ROUTE RELATED DATA OF SHOPPING CENTRE VISITORS
AND GEOGRAPHICAL INFORMATION SYSTEMS

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Abstract

Pedestrian route information can support different research activities such as the calculation of economic performances of shopping streets, the evaluation of parking policy measures, and the development of pedestrian design standards. These research activities are helpful in planning and designing shopping centres. Pedestrians’ routes are used to measure walking distances, calculate other route related data, and estimate pedestrians’ densities. To use route related data efficiently, it is necessary to capture the observed routes of pedestrians in some kind of computer system.

Geographical Information Systems (GIS) might offer an opportunity to deal with route related data because they can handle spatial and non-spatial data for example of line segments. However, very few GIS offer tools to enter, store, analyze and display route related data. In the new version of TransCAD a special Route System module is implemented to handle routes. The route system stores the routes, the different links routes are made up, and the possible stops on the route in separate tables that can be analyzed and displayed in a map.

This paper describes the structure and the contents of pedestrians’ route information as it can be used in various research projects. From these research projects some general requirements to handle route related, are extracted. Special attention is paid to the way TransCAD deals with routes. A parking research conducted in the main shopping centre of Veldhoven is used to describe and illustrate the possibilities of route related data of pedestrians, and evaluate the possibilities TransCAD offers to deal with this kind of data.

1. Introduction

Many research projects for retail planning use information that is derived from pedestrians’ movements to and within shopping areas, shopping centres and shopping malls. Pedestrians’ movements are used for a variety of applications such as the economic performance of individual shops or shopping streets (Timmermans & Van der Waerden, 1992), the design of shopping streets and aisles (Zacharias, 1993), the relative location of shops (Heinritz & Sittenauer, 1992), the accessibility of shops and parking lots (Van der Waerden & Borgers, 1995), and conflicts between shoppers and other traffic (Wigan, 1995). Wigan noticed that planners and environmental designers are more and more concerned with ‘the social and commercial success of space dedicated for pedestrians’. He argued that the analysis of walking movements requires concentration on the route choice behaviour of pedestrians and on the assessment of the quality of pedestrian routes and the influence of factors such as environmental quality, visual design and shopfront activity. Results of these kinds of analyses provide information on for example the distance pedestrians will divert to use a crossing. In addition, pedestrians’ volumes on different streets or links, can be derived from route data (Figure 1).

![Diagram of shopping areas](image)

**Figure 1:** Pedestrian volumes derived from route related data (Zacharias, 1993)

Despite the conviction that route related data supports a variety of planning issues, a little attention is paid to the way this type of data can be handled in a computer environment. Perhaps, Geographical Information Systems (GIS) may offer serviceable possibilities to deal with route related data.
GIS have been developed to capture, store, manipulate, analyze and display geographical information. In theory, three basic spatial objects or data constructs are distinguished: points, lines and areas. More complex spatial objects such as chains, routes and networks, that are used in for example transportation applications, can be derived from these basic objects (Nyerges, 1995). Routes can be defined as a special type of geographical feature that present the paths followed by vehicles, goods or individuals (Caliper, 1995). Most GIS packages can not deal with route related data at all. Some packages only can display the routes that are the result of some kind of wayfinding routine (e.g. shortest path procedure) on a map. The new version of the GIS package TransCAD contains a special Route System module that can handle routes and route related data.

The goal of this paper is to describe the possibilities of route related data of pedestrians, and to evaluate the possibilities the Geographical Information System TransCAD offers to deal with pedestrians’ route information. The description and evaluation deals with three aspects of data handling by a GIS. The first aspect concerns the way route related data can be entered and stored in one or more databases. A second aspect deals with the possibilities to analyze the stored route related data. The final aspect concerns the utilities to display routes and route related data.

To accomplish the formulated goal the paper is organised as follows. First, the structure and contents of pedestrians’ routes are described. The description is illustrated by an overview of various research projects that use route related data. Next, attention is paid to the possibilities TransCAD offers to handle route related data. It should be noted that the description is mainly based on the Pre-release of TransCAD version 3.0 (Caliper, 1995). Hence, a full evaluation of the TransCAD route system features was not possible when this paper was written. A parking research project conducted in the main shopping centre of Veldhoven is used to illustrated and evaluate the Route System module of TransCAD. The paper ends with some concluding remarks about the relevance of route analysis and the way a GIS such as TransCAD should deal with route related data.

2. Routes and route related data

A route can be defined as 'a chain of consecutive (road) segments connected by nodes or a chain of consecutive nodes connected by links' (Bovy & Stern, 1990). The chaining of links and nodes implies that most route attributes are derived from the corresponding attributes of the constituting links and nodes. For example, the total length of a route is the summation of the lengths of the various links of the route. Another example is the percentage footway in a route. This attribute can be calculated by dividing the total length of the route and the lengths of the links that are footpaths. There are also variables conceivable that are only defined at the level of the entire route, like route type or curvature.

Most pedestrian movements within shopping centres start at parking lots, bus stops or bike stands (Borgers & Timmermans, 1986). From these so called entry points, the visitors go to the first shop they have planned to visit. Next, the visitors go to one or more other shops or return to the entry point. The routes might lead through the different streets and the various squares of the shopping centre. A variety of routes can be observed. Zacharias (1995) presents a typology of paths through a public market. He classified 122 plotted trips into 9 categories (Figure 2) from 'Straight through' to 'Multiple loops'. The frequencies show that almost 75 percent of the observed routes starts and ends at the same point. About 40 percent of the observed routes passes one or more streets twice ('Simple return on the same path' and 'T-shaped path').
There are several reasons why it is preferable to use route related data instead of for example link related data or point related data. The first reason concerns the possibility that routes offer to investigate the walking patterns of pedestrians. For example, Borgers and Timmermans (1986) used route related data to investigate the walking patterns around shopping centre entry points to assess the viability of shopping streets. A second reason is that routes provide insight into the connection of several points in a network. In this context, Lorch and Smith (1993) investigated in their research the relation between a downtown shopping mall and the rest of the central shopping area. Routes can also be used to investigate linkage patterns of individual visitors of shopping areas. To evaluate the location of different shops, Heinritz and Sittenauer (1992) studied the shopping linkage behaviour of visitors of a shopping mall. Finally, routes provide insight into total walking distance, time or costs in specific areas. For example, Van der Waerden and Borgers (1995) used route related data to specify different measures that describe the location of parking lots vis-à-vis the various shops in a shopping area.

Both transport-modelling software and GIS might be suitable for the storage, manipulation, analysis and presentation of route related data. Nyerges (1995) discusses some advantages and disadvantages of using the two systems for transportation analysis. The major items he discusses are the connection that can be made between different types of spatial objects, the possibilities for spatial manipulation and analyses, and the presentation of results. In contrast to most transport-modelling software, GIS is able to connect route related data with for example area (e.g. shops) related data. The core of almost each GIS are the spatial manipulation and analyses tools, such as spatial data aggregation, overlay analysis, buffer analysis and network analysis (Stár & Eises, 1990). Another advantage of GIS is the possibilities it offers to display attribute values and results of various analysis in both maps.
(spatial) and reports (non-spatial). Nyerges also describes some disadvantages that has to be faced when comparing transport-modelling software and GIS. The main disadvantage concerns the handling of network problems. Most GIS network analysis software has been written to handle generic network problems through which the software cannot handle complex relations such as occurs in travel-demand forecasting and trip-chain characterization.

To handle route related data in a GIS specific tools are required. Some tools might be already implemented in existing GIS packages. The required tools concern:

1. tools to enter observed route directly from questionnaire or video and to store this information in specific databases with for example route specific data fields;
2. tools to manipulate the routes: add links to and remove links from the defined routes, derive new route characteristics from existing route related data;
3. tools for analyses with route related data such as calculation of the length of a route, the number of stops on a route, and the number of routes passing a link in the network;
4. tools to display the routes and results of analyses in for example different colours, line widths and symbols.

3. The route system of TransCAD

TransCAD stores routes in a so called Route System module which is a map layer that contains a collection of routes. Every route in a system can have data associated with it such as type of pavement, percentage of covering by a roof, number of crossings with traffic signals, etcetera. In TransCAD, the routes are made up of a series of links which are the line features of a line database. Routes can be stored continuously, with all the links connected to each other or with gaps or spaces in it. A route can be defined using whole links, or parts of links. Route systems can also contain information about stops that are made along a route.

The information of the different parts of a route system (routes, links and stops) is stored into three different tables. All tables contain a minimum set of data fields that are filled in and maintained automatically when something changes in the route system. The route table contains one record for each route in the route system and for each record there are at least two data fields: the Route ID and the Route name. Other data fields can be added. The link table lists all links that make up each route. This table contains at least the fields Route ID, Link ID and Direction. The route ID refers to the route the link is part of. The link ID is the identification code of the network link. The direction field contains information of the appearance of the link in the route, in forward or reverse direction. Possible stops in a route are stored in a stop table that contains at least eight data fields. These data fields are Stop ID, Longitude, Latitude, Route ID, Link ID, Pass Count, Sequence, and Milepost. The Longitude and Latitude fields contain the longitude and latitude values of the location of the stop. The identification codes of the route and link along which the stop is located are stored in the route ID and link ID fields. If the link appears in the route more than once, the pass on which the stop is located has to be putted into the Pass Count field. The sequence number of the stop along the route is stored into the Sequence field. The Milepost field contains the location of the stop as measured from the start of the route.

Before entering routes in a new route system, a TransCAD network file has to be built. A network file contains information of the lines and nodes of the line database and is used to find the shortest route between two points in a map. Routes and stops can be edited using the special route system toolbox. This toolbox contains possibilities to add, save and delete routes, links and stops. It also contains tools to modify and display routes such as
reverse the direction of a route, edit portions of a route, and change the offset (Figure 3) and tracking of routes.

![Figure 3: Example of displaying similar routes with the offset option of TransCAD](image)

TransCAD offers some special selection and query features for route system layers. The selection part contains procedures to select all the routes that operate on a particular link and procedures to select portions of routes based on their location or other characteristics, such as accident or ridership rates. In the route query part routes can be identified that service a pair of points. In this context there are two possibilities: (i) routes serving which identifies all the routes that pass through two areas on a map, and (ii) stops serving which identifies all the routes that have stops in both locations. The analyses on routes concern mainly creating milepost values and measuring distances between two stops on one route. The Route System module can also be used to analyze shortest path problems in and performance of transit networks. Finally, TransCAD offers a possibility to show the characteristics of a route and how they vary along the length of the route by a so-called 'Strip Chart'.

4. Route analyses in practice

To illustrate the requirements for using route related data, this section pays attention to a research project conducted in the main shopping centre of the City of Veldhoven. The research project concerned micro spatial behaviour of shopping centres visitors. A major part of this research project dealt with parking issues.
a. Research questions
The 'Veldhoven-project' contained several research questions related to parking that could be answered using route related data. The goal of this part of the project was to investigate the influence of parking lot choice on the walking and shopping patterns of motorists. Major research questions in this respect were: 'What is the walking reach from the different parking lots?', 'What is the average distance walked by motorists through the shopping centre?' and 'How many motorists pass the various shopping links regarding to the various parking lots?'

b. Gathering route related data
The route data was gathered with an on-street questionnaire (Figure 4). When leaving the shopping centre, respondents were asked to draw the route they had walked through the centre during their visit. They were also asked to register the shops they had visited on their route. Figure 4 shows an example of such a route. This information was complemented with some personal characteristics such as origin, mode of transport, gender and age.

Figure 4: Questionnaire with the route followed by a respondent

c. Data entry
With the route toolbox, the track of the route can be entered directly and easily from the questionnaires (Figure 5). However, if there are many routes that have to be entered like in the 'Veldhoven project' the view becomes very complicated. Entering additional information
such as personal characteristics, can only be done by way of the route table. The 'Data Update' option that is available in other layers, is not available in the route system layer.

Figure 5: Entering an observed route from questionnaire

d. Information from routes
To answer the defined research questions, different manipulations and analyses are required on both the route and the link level. On the route level, it is necessary to select different walking patterns from the various parking lots. In TransCAD this selection can be done by choosing the 'selection by location' with the 'touching or contained' option (Figure 6). For modelling purposes, the walking distances of the selected routes must be measured. The length of these routes is not stored in the route table automatically but has to be (manually) transferred from the link table to the route table.

Some research questions only can be answered on the level of links, such as pedestrian densities and serving origin-destination pairs. According to the structure of TransCAD, the derivation of link related data from routes must be a simple task. After getting the database of the line (street) layer, data fields can be filled with information of other layers. This should provide the opportunity to calculate for example the number of routes passing a particular link and to put the results of this calculation in a specific data field of the line database. Several attempts to calculate the number of routes passing the different links of the street network show that this is not easy to do, and that there are still some uncertainties.
Figure 6: Selected route, passing a specific parking lot

5. Conclusion

This paper describes several issues related to the use of data concerning pedestrians' movements in shopping centres. Previous research proved that route related data can provide useful information at both the route and link level. This information can be used to study for example the performance of shops and parking lots. Special attention is paid on how the GIS package TransCAD handles route related data.

To handle route related data in TransCAD a special Route System module is available. This module offers a set of tools to enter, store, analyze and display route related data. Research questions from a research project conducted in Veldhoven are used to illustrated and evaluate the Route System module.

The first experiences with TransCAD’s Route System module are promising for our future research projects that use route related data. The input and storage of routes derived from questionnaires, is very simple. Routes can be stored with an almost unlimited number of additional data fields. However, the input of additional non-spatial data can not be done simultaneously with the input of spatial data. Links can be added at and removed from the starting and end point the routes very easily. It is also possible to add and remove one or more links within the routes. Various selection possibilities provide an easy access to different parts of the route database. A set of tools is available to derived new route related data (e.g., distance) and link related data (e.g., density). With the available display options both routes and results can be presented clearly.

Before using the route system module in our research projects, there are some issues that have to be studied in more detail. One of these issues concerns the import of external data files (ASCII). The external data files have to be organised in accordance to a fixed
structure and some fixed data fields for route and link identifier, route name, and direction. Another point of interest is the translation of route related data to the level of one or more individual links.

6. Literature


