PhD Research Plan

An empirical multi-objective optimization of road traffic externalities considering human road stress based on vehicle activity data

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Introduction

Different road singularities may present distinct impacts regarding the vehicle occupants (VO) quality of life, hence, the importance of analyzing how each type of road singularity affects driver/passenger road stress.

Road noise has been showing to be related with heart conditions, while road stress has showed to have impact in the likelihood of road crash occurrence and a correlation with the driving styles which in turn increase the emission of exhaust pollutants.

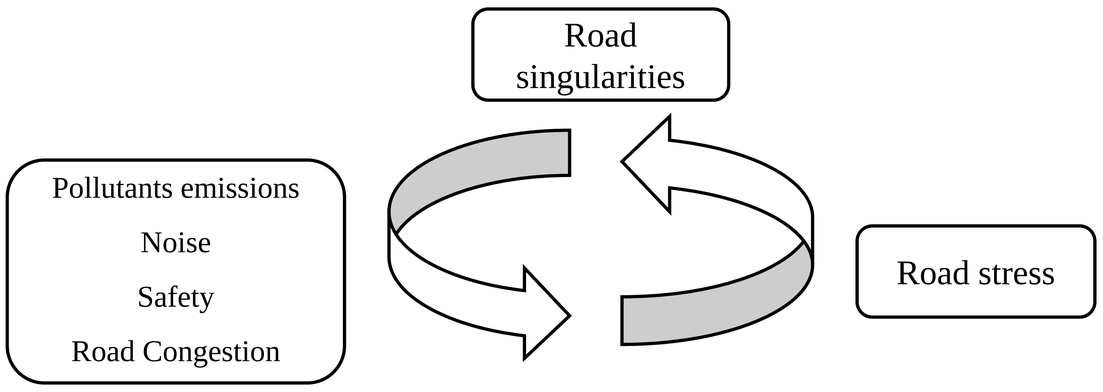

Figure 1: Correlation between road stress with road singularities and road traffic-related externalities.

The evaluation of stress has been widely developed, but the application of such methodologies to assess driver and vehicle passengers stress during a trip based on an integrated correlation of driving behavior parameters, vehicle and engine activity, pollutants emissions, road safety and road noise is yet to be developed. Furthermore, the conversion of a specific stress level to a monetary cost is also an important research gap to be addressed so that the contribution of all components can be added and further analyzed.

Objectives

- Integrate human **road stress** with **road traffic-related externalities (RTE)**, i.e., pollutants and noise emissions, traffic congestion and road safety.
- Provide a model to support research studies related with RTE (including road stress) which is applicable using both real-world and simulation-based data.

Setup

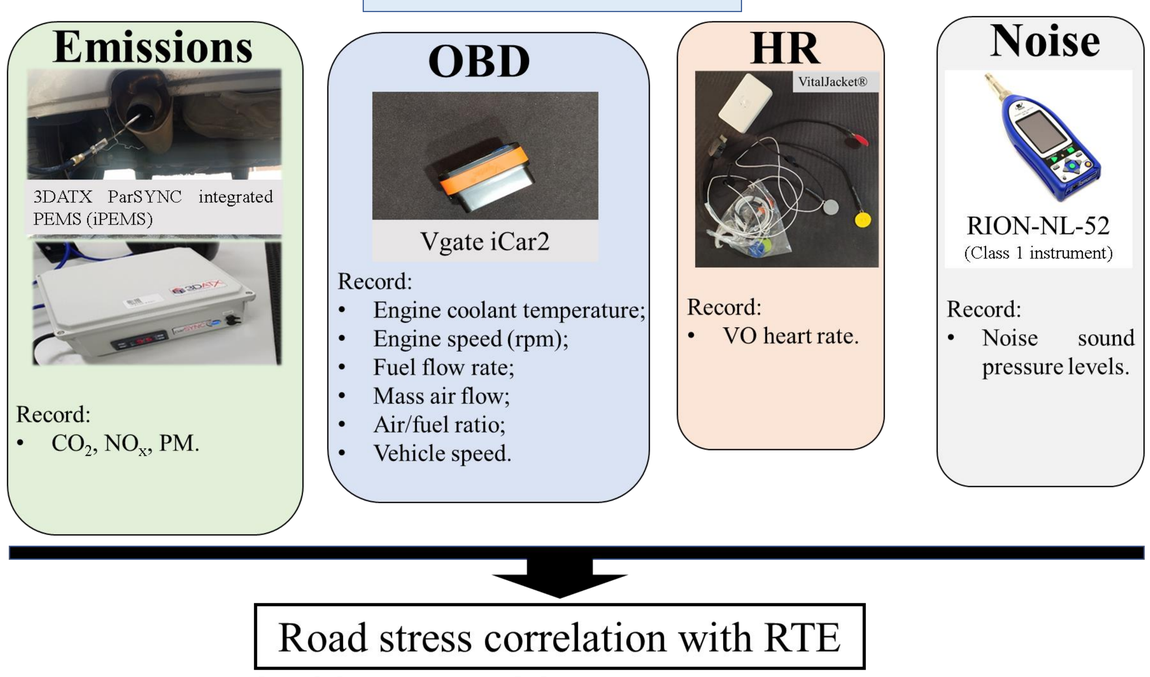

Figure 2: Example of the setup used during monitoring campaigns.

Methodology

The research work consists in the following nine main tasks:

I) **Review of technical literature** → main topics and task-design features, namely: monitoring campaigns, data analysis methodologies, on-board diagnostics (OBD) instruments and heart rate (HR) sensors, and relation between HR and stress index.

II)**Assembly of prototypes for data collection** → OBD to record vehicle and engine activity data, and two prototypes incorporating HR sensors.

III) **Data collection/monitoring campaigns** → record vehicle and engine activity data, tailpipe exhaust emissions, noise levels, traffic volumes, and VO HR.

IV) **Data analysis** → Data pre-processing to obtain unnoisy carefully prepared samples.

V) **Sensitivity and robustness analysis** → Evaluate which parameters perturbations affect the data. Develop statistical tests to find which parameters have significant roles. Finally, perform uncertainty analysis techniques so that robustness is achieved.

VI) **Development of a multivariate function** → Develop a model which estimates VO road stress level based on vehicle and engine activity data.

VII) **Development of a methodology to convert road stress levels to an equivalent cost** → Provide a method that delivers an indicator accounting for road stress, pollutants and noise emissions, traffic performance and road safety.

VIII) **Application of the developed models using real-world and simulation-based data samples**.

IX) **Dissemination of the research and writing of the PhD thesis** → international peer-reviewed journals (e.g., Applied Energy, Sustainable Cities and Society) and to national and international conferences/meetings (e.g., Transportation Research Board Annual Meeting - TRB).

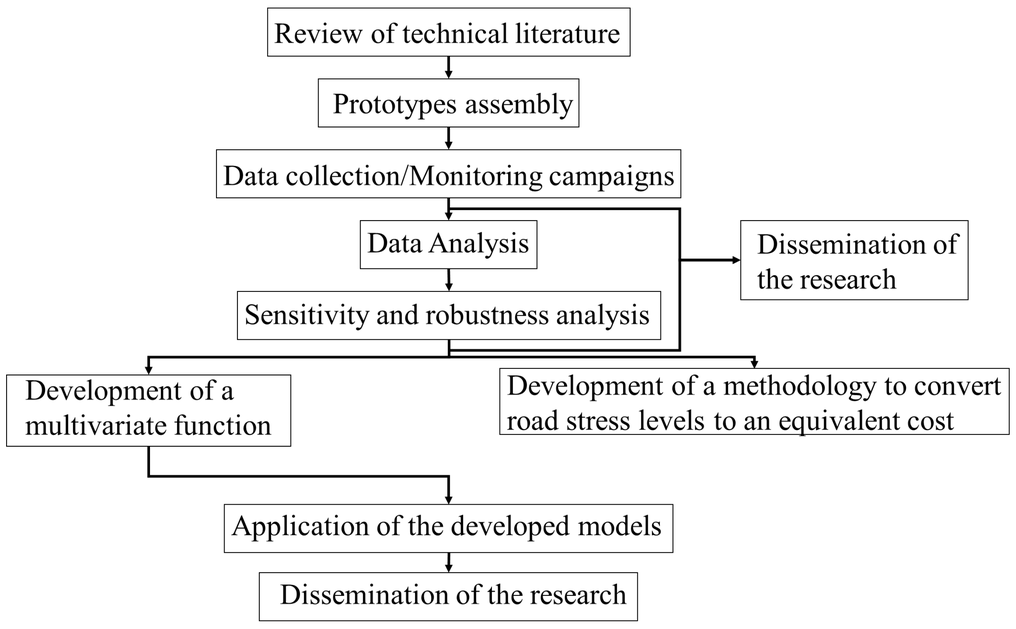

Figure 3: Flowchart of the tasks to be completed.

Research current state and next steps

The research plan is now tackling both the first and second tasks.

The prototypes are being developed by using a single-board computer Raspberry Pi 4 which can control the sensors and record all data collected.

The next steps during these following months until the end of the year are:
1) updating the current literature review;
2) continue with the assembly of the prototypes;
3) development of new monitoring campaigns.

Acknowledgments

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