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(Approved by AICTE and Affiliated to Anna University, Chennai, Accredited by NBA)

NAAN MUDHALVAN -INTERNET OF THINGS BY IBM

SQUID - STREET QUALITY IDENTIFICATION

TEAM ID : NM2023TMID12734

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1. INTRODUCTION

1.1 PROJECT OVERVIEW

The quality of streets and roads is of paramount importance for ensuring safe and efficient transportation. Well-maintained streets not only provide a smoother driving experience but also reduce vehicle wear and tear, decrease accidents, and enhance overall urban liability. However, monitoring and assessing the condition of extensive road networks can be a daunting task for transportation authorities and municipalities.

The introduction of advanced technologies and data-driven approaches presents an opportunity to overcome these challenges. By leveraging machine learning, image analysis, sensor data, and geospatial information, it is possible to develop a system that can automatically identify and classify street quality. Such a system would enable proactive maintenance planning, efficient resource allocation, and timely repairs.

The primary goal of this project is to develop a street quality identification system that can analyze various data sources and provide accurate assessments of road conditions. The system will utilize street images captured by cameras, sensor data collected from vehicles or infrastructure, and geospatial information such as road network data and historical maintenance records. By integrating these diverse data sources, a comprehensive understanding of street quality can be achieved.

Machine learning algorithms will play a vital role in this project. They will be trained on labelled data to analyze and classify street conditions into different categories, such as excellent, good, fair, poor, or deteriorated. The models will continuously learn and adapt, improving their accuracy over time.

The system will not only provide valuable insights into the quality of streets but also offer a user-friendly interface for easy access to information. Decision-makers, transportation authorities, and maintenance personnel will be able to visualize street quality data, analyze trends, and prioritize maintenance and repair efforts efficiently.

By implementing this street quality identification system, communities can benefit from improved road infrastructure, reduced maintenance costs, enhanced road safety, and increased overall livability. It will empower authorities to make data-driven decisions, optimize resource allocation, and ensure timely repairs, ultimately leading to better transportation experiences for everyone.

1.2 PURPOSE

The purpose of the Street Quality Identification project is to develop a system that can accurately assess street conditions, enable proactive maintenance planning, optimize resource allocation, enhance road safety, and contribute to improved urban livability. By leveraging advanced technologies and data-driven approaches, the project aims to provide valuable insights and tools for transportation authorities to effectively manage and maintain their road networks.

2. IDEATION & PROPOSED SOLUTION

2.1 PROBLEM STATEMENT DEFINITION

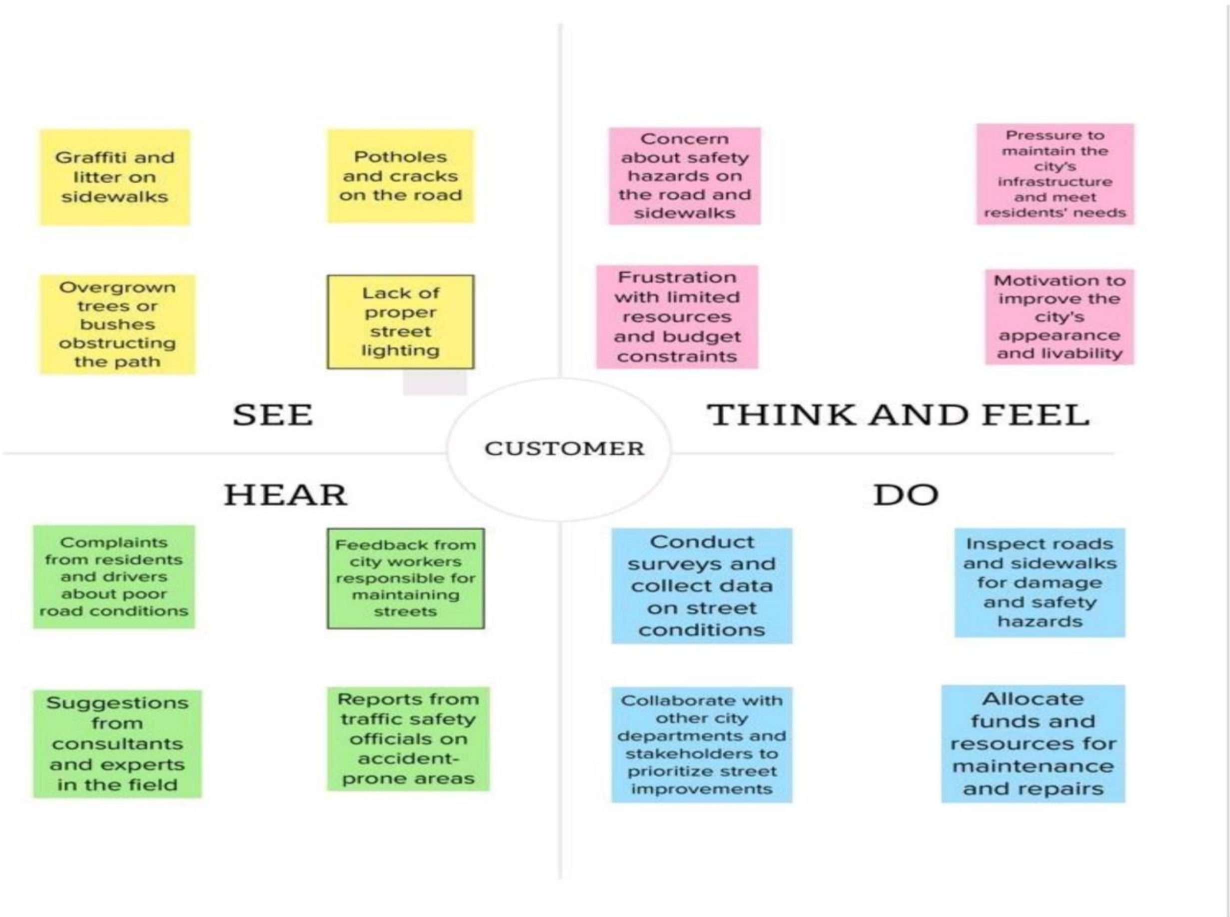
Customer Problem Statement Template:

Problem Statement (PS)	I am (Customer)	I'm trying to	But	Because	Which makes me feel
PS-1	**Worker**	To develop an automated system or method that can accurately assess and classify the condition of a street or road	The goal is to create a reliable and accurate system that can efficiently analyze street quality across a large area or region.	This problem is important because it can help local governments and transportation agencies to identify areas that require maintenance or repair, prioritize funding and resource allocation, and ultimately improve the safety And comfort of drivers and pedestrians	A system or method to automatically assess and classify the condition of a street or road network

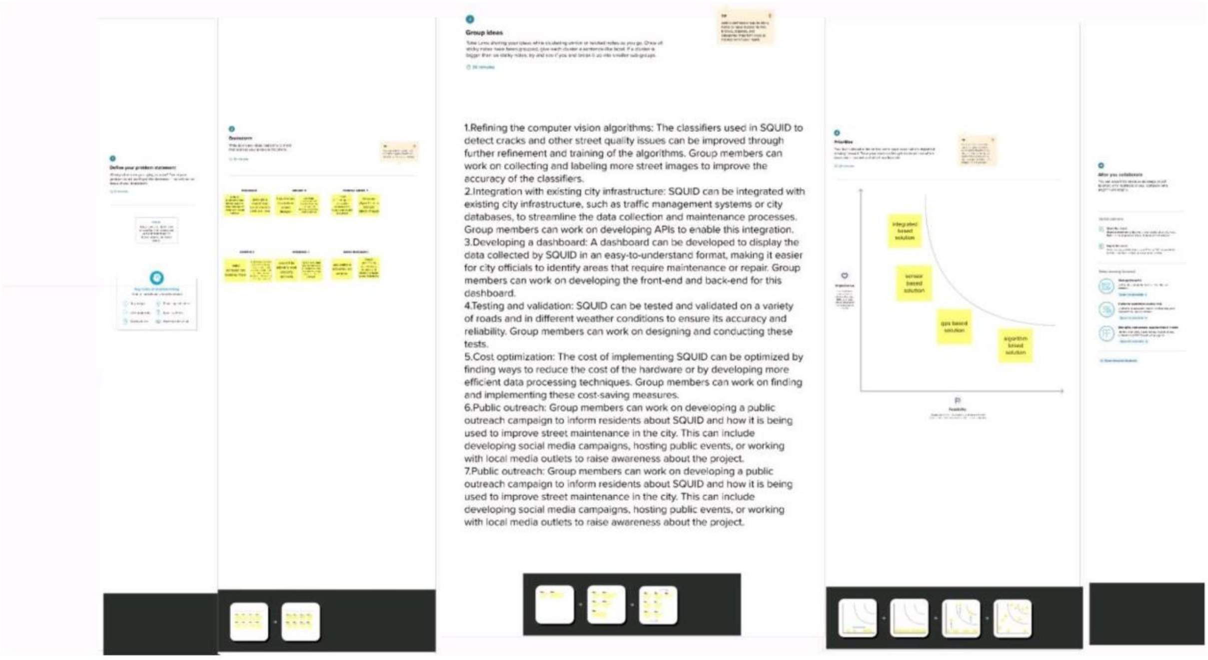
PS-2	**Analyzer**	Identify the street conditions	The system should be able to efficiently analyze street quality across a large area or region	The system should be accurate, scalable, and able to process large volumes of data from various sources such as images, videos, and sensor data.	To provide reliable data to help local governments and transportation agencies prioritize funding and resource allocation for maintenance and repair activities.

2.2 Empathy Map Canvas

Example: Industrial worker's Health and Safety system based on the Internet of Things



2.3 Ideation and BrainStorming



2.4 Proposed Solution

S .NO	PARAMETER	DESCRIPTION
1.	Problem Statement (Problem to be solved)	The identification of street quality is a critical concern for cities and municipalities to ensure safe and well-maintained road infrastructure. However, traditional methods of assessing street quality often rely on manual inspections, which can be time consuming, subjective, and inefficient. To address this challenge there is a need for a digital solution that can accurately and efficiently identify and assess street quality using advanced technologies.
2.	Idea / Solution description	SQUID is a compact device that is mounted on the back of a city vehicle, with its camera facing downwards to capture high resolution imagery of the road surface. The data collected by SQUID is processed in real-time, enabling immediate identification of areas that require maintenance or repair.

3.	Novelty / Uniqueness	SQUID's combination of autonomous vehicle integration, real-time computer vision analysis, holistic assessment, costeffectiveness, seamless integration, scalability, and data-driven decision making sets it apart as a novel and unique solution for street quality identification and maintenance.
4.	Social Impact / Customer Satisfaction	The social impact of SQUID is substantial, leading to improved road safety, enhanced urban infrastructure, reduced commuting disruptions, cost savings, data-driven decision making, transparent communities, and environmental benefits. These factors collectively contribute to increased customer satisfaction and a better quality of life for residents and commuters within cities and municipalities.
5.	Business Model (Revenue Model)	It's important to note that the revenue model for SQUID can be a combination of these approaches, tailored to the specific needs of cities and the market conditions. Flexibility, scalability, and demonstrating the value and cost-effectiveness of SQUID's solution will be key factors in attracting customers and generating revenue.
6.	Scalability of the Solution	SQUID can effectively grow alongside cities and municipalities, accommodating larger road networks, increasing data volumes, and evolving infrastructure requirements. This scalability ensures that SQUID remains a viable solution for street quality identification and maintenance as urban environments expand and evolve.

3.REQUIREMENT ANALYSIS

3.1Functional Requirements

Data Collection: The system should be capable of collecting street images captured by cameras installed in vehicles or at fixed locations. It should be able to gather sensor data from vehicles or infrastructure that can provide information about road conditions, such as vibrations, accelerations, or surface irregularities

Data Pre-processing: The system should clean and pre process the collected data to remove noise, handle missing values, and standardize the data for further analysis. It should perform image enhancement techniques to improve the quality and clarity of street images. Geospatial data should be processed to align with the road network and other spatial references.

Street Quality Analysis: The system should employ machine learning algorithms, such as convolutional neural networks (CNNs), to analyze street images and extract features that indicate street quality. The system should integrate geospatial information to understand the context of street quality, such as the location and surrounding infrastructure.

Street Quality Classification: It should assign a quality score or rating to each street segment based on its condition. The classification should be based on machine learning models trained on labelled data and should continuously learn and adapt to improve accuracy.

User Interface: The system should provide a user-friendly interface that allows users to access street quality information easily. The interface should display visualizations, maps, and summary statistics to present street quality data in a clear and understandable manner.

Reporting and Alerts: The system should generate reports and alerts regarding street quality, highlighting areas that require immediate attention or maintenance. It should provide notifications to relevant stakeholders when street conditions deteriorate beyond a certain threshold.

Integration and Compatibility: The system should be able to integrate with existing infrastructure, databases, and management systems used by transportation authorities. It should be compatible with common data formats and standards to facilitate data exchange and interoperability.

3.2Non-Functional Requirements

Accuracy: The system should accurately identify and assess the quality of streets, minimizing false positives and false negatives. It should provide reliable and precise results.

Speed and Performance: The system should be capable of processing street quality identification in real-time or within a reasonable timeframe. It should handle large volumes of data efficiently to avoid delays or bottlenecks.

Scalability: The system should be scalable to accommodate increasing volumes of street data as the scope expands. It should be able to handle data from multiple sources and support future growth.

Usability: The system should be user-friendly, intuitive, and easy to understand, both for street quality analysts and administrators. It should have a clear and logical user interface, providing relevant information and actionable insights.

Reliability and Availability: The system should operate reliably and consistently, ensuring continuous availability. It should have built-in mechanisms to handle potential failures, minimize downtime, and recover from errors gracefully.

Security: The system should ensure the security and privacy of street data. It should have robust authentication and authorization mechanisms to prevent unauthorized access or tampering of the data.

Integration: The system should be designed to integrate with existing infrastructure and systems, such as geographic information systems (GIS), databases, or third-party applications. It should support data exchange and interoperability standards.

Adaptability and Customization: The system should be flexible and adaptable to different environments and varying street quality assessment methodologies. It should allow customization and configuration based on specific needs or local requirements.

Maintainability: The system should be designed for ease of maintenance and updates. It should have clear documentation, modular architecture, and well-structured code to facilitate enhancements, bug fixes, and future system modifications.

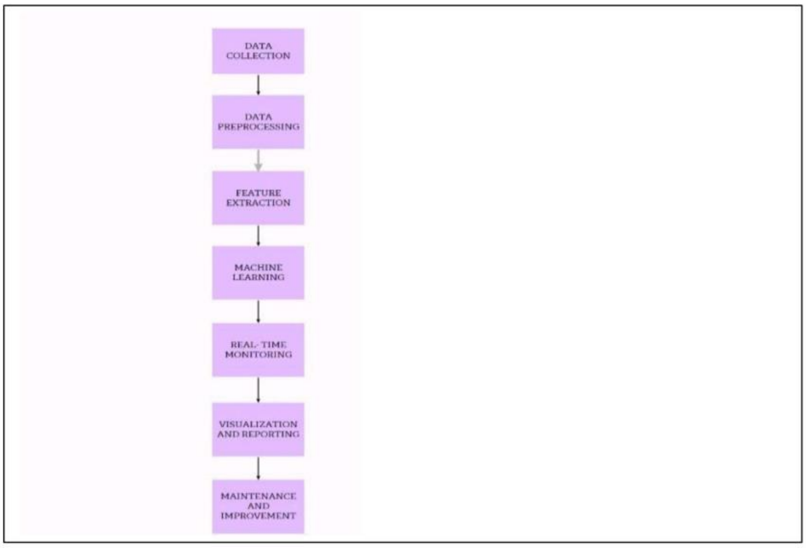
Compliance: The system should adhere to relevant regulations, standards, and best practices, such as data protection regulations or accessibility guidelines. It should ensure compliance with legal and ethical considerations.

4.PROJECT DESIGN

4.1 Data Flow Diagrams

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.

Example: DFD Level 0 (Industry



4.2 Solution and Technical Architecture

An Industrial Workers Health and Safety system based on the IoT requires a robust and scalable solution architecture that integrates various IoT components and technologies. The proposed solution architecture above provides a high-level overview of the key components of such a system.

4.3 User Stories

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Team Member
Customer (Mobile user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Prakash
	Dashboard	USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Shivadevi
		USN-3	As a user, I can register for the application through Facebook	I can register & access the dashboard with Facebook Login	Low	Srihari
		USN-4	As a user, I can register for the application through Gmail		High	Shamita
	Login	USN-5	As a user, I can log into the application by entering email & password		High	Tenna mascelin
		USN-6	As a user, I will receive confirmation email once I have registered for the application		High	Vignesh saren
Customer (Web user)						
Customer Care Executive						
Administrator						

5.CODING AND SOLUTIONING

5.1 FEATURE 1

Image Texture Analysis: Analyze the texture of street images to extract features related to road smoothness or roughness. This can be done by calculating texture descriptors such as entropy, contrast, or homogeneity.

5.2 FEATURE 2

Crack Detection: Utilize image processing techniques to detect and quantify cracks on the road surface. This can involve applying edge detection algorithms or using convolutional neural networks (CNNs) for crack detection.

5.3 FEATURE 3

Pothole Detection: Develop algorithms to identify potholes in street images. This can be achieved through techniques like image segmentation or object detection using machine learning models.

6.RESULTS

6.1 Performance Metrics

Visual Inspection: This method involves manual observation by trained personnel who visually assess the condition of the road surface, looking for cracks, potholes, unevenness, and other signs of deterioration.

Ride Quality Measurements: Specialized vehicles equipped with sensors are driven along the road to measure parameters such as roughness, ride comfort, and unevenness. These measurements provide quantitative data for evaluating the road condition.

Surface Profiling: Profiling equipment is used to measure the texture and profile of the road surface. This technique helps identify roughness, rutting, and other surface irregularities.

Non-Destructive Testing (NDT): NDT techniques, such as ground-penetrating radar and infrared thermography, can be used to assess the subsurface condition of roads. These methods help identify issues like delamination, moisture content, and structural defects.

Mobile Mapping Systems: High-resolution cameras and laser scanners mounted on vehicles can capture detailed 3D data of road surfaces. This data is then analysed to identify cracks, potholes, and other surface defects.

Machine Learning and AI: Advanced techniques like machine learning and artificial intelligence can be used to analyze data from various sources, such as images, sensor data, and historical records, to automatically identify road quality issues and prioritize maintenance or repair effort.

7.ADVANTAGES AND DISADVANTAGES

Advantages:

Cost Savings: By accurately assessing the condition of roads, street quality identification techniques can help prioritize maintenance and repair efforts. This allows resources to be allocated more efficiently, focusing on areas that require immediate attention. By addressing issues before they worsen, it can help prevent more costly repairs in the future.

Improved Safety: Identifying and repairing road defects promptly improves road safety for motorists, cyclists, and pedestrians. By addressing issues like potholes, cracks, or uneven surfaces, the risk of accidents and injuries can be significantly reduced.

Enhanced Efficiency: Street quality identification techniques provide objective and quantitative data about road conditions. This information helps transportation authorities and road maintenance agencies prioritize repair and maintenance work based on actual needs. It allows them to optimize their resources and plan road construction or maintenance projects more effectively.

Data-Driven Decision Making: Street quality identification techniques, particularly those utilizing machine learning and AI, can process large amounts of data and provide actionable insights. By analysing historical records, sensor data, and other relevant information, decision-makers can make informed choices regarding road maintenance strategies, budget allocation, and long-term planning.

Public Satisfaction: Well-maintained roads contribute to the overall quality of life in communities. By using street quality identification techniques, local governments can proactively address road issues, leading to improved public satisfaction and trust. It demonstrates a commitment to providing safe and well-maintained infrastructure.

Long-Term Asset Management: Street quality identification techniques help identify early signs of deterioration and structural issues in road infrastructure. By addressing these problems in a timely manner, it can extend the lifespan of the roads and reduce the need for costly reconstruction.

Disadvantages:

Limited resources: Many individuals and communities face the disadvantage of limited access to essential resources such as clean water, food, healthcare, education, and infrastructure. This can hinder their overall well-being and development.

Inequality and discrimination: Social, economic, and gender inequalities can lead to disadvantages for certain groups of people. Discrimination based on race, gender, ethnicity, religion, or socioeconomic status can limit opportunities and hinder social progress.

Health issues: Poor health or limited access to healthcare can be a significant disadvantage. It can lead to decreased quality of life, reduced productivity, and financial burdens. Additionally, individuals with disabilities may face challenges due to physical or cognitive limitations.

Economic challenges: Financial disadvantages, such as poverty, unemployment, or low wages, can restrict opportunities for personal growth and limit access to basic needs. Economic instability, inflation, or high cost of living can also pose challenges for individuals and communities.

Environmental impact: Climate change, pollution, and natural disasters can have detrimental effects on ecosystems, economies, and human well-being. Disadvantaged communities often bear the brunt of these impacts, leading to displacement, health issues, and economic hardships.

Lack of education: Limited access to quality education can perpetuate inequality and hinder social mobility. Without proper education and skill development, individuals may struggle to find employment opportunities and improve their living conditions.

Social isolation: Loneliness and social isolation can have negative impacts on mental health and well-being. Some individuals, such as the elderly, individuals with disabilities, or those in remote areas, may face barriers to social interaction and connection.

Technological divide: The digital divide refers to the gap between individuals or communities with access to technology and those without. Lack of internet access or technological literacy can limit access to information, job opportunities, and social connections.

Lack of representation: Underrepresentation of certain groups in decision-making processes can lead to a lack of diverse perspectives and perpetuate systemic disadvantages. This can occur in politics, media, workplaces, and other spheres of influence.

Mental health challenges: Mental health issues can significantly impact an individual's quality of life and functioning. Stigma, lack of access to mental health services, and inadequate support systems can further exacerbate these challenges.

8.CONCLUSION

A conclusion is a summary of the main points or findings presented in the preceding discussion. It should reflect the overall understanding or outcome of the topic and provide closure to the reader or listener. A well-constructed conclusion should be concise, clear, and supported by the evidence or arguments presented. When drawing a conclusion, it is essential to consider any limitations or uncertainties in the information or analysis. Acknowledging these limitations can help maintain the integrity of the conclusion and demonstrate intellectual honesty.

9. FUTURE SCOPE

Technology: In the field of technology, the future scope may involve advancements in artificial intelligence, machine learning, robotics, Internet of Things (IoT), blockchain, or virtual reality. These areas present opportunities for innovation, improved efficiency, automation, and the creation of new products and services.

Medicine and Healthcare: Future scope in healthcare could include developments in precision medicine, personalized healthcare, genomics, telemedicine, medical devices, and wearable technology. Additionally, the exploration of new treatments, therapies, and preventive measures for various diseases and conditions remains a crucial area of focus.

Renewable Energy: With the increasing global concern over climate change, the future scope in renewable energy includes the development and implementation of clean energy technologies such as solar power, wind energy, geothermal energy, and energy storage systems. Research and advancements in these areas are essential for transitioning to a sustainable and low-carbon future.

Space Exploration: The future scope of space exploration involves the continued exploration of our solar system and beyond. It includes missions to other planets, asteroids, and moons, as well as advancements in space technology, spacecraft design, and human colonization of other celestial bodies.

Sustainability and Environmental Conservation: Future scope in sustainability involves finding innovative solutions for environmental challenges, such as waste management, water conservation, biodiversity preservation, and combating climate change. This field encompasses research, policy development, and the adoption of sustainable practices across various industries.

10.APPENDIX

SOURCE CODE

```
# importing necessary libraries
import numpy as np
import cv2
from matplotlib import pyplot as plt

import time
import sys
import ibmiotf.application
import ibmiotf.device
import random

#Provide your IBM Watson Device Credentials
organization = "96ei56"
deviceType = "SQUID"
deviceId = "12333"
authMethod = "token"
authToken = "27042023"


def ibmstart(x):

    def myCommandCallback(cmd):
        print("Command received: %s" %
cmd.data['command'])
        print(cmd)

    try:
      deviceOptions = {"org": organization, "type":
deviceType, "id": deviceId, "auth-method": authMethod,
"auth-token": authToken}
      deviceCli = ibmiotf.device.Client(deviceOptions)
      #..............................................

    except Exception as e:
      print("Caught exception connecting device: %s" %
str(e))
      sys.exit()
```

```
    deviceCli.connect()
    lat=random.randint(9,37)
    long=random.randint(68,97)
    data = { 'latitude' : lat, 'longitude': long
,'Status': x}
    #data = { 'Status' : x}
    #print data
    def myOnPublishCallback():
        print ("Published Status = %s" % x, "to IBM
Watson")

    success = deviceCli.publishEvent("SQUID", "json",
data, qos=0, on_publish=myOnPublishCallback)
    if not success:
        print("Not connected to IoTF")


    deviceCli.commandCallback = myCommandCallback
    deviceCli.disconnect()


# read a cracked sample image
img = cv2.imread('Input Set/Cracked_07.jpg')
flag=0
# Convert into gray scale
gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

# Image processing ( smoothing )
# Averaging
blur = cv2.blur(gray,(3,3))

# Apply logarithmic transform
img_log = (np.log(blur+1)/(np.log(1+np.max(blur))))*255

# Specify the data type
img_log = np.array(img_log,dtype=np.uint8)

# Image smoothing: bilateral filter
bilateral = cv2.bilateralFilter(img_log, 5, 75, 75)

# Canny Edge Detection
edges = cv2.Canny(bilateral,100,200)
```

```
# Morphological Closing Operator
kernel = np.ones((5,5),np.uint8)
closing = cv2.morphologyEx(edges, cv2.MORPH_CLOSE, kernel)

# Create feature detecting method
# sift = cv2.xfeatures2d.SIFT_create()
# surf = cv2.xfeatures2d.SURF_create()
orb = cv2.ORB_create(nfeatures=1500)

# Make featured Image
keypoints, descriptors = orb.detectAndCompute(closing,
None)
featuredImg = cv2.drawKeypoints(closing, keypoints, None)

# Create an output image
cv2.imwrite('Output Set/CrackDetected-7.jpg', featuredImg)
flag=1

# Use plot to show original and output image
plt.subplot(121),plt.imshow(img)
plt.title('Original'),plt.xticks([]), plt.yticks([])
plt.subplot(122),plt.imshow(featuredImg,cmap='gray')
plt.title('Output Image'),plt.xticks([]), plt.yticks([])
print(flag)
ibmstart(flag)
plt.show()
```

GITUP LINK:

https://github.com/naanmudhalvan-SI/PBL-NT-GP--418-1680486472

DEMO VIDEO LINK:

https://drive.google.com/file/d/1v6u7EjRf1Mcqz6C8HiAFc5tqCfVHqeCn/view
?usp=drivesdk