Falcoeye

2D Multi-Model platform for intelligent data acquisition and analysis
Application on road damage and potholes identification

Introduction

Potholes are a major issue for road maintenance agencies, causing damage to vehicles and posing a safety risk to drivers and passengers. To efficiently repair potholes, it is important to accurately identify and classify them according to their severity. In this proposal, we propose a solution for automating pothole detection and classification using a low-cost dash-cam equipped with GPS and a set of different pothole detection workflows. These workflows, based on various AI models and aggregation techniques, will be served on **Falcoeye**, a fully containerized platform that allows users to upload dash-cam videos and extract pothole data, including classification, abundance, and shape, along with GIS information. Falcoeye also enables developers to build new workflows and aggregation techniques, and can scale automatically on a Kubernetes cluster. In addition, we will create a 3D application using Unity to visualize the extracted data on a GIS map and facilitate advanced analysis of the data.

Methodology

To use the proposed system, a dash-cam will be mounted on a vehicle to capture video footage of the road as the vehicle travels. The dash-cam will be equipped with GPS to provide accurate geographic information for each frame of the video. The video footage will then be uploaded to Falcoeye, where it will be processed by the set of pothole detection workflows. These workflows will use AI models to detect patholes and a cascade of post-processing nodes to extract depth, width, and shape of information.

The extracted pothole data will be re-projected onto a GIS map using a 3D application built with Unity. This application will use both normal and procedural textures to visualize the data, enabling users to easily identify the most urgent or problematic potholes.

Benefits

The proposed solution has several benefits:

- It is low-cost and can be easily deployed on a large scale, making it an affordable solution for road maintenance agencies. It can be provided to ride-sharing drivers or online food-ordering drivers who will act as a crowdsourcing for collecting data.
- Falcoeye is a fully containerized platform that is easy to extend and can scale automatically, enabling developers to build and deploy new AI models and aggregation techniques. The use of various AI models and aggregation techniques in the workflows allows for a continuous improved accuracy and reliability of the pothole classification and analysis.
- The 3D application allows for advanced visualization and analysis of the extracted pothole data, enabling users to easily identify the most urgent or problematic potholes and plan repair efforts accordingly.

Implementation

Our proposal focuses on building a platform where different AI workflows can be used to analyze the collected videos and extract pathole data. To demonstrate this, we implemented a workflow on Falcoeye based on EfficientNet and various publicly available pre-trained models. The models we used attack the problem by detecting 4 types of road cracks:

- Longitudinal Crack
- Transverse Crack
- Alligator Crack
- Pothole

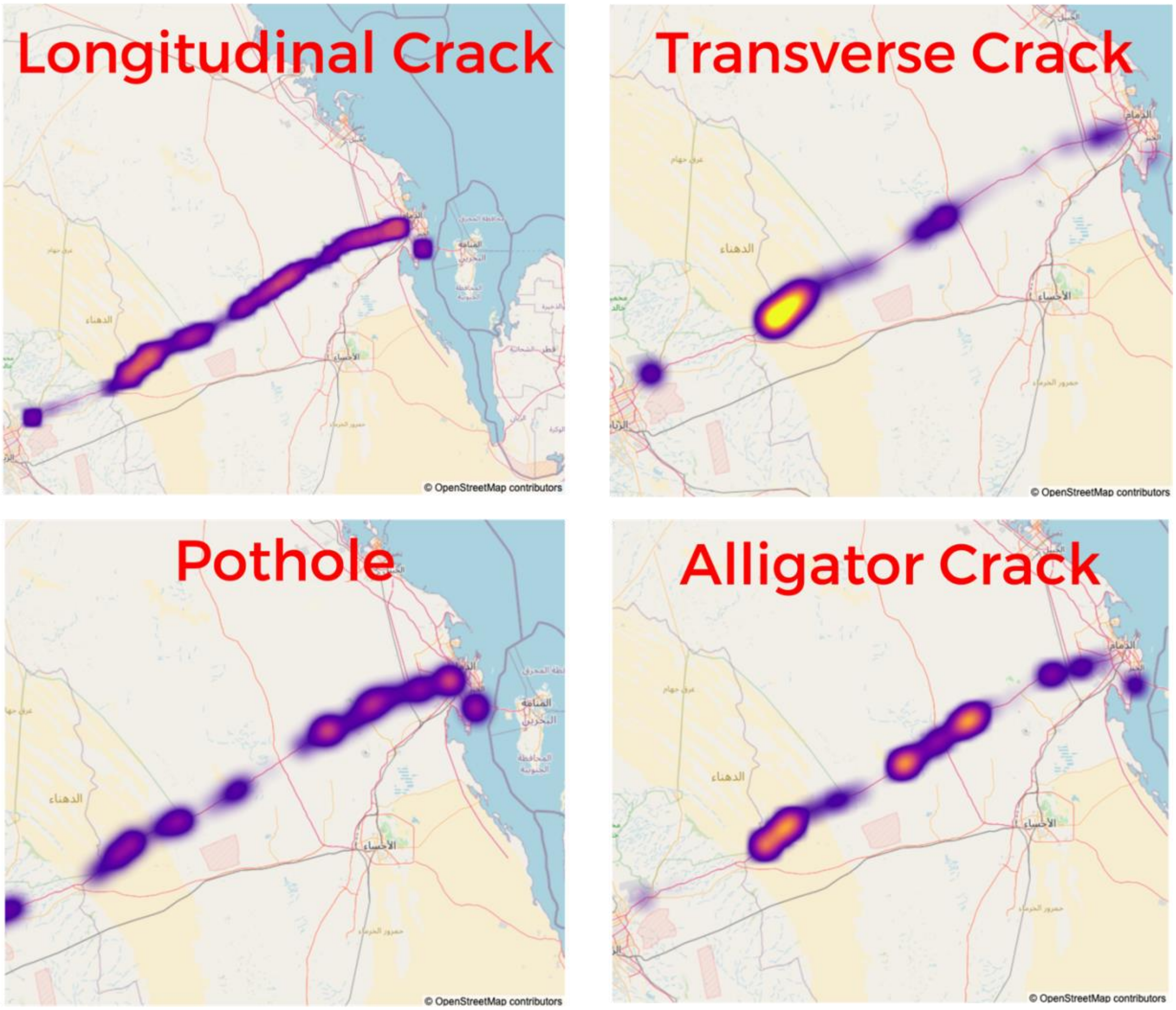
The workflow uses the dash-cam video footage as input and runs it through the pre-trained models for cracks detection and classification. Additionally, we use simple crack size calculation based on the diameter of the bounding box. For the purpose of this hackathon, we used 70mai Dash Cam M500 to collect data. This dash-cam model stores the GIS information for every frame. In our workflow, we use OCR to extract this information and associate it with each crack.

We have also implemented a Unity application with a GIS map and filters. The CSV data produced by Falcoeye's workflow is reprojected on the GIS map, allowing for a better understanding of the distribution of potholes in a given area and can aid in prioritizing repairs.

Falcoeye is demonstrated in the presentation and the video but access to the platform is still not publicly available (access can be granted to the committee in a private setting). Meanwhile, we provide a scripted version of the workflow along with the checkpoints, and a notebook hosted on google colab for easy access and running. The notebook demonstrates the workflow both on the provided video (no gps) and our own (with gps).

Case Study

We conducted a study to test the reliability and the robustness of our submission. The data used in this study was 4 hours of driving video on the Riyadh Dammam highway, recorded at an average speed of 120 km/h using 70mai Dash Cam M500. The resolution of the video was 2592X1944 at a frame rate of 30 fps. The model used for the detection and classification was an EfficientNet with approximately 4 million parameters. The prediction sample rate was 6 samples per second, or 1 sample every 5 frames, and the device used for inferencing was an Nvidia A100. The total time taken for the analysis was 5 hours. The findings of the analysis revealed 20814 instances of longitudinal cracks, 570 instances of transverse cracks, 3449 instances of alligator cracks, and 236 instances of potholes. We also calculate the size of the cracks by simply measuring the normalized diameter of the bounding box over the frame diameter. Below are density charts for each category. We are currently working on validating the results and re-runing other workflows with larger model sizes.



Future work

To provide more realistic visualizations of the potholes based on 2D images, we need to extract detailed information per detection such as shape, size, direction, and depth. With such data, we can create realistic visualization using a parametric pothole mesher and hence reconstruct the recognized potholes in a 3D environment.

Another approach is to use computer vision techniques where we can make a displacement depth map and use it to construct the 3D mesh. The collection of depth information can be done using machine learning approaches or using pair of calibrated dash-cams. The implementation of these post-processing tools can be easily integrated into Falcoeye workflows providing a continuously growing mechanism for evaluation and various options for the extraction and analysis of the data

Finally, having a long 3D modeling and rendering experiences in the team will allow us to take the 3D visualization dashboard we built further. By building a 3D model either using parametric mesher or a displacement map, we can create augmented reality (AR) experiences for road maintenance companies. The AR experience will give maintenance workers detailed information about the condition of a road, including information about cracks, potholes, and other damage. This can help companies to quickly and easily identify areas that need repair, reducing downtime and increasing the efficiency of their operations.