Sensitivity analysis of the transportation decision

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***Abstract*—This document elaborates on the problem statement for MSSI - Modelação e Simulação de Sistemas. The influence of the different decision factors for transportation method are not fully known. The paper expands on the evaluation methodology to analyze and detect the main drivers.**

***Index Terms*—sensitivity, transports, system, congestion**

I. Introduction

Modern transportation is split in two main categories: private and public transportation. Private transports are owned by an individual and used for his/her needs, having a relatively low capacity. Public transportation is managed by a third-party and has a big capacity.

While a private transport can freely choose the route to the destination, public transports have a predefined route. This is the main difference and deciding factor between them.

A. Motivation and Goals

Even though public transportation is getting cheaper the general tendency remains that private transportation is the majority. This implies cost is not the main driver for the decision, thus there are other variables that need to be factored in.

The goal of the project is to factor the most variables possible and do a sensitivity analysis of the system. Ultimately it'll be possible to infere the main drivers of the decision.

II. System

The system will model monetary, social and geographical variables [1]. The decision making and action taking processes will be made using Reinforcement Learning based on tabular Q-Learning.

A. Inputs and Outputs Variables

- **Input Variables**
  - Number of private and public transports
  - Number of commuters
  - CO_2 emissions per transport
  - Transports speed limitations
  - Public transports average waiting time
  - Fuel prices
  - Toll fares
  - Ticket prices
  - Commuters' social awareness
  - Road's length
  - Road's condition
  - Policy to be applied[1]

[1]Certain policies may not include all of the Input Variables specified above.

- **Output Variables**
  - Average travel time
  - System's CO2 emissions
  - Commuters chosen transportation percentages
  - Average transportation costs

III. Scenarios

This section addresses the different scenarios that will be the target of evaluation throughout the simulation.

In order to ascertain the influence of the different factors/parameters when deciding which transport to use, different scenarios will be compared. For this, it is necessary to define a default case, which will serve as a basis for comparison. This scenario will present values appropriate to the environment in which it operates, that is, the price of fuels, tolls and tickets will be similar to the prices that are practiced in Portugal.

As the focus of the simulation will consider only two roads (one for public transport and one for private transport), the different analyzes will be based on 3 different scopes, that is, each policy stated below will be tested for 3 different road sizes (5 , 10 and 20km). In this way, by varying the length of the road, factors such as cost, time and emissions will also be affected, and in this way there will be the possibility to study in detail the weight of each parameter in decision making.

Each scenario presented below contains a variation of extremes, in other words, there will be a very significant decrease or increase in the parameter to be considered.

- **Variation in the price of bus tickets**
  - There will be a comparison against the default scenario of what happens when the ticket price is 0 and the same when the value is three times the usual value. In this way, it will be possible to identify and perceive certain behavioral patterns and understand the extent to which price is a key factor in this decision making.
- **Variation in fuel prices**
  - Variation associated with private transportation, more specifically in fuel's price. This variation intends to study how private drivers will react and what degree of variation they support, that is, the maximum amount they are willing to spend on fuel to avoid having to use buses.
- **Variation in commuters' social awareness**
  - Variation associated with public transportation to test to what extent the commuters' social awareness affects their decision-making process. This scenario

consists in having a value, varying from 0 to 1, to measure the impact of situations, like the marginality in some locals or extreme cases like the COVID-19 pandemic, that rocket the commuters' fear to travel in buses.

- **Variation in public transports average waiting time**
  - Variation associated with public transportation, more specifically the average time a commuter has to wait for its transport. This variation intends to identify the maximum time that commuters that usually travel in public transports are willing to wait for the transportation to avoid using their own car.
- **CO_2 emissions per transport**
  - Scenario to compare how CO_2 emissions affect each transportation mode. It will be possible to identify and perceive how this affects both the public and the private transportation and to what extent it is a key factor in the commuter's decision-making process.
- **Toll fares**
  - Variation associated with private transportation, more specifically in toll fares' price. This variation intends to identify the maximum amount commuters are willing to spend on toll fares to avoid having to use buses.
- **Speed limitations**
  - Scenario to compare how speed limitations affect each transportation mode. It will be possible to identify and perceive how this affects both the public and the private transportation and to what extent it is a key factor in the commuter's decision-making process.
- **Variation in the road's condition**
  - Scenario to compare how the road's condition affects each transportation mode. In this case, it will be possible to identify and perceive how this aspect affects both the public and the private transportation and to what extent it is a key factor in the commuter's decision-making process, in other words, test if a commuter that usually uses its own car to travel will change to public transports if the road he uses is in bad condition or vice versa.

REFERENCES

[1] Z. Kokkinogenis, N. Monteiro, R. J. F. Rossetti, A. L. C. Bazzan and P. Campos, "Policy and incentive designs evaluation: A social-oriented framework for Artificial Transportation Systems," 17th International IEEE Conference on Intelligent Transportation Systems (ITSC), Qingdao, China, 2014, pp. 151-156, doi: 10.1109/ITSC.2014.6957682.