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Project Title

Mobile Phone-Based Artificial Intelligence Development for Maintenance Asset Management

University

University of Utah

Principal Investigators

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Research Needs

Road asset management aims at optimizing the resources allocation of road maintenance funding to different maintenance tasks based on the asset conditions and the associated costs. To help state DOTs develop maintenance plans throughout the year, it is crucial to understand the current asset conditions. Moreover, the damage of some assets may post high safety risks and the maintenance of them shall be prioritized. Hence, there is an urgent need of developing an efficient data collection technology that can gather the required information on a more frequent basis. Currently, many state DOTs rely on the LIDAR inspection for data collection. However, due to the high operational cost, the inspection of the entire state highways using LIDAR can only be completed once per a couple of years. The lack of more timely data would inevitably create barriers to the maintenance group in determining the allocation of budget and optimizing the task order.

Research Objectives

The primary research objective of this project is to develop an artificial intelligence (AI) package to process gathered road asset information, on a more frequent basis, for certain maintenance asset tasks. As mentioned, current process of road asset data collection and processing is slow and effort demanding. To tackle this critical issue, this research aims to introduce an efficient, convenient, and affordable approach based on smartphone, which can be easily attached to UDOT fleet vehicles for road asset data collection, as shown in Fig. 1 below. In addition, after the data collection, the project also aims to establish proof of concept to leverage AI techniques to extract road asset information based on videos and GPS locations, which will be recorded in the fleet vehicle operation.

Fig.1. Smartphone on Vehicles for Road Asset Information Collection

Research Methods

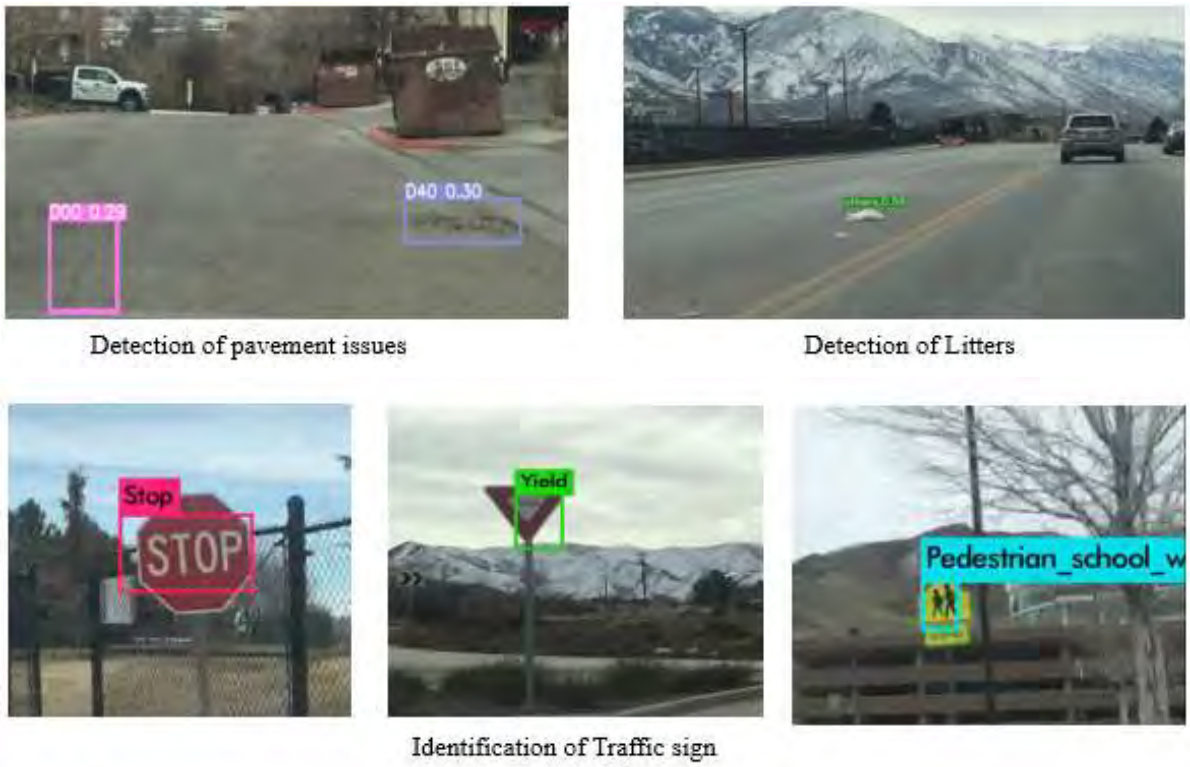
In practice, there are two ways of developing AI models, where the first is to collect sufficient data (e.g., videos and images), label the objectives of interest (e.g., road signs), and implement the labeled data for model training. Usually, the labeling process is done manually and would require tremendous manpower, making this approach to be infeasible in a UTRAC project. Hence, this research will choose the second way which leverages existing trained AI models for applications. Based on the preliminary study and literature review, the difficulty of gathering and analyzing different types of asset information varies:

1. Conditions of pavement, striping, and signing: mature software is already available to carry out the condition assessment of those assets;
2. Road trashes and litters: some trained AI models are available to detect trashes and litters on the road but additional efforts would require to integrate them into the software package;
3. Conditions of barriers and guardrails: there is no existing trained AI model that can be directly used but some similar models, which focus on the detection of barriers and guardrails, can be potentially extended.

Hence, in this research, we will firstly perform a thorough review of existing computer vision techniques that could potentially be applied for road asset management. Then, to analyze different types of asset information, we will further customize available AI packages and develop corresponding tools utilizing most up-to-date computer vision algorithms. To ensure the effectiveness of developed algorithm, road asset data of all types mentioned above will be collected for algorithm retrain and evaluation purpose.

Expected Outcomes

This proposed approach in this research will provide a reliable and handy approach to facilitate road asset management for UDOT. Once successfully deployed, the easily carriable smartphones in UDOT vehicle fleet will help collect road asset data (pavement, striping, signing, road trashes, litters, barriers, and guardrails) in a timely manner. Based on collected data, the AI package will be developed to be capable of assessing conditions and identifying potential issues of road assets, which could significantly contribute the road safety and travel experience improvement. The examples of road asset assessment outcomes are shown in the Fig. 2 below.



Detection of pavement issues

Detection of Litters

Identification of Traffic sign

Fig. 2. Examples of Road Asset Assessment

Relevance to Strategic Goals

This research will develop a mobile phone-based AI package that can automatically assess the conditions of pavement, striping, and signing and detect road trashes and litters. Moreover, a demonstration of gathering information for barriers and guardrails would be provided. Therefore, this research will provide a new solution to tackle the difficulty of collecting maintenance asset data on a more frequent basis. Emerging imaging technology will be also developed for timely evaluation of road asset conditions. These help to achieve the primary goal of 'State of Good Repair' dictated by USDOT. The proposed technology is completely doable and affordable as UDOT fleet vehicles can easily attach the mobile phone to the dashboard in daily operations to collect the required data. Hence, road asset management practice of UDOT will be improved as the outcome of this project.

Educational Benefits

One PhD student and one Post-doc from the Department of Civil & Environmental Engineering at the University of Utah will be involved in this project to develop the AI algorithms for road asset management. The research results will be shared in the graduate and undergrad course of transportation and construction in the department to broaden the project impacts and demonstrate the capability of AI techniques for improved infrastructure maintenance practice.

Technology Transfer

The main objective of this research is to develop the AI-based solution utilizing smartphones and computer vision techniques to facilitate timely road asset management. The developed

technology will significantly simplify the existing LIDAR-based road asset data collection process and alleviate the workload in identifying road asset issues. These works will be directly utilized in the practice of UDOT road asset maintenance. Meanwhile, the project outcomes will be documented and shared in conferences held by UDOT, the Transportation Research Board Meeting, and other journals in relevant fields. Also, the project will be published through workshops, websites, seminars and so on.

Work Plan

1. Literature review: review existing technologies and current practices in asset data collection. (M1 – M2)

The objective of this task is to comprehensively review existing practice and computer vision algorithms usable to support road asset maintenance. Recently, image processing techniques are significantly advanced for automatic evaluation of infrastructure status, such as pavement conditions, traffic signs, road cleaning status, barriers and guardrails etc [1], [2], [3], [4]. State-of-the-art algorithms applicable for accurate road asset assessment will be reviewed and summarized to facilitate artificial intelligence development in the following tasks.

2. Preliminary study: record some road videos through mobile phones and pre-evaluate the capability of AI in data collection (M3 – M4)

In this task, the project team will attach the smart phone on the dashboard and drive around to collect video data with location information for different types of road assets, including pavements, traffic signs, litter and trashes on the road, and guardrails. Collected video data will be manually evaluated first to generate the ground truth of road asset conditions. Prototype algorithms will be developed to pre-evaluate the capability of artificial intelligence in identifying and assessing the conditions of these road assets.

3. Proof-of-concept 1: develop and customize AI models for assessing the conditions of pavement, striping, and signing (M5 – M7)

In this task, the research team will leverage and develop the AI algorithms based on the literature review to perform condition assessment of pavement and traffic signing. The developed algorithm is expected to be able to successfully identify pavement (cracking, potholes) and traffic signings (stop sign, speed limit etc.) issues in collected video data.

4. Proof-of-concept 2: develop and customize AI models for detecting trashes and litters on the road (M8 – M10)

After developing the capability of assessing pavement and traffic sign conditions, the algorithm will further be expanded and customized to identify the trash and litters on the road. Training data to support algorithm for effective trash and litter identification will be collected and utilized to further tune the algorithms.

5. Proof-of-concept 3: provide a demonstration of assessing the conditions of barriers and guardrails. (M11 – M12)

This task focuses on exploring the potential of customizing trained AI algorithms to further assess conditions of barriers and guardrails in roads. Proof-of-the-concept algorithms will be

developed as the preliminary investigation of how computer vision techniques could help accurately evaluate the road barriers and guardrails.

Project Cost

Total Project Costs:	$90,495
MPC Funds Requested:	$39,890
Matching Funds:	$50,605
Source of Matching Funds:	Utah Department of Transportation, $27,000 University of Utah, $23,605

Reference

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