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Development of the Roadway Pothole Management Program

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Introduction

Road infrastructure in California has been a source of concern as highlighted by the 2021 Report Card for America's Infrastructure. The report assigned a grade of "D" to the roads. The assessment was based on the condition of California roads, which was among the worst in the nation, ranking 49th according to the latest US News & World Report Ranking. Meanwhile, Southern California and the Bay Area were the second and third most congested urban areas in the nation, respectively. Repair and improvement of these roads is vital to California's economic health and public safety. This assessment aligns with the findings of the Metropolitan Transportation Commission's Pothole Report from 2018, which underscored the risks facing Bay Area roads and emphasized the urgency for maintenance and upgrades to ensure safety and efficiency. Bigger cities especially struggle to respond to the record number of pothole reports. The correlation between poor pavement conditions and the emergence of potholes is well documented, with the latter posing risks not only to vehicular safety, but also contributing to increased maintenance costs and environmental emissions. The statistics provided by AAA underscore the economic impact of potholes on American drivers, highlighting a substantial annual expense. AAA found two-thirds of American drivers to be concerned about potholes, and a study from AAA revealed that potholes cost U.S. drivers approximately $3 billion annually (AAA, 2016). Without proper repair, potholes can further damage other parts of the roadway at an accelerated rate. The condition of the roads not only affects daily commutes but also has broader economic implications. Poor infrastructure with many potholes can lead to increased vehicle operating costs and hinder economic growth. In this study, the research team has developed a prototype pothole management program (PMP). Advantages and benefits of using the PMP include:

- Along with the usual tracking done by maintenance crews, the PMP empowers citizens to report and track potholes, and helps them be more involved in their community's infrastructure.
- The app's design makes it much faster and simpler to report potholes. The app is available on any smartphone, which is an accessible tool that most people always have with them.

- AI technologies that are part of the PMP can be used to extract pothole information. They can:
  - Differentiate pothole photos from no-pothole photos,
  - Detect the location and number of potholes in submitted photos, and
  - Estimate the size of detected potholes.
- Summaries of pothole information can be used by agencies to plan future roadway maintenance budgets and improve pavement management.

Study Methods

Maintaining transportation pavement conditions presents a significant challenge, with potholes being a primary concern for comfort, safety, and vehicle damage. To address this issue, the research team utilized the citizen science approach and modern technologies to develop a prototype pothole management program (PMP) consisting of a mobile application and two machine learning models.

The mobile application serves as a crucial element of the program, allowing users to upload images of potholes, report relevant information, and provide driving directions to a pothole's location. Figure X shows some interfaces of the mobile phone app. The app streamlines the process of capturing images, recording pertinent data, and submitting information for the necessary action, enhancing the program's efficiency, effectiveness, and user experience.

The first machine learning model, Visual Geometry Group (VGG16), utilizes deep learning neural network technology to classify potholes with an accuracy rate of over 90%. VGG is a classical deep Convolutional Neural Network (CNN) architecture that excels in image recognition. Developed by the Visual Geometry Group at the University of Oxford, it is widely regarded as one of the best vision model architectures to date (Great Learning, 2021). The second machine learning model, You Only Look Once (YOLO), is designed to detect and accurately mark potholes on submitted photos.

YOLOv8, developed by Ultralytics, is one of the most popular model architectures and object detection algorithms (Vina, 2024). It uses one of the best and most current neural network architectures for speed and accuracy. As a result, fast and accurate detection of objects in images can be achieved. Figure Y illustrates some results from the machine learning models.

Findings

Overall, this innovative PMP presents a potential comprehensive solution to address the critical issue of potholes in urban areas. It incorporates advanced machine learning techniques and a user-friendly mobile application to provide an efficient and effective approach to pothole management.

Policy Recommendations

Agencies should take advantage of the power of citizens and utilize the PMP to manage roadway potholes. The PMP will help agencies to obtain faster detection of potholes, estimate the amount of work to repair potholes, and assign crews to the reported pothole locations.

About the Author

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