional to the square of the current through the wire. By transforming electrical power to a high-voltage, and therefore low-current form for transmission and back again afterwards, transformers enable the economic transmission of power over long distances. Consequently, transformers have shaped the electricity supply industry, permitting generation to be located remotely from points of demand. All but a fraction of the world's electrical power has passed through a series of transformers by the time it reaches the consumer[11].

Transformers are some of the most efficient electrical 'machines', with some large units able to transfer 99.75% of their input power to their output. Transformers come in a range of sizes from a thumbnail-sized coupling transformer hidden inside a stage microphone to huge gigavolt-ampere-rated units used to interconnect portions of national power grids. All operate with the same basic principles, though a variety of designs exist to perform specialized roles throughout home and industry.

The transformer is based on two principles: first, that an electric current can produce a magnetic field (electromagnetism) and, second, that a changing magnetic field within a coil of wire induces a voltage across the ends of the coil (electromagnetic induction). By changing the current in the primary coil, one changes the strength of its magnetic field; since the secondary coil is wrapped around the same magnetic field, a voltage is induced across the secondary.

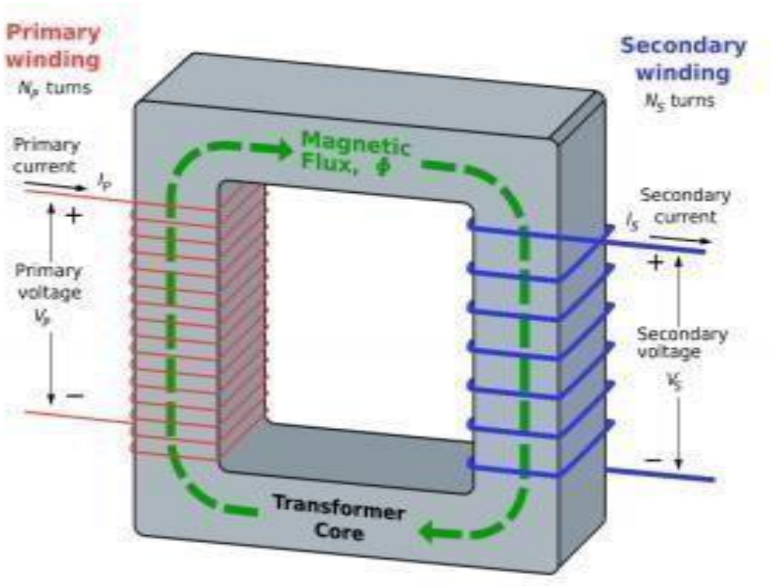

Figure 5.2 An ideal step-down transformer

Figure 5.2 Illustrated is an ideal step-down transformer, seamlessly converting high-voltage input to lower-voltage output with maximum efficiency and minimal loss.This portrayal emphasizes the fundamental principles of transformer operation, pivotal in diverse applications spanning power distribution to electronic circuitry.

A current passing through the primary coil creates a magnetic field. The primary and secondary coils are wrapped around a core of very high magnetic permeability, such as iron; this ensures that most of the magnetic field lines produced by the primary current are within the iron and pass through the secondary coil as well as the primary coil.

5.3.3 Rectifier

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification. Rectifiers are used as components of power supplies and as detectors of radio signals. Mainly there are three types of rectifier i.e. half wave rectifier, full wave rectifier and Bridge Rectifier.

Bridge Rectifier

A diode bridge is an arrangement of four (or more) diodes in a bridge circuit configuration that provides the same polarity of output for either polarity of input. When used in its most common application, for conversion of an alternating current (AC) input into a direct current (DC) output, it is known as a bridge rectifier. A bridge rectifier provides full-wave rectification from a twowire AC input, resulting in lower cost and weight as compared to a rectifier with a 3wire input from a transformer with a center-tapped secondary winding. The essential feature of a diode bridge is that the polarity of the output is the same regardless of the polarity at the input.

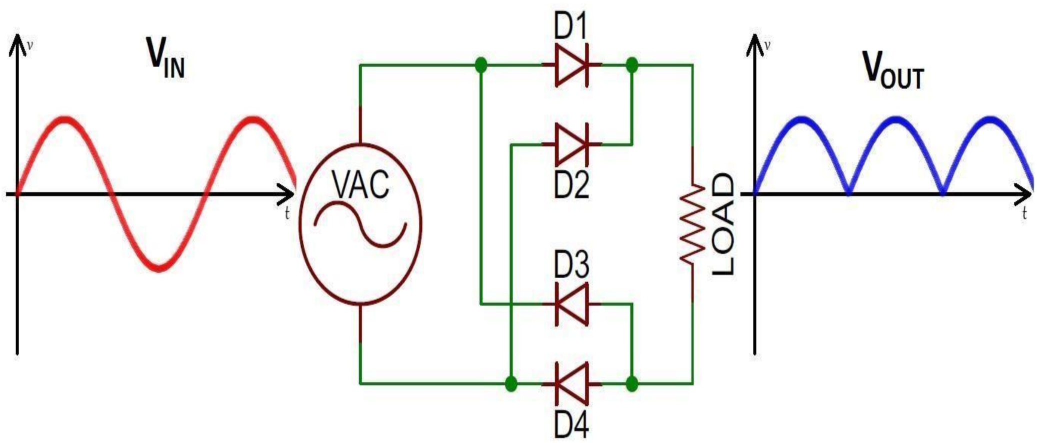

Figure 5.3 Bridge rectifier

Figure 5.3 is a schematic representation of a bridge rectifier, comprising diodes arranged in a bridge configuration, effectively converting alternating current (AC) to direct current (DC).

5.3.4 Basic operation

According to the conventional model of current flow, current is defined to be positive when it flows through electrical conductors from the positive to the negative pole. In actuality, free electrons in a conductor nearly always flow from the negative to the positive pole. In the vast majority of applications, however, the actual direction of current flow is irrelevant. Therefore, in the discussion below the conventional model is retained.

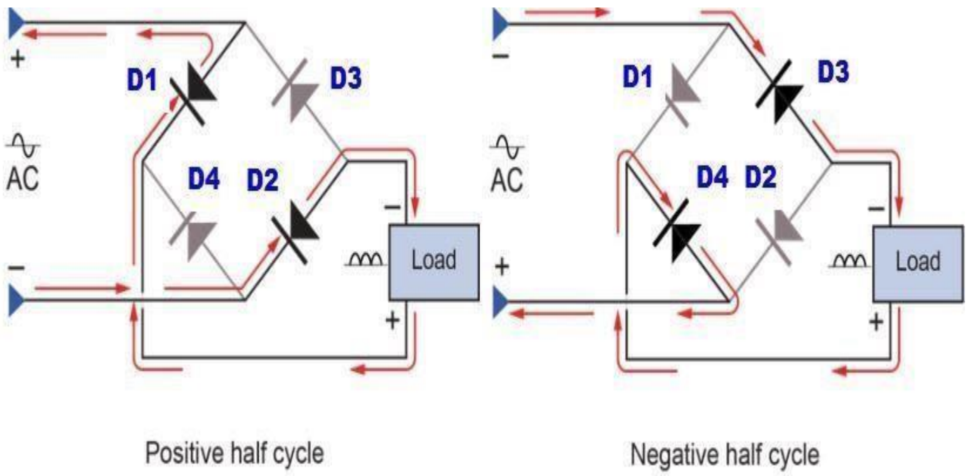

Figure 5.4 Operation of bridge rectifier

Figure 5.4 illustrates the operation of a bridge rectifier, showcasing the sequential conduction of diodes to rectify alternating current (AC) into pulsating direct current (DC).

In each case, the upper right output remains positive and lower right output negative. Since this is true whether the input is AC or DC, this circuit not only produces a DC output from an AC input, it can also provide what is sometimes called "reverse polarity protection". That is, it permits normal functioning of DC powered equipment when batteries have been installed backwards, or when the leads (wires) from a DC power source have been reversed, and protects the equipment from potential damage caused by reverse polarity.

5.3.5 IC Voltage Regulators

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. Although the internal construction of the IC is somewhat different from that described for discrete voltage regulator circuits, the external operation is much the same. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustable set voltage. A power supply can be built using a transformer connected to the ac supply line to step the ac voltage to desired amplitude, then rectifying that ac voltage, filtering with a capacitor and RC filter, if desired, and finally regulating the dc voltage using an IC regulator. The regulators can be selected for operation with load currents from hundreds of milliamperes to tens of amperes, corresponding to power ratings from milliwatts to tens of watts.

Three-Terminal Voltage Regulators

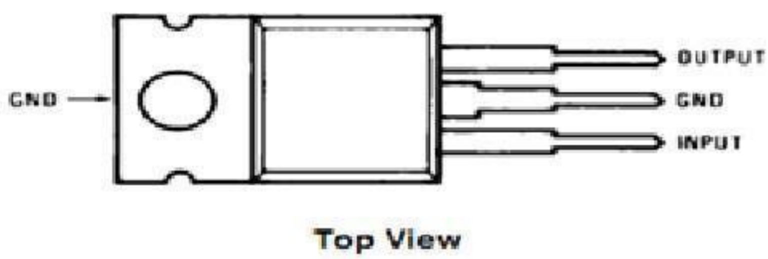

Figure 5.5 Three-Terminal Voltage Regulators

Figure 5.5 shows the basic connection of a three-terminal voltage regulator IC to a load. The fixed voltage regulator has an unregulated dc input voltage, V_i, applied to one input terminal, a regulated output dc voltage, V_o, from a second terminal, with the third terminal connected to ground. For a selected regulator, IC device specifications list a voltage range over which the input voltage can vary to maintain a regulated output voltage over a range of load current. The specifications also list the amount of output voltage change resulting from a change in load current (load regulation) or in input voltage (line regulation). The series 78 regulators provide fixed regulated voltages from 5 to 24 V. Figure shows how one such IC, a 7805, is connected to provide voltage regulation with output from this unit of +5V dc. An unregulated input voltage V is filtered by capacitor C1 and connected to the IC's IN terminal. The IC's OUT terminal provides a regulated + 12V which is filtered by capacitor C2 (mostly for any high-frequency noise). The third IC terminal is connected to ground (GND). While the input voltage may vary over some permissible voltage range, and the output load may vary over some acceptable range, the output voltage remains constant within specified voltage variation limits. These limitations are spelled out in the manufacturer's specification sheets. There are two types of voltage regulator they are 78xx series and 79xx series.

78xx series

There are common configurations for 78xx ICs, including 7805 (5 V), 7806 (6 V), 7808 (8 V), 7809 (9 V), 7810 (10 V), 7812 (12 V), 7815 (15 V), 7818 (18 V), and 7824 (24 V) versions. The 7805 is the most common, as its regulated 5volt supply provides a convenient power source for most TTL components.

Less common are lower-power versions such as the LM78Mxx series (500 mA) and LM78Lxx series (100 mA) from National Semiconductor. Some devices provide slightly different voltages than usual, such as the LM78L62 (6.2 volts) and LM78L82 (8.2 volts) as well as the STMicroelectronics L78L33ACZ (3.3 volts).

79xx series

The 79xx devices have a similar "part number" to "voltage output" scheme, but their outputs are negative voltage, for example 7905 is -5 V and 7912 is -12 V. The 7912 has been a popular component in ATX power supplies, and 7905 was popular component in ATX before -5 V was removed from the ATX specification.

Table 5.1 Positive Voltage Regulators in 7800 series

IC Part	Output Voltage (V)	Vi (V)
7805	+5	7.3
7806	+6	8.3
7808	+8	10.5
7810	+10	12.5
7812	+12	13.6
7815	+15	17.7
7818	+18	21.0
7824	+24	27.1

Table 5.1 offers a comprehensive summary of positive voltage regulators within the 7800 series, including model numbers, output voltages, maximum current ratings, and package types, aiding in component selection for various electronic circuit designs and applications.

5.3.6 ARDUINO:

5.3.6.1 Introduction:

Arduino is an open source platform for prototyping based on user-friendly software. It provides a flexible base for engineers to experiment on designing interactive environments. They can be programmed for specific applications to create embedded systems which can control and sense real time parameters. It consists of a microcontroller ATmega328 which is programmed using the arduino software. The Arduino R3/Genuino R3 is the Indian version of the Arduino Uno Board with an Arduino Uno Boot loader. It behaves like the arduino board and programmed using the arduino IDE.

Its main components are ,

- 14 digital input/output pins (6 can be used as PWM outputs)
- 6 analog inputs(can also be used for digital I/O - so a total of 20 digital I/O's)
- 16 MHz crystal oscillator
- USB connection
- ICSP header
- reset button

Table 5.2 List of On-Board Peripherals

Function	Peripheral	Pin number
LED Output	1 LED	13
Digital Input/output	-	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
PWM Output	-	3,5,6,9,10,11
Serial Tx and Rx	-	0,1
Analog Input	-	A1,A2,A3,A4,A5

Table 5.2 presents a catalog of on-board peripherals integrated into a system, encompassing components such as Ethernet controllers, USB hubs, audio codecs, and Wi-Fi modules, along with their specifications including interface types, data transfer rates, and supported protocols, facilitating efficient management and utilization of system resources.

5.3.7 THE MICROCONTROLLER

The Arduino R3 comes with an ATmega 328 Microcontroller with an Arduino Uno Bootloader. The Bootloader facilitates the Programming of the IC from within the Arduino IDE.

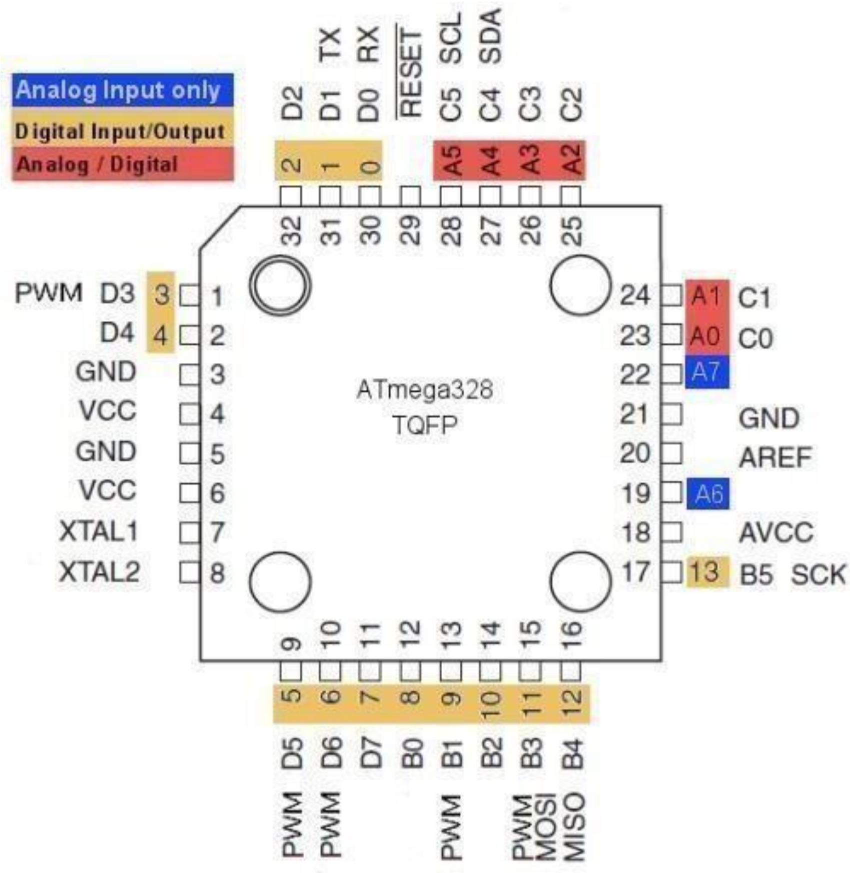

Figure 5.6 Microcontroller AT328-Pin Diagram

Figure 5.6 presents the pinout configuration of the AT328 microcontroller, illustrating the arrangement of digital and analog input/output pins, power supply connections, and communication interfaces

Memory

Memory can be broadly divided into 3 classes:

- 32KB Flash memory –This is the storage space of the compiled program of which the boot loader uses 0.5 KB.
- 2KB SRAM – This is mainly used during run time.
- 1KB EEPROM –This is used for storing data that should not be erased upon switching off power.

Power Setup

The Arduino R3 operates at 5 Volts. It can either be powered through USB cable from the computer or through the DC jack provided on the Board.

The DC Jack

The voltage regulator 7805 is provided in the board for obtaining 5v regulated output voltage. The input voltage applied can be between 7-25 volts DC power.

USB Power

When powered through the USB, the 500mA Re-settable fuse on the USB power line is used to abstain the board from drawing current in excess.

USB Connectivity

Since the ATmega328 does not use USB communication directly, the need for a dedicated IC arises. FTDI FT232 IC is used to communicate between the microcontroller and USB serially .The drivers required for the Serial to USB converter has to be installed.

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage	7-12V
Digital I/O Pins	14 (of which 6 provide PWM output)

Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB use Bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

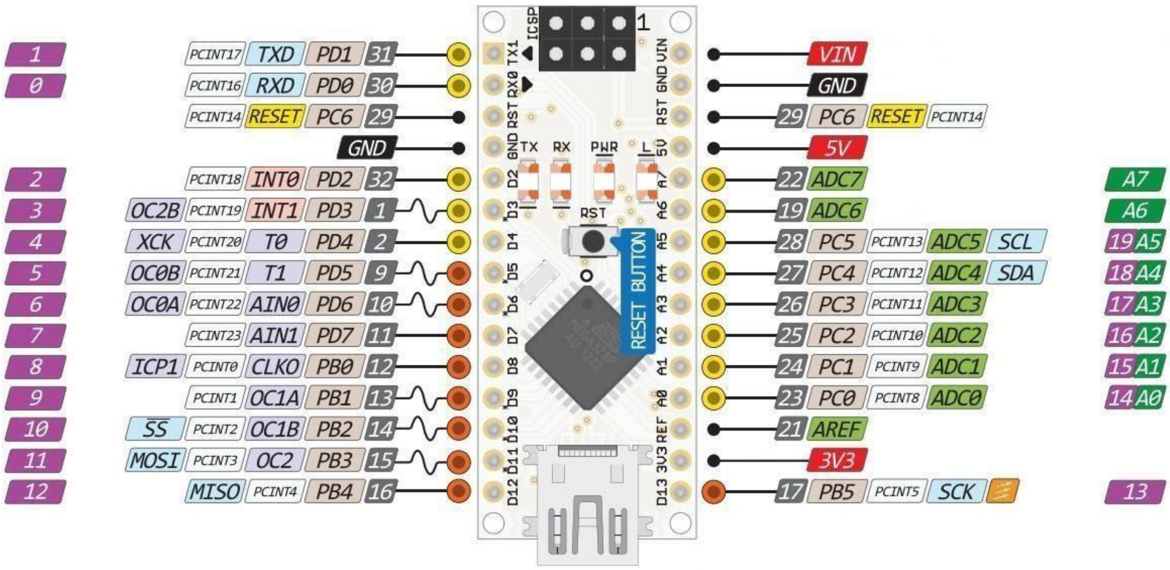

Figure 5.7 Arduino Pin Mapping Hardware

Figure 5.7 provides a comprehensive mapping of hardware pins on an Arduino board, including digital input/output (I/O) pins, analog input pins, power supply connections, and communication interfaces such as UART, SPI, and I2C.

The Arduino R3 / Arduino Uno Boards have 20 programmable I/O's.They are grouped mainly as

- Pins 0 to 13
- Pins 0 to 5 [Analog Inputs 0 to 5]

Digital I/O's

The 20 I/O's can accept digital signals as input as well as outputs. The digital pins are numbered from 0 to 19. The Digital Pins can be used for controlling LED's, Relays and for accepting input from Push-Buttons, Digital Sensors

Analog I/O's

Analog inputs can be given to pins A0-A5.An inbuilt ADC analog to digital converter is present that converts analog voltages in the range of 0 to 5 volts to a 10-bit value. Analog sensors that sense changes in temperature or light can work with these inputs.

Analog Output

The six pins marked PWM are pins dedicated to produce Analog Output Signal. They can produce analog voltages in the range of 0 to 5 volts with a resolution of 8-bits. They can be used for Intensity Control, Speed Control, Etc.

5.3.8 COMMUNICATION

Serial Communication

The communication can be established with the computer or other arduino boards. For this purpose, the ATmega328 provides UART TTL (5V) serial communication, existing on digital pins 0 (RX) and 1 (TX). A FT232RL IC on the board paves the way for this serial communication over USB and appears as a virtual com port to the computer.

The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USBto-serial chip

I2C Communication or Two Wire Communication

The Atmega328 provides I2C / Two Wire Communication through the Analog Pins A4 (SDA) & A5 (SCL). The Arduino software includes a Wire library to simplify use of the I2C bus. I2C Communication can be used for communicating with other microcontrollers / ICs.

SPI Communication

The Atmega328 supports SPI communication through pins 10 (SS), 11(MOSI), 12 (MISO), 13 (SCK). SPI communication is supported by the Arduino IDE using the SPI library. SPI Communication can also be used to communicate with other peripherals / ICs - SD Cards, Ethernet Controller, Etc.

Software Serial

In addition to the Hardware Serial Communication provided by the ATmega328, The Software Serial Library for Arduino allows the use of any pin on the board for additional Serial Communication.

Arduino IDE

The Arduino IDE (Integrated Development Environment) is the software to program Arduino Arduino board. It is available as an open source in the internet.

Bootloader

The Bootloader is the Software that is loaded on to the ATmega 328 to facilitate programming of the ATmega328 from within the Arduino IDE. The Bootloader is loaded initially when the board is powered on / reset. Upon receiving a signal from the IDE that a new program needs to be uploaded ,it
writes into the program memory of the microcontroller using serial communication for reception.

Programming

The programming in Arduino IDE is much similar to 'c' programming.

Setup () and Loop ()

There are two special functions that are a part of every Arduino sketch: setup () and loop (). At the start of power or a reset, the setup () function is called once. It is used only for one time operations required at power on.

The loop () function takes care of the application code. It keeps on executing until the power supply is switched off. It is mandatory to include both the functions, whether needed or not.

Analog I/O's

Analog inputs can be given to pins A0-A5.An inbuilt ADC analog to digital converter is present that converts analog voltages in the range of 0 to 5 volts to a 10-bit value. Analog sensors that sense changes in temperature or light can work with these inputs.

Analog Output

The six pins marked PWM are pins dedicated to produce Analog Output Signal.They can produce analog voltages in the range of 0 to 5 volts with a resolution of 8-bits. They can be used for Intensity Control, Speed Control, Etc.

5.3.9 LCD (LIQUID CRYSTAL DISPLAY)

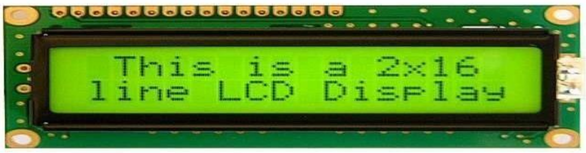

Figure 5.8 LCD Display

Figure 5.8 illustrated is the configuration of an LCD display, highlighting its segmented or dot matrix layout, backlighting elements, and interface connectors.

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD, The data register stores the data to be displayed on the LCD

The data is the ASCII value of the character to be displayed on the LCD. Liquid crystal displays are used for display of numeric and alphanumeric character in dot matrix and segmental displays. The two liquid crystal materials which are commonly used in display technology are nematic and cholesteric whose schematic arrangement of molecules is shown in fig. The most popular liquid crystal structure is the Nematic Liquid Crystal (NLC). In this all the molecules align themselves approximately parallel to a unique axis (director), while retaining the complete translational freedom. The liquid is normally transparent, but if subjected to a strong electric field, disruption of the wellordered crystal structure takes place causing the liquid to polarize and turn opaque. The removal of the applied electric field allows the crystal structure to regain its original form and the materials become transparent. Based on the construction, LCDs are classified into two types. They are,

(i) Dynamic scattering type

(ii) Field effect type.

Dynamic scattering type

The construction of the dynamic scattering liquid crystal cell is shown in the fig. The display consists of two glass plates, each coated with tin oxide (SnO_2) on the inside with transparent electrodes separated by a liquid crystal layer,5µA to 50 µA thick. The oxide coating on the front sheet is etched to produce a single or multi- segment pattern of characters, with each segment properly insulated from each other. A weak electric field applied to liquid crystal tends to align molecule in the direction of the field. As soon as the voltage exceeds certain threshold value, the domain structure collapses and the appearance is changed. As the voltage grows further, the flow becomes turbulent and the substance turns optically homogenous. In this disordered state, the liquid crystal scatters light.

Thus, when the liquid is not activated, it is transparent. When the liquid is activated, the molecular turbulence causes light to be scattered in all directions and the cell appears bright. This phenomenon is called dynamic scattering [12].

Field effect type

The construction of the field effect LCD display is similar to that of the dynamic scattering type, with the expectation that two thin polarizing optical filters are placed at the inside of each glass sheet.

The LCD material is of twisted nematic type which twists the light (change in direction of polarization) passing through the cell when the latter is not energized. This allows light to pass through the optical filters and the cell appears bright. When the cell is energized, no twisting of light takes place and the cell appears dull.

Liquid crystal cells are of two types (i) transitive type (ii) reflective type. In the transitive type cell both glass sheets are transparent so that the light from the rear source is scattered in the forward direction when the cell is activated. The reflecting type cell has a reflecting surface on one side of the glass sheet. The incident light on the front surface of the cell is dynamically scattered by an activated cell. Both types of cells appear quite bright when activated even under ambient light conditions.

Liquid crystals consume small amount of energy, in a seven segment display the current drawn is about 25 μA for dynamic scattering cells and 300 μA .for field effect cells LCD's require ac voltage supply. A typical voltage supply to dynamic scattering LCD's are normally used for seven-segmental displays.

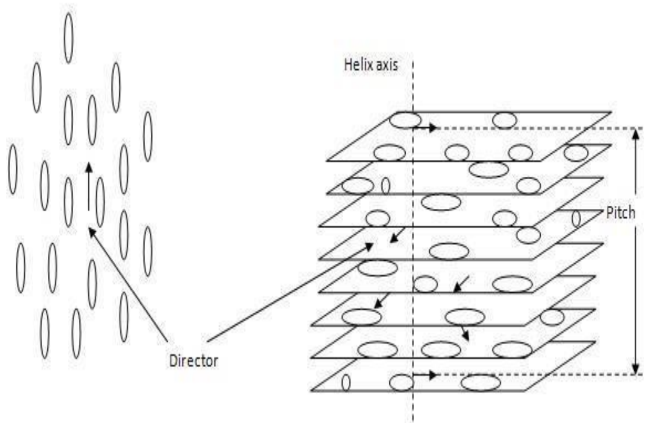

Figure 5.9 Schematic arrangement in liquid crystal

Figure 5.9 illustrates the molecular alignment within a liquid crystal layer, showcasing the directional orientation of molecules in response to an applied electric field.

Features of LCD

- Operating voltage range is 3-20V ac.
- It has a slow decay time. Response time is 50 to 200 ms.
- Viewing angle is 100 degree.
- Invisible in darkness. Requires external illumination.
- Life time is limited to 50,000 hours due to chemical graduation.

Advantages of LCD

- The voltage required is small.
- They have low power consumption. A seven segment display requires about 140 W (20 W per segment).

Table 5.3 Pin Description

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	VEE
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight VCC (5V)	Led+
16	Backlight Ground (0V)	Led-

Table 5.3 delineates the pin configurations and functions of electronic components or integrated circuits, providing details such as pin number, signal name, input/output designation, and voltage levels, aiding in circuit design, troubleshooting, and system integration

5.3.10 Accelerometer

An accelerometer is a crucial device used in various fields, including engineering, physics, biomechanics, and consumer electronics. It serves the primary function of measuring acceleration, whether it's linear, rotational, or gravitational. This device has evolved significantly over time, becoming smaller, more accurate, and more versatile, enabling its integration into a wide array of applications.

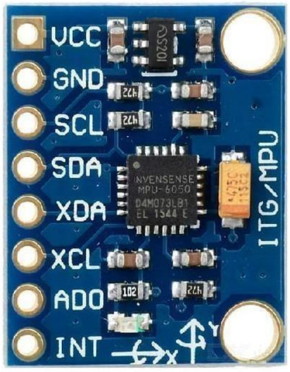

Figure 5.10 Accelerometer (MEMS)

Figure 5.10 depicts the internal structure of a Microelectromechanical Systems (MEMS) accelerometer, showcasing the arrangement of miniaturized

mechanical components and sensing elements.

At its core, an accelerometer operates on the principle of inertia. It consists of a mass suspended within a casing, typically using springs or piezoelectric materials. When subjected to acceleration, the mass experiences a force proportional to the acceleration applied. This force causes the mass to move relative to the casing, and by measuring this movement, the accelerometer determines the acceleration.

The earliest accelerometers date back to the early 20th century when they were primarily used in seismology to detect earthquakes. These early devices were large, bulky, and not very sensitive. However, advancements in microfabrication techniques in the latter half of the century led to the development of microelectrode mechanical systems (MEMS) accelerometers, which revolutionized the field.

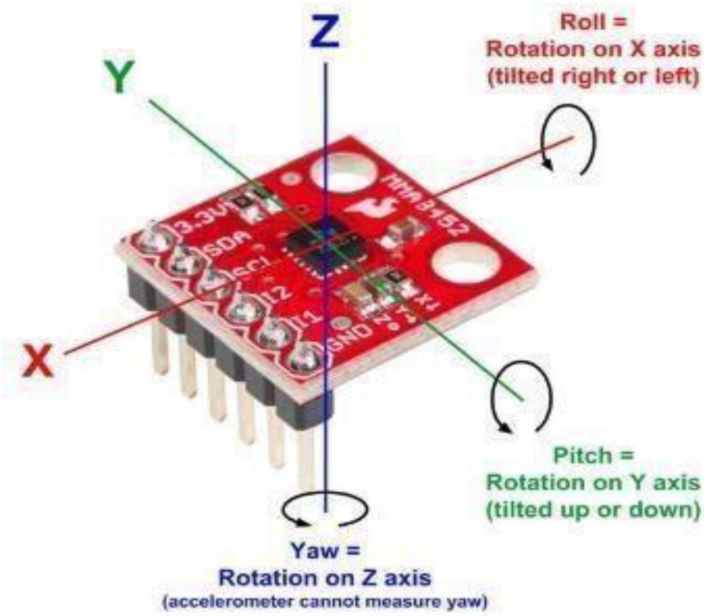

Figure 5.11 Operation of Accelerometer

Figure 5.11 illustrates the operational principle of an accelerometer, depicting the detection of acceleration forces through the deflection of a mass suspended by microstructures.

MEMS accelerometers are incredibly small, often just a few millimetres in size, yet they can measure acceleration with high precision and sensitivity. They consist of a tiny proof mass suspended by springs, with microstructures integrated onto a silicon substrate. As the proof mass moves in response to acceleration, it generates an electrical signal that can be measured and analyzed.

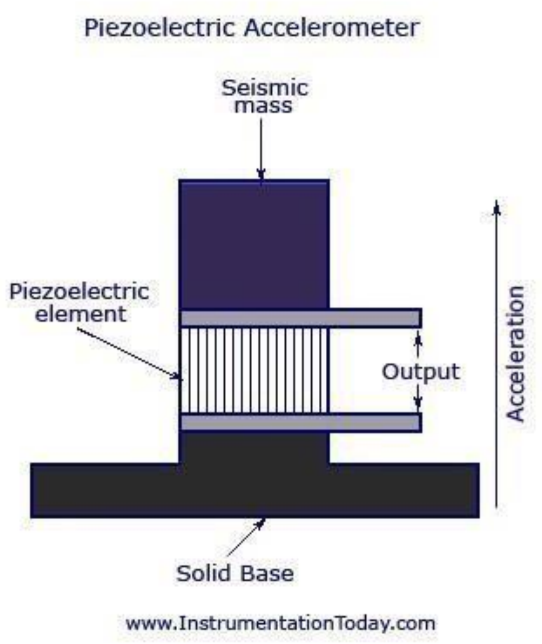

Figure 5.12 Piezoelectric Accelerometer

Figure 5.12 Displayed is the structure of a piezoelectric accelerometer, featuring a piezoelectric material sandwiched between inertial masses, which generate electrical charges in response to mechanical strain.

One of the key advantages of MEMS accelerometers is their cost-effectiveness and mass production capabilities. This has led to their widespread adoption in consumer electronics, such as smartphones, tablets, and gaming controllers. In these devices, accelerometers are used for various purposes, including screen orientation detection, gesture recognition, and gaming motion control.

In addition to consumer electronics, accelerometers find applications in automotive systems, aerospace technology, robotics, and healthcare. In automotive systems, they are used for airbag deployment, vehicle stability control, and anti-lock braking systems. In aerospace technology, accelerometers play a crucial role in navigation, attitude control, and structural health monitoring of aircraft and spacecraft[13].

In robotics, accelerometers enable robots to perceive their environment and adjust their movements accordingly. They are used for balance control in humanoid robots, navigation in autonomous drones, and vibration monitoring in industrial robots. In healthcare, accelerometers are utilized in wearable devices for activity tracking, fall detection in elderly care systems, and monitoring of tremors in patients with Parkinson's disease.

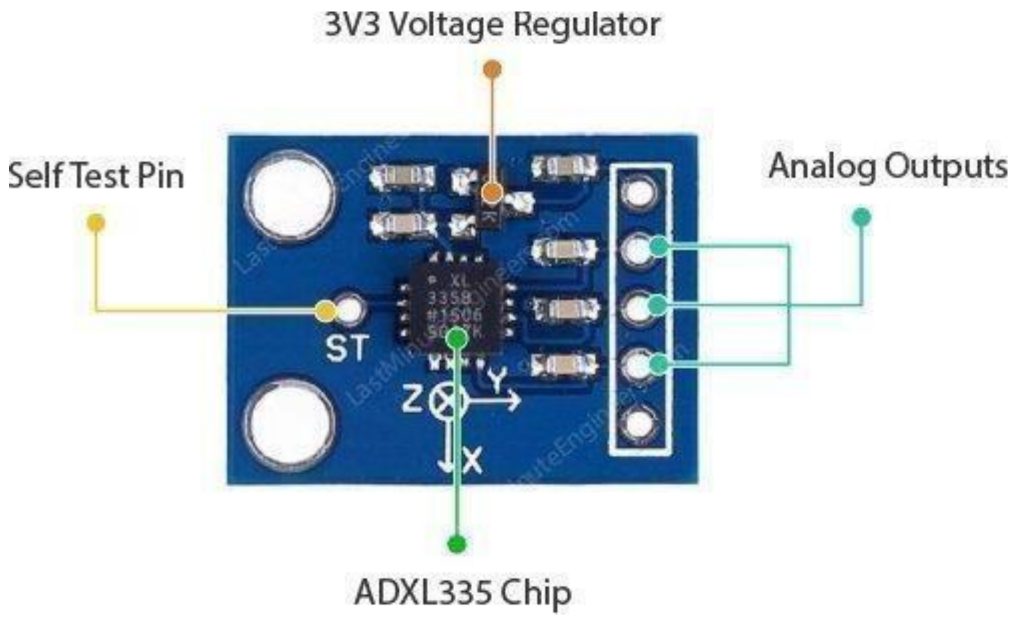

Figure 5.13 ADXL335 Accelerometer Module

Figure 5.13 showcases the ADXL335 accelerometer module, highlighting its compact size and integrated sensor components for measuring acceleration across multiple axes.

Beyond MEMS accelerometers, other types of accelerometers exist, each with its own principles of operation and applications. Piezoelectric accelerometers, for example, generate electrical signals in response to mechanical stress, making them suitable for high-frequency vibration measurements. Capacitive accelerometers measure acceleration by detecting changes in capacitance between two plates as the proof mass moves.

Accelerometers have also found their way into emerging technologies such as virtual reality (VR) and augmented reality (AR). In VR headsets, accelerometers track head movements to provide immersive experiences, while in AR devices, they enable precise spatial tracking of virtual objects overlaid onto the real world.

5.3.11 Ultrasonic Sensor

An ultrasonic sensor is a sophisticated device that operates on the principle of sound waves beyond the range of human hearing. This technology is widely used in various fields, including automotive, healthcare, industrial automation, robotics, and consumer electronics, due to its accuracy, reliability, and versatility.

Figure 5.14 Ultrasonic Sensor

Figure 5.14 presents the configuration of an ultrasonic sensor, featuring a transducer for emitting ultrasonic waves and a receiver for detecting reflected signals.

At its core, an ultrasonic sensor consists of several key components working in tandem to detect objects or measure distances using ultrasonic waves. These components typically include a transducer, a control circuit, and a housing.

The transducer is the heart of the ultrasonic sensor. It converts electrical energy into ultrasonic waves and vice versa. Piezoelectric crystals, such as quartz or ceramics, are commonly used in transducers due to their ability to generate and detect ultrasonic waves efficiently. When an electrical signal is applied to the transducer, it vibrates at a specific frequency, producing ultrasonic waves that propagate through the air.

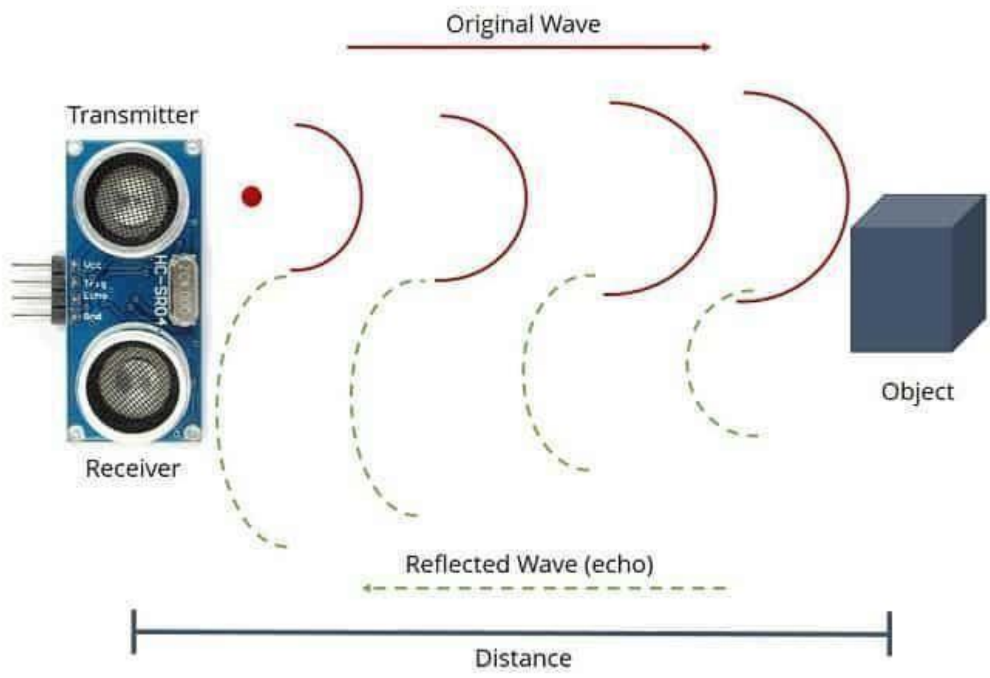

Figure 5.15 Working of Ultrasonic Sensor

Figure 5.15 illustrates is the operational process of an ultrasonic sensor, demonstrating the emission of high-frequency sound waves and the detection of their reflection.

The control circuit is responsible for generating electrical signals to drive the transducer and processing the received signals to determine the distance to the target object. It typically includes a microcontroller or dedicated signal processing circuitry, along with supporting components such as amplifiers, filters, and timing circuits. The control circuit controls the timing of the ultrasonic pulses transmitted by the transducer and measures the time it takes for the pulses to travel to the target object and back, using this information to calculate the distance based on the speed of sound in the medium.

The housing of the ultrasonic sensor provides mechanical support and protection for the internal components. It is designed to be robust and durable to withstand harsh environmental conditions and mechanical shocks. The housing also includes openings or windows to allow the transmission and reception of ultrasonic waves.

Ultrasonic sensors operate based on the principle of echo ranging, similar to how bats and dolphins use echolocation to navigate and detect prey. When the sensor emits a short burst of ultrasonic waves, it creates a sound wavefront that propagates through the air until it encounters an object in its path. Upon striking the object, the sound waves are reflected back towards the sensor. The sensor then detects the reflected waves using its transducer and measures the time it takes for the waves to travel to the object and return[14].

5.3.12 Limit Switch

A limit switch is a crucial component within various mechanical and industrial systems, serving to detect the presence or absence of an object, limit the movement of machinery, or trigger a specific action based on the position of an object or machine part. This multifaceted device plays a fundamental role in ensuring the safety, efficiency, and precision of numerous applications across industries such as manufacturing, automotive, aerospace, and robotics.

At its core, a limit switch consists of a mechanical actuator, often in the form of a lever or plunger, which is engaged by the motion of a machine part or an external object. This actuator is connected to a set of electrical contacts within the switch housing. When the actuator is activated by reaching a predefined position, it triggers a change in the state of these contacts, thereby signaling the desired condition to the control system or operator.

The versatility of limit switches lies in their ability to operate in various environments and under different conditions. They can be designed to withstand extreme temperatures, high levels of vibration, exposure to moisture or dust, and other challenging conditions, making them suitable for use in a wide range of industrial settings. Additionally, limit switches come in different configurations, including lever-type, plunger-type, roller-type, and rotary-type, each tailored to specific application requirements.

One of the primary functions of a limit switch is to provide positional feedback within a system. By detecting the presence or absence of an object or the position of a moving component, limit switches enable precise control over machinery and equipment. For example, in a conveyor system, limit switches may be used to detect the arrival of packages at certain points along the conveyor belt, signaling the activation of sorting mechanisms or stopping the conveyor to prevent collisions.

Safety is another critical aspect of limit switch functionality. In many industrial applications, limit switches are employed as safety interlocks to prevent accidents and injuries. For instance, in automated manufacturing processes, limit switches can be strategically placed to ensure that machine components are in the correct position before a dangerous operation is initiated. If the limit switch detects an unsafe condition, it can immediately halt the machine's operation, averting potential hazards.

Figure 5.16 Limit Switch

Figure 5.16 Displayed is the configuration of a limit switch, featuring a mechanical lever or button actuated by physical contact with an object or surface**.**

Furthermore, limit switches contribute to the optimization of production processes by facilitating automation and streamlining workflows. By integrating limit switches into control systems, manufacturers can automate repetitive tasks, improve accuracy, and reduce the need for manual intervention. This not only increases productivity but also enhances product quality and consistency.

In the automotive industry, limit switches play a vital role in various vehicle systems, including door locks, windows, trunk lids, and seat adjustments. For instance, in power windows, limit switches are used to detect when the window reaches its fully closed or fully open position, signaling the motor to stop. Similarly, in seat adjustment mechanisms, limit switches help ensure that the seat is in the desired position, enhancing comfort and safety for the driver and passengers.

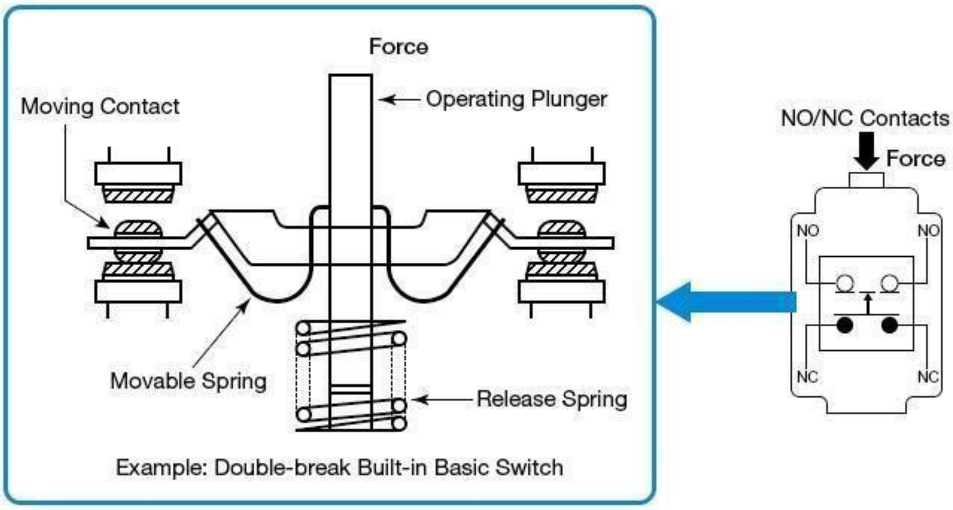

Figure 5.17 Operation of Limit Switch

Figure 5.17 illustrates the operational mechanism of a limit switch, showcasing how physical contact with an object triggers the mechanical actuator, which in turn toggles the electrical contacts.

In aerospace and aviation applications, limit switches are utilized in critical systems such as landing gear, wing flaps, and cargo doors. These switches help monitor the position of movable components during flight operations, ensuring proper functionality and safety. For example, in landing gear systems, limit switches detect when the landing gear is fully extended or retracted, allowing pilots to receive accurate feedback and maintain control over the aircraft's landing gear deployment.

5.3.13 USB Interface Cable

The USB interface cable, often simply referred to as a USB cable, is an indispensable component in modern computing and technology. Its ubiquity is matched only by its versatility, serving as a conduit for data transfer, power delivery, and device connectivity across a vast array of electronic devices. In this comprehensive exploration, we delve deep into the intricacies of USB interface cables, tracing their evolution, dissecting their technical specifications, and uncovering their myriad applications in the contemporary digital landscape.

The Universal Serial Bus (USB) standard was conceived in the early 1990s as a solution to the growing complexity and fragmentation of peripheral connectivity in personal computers. Prior to USB, various proprietary standards and connectors were used for devices such as keyboards, mice, printers, and storage devices, leading to compatibility issues and user inconvenience. The USB standard sought to streamline this landscape by introducing a unified, standardized interface for connecting peripherals to computers and other host devices.

One of the defining features of USB is its simplicity and ease of use. The physical connector of a USB cable consists of a rectangular plug with a distinctive shape that ensures proper orientation during insertion. This plug is designed to fit into a corresponding receptacle on the host device, which may be a computer, laptop, tablet, smartphone, or other compatible hardware. The plugand-play nature of USB allows devices to be hot-swapped without the need for rebooting or manual configuration, making it exceptionally user-friendly.

The USB standard has undergone several iterations since its inception, each introducing improvements in data transfer speeds, power delivery capabilities, and protocol efficiency. The original USB 1.0 specification, released in 1996, supported data transfer rates of up to 1.5 Mbps (Low-Speed) and 12 Mbps (FullSpeed). Subsequent iterations, including USB 2.0, USB 3.0, USB 3.1, and USB 3.2, have progressively increased data transfer speeds, with the latest versions supporting rates of up to 20 Gbps (SuperSpeed USB 3.2 Gen 2x2).

In addition to data transfer, USB cables are also commonly used for power delivery, allowing devices to draw power from a host device or charger. This feature is particularly useful for charging smartphones, tablets, and other portable electronics, eliminating the need for proprietary power adapters and simplifying cable management. The USB Power Delivery (USB PD)

specification further enhances this capability by enabling higher power levels and bidirectional power delivery, facilitating fast charging and powering of a wide range of devices.

Figure 5.18 USB Interface Cable

Figure 5.18 Displayed is the structure of a USB interface cable, featuring connectors at both ends for data transmission and power supply.

The physical construction of USB cables varies depending on their intended use and the specific USB standard they adhere to. A typical USB cable consists of multiple wires encased in a protective sheath, with each wire serving a distinct purpose in facilitating data transmission, power delivery, or both. The most common types of USB cables include Type-A to Type-B, Type-A to Type-C, and Type-C to Type-C, each featuring different connector configurations suited to specific devices and applications.

Type-A to Type-B cables, characterized by the familiar rectangular TypeA plug on one end and a square-shaped Type-B plug on the other end, are commonly used to connect peripherals such as printers, scanners, and external hard drives to computers. Type-A to Type-C cables, featuring a Type-A plug on one end and a reversible Type-C plug on the other end, are widely used for connecting legacy USB devices to modern USB-C equipped hosts, as well as for charging smartphones and tablets.

5.4 SOFTWARE DESCRIPTION

5.4.1 ARDUINO

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

5.4.1.1 FEATURES

Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than Rupees 2500

Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.

Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.

Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.

Open source and extensible hardware - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

5.4.2 ARDUINO SOFTWARE (IDE)

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

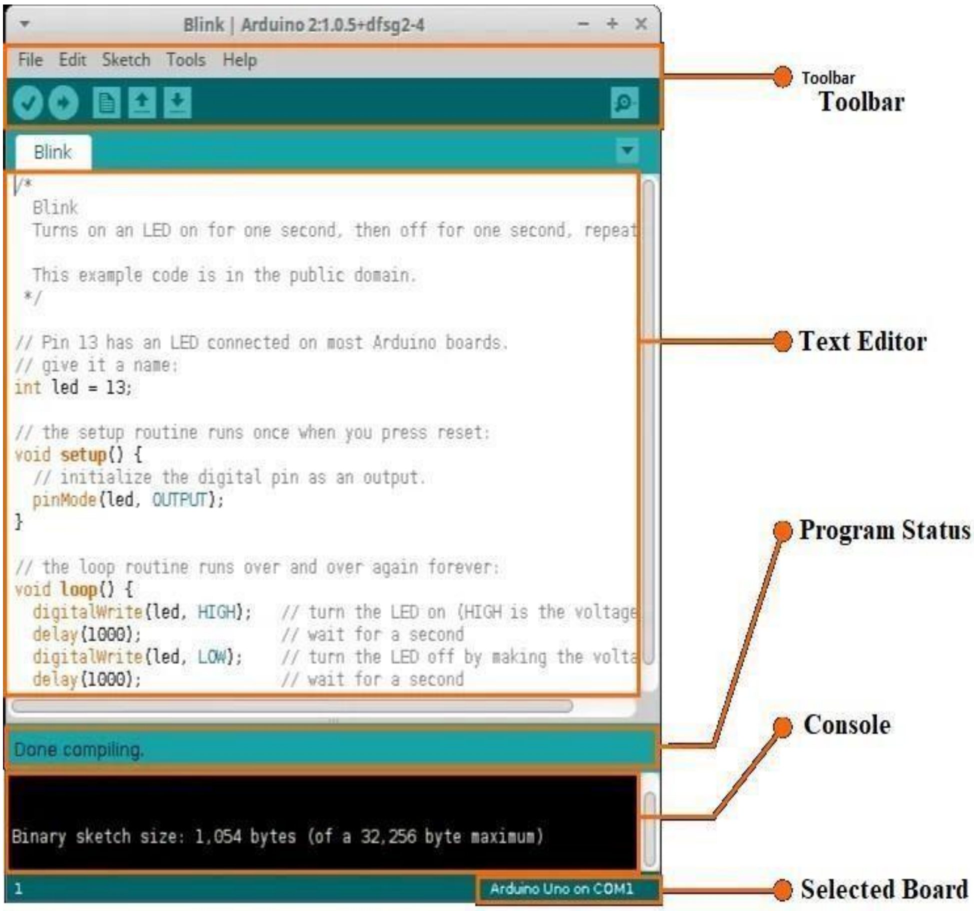

Figure 5.19 Arduino IDE

Figure 5.19 depiction showcases the Arduino IDE, highlighting its user-friendly interface with code editor, serial monitor, and tools for programming Arduino microcontrollers.

Writing Sketches

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension. ino.The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

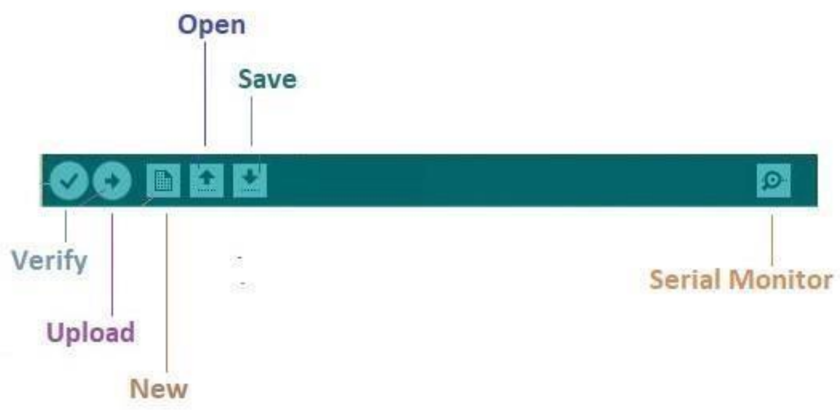

Figure 5.20 Arduino IDE Tool Icon

Figure 5.20 presents a collection of tool icons from the Arduino Integrated Development Environment (IDE), including buttons for compiling, uploading code, and accessing serial monitor.

- **Verify** Checks your code for errors compiling it.
- **Upload** Compiles your code and uploads it to the configured board. See uploading below for details. Note: If you are using an external programmer with your board, you can hold down the "shift" key on your computer when using this icon. The text will change to "Upload using Programmer"

- **New** Creates a new sketch.

Open Presents a menu of all the sketches in your sketchbook. Clicking one will open it within the current window overwriting its content.

- **Save** Saves your sketch.
- **Serial Monitor** Opens the serial monitor.

Additional commands are found within the five menus: File, Edit, Sketch, Tools, Help.

i.File

- **New** Creates a new instance of the editor, with the bare minimum structure of a sketch already in place.
- **Open** Allows to load a sketch file browsing through the computer drives and folders.
- **Open** Recent Provides a short list of the most recent sketches, ready to be opened.
- **Sketchbook** Shows the current sketches within the sketchbook folder structure; clicking on any name opens the corresponding sketch in a new editor instance.
- **Examples** Any example provided by the Arduino Software (IDE) or library shows up in this menu item. All the examples are structured in a tree that allows easy access by topic or library.
- **Close** Closes the instance of the Arduino Software from which it is clicked.
- **Save** Saves the sketch with the current name. If the file hasn't been named before, a name will be provided in a "Save as.." window.
- **Save as...** Allows to save the current sketch with a different name.
- **Page Setup** It shows the Page Setup window for printing.
- **Print** Sends the current sketch to the printer according to the settings defined in Page Setup.

- **Preferences** Opens the Preferences window where some settings of the IDE may be customized, as the language of the IDE interface.
- **Quit** Closes all IDE windows. The same sketches open when Quit was chosen will be automatically reopened the next time you start the IDE.

ii.Edit

- **Undo/Redo** Goes back of one or more steps you did while editing; when you go back, you may go forward with Redo.
- **Cut** Removes the selected text from the editor and places it into the clipboard.
- **Copy** Duplicates the selected text in the editor and places it into the clipboard.
- **Copy for Forum** Copies the code of your sketch to the clipboard in a form suitable for posting to the forum, complete with syntax coloring.
- **Copy as HTML** Copies the code of your sketch to the clipboard as HTML, suitable for embedding in web pages.
- **Paste** Puts the contents of the clipboard at the cursor position, in the editor.
- **Select All** Selects and highlights the whole content of the editor.
- **Comment/Uncomment** Puts or removes the // comment marker at the beginning of each selected line.
- **Increase/Decrease** Indent Adds or subtracts a space at the beginning of each selected line, moving the text one space on the right or eliminating a space at the beginning.
- **Find Opens** the Find and Replace window where you can specify text to search inside the current sketch according to several options.
- **Find Next** Highlights the next occurrence - if any - of the string specified as the search item in the Find window, relative to the cursor position.

- **Find Previous** Highlights the previous occurrence - if any - of the string specified as the search item in the Find window relative to the cursor position.

iii.Sketch

- **Verify/Compile** Checks your sketch for errors compiling it; it will report memory usage for code and variables in the console area.

- **Upload** Compiles and loads the binary file onto the configured board through the configured Port.

- **Upload Using Programmer** This will overwrite the bootloader on the board; you will need to use Tools > Burn Bootloader to restore it and be able to Upload to USB serial port again. However, it allows you to use the full capacity of the Flash memory for your sketch. Please note that this command will NOT burn the fuses. To do so a Tools -> Burn Bootloader command must be executed.

- **Export** Compiled Binary Saves a .hex file that may be kept as archive or sent to the board using other tools.

- **Show Sketch Folder** Opens the current sketch folder.

- **Include Library** Adds a library to your sketch by inserting #include statements at the start of your code. For more details, see libraries below. Additionally, from this menu item you can access the Library Manager and import new libraries from .zip files.

Add File... Adds a source file to the sketch (it will be copied from its current location). The new file appears in a new tab in the sketch window. Files can be removed from the sketch using the tab menu accessible clicking on the small triangle icon below the serial monitor one on the right-side of the toolbar.

iv.Tools

- **Auto Format** This formats your code nicely: i.e. indents it so that opening and closing curly braces line up, and that the statements inside curly braces are indented more.

- **Archive Sketch** Archives a copy of the current sketch in .zip format.

  The archive is placed in the same directory as the sketch.

- **Fix Encoding & Reload** Fixes possible discrepancies between the editor char map encoding and other operating systems char maps.

- **Serial Monitor** Opens the serial monitor window and initiates the exchange of data with any connected board on the currently selected Port

- **Board** Select the board that you're using. See below for descriptions of the various boards.

- **Port** This menu contains all the serial devices (real or virtual) on your machine. It should automatically refresh every time you open the top-level tools menu.

- **Programmer** For selecting a hardware programmer when programming a board or chip and not using the onboard USB-serial connection. Normally you won't need this, but if you're burning a bootloader to a new microcontroller, you will use this.

- **Burn Bootloader** The items in this menu allow you to burn a bootloader onto the microcontroller on an Arduino board. This is not required for normal use of an Arduino board but is useful if you purchase a new ATmega microcontroller (which normally comes without a bootloader). Ensure that you've selected the correct board from the Boards menu before burning the bootloader on the target board. This command also set the right fuses.

v.Help

Here you find easy access to a number of documents that come with the Arduino Software (IDE). You have access to **Getting Started, Reference**, this guide to the IDE and other documents locally, without an internet connection. The documents are a local copy of the online ones and may link back to our online website.

Find in Reference This is the only interactive function of the Help menu: it directly selects the relevant page in the local copy of the Reference for the function or command under the cursor.

vi.Sketchbook

The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog.

Tabs, Multiple Files, and Compilation ;

Allows you to manage sketches with more than one file (each of which appears in its own tab). These can be normal Arduino code files (no visible extension), C files (.c extension), C++ files (.cpp), or header files (.h).

Before compiling the sketch, all the normal Arduino code files of the sketch (.ino, .pde) are concatenated into a single file following the order the tabs are shown in. The other file types are left as is.

vii.Uploading

Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Keyspan USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyACMx , /dev/ttyUSBx or similar. Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (preDiecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

When you upload a sketch, you're using the Arduino bootloader, a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The bootloader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The bootloader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets).

viii.Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the

Sketch > Import Library menu. This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #include statements from the top of your code.

There is a list of libraries in the reference. Some libraries are included with the Arduino software. Others can be downloaded from a variety of sources or through the Library Manager. Starting with version 1.0.5 of the IDE, you do can import a library from a zip file and use it in an open sketch. See these instructions for installing a third-party library.

5.4.3 Third-Party Hardware

Support for third-party hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, bootloaders, and programmer definitions. To install, create the hardware directory, then unzip the third-party platform into its own sub-directory. (Don't use "arduino" as the subdirectory name or you'll override the built-in Arduino platform.) To uninstall, simply delete its directory.

Serial Monitor

This displays serial sent from the Arduino board over USB or serial connector. To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down menu that matches the rate passed to Serial. Begin in your sketch. Note that on Windows, Mac or Linux the board will reset (it will rerun your sketch) when you connect with the serial monitor. Please note that the Serial Monitor does not process control characters; if your sketch needs a complete management of the serial communication with control characters, you can use an external terminal program and connect it to the COM port assigned to your Arduino board.

Preferences

Some preferences can be set in the preferences dialog (found under the Arduino menu on the Mac, or File on Windows and Linux). The rest can be found in the preferences file, whose location is shown in the preference dialog.

Boards

The board selection has two effects: it sets the parameters (e.g. CPU speed and baud rate) used when compiling and uploading sketches; and sets and the file and fuse settings used by the burn bootloader command. Some of the board definitions differ only in the latter, so even if you've been uploading successfully with a particular selection you'll want to check it before burning the bootloader.

Arduino Software (IDE) includes the built-in support for the boards in the following list, all based on the AVR Core. The Boards Manager included in the standard installation allows to add support for the growing number of new boards based on different cores like Arduino Due, Arduino Zero, Edison, Galileo and so on.

5.4.4 STARTED WITH THE ARDUINO NANO

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P. It offers the same connectivity and specs of the UNO board in a smaller form factor.

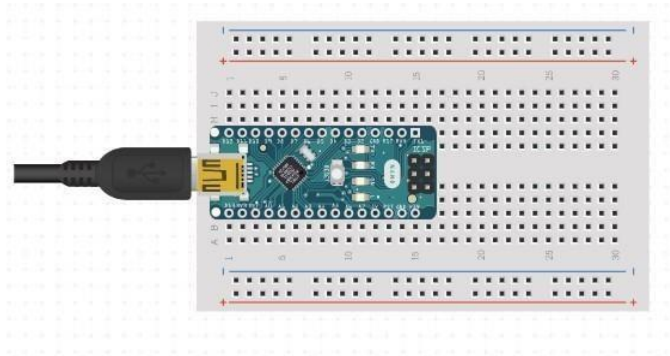

Figure 5.21 Arduino NANO Interface

Figure 5.21 Displayed is the interface of an Arduino Nano microcontroller board, showcasing its compact size and arrangement of digital and analog pins, power connections, and communication interfaces. This depiction provides a visual reference for users, aiding in the identification and utilization of various features on the Arduino Nano board for prototyping and project development.

The Arduino Nano is programmed using the Arduino Software (IDE), our Integrated Development Environment common to all our boards and running both online and offline. For more information on how to get started with the Arduino Software visit the Getting Started page.

Arduino Nano on the Arduino Desktop IDE

If you want to program your Arduino Nano while offline you need to install the Arduino Desktop IDE To connect the Arduino Nano to your computer, you'll need a Mini-B USB cable. This also provides power to the board, as indicated by the blue LED (which is on the bottom of the Arduino Nano 2.x and the top of the Arduino Nano 3.0).

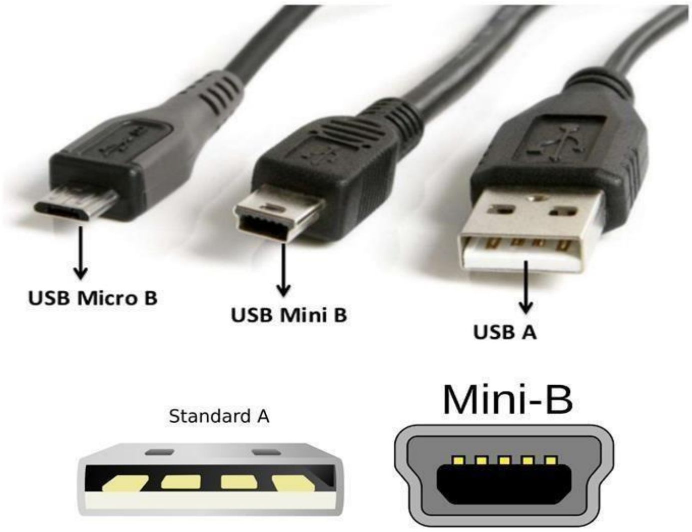

Figure 5.22 NANO Interfacing USB Types of Port

Figure 5.22 Illustrated is the USB port interface of the Arduino Nano, highlighting its Type-B connector for data transfer and power supply.

Open your first sketch

- Open the LED blink example sketch: File > Examples > 01.Basics > Blink. **Select your board type and port**

- Select Tools > Board > Arduino AVR Boards > Arduino Nano.

NOTE: We have updated the Nano board with a fresh bootloader. Boards sold by us from January 2018 have this new bootloader, while boards manufactured before that date have the old bootloader. First, check that **Tools > Board > Boards Manager shows you have the Arduino AVR Boards** 1.16.21 or later installed. Then, to program the NEW Arduino NANO boards you need to choose **Tools > Processor > ATmega328P**. To program old boards you need to choose **Tools > Processor > ATmega328P (Old Bootloader)**. If you get an error while uploading or you are not sure which bootloader you have, try each Tools > Processor menu option until your board gets properly programmed.

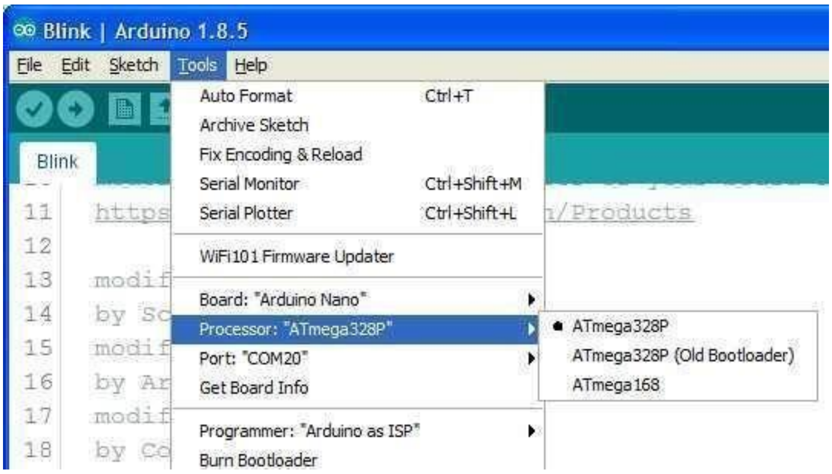

Figure 5.23 Select the NANO Processor Type

Figure 5.23 Depicts, aids users in correctly configuring the IDE settings for their Arduino Nano projects, ensuring compatibility and optimal performance

with the chosen microcontroller.

Select the serial device of the board from the Tools | Serial Port menu. This is likely to be COM3 or higher (COM1 and COM2 are usually reserved for hardware serial ports). To find out, you can disconnect your board and re-open the menu; the entry that disappears should be the Arduino board. Reconnect the board and select that serial port.

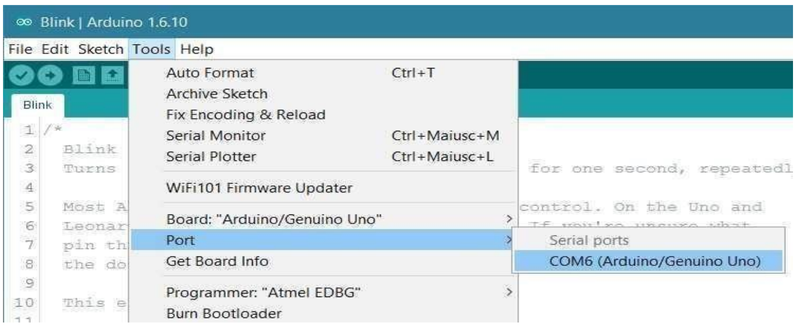

Figure 5.24 Select Board Type

Figure 5.24 depiction guides users through the initial setup process, enabling them to choose the appropriate board type for their Arduino projects, ensuring compatibility and accurate compilation of code.

Upload and run your first Sketch

To upload the sketch to the Arduino Nano, click the Upload button in the upper left to load and run the sketch on your board:

Figure 5.25 Upload to Nano

Figure 5.25 illustrates is the process of uploading code to an Arduino Nano microcontroller board via the Arduino IDE, with the "Upload" button highlighted.

Wait a few seconds - you should see the RX and TX LEDs on the board flashing. If the upload is successful, the message "Done uploading." will appear in the status bar.

CHAPTER 6

SIGNIFICANCE OF PROPOSED METHOD TOWARDS SUSTAINABLE FUTURE

6.1 SUSTAINABLE DEVELOPMENT GOALS:

Sustainable development is a concept and method that aims to balance economic growth, social progress, and environmental protection in a way that serves the demands of the current generation without jeopardizing future generations' ability to satisfy their own needs. To create a more sustainable and resilient future entails merging economic development, social fairness, and environmental stewardship.

Figure 6.1 Sustainable Development Goals

Figure 6.1 describes the 17 goals strive for the universal reduction of climate change and poverty, and the improvement of education, health, and economic growth. United Nations describes the SDGs as seeking to "protect the planet, and improve the lives and prospects of everyone, everywhere."

6.2 SIGNIFICANCE CONTRIBUTION TOWARDS SDG:

Goal 9: Industry, innovation and infrastructure

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Our project, focusing on the development of a real-time pavement surface condition detecting system using deep learning models and MEMS signals from on-car sensors, aligns closely with Goal 9: Industry, Innovation, and Infrastructure of the United Nations Sustainable Development Goals. By leveraging advanced technology and innovative approaches, Our initiative contributes to promoting sustainable industrialization, fostering international cooperation in technology transfer, enhancing infrastructure resilience, and promoting inclusive and sustainable innovation. Through data-driven decisionmaking processes and capacity building efforts, Our project aims to improve the efficiency, safety, and accessibility of transportation infrastructure, thereby supporting economic growth, social development, and environmental sustainability in both emerging and established countries.

This approach not only addresses the immediate concern of pavement maintenance but also lays the groundwork for long-term infrastructure resilience and inclusive development. By emphasizing low-cost solutions and real-time detection systems, Our project underscores the importance of accessibility and affordability in advancing technological innovation, ensuring that the benefits of infrastructure advancements reach all segments of society. Furthermore, Our focus on accurate and timely information about pavement conditions facilitates more efficient allocation of resources for road repairs and maintenance, contributing to the overall efficiency and sustainability of transportation systems on a global scale.

CHAPTER 7

IMPLEMENTATION AND RESULTS

In this project model is, Automatic detection of pothole and humps and alerting vehicle drivers, to reduce the vehicle speed and then avoid potential accidents. Well maintained roads contribute a major portion of the country's economy. In our project we are using single node. In future it may require one data base server. If we are using n number of nodes we have to make a cloud. It can be integrated in the proposed system to improve user experience. Arduino based sensing module system is developed for vehicle who has to go ordeal of driving on uneven roads are successfully tested and designed. According to the real-time potholes detection, the location of abnormal road condition can be detected and saved in open-source Thing speak data center.

System consists of two major components i.e. hardware side which consist of supporting hardware component and second is software side. Hardware part consists of accelerometer (MEMS sensor), GPS, GSM module, LCD display, buzzer & power supply unit. While software part based on Arduino IDE software. Hardware side of system consist of Arduino Atmega328 a low power microcontroller.Adxl335 3-axis accelerometer selected from wide range of accelerometer. It is consist of three output pins X, Y, Z which gives out 3dimensional vibration reading. We can take value from z pin and output of z pin directly given to arduino. Arduino have inbuilt ADC it converts analog value into digital value. GPS track the real-time position of the system's module maintained real-time wireless connection between system & server

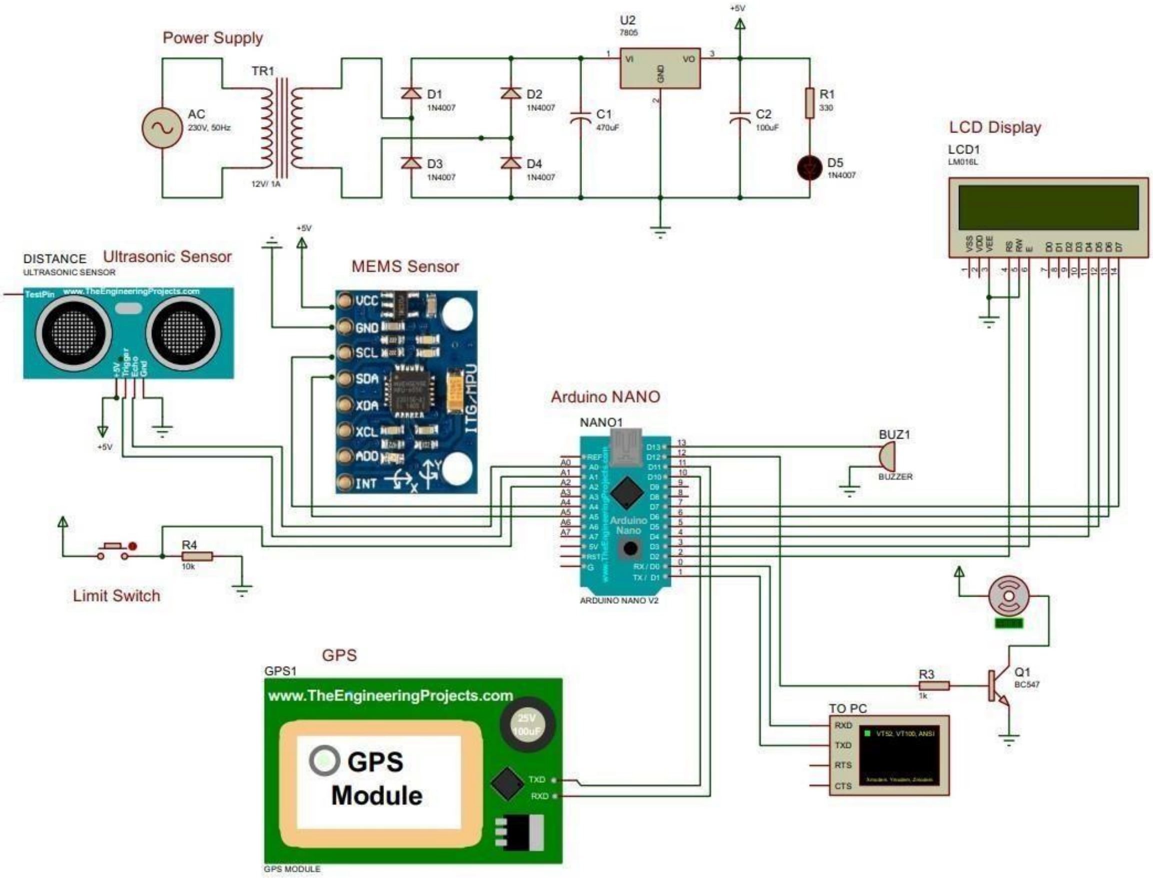

Figure 7.1 Proposed Circuit Diagram

Figure 7.1 displayed is the schematic representation of the proposed circuit, featuring components such as resistors, capacitors, integrated circuits, and connectors, interconnected according to the desired functionality.

Software side system: Software side is a dedicated IOT Thing speak server, consisting of Google Map which shows the potholes as soon as detected by the sensing hardware, Thing speak server not only pin the position in the Google map, but also create a log file which stores the latitude and longitude of detected potholes in real-time.

For the real time road inspection system with distance intimation technique, the sensor senses the pothole which can be based on z-axis value. This value directly given to arduino & that time GPS send real time latitude & longitude data.

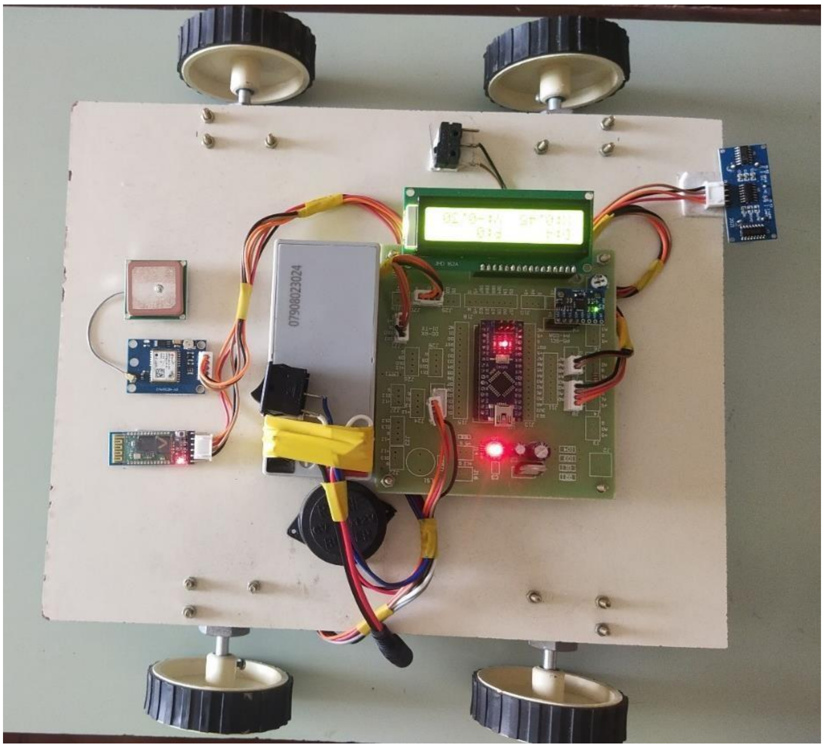

Figure 7.2 Hardware Output

Implementing an AI-based real-time road analysis system using MEMS (Microelectromechanical Systems) data with IoT (Internet of Things) application can offer several benefits such as improved traffic management, enhanced road safety, and efficient infrastructure planning. Here's how the system could work and the potential output and results it could provide:

- **Data Acquisition**: MEMS sensors installed on vehicles or on road infrastructure collect real-time data on various parameters such as vehicle speed, acceleration, braking, road surface conditions, and environmental factors.

- **Data Transmission**: The collected data is transmitted to a central server or cloud platform via IoT protocols such as MQTT (Message Queuing Telemetry Transport) or HTTP (Hypertext Transfer Protocol). This ensures that the data is readily available for analysis and decision-making.

- **Data Analysis with AI:** AI algorithms analyze the incoming data streams to identify traffic patterns, congestion levels, accident-prone areas, road surface quality, and other relevant insights. Machine learning models can be trained to predict traffic flow, detect anomalies, and optimize traffic signal timings.

- **Road Maintenance Planning**: By monitoring road surface conditions and identifying areas with high wear and tear, city planners can schedule maintenance activities more effectively. This proactive approach can help reduce road accidents and prolong the lifespan of infrastructure.

- **Performance Evaluation**: Regular evaluation of the system's performance allows for continuous improvement and optimization. Metrics such as average travel time, accident rates, and infrastructure utilization can be tracked over time to measure the system's impact.

- **Mail System** The system's values have been recored and sent, together with the precise location of Pathole, to the National Highways Authority of India (NHAI) Via Mail System.

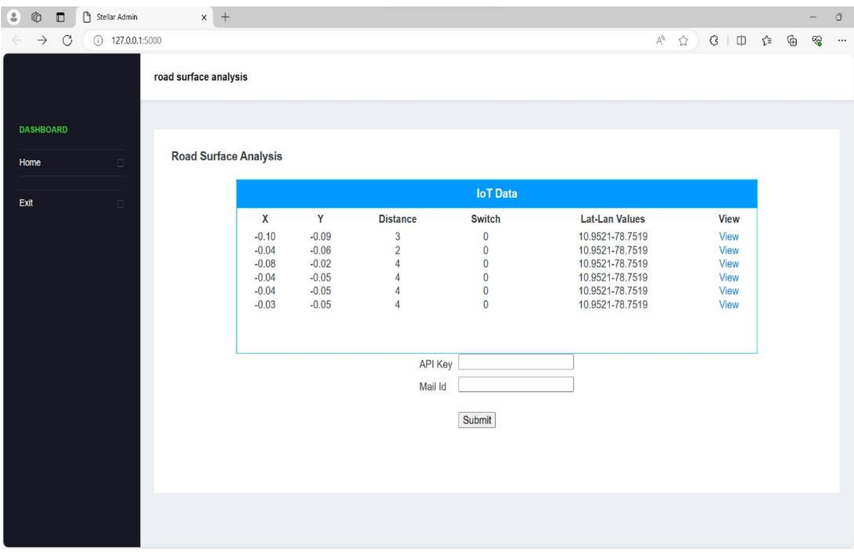

Figure 7.3 Software Output

Figure 7.3 describes the values X and Y axis of the sensor movements and also mention about the distance from the ground to the vehicle, lat-lan values of GPS.

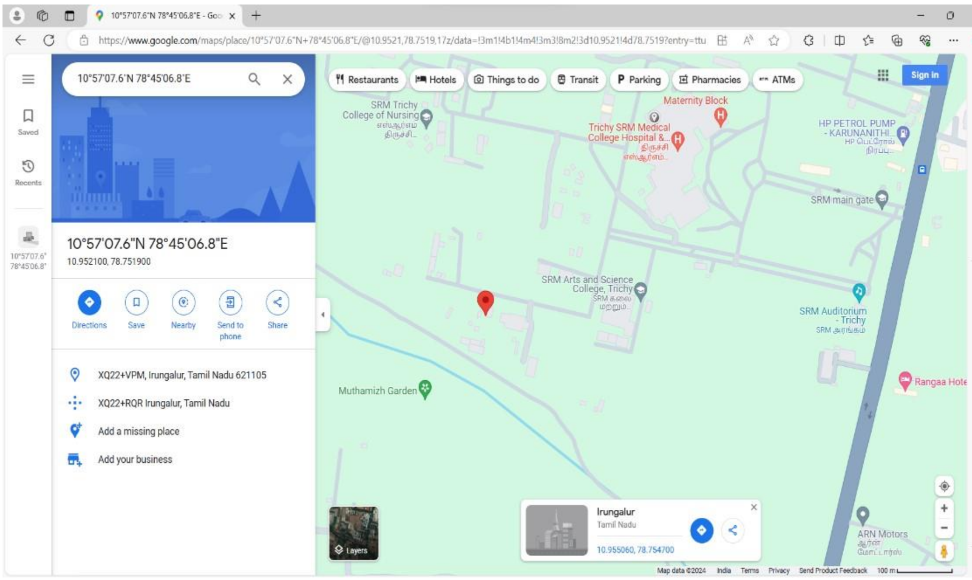

Figure 7.4 Map view of Pathole

Figure 7.4 describes a digital snapshot from Google Maps displaying a web of patholes etched onto the road surface, illustrating the extent of pavement deterioration and potential navigation challenges for motorists.

- Reduced traffic congestion: AI-based traffic management strategies optimize traffic flow and reduce congestion in urban areas.
- Improved road safety: Real-time alerts and proactive maintenance help prevent accidents and enhance overall road safety.
- Enhanced public satisfaction: Timely information about road conditions and alternative routes improves the commuting experience for drivers and pedestrians.
- Efficient infrastructure planning: Data-driven insights support evidence-based decision-making for infrastructure investments and urban development projects.

- Environmental benefits: Smoother traffic flow and reduced idling times contribute to lower carbon emissions and improved air quality in cities.

The algorithm works as expected and performs real-time processing, classification and PC communication achieving very promising preliminary results.

CONCLUSION

In this work, we have presented an application for real-time road surface monitoring based on AI tools. The algorithm is designed to be implemented on a microcontroller board equipped with a microphone that captures sounds inside the cavity of a tyre. Preliminary experimental results show that the device is capable of detecting the quality of the asphalt with an accuracy of 91% on the test set. This demonstrates the suitability of the proposed tiny architecture for this application and of the Mel inspired spectrogram as input to detect road health. The presented approach takes advantage of innovative techniques. In fact, the deployment of AI system settled on embedded system is a cutting-edge technology, focus of much current research.

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APPENDIX – 1

AURDINO CODE:

```
#include <TinyGPS++.h>

#include <SoftwareSerial.h>

#include <String.h>

#include <Wire.h>

#include <Adafruit_MPU6050.h>

#include <Adafruit_Sensor.h>

 Adafruit_MPU6050 mpu;

  #include <LiquidCrystal.h>

 const int RS = 7; const int E  = 6;

const int D4 = 5; const int D5 = 4;

 const int D6 = 3; const int D7 = 2;

LiquidCrystal lcd(RS, E, D4, D5, D6, D7);


 // Ultrasonic pins numbers

const int trigPin = A0;

const int echoPin = A1; //
```

```
defines variables long

duration; int dCm; int

dcent;


 // Choose two Arduino pins to use for software serial
int RXPin = 10; int TXPin = 11; int GPSBaud = 9600;

 // Create a TinyGPS++ object

TinyGPSPlus gps;

 // Create a software serial port called "gpsSerial"

SoftwareSerial gpsSerial(RXPin, TXPin);

String latlann;

String latlan = "";

 // Key int ek = A2; int key= 0;

 //Buzzer int buzzer = 13; int msg = 0; int count = 0; int motion = 0;   int

incomingByte = 0;

 //L293D //Left Motor A const int L1  = 12;  // Pin 14 of L293 const int L2  = A0;
// Pin 10 of L293

//Right Motor B const int R1  = 8;

// Pin  7 of L293 const int R2  = 9;
```

```
// Pin  2 of L293   void

setup() {

  // put your setup code here, to run once:

  pinMode(buzzer, OUTPUT);

   pinMode(ek, INPUT);   //L293D Output

  pinMode(L1, OUTPUT);

  pinMode(L2, OUTPUT);

    pinMode(R1, OUTPUT);

   pinMode(R2,

  OUTPUT);


  pinMode(trigPin, OUTPUT);

  pinMode(echoPin, INPUT);

   lcd.begin(16, 2);   lcd.setCursor(0,0);

  lcd.print("  ROAD SURFACE ");

 lcd.setCursor(0,1);   lcd.print("    ANALYSIS  ");

 Serial.begin(9600);

gpsSerial.begin(GPSBaud);

   // Try to initialize!

 if (!mpu.begin()) {     lcd.setCursor(0,1);
```

```
  lcd.print(" MPU6050 Failed   ");
 while (1) {      delay(10);
   }
  }
  Serial.println("");   delay(100);
gpsSerial.begin(GPSBaud);     delay(1500);
digitalWrite(buzzer,HIGH);     delay(500);
digitalWrite(buzzer,LOW);    lcd.clear();
 mpu.setAccelerometerRange(MPU6050_RANGE_16_G);
mpu.setGyroRange(MPU6050_RANGE_250_DEG);
mpu.setFilterBandwidth(MPU6050_BAND_21_HZ);
mpu.setHighPassFilter(MPU6050_HIGHPASS_0_63_HZ);
mpu.setMotionDetectionThreshold(1);
 mpu.setMotionDetectionDuration(20);
 mpu.setInterruptPinLatch(true);
 // Keep it latched. Will turn off when reinitialized.
mpu.setInterruptPinPolarity(true);
 mpu.setMotionInterrupt(true);   delay(100);
}
 void loop() {
  // put your main code here, to run repeatedly:
   // Ultrasonic Sensor   digitalWrite(trigPin, LOW);
```

```
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
 delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
 // Calculating the distance
dCm= duration*0.034/2;
if(dCm > 99){      dcent =
99;
}   else{     dcent
= dCm;
  }
  sensors_event_t a, g, temp;
  mpu.getEvent(&a, &g, &temp);
  // Key   key = analogRead(ek);   key = key/110;
 count = 0;
 lcd.setCursor(0,0);
lcd.print("D:");   lcd.print(dcent);
 lcd.print(" ");  lcd.setCursor(8,0);
lcd.print("P:"); lcd.print(key);
```

```
 lcd.print("  ");    lcd.setCursor(0,1);

 lcd.print("X:");   lcd.print(a.acceleration.x);

   lcd.print("  ");    lcd.setCursor(8,1);

lcd.print("Y:");   lcd.print(a.acceleration.y);

 lcd.print("  ");

   if(mpu.getMotionInterruptStatus()) {

   /* Get new sensor events with the readings */    sensors_event_t a, g, temp;
mpu.getEvent(&a, &g, &temp);

    digitalWrite(buzzer, HIGH);

//    count++;

//    if(count > 3){

//      motion = 1;

//    }
//    else{

//      motion = 0;

//      count = 0;

//    }

//    digitalWrite(buzzer, LOW);

   }   else{     digitalWrite(buzzer, LOW);

  }
```

```
  if(dCm < 15)
  {
   digitalWrite(buzzer, HIGH);    delay(100);
digitalWrite(buzzer,
LOW);   delay(100);  }
else
  { digitalWrite(buzzer,
   LOW);
  }
  Serial.print(a.acceleration.x);
  Serial.print(" ");
  Serial.print(a.acceleration.y);
  //Serial.print(" ");
  //Serial.print(motion);
  Serial.print(" ");
  Serial.print(dcent);
  Serial.print(" ");
  Serial.print(key);
  Serial.print(" ");   while
(gpsSerial.available() > 0)    if
```

```
(gps.encode(gpsSerial.read()))

displayInfo();

  // If 5000 milliseconds pass and there are no characters coming in   // over the
software serial port, show a "No GPS detected" error   if (millis() > 5000 &&
gps.charsProcessed() < 10)

  {

    Serial.println("No GPS detected");

    //while(true);
  }
  //Serial.print(latlan);

Serial.println();   serialmotor();

delay(700);

}                   void

displayInfo()

{   if

(gps.location.isValid())

  {

    //Serial.print("Latitude: ");

    //Serial.println(gps.location.lat(), 6);

    //latt = (gps.location.lat(),6);

    //Serial.print(" ");
```

```
   //Serial.println(gps.location.lng(), 6);

   //longi = (gps.location.lng(),6);

  //Serial.print("http://maps.google.com/?q=");

   Serial.print(gps.location.lat(), 6);

   Serial.print(" ");
   Serial.print(gps.location.lng(), 6);

   Serial.println();

  }   else

{


   Serial.println("Location: Not Available");

  }

delay(100);  }

void serialmotor()

{   if (Serial.available() >

0)

  {

   incomingByte = Serial.read();

  }

  switch(incomingByte)

  { case '1':
```

```
   digitalWrite(L1, LOW); // control for stop
digitalWrite(L2, LOW);  digitalWrite(R1, LOW);
digitalWrite(R2, LOW);     //Serial.println("Stop\n");
incomingByte='*';     break;
    case '2':
   digitalWrite(L1, HIGH); // control for right     digitalWrite(L2,
LOW);     digitalWrite(R1,
HIGH);     digitalWrite(R2, LOW);
//Serial.println("Back\n");     incomingByte='*';
break;
    case '3':
   digitalWrite(L1, LOW); // control for left     digitalWrite(L2,
HIGH);     digitalWrite(R1,
LOW); digitalWrite(R2, HIGH);
//Serial.println("Forward\n");
incomingByte='*';  break;
    case '4':
   digitalWrite(L1, HIGH); // control for forward
digitalWrite(L2, LOW);     digitalWrite(R1, LOW);
digitalWrite(R2, HIGH);
```

```
//Serial.println("Left\n");     incomingByte='*';

break;

    case '5':

   digitalWrite(L1, LOW); // control for backward     digitalWrite(L2,

HIGH);     digitalWrite(R1,

HIGH);     digitalWrite(R2, LOW);

//Serial.println("Right\n");     incomingByte='*';     break;

  }

}
```

APPENDIX – 2

PYTHON CODE:

```
//main.py import os
 import glob
  import serial  # import serial package
 import sys  # import system package import urllib3
import urllib.request from time import sleep import
mysql.connector   arduino  =  serial.Serial('COM5',
9600, timeout=.1)
count = 0 while True:     data = arduino.readline()[:-2]  # the last bit gets rid
of the new-line chars
if data:        data = data.decode('utf-8')       data_v = str(data)       print(data_v)
data_v = data_v.split(' ')       t = data_v[0]       h = data_v[1]       s = data_v[2]
r  =  data_v[3]             l  =  data_v[4]             la=data_v[5]             conn  =
mysql.connector.connect(user='root',          password='',          host='localhost',
database='1trpiot')        cursor = conn.cursor()        cursor.execute("insert into
iotdata
values('','"+t+"','"+h+"','"+s+"','"+r+"','"+l+"','"+la+"')")        conn.commit()
conn.close()
//app.py from flask import
Flask, render_template, flash, request,session
#from wtforms import Form, TextField, TextAreaField, validators,
StringField, SubmitField  from werkzeug.utils import secure_filename import
mysql.connector import tkinter as tk from tkinter import * import datetime
```

import time import yagmail app = Flask(__name__)

app.config.from_object(__name__) app.config['SECRET_KEY'] =

'7d441f27d441f27567d441f2b6176a' @app.route("/") def homepage():

conn = mysql.connector.connect(user='root', password='', host='localhost',

database='1trpiot')   cursor = conn.cursor()   cursor.execute("SELECT *

FROM iotdata ORDER BY id DESC LIMIT 6")

data=cursor.fetchall()   return

render_template('index.html',data=data)

@app.route("/email",methods=['GET','POST'])

def view11():   if request.method == 'POST':

email = request.form['email']   lvar = request.form['lvar']   conn =

mysql.connector.connect(user='root', password='', host='localhost',

database='1trpiot')   cursor = conn.cursor()   cursor.execute("SELECT

* FROM iotdata WHERE s NOT BETWEEN 3 AND 10 ORDER BY id

DESC LIMIT

1")   data = cursor.fetchone()   mail

= 'testsam360@gmail.com';

password = 'rddwmbynfcbgpywf';   #

list of email_id to send the mail   li =

[email]   body =

"X:"+str(data[0])+",Y:"+str(data[1])+",Distance:"+str(data[2])+",Switch:"+str(d

ata[3])+",Lat-Lan

Values:"+str(data[4])+","+str(data[5])+",link=https://www.google.com/maps/se

a rch/?api=1&query="+data[4]+","+data[5]   yag = yagmail.SMTP(mail,

password)   yag.send(to=email, subject="Alert...!", contents=body) conn = mysql.connector.connect(user='root', password='',

host='localhost', database='1trpiot')   cursor = conn.cursor()

cursor.execute("SELECT * FROM iotdata ORDER BY id DESC LIMIT

6")   data1 = cursor.fetchall()

return

render_template("index.html

",data=data1) if __name__

== '__main__':   app.run(debug=True,

use_reloader=True)

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