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Coupling Random Demand and Route Selection in the Transportation Network Design Problem

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Abstract : Network design problem (NDP) is used to determine the set of optimal values for certain pre-specified decision variables such as capacity expansion of nodes and links by optimizing various system performance measures including safety, congestion, and accessibility. The designed transportation network should improve objective functions defined for the system by considering the route choice behaviors of network users at the same time. The NDP studies mostly investigated the random demand and route selection constraints separately due to computational challenges. In this work, we consider both random demand and route selection constraints simultaneously. This work presents a nonlinear stochastic model for land use and road network design problem to address the development of different functional zones in urban areas by considering both cost function and air pollution. This model minimizes cost function and air pollution simultaneously with random demand and stochastic route selection constraint that aims to optimize network performance via road capacity expansion. The Bureau of Public Roads (BPR) link impedance function is used to determine the travel time function in each link. We consider a city with origin and destination nodes which can be residential or employment or both. There are set of existing paths between origin-destination (O-D) pairs. Case of increasing employed population is analyzed to determine amount of roads and origin zones simultaneously. Minimizing travel and expansion cost of routes and origin zones in one side and minimizing CO emission in the other side is considered in this analysis at the same time. In this work demand between O-D pairs is random and also the network flow pattern is subject to stochastic user equilibrium, specifically logit route choice model. Considering both demand and route choice, random is more applicable to design urban network programs. Epsilon-constraint is one of the methods to solve both linear and nonlinear multi-objective problems. In this work epsilon-constraint method is used to solve the problem. The problem was solved by keeping first objective (cost function) as the objective function of the problem and second objective as a constraint that should be less than an epsilon, where epsilon is an upper bound of the emission function. The value of epsilon should change from the worst to the best value of the emission function to generate the family of solutions representing Pareto set. A numerical example with 2 origin zones and 2 destination zones and 7 links is solved by GAMS and the set of Pareto points is obtained. There are 15 efficient solutions. According to these solutions as cost function value increases, emission function value decreases and vice versa.

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