（様式６号）「課程博士用」

学位論文の要旨

専攻名	システム工学　専攻	ふりがな 氏名	こう　じゅぐん 侯　樹軍

学位論文題目　Study on Enhancing Road Network Performance through Traffic Reliability Modeling

（英訳又は和訳　信頼性の高い交通モデルを用いた道路機能向上に関する研究）

Traffic congestion has become a serious problem with increasing motorization. It not only reduces the efficiency of a road network system, but is also time-consuming for passengers, and increases the fuel consumption and emissions. Improving the road network has become an important task for planners and managers. The improvement of a road network is judged by a performance index. So, it is necessary to develop the new method of performance assessment and establish a new planning model.

With the increasing demands for reliable service, the road network system has incorporated a reliability analysis as an integral part in its planning and operation. In this thesis, a four-level model of Unblocked Reliability (link, path, Origin-Destination pair and entire road network) is proposed. To optimize a road network, a bi-level program is established based on the new model of Unblocked Reliability, in which an upper-level part represents system design and a lower-level part represents travelers' responses. A set of link capacity expansions is determined as a planning scheme by solving this bi-level program. The improvement is reflected in each level of the road network. Links of the lower reliability are identified. The lower the link reliability is, the greater the capacity of the link can be improved and the level of link reliability can be promoted. Similarly, the lower the path reliability is, the more the path can be promoted. The performance of an Origin-Destination pair with high traffic demand has been taken into account in the optimizing process. The proposed method is capable of improving the road network to its highest possible level with the minimum scale of road network expansion.

This thesis consists of 7 chapters:

Chapter 1 is the general introduction of background and purpose of thesis.

In chapter 2, traffic assignment model is studied for route choice behavior of travelers. Characteristics of a road network have been described. A road network is a flow network since it is characterized by its topology and flow properties such as Origin-Destination demands, capacity constraints, route choice and flow travel time function. The equivalent program of equilibrium traffic assignment is used in consistency with route choices to model the congestion effect in the network. This approach offers the information of route choice behavior for the Unblocked Reliability analysis and is regarded as the lower-level program. An extended Frank-Wolf algorithm for traffic assignment is proposed to find route choice pattern which satisfies the Deterministic User Equilibrium criterion. The route choice pattern is comprised of paths selected by drivers (road network users) and the loading proportion on each used path between each Origin-Destination pair. And, for relaxing the assumption that all drivers are perfectly aware of the travel times and always capable of identifying the shortest travel time path in Deterministic User Equilibrium, the algorithm with the logit loading model and simple path enumeration is studied for Stochastic User Equilibrium traffic assignment.

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ふりがな 氏　名	こう　じゅぐん 侯　樹軍

In chapter 3, a four-level model of the Unblocked Reliability is proposed to assess the performance of each level of the road network. Unblocked Reliability is the probability of the road unit or system being able to maintain in the unblocked state during peak hours when the highest traffic volumes are observed for a day. The value of the link Unblocked Reliability is the probability of the unblocked trips in total trips, which depends on the ratio of link flow to link capacity. The path Unblocked Reliability is a function of its nominal congestion degree. There two ways to define the Origin-Destination pair Unblocked Reliability: the first when all paths between an Origin-Destination are regarded as a parallel combined system, the entire road network Unblocked Reliability is the weighted mean of the total Origin-Destination pair's Unblocked Reliability. The second way is that the Origin-Destination pair Unblocked Reliability is derived by the law of total probability that is limited in one Origin-Destination pair when the Unblocked Reliability of a path is the conditional probability of path choice. Then, the entire road network Unblocked Reliability is derived by the law of total reliability when a simple space is the set of all used paths.

In chapter 4, a new bi-level program is proposed to solve the problem of road network optimization. Planners in the upper level part determine the parameters of a road network, and drivers in the lower level part make choices with regard to the route of their travel in response to the changes in the road network. A bi-level program has a hierarchical structure in which upper-level and lower-level decision makers select their strategies so as to optimize their objective functions, respectively. The objective function of the upper-level program is the maximized balance between the Unblocked Reliability of the entire road network and the road network expansion ratio. The lower-level program is actually the equilibrium traffic assignment in which the link capacity expansion is included.

Chapter 5 presents the algorithm to solve the proposed bi-level program with the Unblocked Reliability. The Hooke-Jeeves algorithm is applied to solve the proposed bi-level program. The algorithm is a direct search method which includes an exploratory move and pattern move. The goal of solving the proposed bi-level program is to find a set of link capacity expansions to maximize the objective function of the upper-level program, which responds to the traffic assignment result.

Chapter 6 applies the proposed method to analyze two road networks, as case study, to demonstrate the advantages and usefulness of the new model. The dispersion parameter of logit model is estimated by minimum total travel time in the entire road network. A planning scheme of a road network in the form of a set of link capacity expansions is obtained. The results of traffic assignment and Unblocked Reliability in existing road network and improved road network are compared. The improved road network shows a significant improvement in the Unblocked Reliability of the entire road network over the existing road network. The higher index of Unblocked Reliability and the lower link capacity expansions are obtained for the improved network since Stochastic User Equilibrium assignment is closer to the reality of the traffic system. The case study also shows the proposed bi-level program can comply with various limits of environment and financial resources.

In chapter 7, the conclusions of the study and further works on this topic are given.

The detailed computer program of road network planning used in this study is given in the appendix.