New England Transportation Consortium

NEW ENGLAND TRANSPORTATION CONSORTIUM
RESEARCH PROBLEM STATEMENT FORMAT

Due to netc@ctcandassociates.com **by January 22, 2021**

I. PROBLEM TITLE

A suggested title in as few words as possible.

Developing an Affordable, Accurate and Safe Pavement Survey Method by Applying Machine Learning Techniques on the Road Images.

II. RESEARCH PROBLEM STATEMENT

*Clearly define the problem and provide **sufficient evidence to support its importance to the New England region**. The statement should discuss the gaps in current knowledge, literature, and studies that demonstrate the research need.*

Pavement condition assessment provides information to make more cost-effective and consistent decisions regarding management of pavement network.

In New England states, usually, pavement distress inspections are either performed by departments of transportation using sophisticated data collection vehicles and/or foot-on-ground/Windshield surveys. In either approach, the process of distress detection is human-dependent, expensive, inefficient, and/or unsafe. In recent years, advances in computer science and more specifically in the machine learning area, have enabled researchers to develop more robust models for analyzing pavement images and measure distress with unprecedented accuracy.

The output of such models could be used to develop a comprehensive pavement condition tool which rates each pavement image (and consequently a whole road section) according to the type and severity of distress extracted. As a result, DOTs and municipalities will be able to have a considerably more affordable data gathering method as compared with using sophisticated data collection vehicles and foot-on-ground surveys. For example, in 2013, the total price of an Automatic Road Analyzer (ARAN) was reported by the Ohio Department of Transportation at $1.2M, with an annual operating expense of $70K (Vavrik, et al., 2013). These numbers are even higher now.

What are Artificial Neural Networks (ANN)

Artificial Neural Networks (ANN) are the pieces of a computing system designed to simulate the way the human brain analyzes and processes information. They are the foundations of Artificial Intelligence (AI) and solve problems that would prove impossible or difficult by human or statistical standards. ANN have self-learning capabilities that enable them to produce better results as more data become available (Frankenfield 2018). In this study a project level AI-PMS will be designed to assist PMS- decision makers. Having such a system they would be able to determine the right treatment for each section by only using the provided raw data from the inspection vendors/staff without any direct human interference and involvement. And here by the raw data it means top-down images of the road, captured by one optic camera, in contrast with ARAN vehicles equipped with two super expensive laser scanners.

Several studies have taken advantage of ANN for distress detection and recommendation of appropriate M&R treatments.

Plati et al. (2016) performed a study that focused on the incorporation of the ANN technique as a surrogate tool for the modelling and assessment of pavement structural condition for use in PMS, Fathi et al. (2019) used a hybrid machine learning (ML) method that combines random forest (RF) and artificial neural network (ANN) to predict the alligator deterioration index (ADI). Piryonesi and El-Diraby (2019) used historical distress data in the LTPP database to develop a decision trees- based algorithm to predict PCI of asphalt roads. Recently, Majidifard et al. (2020) applied a machine learning approach to develop a new asphalt pavement condition index. They extracted 7237 google street-view images and manually annotated for classification (nine categories of distress classes). However, these studies and many other ones which have not been mentioned here have limitations such as:

- Relying on manual inspection of distresses
- Using old image processing techniques with relatively low accuracies
- Developing pavement condition indices, which are either obsolete in DOTs (e.g., PCI) or not applicable to the New England DOTs pavement management systems (e.g., PASER).
- Being incomprehensive by detection of only some types of distress (e.g., only potholes)
- Lack of conducting all necessary tasks to be considered as complete pavement survey tools. Those tasks are detection, classification, and quantification of distress. Just by conducting all these, later data would be useful as input of a pavement prediction model in a secondary software (e.g., in dTIMS software)

- Impractical as a final product to be applied in the industrial projects

III. RESEARCH OBJECTIVES

Define specific research objectives. These may be more specific than the broad need described in Section II. These should be project objectives (expected results) and not tasks or methodology.

In the first phase of this study, we will develop a robust pavement distress detection, classification and segmentation (quantification) model, based on machine learning approaches (such as deep convolutional neural networks). As a result, distresses could be classified and then quantified in the image processing step. Those corresponding distress measures could be later fed into the existing/developed software, to calculate pavement condition indices.

In the second phase, we will develop another machine learning-based model to predict pavement condition, based on the collected data as the inputs. Such prediction model could be either a modified version of currently using pavement condition indices used in the New England DOTs, or a new index (or both). Indices and trigger thresholds which are common (as criteria) in treatment selection process , will be applied as conditions in decision making algorithms. As a result, trained algorithms (models) will be able to select appropriate M&R strategy for each section of road which could be used in the project level PMS by the New England DOTs, municipalities, and counties.

Developed models at these two phases of study, could be finally offered as software to the stakeholder.

IV. COST ESTIMATE

An estimate of the funds necessary to accomplish the objectives described in Section III.

$140,000

V. RESEARCH PERIOD

An estimate of the number of months necessary to complete the research. In addition, include preparation of a Draft and Final Report and its review by the NETC project Technical Committee (90 days).

18 months

VI. URGENCY AND PAYOFF POTENTIAL

A description of the urgency of the need for this research in relation to the transportation needs of the six New England States. A discussion of the potential benefits to be derived from the anticipated research results i.e., time/cost savings, enhanced practice/performance, improved safety, other.

Most transportation agencies in New England are using their own pavement management system (PMS); however, a coordinated system for state highways and municipally maintained roads appears to be absent (Faramarzi et al, 2019). For example, while State- maintained highways are annually surveyed by states department of transportation, using ARAN vehicles, most of cities and towns-maintained roadways either do not perform annual pavement surveys, or do it manually. There are two main reasons why cities and counties have not shown interest to adopt automated pavement survey as needed. First reason is lack of budget for such a costly process and second reason is lack of experienced staff for running relatively complicated survey machines and methods.

Developing a new alternative to be both affordable and user-friendly to DOTs and smaller agencies would be the solution for that. This goal could be accomplished by developing a new survey method based on a simple optic camera, instead of expensive and complicated laser scanners which are currently being used on the ARAN vehicles. Images collected by the optic cameras will be processed by state of art image processing methods and algorithms to detect, classify, and quantify different types of pavement distress. These data could be fed into the dTIMS software (used currently in every New England DOT) to evaluate pavement condition and consequently choose an appropriate maintenance and rehabilitation (M&R) solution for each section of roads, according to the project level/network level policies.

VII. IMPLEMENTATION POTENTIAL

To aid NETC in deciding whether to fund this project, describe:

- *The intended transportation agency audience(s) for using the research products.*

All six New England DOTs, cities, and towns.

- *Type of implementation anticipated as a result of the project (i.e. confirm existing, adopt new or eliminate current standards, specifications, processes, policies, regulations or drawings, GIS application).*

In short term could be used as a supplementary/ validatory method in parallel with ARAN vehicles and manual inspection for DOTs and cities/counties, respectively. In long term could be a replacement for those expensive and/or unsafe methods.

- *Activities to facilitate implementation (e.g. brochures, posters, exhibits at conferences, tech sheet summaries, webinars, presentations, training workshops, peer exchanges, pilot or demonstration project at host agency) to help create awareness and facilitate implementation of the research results.*

We plan to work with the RIDOT to implement the research results/products. The progress and results will be presented at workshops and/or demonstrations will be held for all potential users. The findings will be also prepared as a technical paper, and will be presented at technical conferences, e.g., TRB and/or published in technical journals, e.g., TRR to interact with other researchers and practitioners for the improvement.

- *Anticipated barriers or constraints to implementation and ways to overcome them.*

The research group believes to be able to conduct this research without any serious barriers, since the knowledge to conduct this research exists and feasibility and capability of this topic have been already evaluated by conducting similar studies in smaller scale (Faramarzi 2020). Also required tools and software for the purpose of this research are all available in the group.

- *Methods of tracking and measuring the impacts of implementation.*

Results could be validated through comparison with annual manual inspections, ARAN inspection data and other RIDOT pavement management reports.

TWO TRANSPORTATION AGENCY STAFF ENDORSEMENTS ARE REQUIRED

(To be signed by separate individuals.)

VIII. ENDORSEMENT BY THE SPONSORING TRANSPORTATION AGENCY REPRESENTATIVE TO THE NETC ADVISORY COMMITTEE

By signing the endorsement, the transportation agency representative is certifying that:

1. *The Research Problem Statement follows the required format.*
2. *The Research Problem Statement addresses a transportation issue of relevance to NETC and does not duplicate another Research Problem Statement being submitted at this time.*

Colin Franco and (Christos Xenophontas)

Name — RIDOT Transportation Agency

Christos Xenophontos

Colin Franco — Jan19 2021

Signature* — Date

ENDORSEMENT BY THE SPONSORING TRANSPORTATION AGENCY RESEARCH PROBLEM STATEMENT AUTHOR/SUBMITTER

By signing the endorsement, the transportation agency Research Problem Statement author/submitter is certifying that:

1. *I have technical knowledge of the project topic and will be committed to the research outcome.*
2. *I agree to serve as Chair of the project's Technical Committee if this Research Problem Statement is selected for funding by NETC.*

___Colin Franco_____Peter A. Healey_____ _RIdot_____1/20/2021_____
Name Peter Healey, P.E. Transportation Agency

___Colin Franco_____Jan19 2021__
_____
Signature* Date

*Electronic signatures are acceptable.

NOTE: To expedite the processing of Research Problem Statements, NETC requires submittal by e-mail from signing Advisory Committee member to (netc@ctcandassociates.com) by January 22, 2021.