Abstract:

In the escape interdiction problem, law enforcement agencies (called as defenders) deploy their vehicles in the road network and establish checkpoints to prevent the criminal escape from the city limits. Since the road network is complex in urban areas and the number of police vehicles is limited, an intelligent vehicle allocation and routing scheme are essential to maximize the probability of interdiction. In this type of problem, criminal flees from the crime scene, and therefore, the interdiction is quite challenging due to an enormous number of choices in defender search strategies.

Three variants of the problem are addressed in this thesis. In the first variant, which is akin to the current police practice, the vehicles are allocated optimally to the most critical junctions that are identified based on a network centrality measure. The criminal vehicle is assumed to take the shortest path to a randomly chosen exit point. The interdiction problem is modeled as an assignment problem, in which the cost elements are derived from Dijkstra's shortest path approach, and subsequently solved by the Hungarian algorithm. The model is tested in an open source traffic simulator with no-traffic and simulated traffic conditions.

In the second problem, a vehicle routing problem is considered along with vehicle allocation from the defender's perspective. The attacker is assumed to use the shortest path approach to escape from the crime scene. A genetic algorithm is developed to compute the defender strategies in large transportation networks. The results indicate the superiority of the vehicle routing strategy to the previous strategy of static vehicle allocation to critical junctions.

In the third problem, the attacker is also assumed to be intelligent, and the interaction between defender and attacker strategies takes the form of a zero-sum game. A variable neighborhood search based metaheuristic algorithm is developed to identify the best defender strategy in a double oracle framework. The thesis presents an analytical basis for the strategies for the three variants of the problem and delivers a set of algorithmic tools to the defenders for quick and near-optimal decision making.

Keywords: Vehicle Routing and Scheduling, Network Optimization, SUMO Simulator, Genetic Algorithm, Variable Neighborhood Search, Escape Interdiction Game.