POTHOLE DETECTION AND MONITORING SYSTEM USING AI AND CLOUD COMPUTING

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Introduction

Visual pollutants, such as potholes, can lead to accidents and reduced quality of life in affected cities. Our goal is to create a comprehensive system that will detect, document, and report potholes to municipalities. Aiding in overall repair efforts.

Problem Statement

We don't have a cost-effective system capable of continuously detecting potholes and providing an intuitive dashboard that allows users to monitor the results over time.

Proposed Solution

We use a dashcam-like device to detect potholes and estimate their severity, while providing an intuitive dashboard for users to analyze the data.

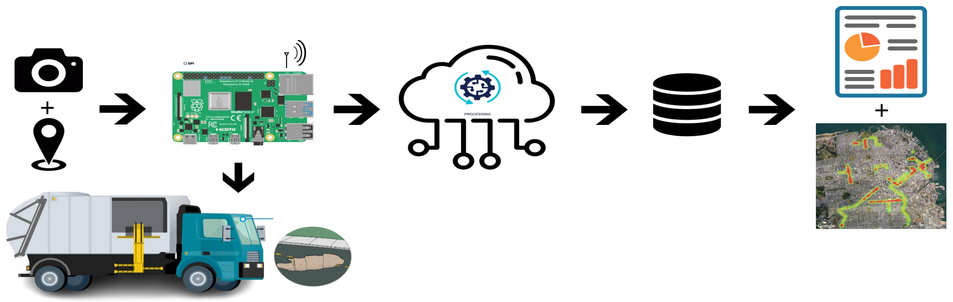
Constraints

- Data collection and availability.
- The time to complete the system.

Target Specifications

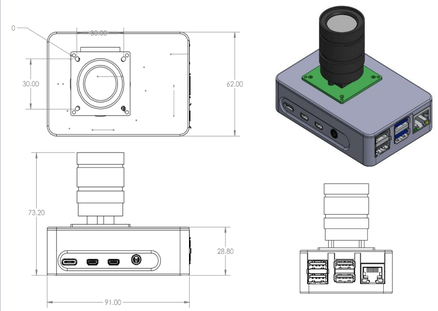
- Steps to install the device: 4 steps
- Device Volume: 20 * 10 * 10 cm
- GPS Module Accuracy: 7m
- Camera Resolution: 12.3MP
- Power Consumption: 5.5 Watts
- Device Cost: 1500 SAR
- Detection Model Precision: 80%
- Time to Detect Pothole: 0.1s
- Time to Estimate Severity: 2s
- Time to Display Pothole Data: 1s
- Time to Generate Heatmap: 5s

Prototype Design



Prototype Design. A representation of the entire system, which starts by capturing images with their locations and sending them to the cloud. Using AI and Computer Vision techniques, potholes are detected, and their severities are estimated based on depth. Then, the data is saved in a database that is linked with the dashboard.

Hardware Design



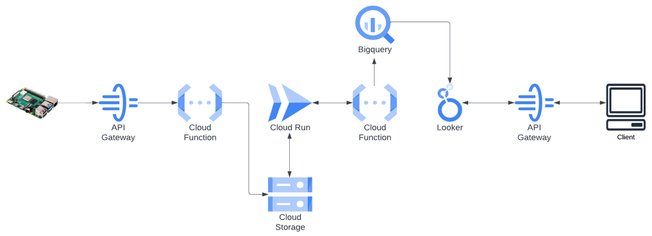
3D Design. A 3D design for the device with its measurements.

Validation of Specs

- Steps to install: The device only needs to be mounted using any phone/dashcam mount, and then connected to the internet. In total, it takes 2 steps.
- Device Volume: As can be seen in the 3D design, the measurements are 9.1cm x 6.2cm x 7.3 cm.
- GPS Module Accuracy: 2 m radius according to manufacturer documentation. *
- Camera Resolution: 12.3 MP according to the camera documentation. *
- Power Consumption: Our device consumes less than 4.5 Watts with around 20% CPU utilization. *
- Device Cost: 1227.53 SAR. *
- Detection Model Precision: Our model was able to reach 89% mAP, which can be seen in the precision figure on the left.
- Time to Detect Pothole: Our model can detect in 0.54 s. *
- Time to Estimate Severity: The severity estimation takes 1.13 s. *
- Time to Display Pothole Data: s. *
- Time to Generate Heatmap: 3 s. *

* Refer to additional materials for proof of results.

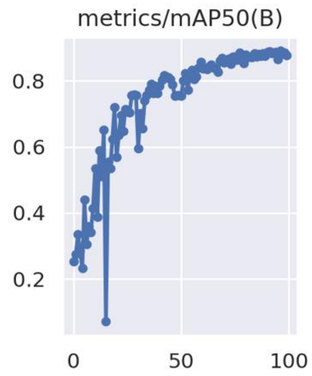
Cloud Architecture



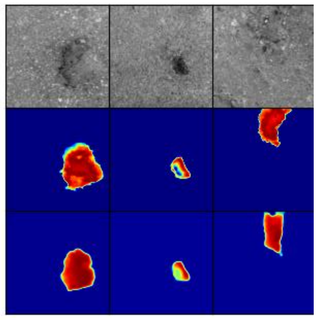
Cloud Architecture. The API gateway receives an image and its location from the edge device. Then, a Cloud Function stores this data in a Google Bucket. The Cloud Run container continuously scans the Bucket and runs the AI algorithm on the images. The output is sent to another Cloud Function where a reverse geocoding algorithm runs to retrieve the address of the image. The outputs are then stored in a BigQuery database. Lastly, Looker Studio uses the stored data and formats it for the end user.

AI Models

Labeled Image. An example of a labeled image from our dataset.

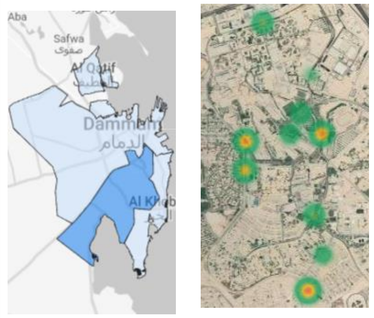


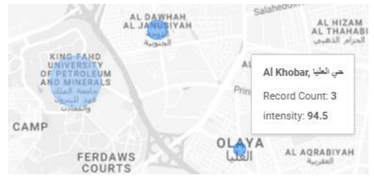
Detection Precision. mAP of the detection model.



Depth Model Outputs. Showing the image, the ground truth depth, and the predicted depth.

Dashboard





Snippets From the Dashboard. Showing the expected maps, we can see the data based on cities or neighborhoods. We can also see each pothole separately with the severity displayed as the color of the point on the heatmap.

Conclusions

This system can be further improved by collecting more data on other types of visual pollution, such as faded signs and damaged sidewalks, making it a more comprehensive system capable of producing metrics that measure a city's quality of life.

Additional Materials

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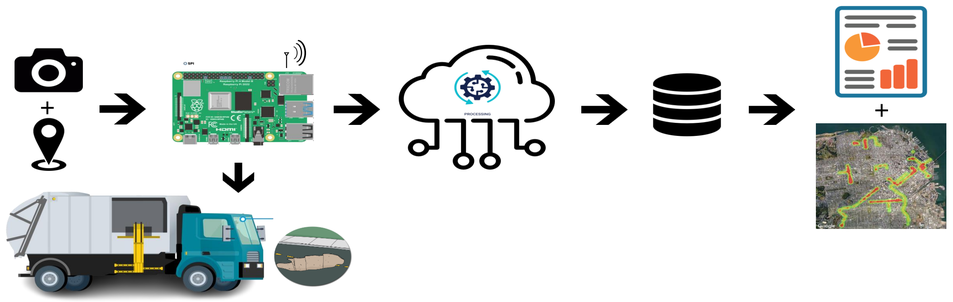

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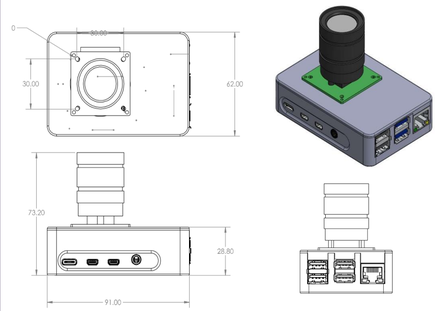

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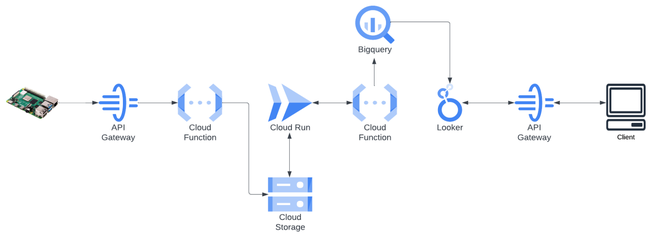

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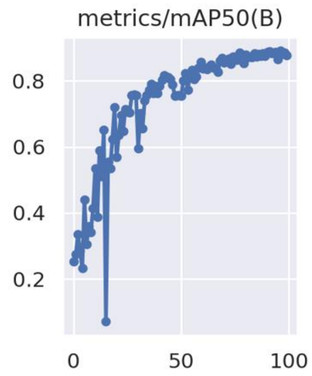

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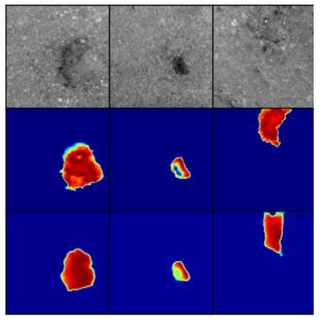

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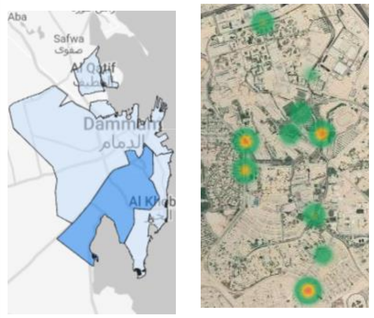

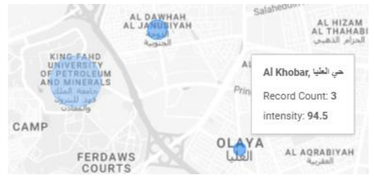

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