Expert Systems with Applications 37 (2010) 6850–6861

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

The multimodal trip planning system of intercity transportation in Taiwan

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ARTICLE INFO

Keywords:
Multimodal trip planning system
Transit trip information system
Transit network

ABSTRACT

The multimodal trip planning system (MTPS) described in this paper can efficiently identify reasonable journeys. Our methodologies could be implemented in future transit trip information systems. An effective MTPS would be of value to transit agencies or administrators due to the large number of different yet related characteristics of the transit network. In Taiwan, no successful MTPS exists owing to the fact that there are many intercity transit options, including airlines, ships, intercity buses, rail, high-speed rail, local buses, and mass rapid transit. The purpose of this study is to develop an MTPS that will ensure that transit stops are accurately sequenced and integrated into appropriate route patterns, including schedule and route data, as well as intermodal transfer locations and multi-agency transit center walking directions. The MTPS will provide landmark-to-landmark journey planning for transit users. We combine a data structure and multimodal trip planning algorithm in the MTPS that can swiftly propose reasonable travel plans. Finally, we develop a transit trip planning system for Taiwan.

1. Introduction

In recent years, many transit agencies have developed advanced transit trip information systems to aid travelers in making decisions regarding transportation mode, route, and departure time before they begin a trip. There are two main types of transit trip information systems: urban and intercity. Because transit that serves urban areas operates at very short time intervals, we mostly study the transit inquiry system without considering departure times. To date we have explored the following Asian urban centers (Table 1): Hong Kong, Beijing, Nanjing, Shanghai, Xian, Dalian, Singapore, Seoul, Osaka, Nagoya, Taipei, Kaohsiung, Taichung, Tainan, among others. All of these have established transit inquiry systems. In addition, some urban areas, such as Sapporo and Hsinchu, have further provided travelers with a trip planning system that considers their departure time and user preference. In terms of intercity transportation information systems, the trip planning function for each transportation company is applied to its own modes of transport, and may lack integrated cross-service information. There are a few transit trip information systems that can provide intercity multimodal trip planning, such as the Japanese ekitan system (www.ekitan.com) and Taiwan's e-Trans system (e-trans.iot.gov.tw/). In Asia, only 24% of systems provide a trip planning function in their transit information packages. In Europe, 66% of systems provide a trip planning function in transit information packages, and 78% of systems can recommend multimodal transport options. This is the case in Britain and Germany, among others. In the United States, over 90% of systems provide a trip planning function with departure/arrival time and preference settings of users, but the modes of these systems focus primarily on bus or subway systems.

In Taiwan, the government has actively promoted its own APTS program in recent years, and many urban areas have already implemented comprehensive transit information systems. In addition, for intercity transportation, the e-Trans system constructed by the Institute of Transportation, also known as MOTC, has also provided an intermodal trip planning system that covers various forms of transportation, including airline, ship, train, high-speed rail, and intercity buses. Moreover, organizations that operate high-speed and traditional railroads have also provided a trip planning system for their individual transit systems. To date, among all the intercity transportation trip planning systems in Taiwan, the e-Trans system seems the most complete. However, according to a report from the MOTC, such a system still has room for improvement for several reasons. First, the system is currently only able to use transit stations or stops as the origin and destination points for trip planning, but in the future it is expected to follow other ATIS systems that can use landmarks, intersections, or addresses as origin and destination points. Second, the inquiry time required to generate trip planning alternatives is slow, at 2.57 s on average. Its accuracy is about 94%, but the accuracy of calculating traditional rail trips is lower. Last, there exists a competing service from Taiwan Railways Administration that provides trip planning for

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doi:10.1016/j.eswa.2010.03.037

Table 1
Type of transit trip planning system.

Region	Country	Modes[a]	Time	Preference[b]	Limitation[c]
Asia	Taiwan (ROC)	B,R,M,H,A	○	TR	X
Asia	Keelung (ROC)	B	X	X	X
Asia	Taipei area (ROC)	B	X	T	X
Asia	Taichung (ROC)	B	X	X	X
Asia	Taipei (ROC)	B,R	X	X	X
Asia	Taipei (ROC)	B	X	X	X
Asia	Tainan (ROC)	B	X	X	X
Asia	Taipei (ROC)	B	X	X	X
Asia	Taiwan (ROC)	R	○	TR	X
Asia	Taiwan (ROC)	H	○	X	X
Asia	Hsinchu (ROC)	B	○	T,Dw	Dw
Asia	Hong Kong (PRC)	B	○	X	X
Asia	Hong Kong (PRC)	B	○	X	X
Asia	Beijing (PRC)	B	X	D	X
Asia	Nanjing (PRC)	B	X	X	X
Asia	Xi'an (PRC)	B,A	X	X	X
Asia	Dalian (PRC)	B	X	X	X
Asia	Shanghai (PRC)	B	X	X	X
Asia	Singapore (Singapore)	B	X	Tr,Dw,TR	Dw,Tr
Asia	Head (Korea)	B,R,M,A	X	X	X
Asia	Osaka (Japan)	B	X	D	X
Asia	Sapporo (Japan)	B	X	C,Tr,T	Tr
Asia	Nagoya (Japan)	B	○	T,Tr,C	Tr
Asia	Japan (Japan)	B,R,A	○	T,Tr,D	Tr
Europe	Central London (Britain)	B,R	○	X	X
Europe	London (Britain)	M,A,R,,B	○	X	X
Europe	Europe	B	○	X	X
Europe	Paris (France)	B	○	X	X
Europe	Britain	B,M,A	○	X	X
Europe	Britain	B,R,A	X	X	X
Europe	Germany	B,M	○	T	X
Europe	England, including London (Britain)	B,R	○	T,Tr,Dw	Dw,Tr
North America	USA	B,A	X	Dw	Dw
North America	California (USA)	B, R	○	T,Tr,C,Dw	Dw,Tr
North America	California (USA)	B	○	T,Dw,Tr	Tr
North America	Los Angeles (USA)	B	○	T,Dw,Tr	Dw,Tr
North America	California, Colorado (USA)	B	○	T,Dw,Tr	Dw,Tr
North America	Santiago (USA)	B	○	T,Dw,Tr	Dw,Tr
North America	Chicago (USA)	B	○	T,Dw,Tr	Dw,Tr
North America	Massachusetts (USA)	B,R,M	○	T,Dw,Tr	Dw,Tr
North America	City of Portland (USA)	B	○	T,Dw,Tr	Dw,Tr
North America	Twin Cities (USA)	B	○	T,Dw,Tr	Dw,Tr
North America	Dallas (USA)	B	○	T,Dw,Tr	Dw,Tr
North America	Austin, San Francisco Bay Area, Boston, Chicago, Dallas, Houston, Seattle, New Jersey, New York (USA)	B	X	X	X
North America	New York (USA)	B,R,M	○	T,Tr	Dw,Tr
North America	Pierce County, Washington state (USA)	B	○	T,Dw,Tr	Dw,Tr
North America	Seattle (USA)	B	○	T,Dw,Tr	Dw,Tr
North America	Utah state (USA)	B	○	T,Dw,Tr	Tr

[a] A = aviation; B = bus; H = high-speed rail; R = rail; M = maritime.
[b] C = cost; D = travel distances; T = travel time; Tr = transfer; Dw = walking distances.
[c] Tr = Transfer; Dw = walking distances.

traditional railroad journeys. For the TRA system, the accuracy is 96%, but the inquiry time can be as long as 103 s.

The paper is structured as follows. The first section provides an introduction, and the second section describes the types and characteristics of intercity transportation in Taiwan. In the third section, we discuss the challenges encountered while developing our methodology for trip planning in accordance with the characteristics of intercity transportation. In the fourth section we summarize our proposal for a methodology for intermodal intercity trip planning. The fifth section offers a summary of the testing results for our methodology as well as a review. Conclusions and suggestions for future work are provided in the last section.

2. Characteristics of intercity transportation in Taiwan

In Taiwan, intercity transportation systems include the following five modes: high-speed railroad, traditional railroad, airlines, ships, and intercity bus (Table 2).

Table 2
Intercity transportation in Taiwan.

Mode	Types/routes	Stations/stops	Trips per day
Aviation	1/53	17	291
Bus	1/167	2000+	8000+
Rail	8/1	215	860
High speed rail	3/1	8	130
Maritime	1/59	24	267

- Airlines: In Taiwan, airlines mainly serve as transportation between off-shore islands, such Kinmen, Matsu, and Penghu, and the main island of Taiwan, as well as for intercity trips between the eastern and western parts of Taiwan, and intercity transportation among the main cities in western Taiwan, such as Taipei, Taichung, and Kaohsiung. Currently, Taiwan has ten airports, and eight off-shore island airports (as shown in Fig. 1) that serve a total of 27 routes. Although the high travel