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Geovisualization of Tourist Activity Travel Patterns Using 3D GIS: An empirical study of Tamsui, Taiwan

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***Abstract*—**The study of tourist activities and the mapping of their routes in space and time has become an important issue in tourism management. Here we represent space-time paths for the tourism industry by visualizing individual tourist activities and the paths followed using a 3D Geographic Information System (GIS). Considerable attention has been devoted to the measurement of accessibility to shopping, eating, walking and other services at the tourist destination. I turns out that GIS is a useful tool for studying the spatial behaviors of tourists in the area. The value of GIS is especially advantageous for space-time potential path area measures, especially for the accurate visualization of possible paths through existing city road networks. This study seeks to apply space-time concepts with a detailed street network map obtained from Google Maps to measure tourist paths both spatially and temporally. These paths are further determined based on data obtained from map questionnaires regarding the trip activities of 40 individuals. The analysis of the data makes it possible to determining the locations of the more popular paths. The results can be visualized using 3D GIS to show the areas and potential activity opportunities accessible to tourists during their travel time.

***Keywords*—**tourist activity analysis, space-time path, GIS, geovisualization, activity-travel pattern.

I. Introduction

THE analysis of space and place has recently become an important component of tourism research. With the rapid growth of the industry, many governments, both local and international, are choosing to develop tourism as a means of increasing people's income. Many related studies have been carried out. Janelle and Gillespie (2004) reviewed the integration of information and communication technologies (ICTs) for the transportation field for the purpose of understanding the underlying space-time dynamics of changes in mobility behavior [1]. The increasing need for tourism development suggest the need to study tourist activity-travel patterns. For example, Kemperman *et al.* (2009) found that route choice behavior of the traveler is influenced by accessibility to shopping, some physical characteristics, and the history of the route followed [2]. In another study a multi-agent geosimulation in a real street network was used for realize ad-hoc shared-ride trip planning [3]. This study applied spatio-temporal concepts from time geography to significantly reduce communication costs during the planning process. O'Connor *et al*. (2005) examined the technical aspects of tracking individuals. They analyzed tracking data and demonstrated the typologies of tourist behavior that exist at the Twelve Apostles National Park, Victoria, Australia [4].

Krantz (2006) pointed out that time geography provides a theoretical framework for describing and analyzing environmental actions in households and the residents' routines [5]. Furthermore, modern ICTs are changing human activity and travel patterns in both physical and virtual space. Shaw *et al.* (2008) presented a generalized space-time path (GSTP) approach to facilitating the visualization and exploration of spatiotemporal changes among individuals in a large dataset [6]. Shaw and Yu (2009) presented a space-time GIS design capable of organizing complex activity and interaction data in an integrated space-time environment [7].

Buliung and Kanaroglou (2006) used a standard deviational ellipse (SDE) method to explore the spatial patterns of household and individual activities. They used the household ellipse to characterize the spatial behavior of households and enables interactive GIS-based visualization and exploration of household activity patterns [8]. Kang and Scott (2008) reported on the use of two tools in the integrated spatio-temporal GIS toolkit [9]. They suggested that the tools facilitate the exploration of intra-household interactions (joint episodes). Further, their results also showed that some key attributes for independent and joint activity/travel episodes (i.e., frequency per household, starting time, ending time and duration) vary based on different classification criteria.

Shoval and Isaacson (2007) reported on the application of digital tracking technologies to collect tourist data on both spatial and temporal activities [10]. The available systems include land-based tracking, satellite navigation and hybrid

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systems. They also suggested that commercial mobile phone companies have the ability to locate and record the position and path of cell phone users. Shoval (2008) suggested using visitor data obtained from a global positioning system (GPS) to better assess the impact of visitors to cities fir urban analysis [11]. He pointed out that tracking technologies are able to provide high-resolution spatial and temporal data.

The objective of this current study is to apply space-time path concepts to tourism planning. The tourist path data were collected using map questionnaire and visualized using a three-dimensional (3D) geographical information system (GIS). We select a well-known tourism destination for which to visualize the 3D presentation of the space-time path.

II. Using Time-Geographic Concepts representing the Physical Space for Tourist Management

A. Concepts related to the space-time path in the time geography

Space-time paths depict the tourist's spatial movement over time [6, 12]. Such paths can be presented on various spatial (e.g., local, regional, national) and temporal scales (e.g., hour, day, month).

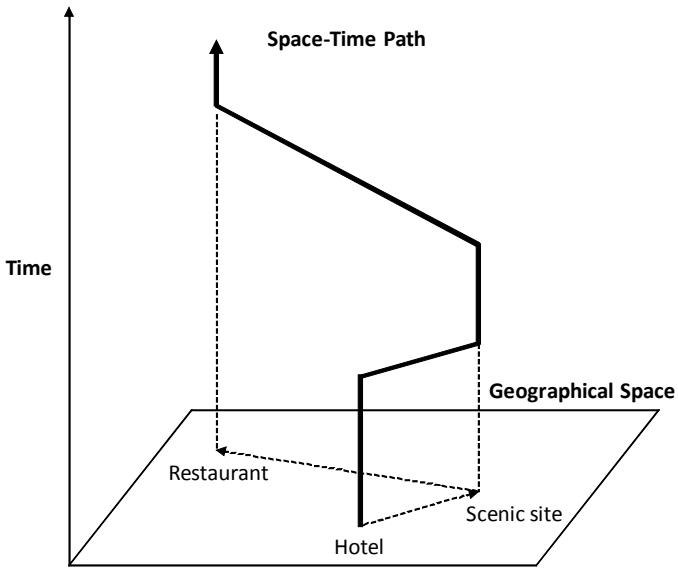


Fig. 1 Simplistic illustration of a tourist's space-time path

A tourist has a limited time budget within which to arrange activities at a tourism destination (Fig. 2). The tourist has to be at specific locations (scenic sites) for different time durations to enjoy what the destination has to offer. The tourist must also spend some of his time budget traveling between different locations (Fig. 3). The tourist's spatial behavior is constrained by their starting point at the destination. Further, a tourist has to stay at several fixed locations in space to participate in activities there. The fixed locations are called stations/anchors in the visualization; see Fig. 3.

B. Geovisualization of the space-time path

A space-time path records a tourist's movement in space with respect to time. The travel time of the tourist is represented as the Z value in order to visualize the space-time path in a three-dimensional environment. The prism represents all points on a path in space during the time budget of that tourist. The projection of the prism onto the geographical space is called the potential path area (PPA) [12]. Knowledge of the spatial extent of the PPA is useful for tourism planning and providing exact spatial locations to reduce costs of government.

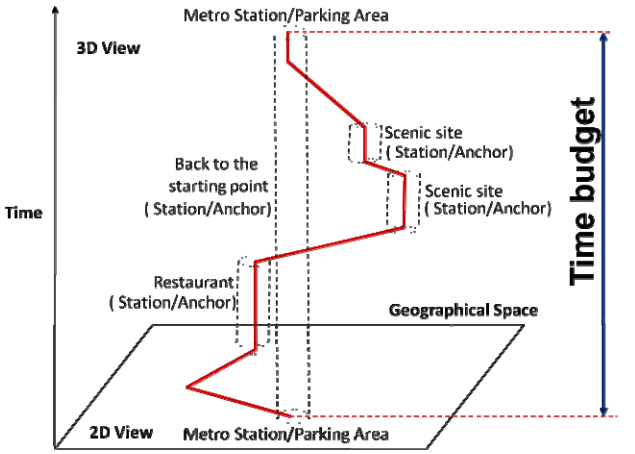


Fig. 2 Space-time path with key anchor activities (e.g., having dinner, eating and drinking, waiting for transportation, sightseeing)

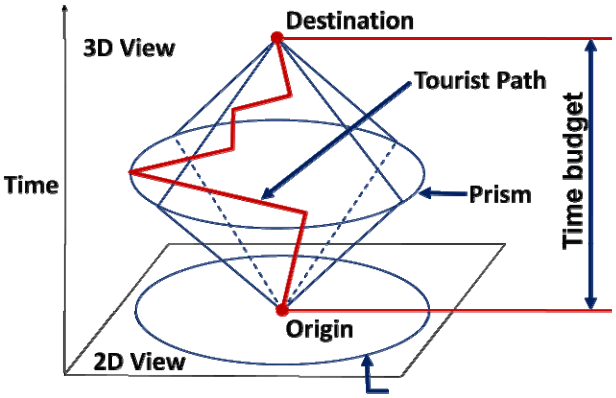


Fig. 3 Time geographical concepts: space-time path, space-time prism and potential path area (adapted from Neutens, 2004) [12]

III. Data and Method

The dataset used in this study was collected through a map questionnaire survey of the Tamsui area (Taipei, Taiwan) carried out in July, 2009. Besides collecting tourist activity-travel information on maps of Tamsui, the survey also included a questionnaire to collect detailed data about tourists' preferences and individual information.

The tourist activity-travel information was collected using a questionnaire based on a Tamsui map downloaded from Google Maps (Fig. 4). The interviewed tourists were asked to illustrate their paths and record their activities during this trip to

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Tamsui over time. The tourist paths and related activities were represented in virtual space using 3D GIS based on the space-time concept of Time Geography.

The sample of 40 tourists includes 27 women and 13 men. Most are tourists (31 individuals) but others are local residents. Further, 40% of the participants have a leisure budget of less than 2,000 Taiwan dollars (TWD) per month; only 22.5% of the tourists spend higher than 5,000 TWD per month. The mean expenditure for each individual is 845 New TWD.

Due to the characteristics of the sample, the results reported in this study do not represent the entire population of the study area. This is simply a pioneer study for spatial analysis of tourist activity-travel patterns.

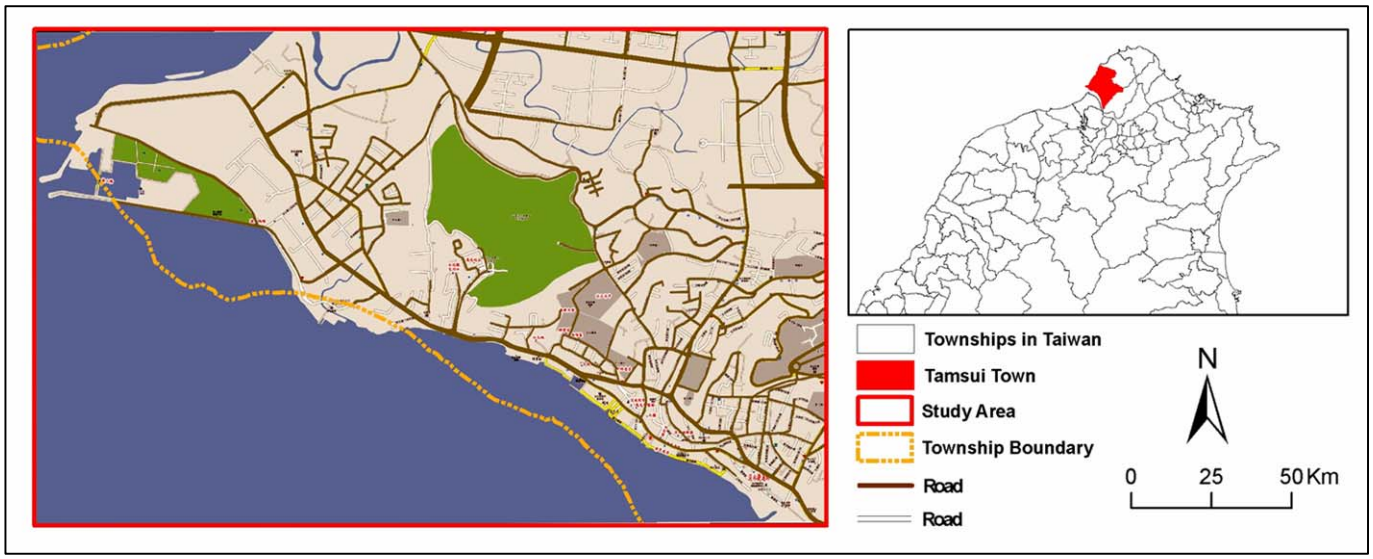


Fig. 4 Map of study area: Tamsui, Northern Taiwan

IV. Empirical Study

A. Visualizing the Space-Time Paths of Individual Tourists

We demonstrate the usefulness of 3D GIS for visualizing the tourist space-time paths by conducting an empirical study comparing the tourist space-time paths of the 40 individuals interviewed using the map questionnaire in Tamsui. Fig. 5 shows an example of the tourist space-time path of one sample tourist selected from the survey dataset. The vertical dimension (t) in represents the travel time in one day and (x, y) represent the spatial dimensions as depicted at the town level based on a Tamsui Google Map.

A tourist space-time path is composed of two types of line segments: (1) horizontal segments and (2) vertical segments. The horizontal segments along a specific path indicate movement from one site to another in time on one day. The vertical segments represent the time that a tourist stays at the same site.

Fig. 6 shows an attempt at geovisualization of the space-time paths of the 40 tourists in the sample as a three-dimensional representation. The characteristics of the more popular paths and travel times for the sample group are illustrated clearly using the three-dimensional presentation.

The observational results show both spatial and temporal information. This geovisualization of tourist paths is critical decision support information for planners and government administrators to better prepare integrated tourism development strategies. The spatial and temporal information is also useful for assessing better locations for tourist infrastructure, such as public paths, public toilets, sightseeing platforms and other needed public buildings.

B. Visualization of Potential Path Areas

The geographical space for the specific activities of each tourist can be mapped and identified. Using the space-time path concept in Time Geography, the PPA for each tourist shows the maximum spatial range in this trip and potential locations where they may stay and paths they might traverse (Fig. 7). The information acquired from the PPAs is important as it represents the areas of interest at a tourism destination spatially.

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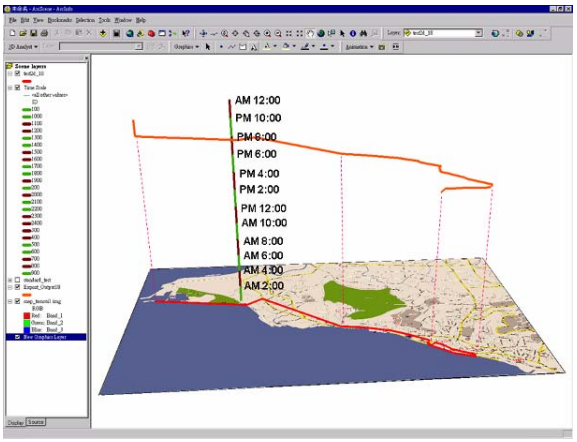


Fig. 5 Three-dimensional representation of space-time path for one tourist in ArcScene

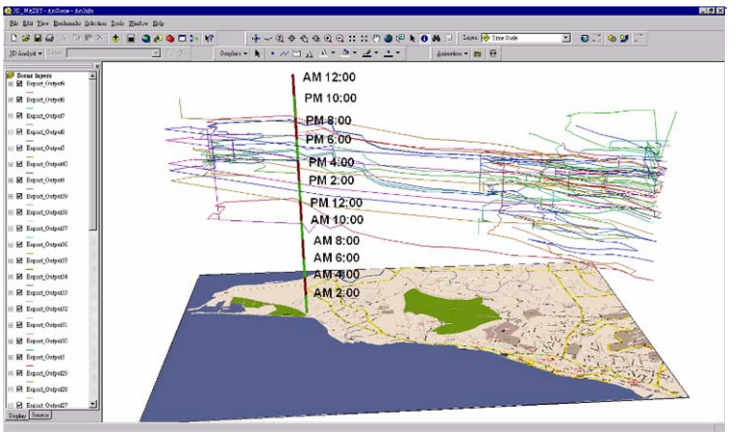


Fig. 6 Visualization of the tourist space-time paths in Tamsui for the 40 tourists in the sample using ArcScene

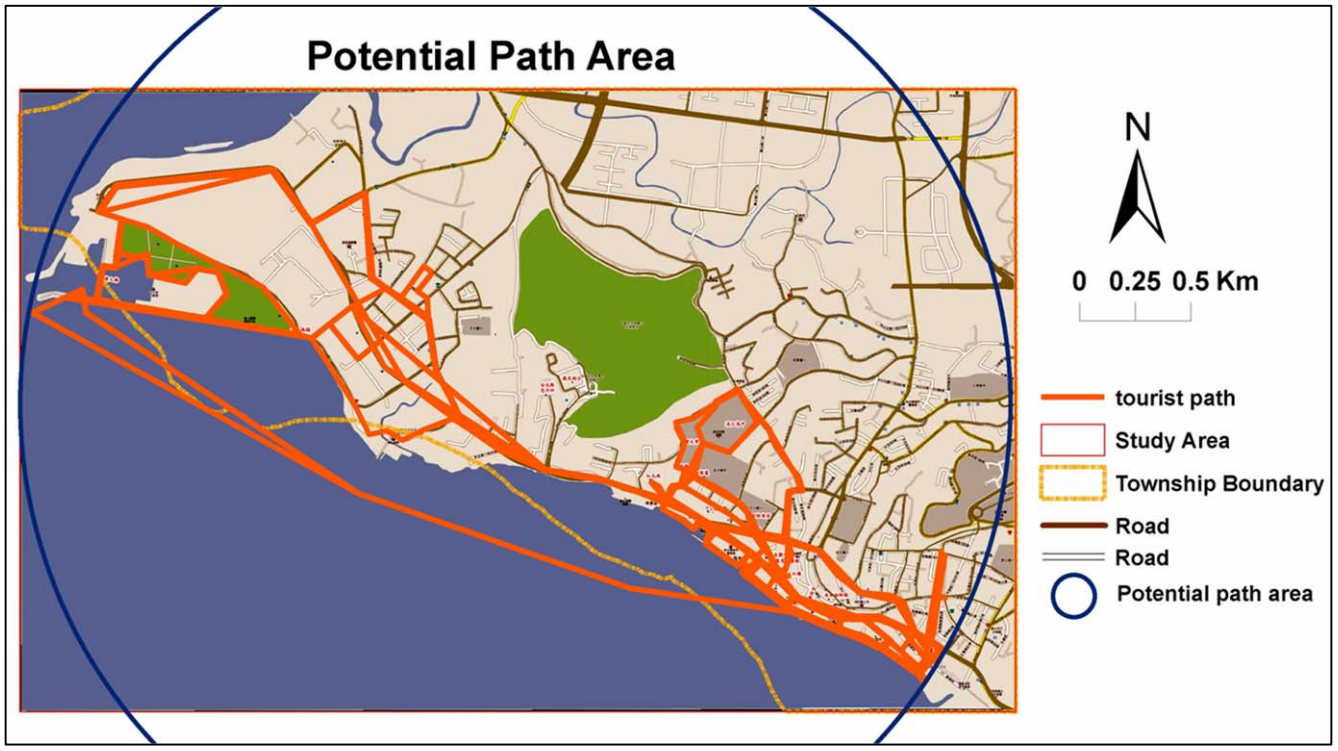


Fig. 7 Potential path area derived from the 40 sample tourists

V. Conclusion

The study adds to our knowledge of the space-time paths followed by tourists at a renowned tourism destination, Tamsui, in Northern Taiwan. 3D GIS is used to visualize the space-time structure of tourist activities. The method is demonstrated to form a useful framework for assessing the mixed and complicated spatio-temporal relationships of tourist activities and their interactions at tourism destinations. One important finding of this study is that the space-time patterns of possible tourist paths provide important information about the more popular attractions. Such information will assist planners and decision makers to set up new attractions or refurbish old ones. The results indicate that GIS can effectively capture potential path areas both spatially and temporally. The geovisualization of the space-time pattern of tourist behaviors is also useful for planners and administrators to meet actual commercial needs for tourists. This space-time GIS approach demonstrates that the spatial analysis of potential path area for tourists can provide a useful geovisualization of tourist needs for improving path planning.

The space-time patterns are highly uneven spatially and temporally. Recent studies have applied ICTs to human activity-travel patterns. Such high-tech techniques, such as GPS and mobile phone tracking can be used to acquire large amounts of data for commercial analysis as assistance for marketing. It is also useful to integrate Location-Based Services (LBS) and 3D GIS to achieve better location-based marketing and services.

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