SEMS: RESEARCH PROJECT DESCRIPTION

1. Project Background and Description

Multi-Objective Multigraph Shortest Path Algorithms for Scalable and Flexible Routing and Scheduling

During the pandemic, countries have to repeatedly take a broad approach to reimpose localised/national restrictions to "flatten the curve". Even with vaccination, having some smart social distancing measures as a complementary approach, for the long haul, is the key to reducing the transmission risk and a heavy socio-economic price due to the broad approach. This is important as some sectors are impossible to maintain strict social distancing. Public mass transit is one of the sectors that has been hit the hardest by the pandemic.

The project aims to identify smarter intervention measures for safer travel by assessing the risk of COVID-19 exposure pertaining to different trip options, integrating different transport modes based on the assessed risk and providing alternative mobility options. The fundamental stance taken in this project is: we must have scalable and flexible multi-objective routing and scheduling systems to safely and efficiently coordinate movements within complex and dynamic environments.

2. Project Scope

This project aims to formulate a type of movement problems in a directed multigraph, in which each pair of preceding/succeeding nodes are connected with parallel edges, each containing a vector of weights, representing trade-offs among conflicting objectives. Since vectors of parallel edges are Pareto optimal, they can be collected in a linearly independent matrix, representing different options between the nodes. The dimension of the matrix can be excessive due to many objectives, providing smooth transition between different options, which are desirable in many applications (e.g. decision making in dynamic environments). This formulation represents a densely connected multi-objective multigraph (DCMM).

This project represents the first attempt of using metaheuristics to address the problems in a DCMM. The project will be evaluated against the following measurable objectives.

O1: Generate synthetic problems, ranging from a sparsely connected multigraph to a DCMM. Prepare test cases using the real-world problems arising from multi-modal transportation.
O2: Design and implement the metaheuristics based multi-objective shortest path algorithms. Test the algorithms using synthetic problems generated in O1. Implement representative enumerative, ranking and metaheuristics-based methods as baselines for comparison in O4.
O3: Drawing upon O2, extend the developed metaheuristics to integrate routing and scheduling. Test the algorithms using test cases. Extend enumerative and ranking methods implemented in O2 to incorporate scheduling for comparison in O4.
O4: Conduct a wide-ranging evaluation of the proposed algorithms to validate its scalability to different benchmark problems, and its flexibility to real world problems.

3. Desired Skills from the Student

- *A top Master or undergraduate student (top 5%) in at least one of the following areas: Multiobjective Evolutionary Computation, Machine Learning, Combinatorial Optimisation, Operational Research.*
- *English minimum requirement: IELTS 6.5 or equivalent English tests.*
- *Preferably from a top Mexican university.*

- *Preferably with some decent publications.*

4. Supervisory Team

Add supervisory team details

Primary: Dr Jun Chen

Secondary: Prof Vassili Toropov

Additional: Prof Adriana Lara/ Departamento de Matemáticas de la, Escuela Superior de Física y Matemáticas del Instituto Politécnico Nacional, ESFM-IPN.