Team ComSigh Solution

Steffan Schoonbee, Gunther Tonitz
Dirk Hoffmann, Shriyan Singh, Franco Uys,

1 Product Overview: PatchPerfect

PatchPerfect is the primary product developed by Team ComSigh, designed as a web application for automated pothole detection and repair planning. The product leverages a custom-built convolutional neural network (CNN) that has been trained to detect and assess the severity of potholes from images.

The application allows users to upload images of roads, which are then processed by the CNN to detect potholes and other road surface issues. The application provides an interface where users can visualize detected potholes, view severity scores, and generate reports for road maintenance teams. PatchPerfect aims to streamline the process of road maintenance by offering an easy-to-use, efficient, and accurate solution.

2 Model Development

2.1 Final CNN Solution

The core of PatchPerfect is a custom convolutional neural network (CNN) designed to process images of road surfaces and identify potholes. The CNN architecture consists of two convolutional layers (C layers) followed by two dense layers. We applied max pooling after each convolutional layer to reduce spatial dimensions and capture the most critical features. Dropout was employed in the dense layers to prevent overfitting and enhance generalization.

To preprocess the images, each input is scaled based on the size of a reference object (a stick) present in the image. The images are then resized to a uniform shape, padded with black pixels to retain the size information as a feature. This preprocessing step ensures that the CNN can effectively learn from the spatial relationships within the images.

We addressed overfitting by developing a custom TensorFlow layer named `Augment`, which randomly applies transformations such as altering orientation, color hue, contrast, brightness, and injecting random colors. These augmentations are performed during training to ensure the model is exposed to a wide variety of image conditions, improving its robustness.

The final CNN model achieved an impressive accuracy, consistently outperforming traditional manual feature extraction methods. It forms the backbone of PatchPerfect, providing reliable detection and assessment of potholes in real-world scenarios.

2.2 YOLOv8 Pre-trained Model (Supporting Component)

The YOLOv8 model was initially employed as a supporting component to aid in object detection during the early stages of development. We opted for the medium-sized YOLOv8 model due to its balance between accuracy and training time. Training was conducted on an AWS EC2 instance, which was familiar to our team and allowed us to efficiently set up and execute the training process.

Although the YOLOv8 model achieved strong performance, with a precision of 95%, recall of 96%, and mAP@50 of 97%, it served primarily as a starting point. The focus of our development shifted to the custom CNN, which provided more control and flexibility in addressing the specific requirements of pothole detection and assessment.

3 Web Application Development

The PatchPerfect web application serves as a proof of concept for a larger scale, community-based application. The application was developed using a modern JavaScript framework (React) along with Firebase to incorporate cloud functionality. Users can take or upload pictures of potholes, and the location is automatically obtained and stored in the database. A municipality user (or partnering companies) can then see the added pothole and view its location using a Google Maps link.

Furthermore, using Firebase Cloud Functions, the image is processed via a serverless function that predicts the number of bags necessary to fill the hole. This functionality allows the application to scale easily and supports asynchronous usage across both types of users. Information is updated in real-time to allow for the quick propagation of new potholes.

We believe that a community-based app is the best way to apply this model. It provides a method by which users can quickly notify their local municipality (or other local organizations) of potholes and provides them with the necessary information to fix them. This not only improves the road quality and driving experience for users but also increases brand positivity for partnering companies like Motus, who aim to lessen the impact of potholes nationwide.