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A Framework for Individualized Route Planning and Navigation for Pedestrian Users

1. INTRODUCTION

In earlier publications [1][2][3] we introduced our researches on an assistance system for tourists with special needs. While the above-mentioned works focused on user interface and infrastructure issues, we'll now present an information framework that extends the functionality of well known route planning algorithms in a way to include the users physical abilities as well as the personal interests.

2. ENERGY EQUIVALENT ROUTE SECTIONS

Nowadays route planning algorithms are mostly used for car navigation systems, either on web-based applications and information systems or on mobile navigation systems. Besides the length of the route, the time used to get from the starting point to the end point is a major criteria to select the best route. But pedestrians usually have more complex demands. According to the personal physical condition the one or the other route might be more comfortable to a certain user. If you include bodily-impaired users to the potential user group, the complexity increases furthermore. This paper introduces a heuristic approach based on personalized energy equivalent values of route sections l° for the route planning. l° is calculated as in the following equation:

$$l^{\circ} = (l \cdot c(\alpha) \cdot c^{\circ}(c_{underground}, c_{weather})) \cdot c_{physicalcondition} + H_{see} + H_{hear} + H_{walk} \qquad (1)$$

where a route section is a real world path from one junction to the next, or parts of such a real world path, l is the actual length of this route section, $c(\alpha)$ is a function of the sections' inclination that represents the change in the needed effort to overcome a way with the given inclination. Note that $c(\alpha)$ is not symmetrical, as different efforts are needed to walk a hill up or down [4]. The factor c° represents the effort needed to overcome a certain type of surface at certain weather conditions.

So far each parameter of the equation does not depend on the actual user and changes in those parameters do not occur at all (inclination) or occur only long-term (track surface) or in mid-term (weather) periods.

The parameters for the personalized part of Equation (1) are acquired by a knowledge based system based on a user survey which is held prior the route planning itself [2][3][5]. Of these personalized parameters only $c_{physicalcondition}$ is used to scale the physical effort up or down. The result of this computation so far represents the effort to walk this route section assuming there are no further obstacles. A route planning based on a path-network like this would be sufficient for most users without any physical limitations. To pay attention to the needs of users with a certain kind of limitation, a modular approach was chosen to add the effort needed to overcome specific obstacles located on the route section.

So far three adjacent modules for seeing impairments (H_{see}), hearing impairments (H_{hear}) and walking impairments (H_{walk}) are intended. Further works might include more modules and also interaction between the modules. The value of each module output H can range from 0 (no obstacles for this type of impairment) to $+\infty$ (an obstacle can not be bypassed at all).

The modules themselves can be implemented in different approaches. So far decision trees and fuzzy logic have been tested.

As a result you will get a weighted, directed graph, in which the weights of the edges represent the effort a certain user needs to overcome the route section and all obstacles on this route sections. To find an optimized route, a shortest path algorithm is run on this graph [6].

3. EXAMPLES AND TEST RESULTS

To evaluate our approach a web-based route planning system was implemented using JBoss as J2EE Application Server and PostGreSQL with PostGIS extension as geographical database system. The routes planned on this system can later be loaded onto mobile devices (PDAs) to guide the user on the planned tour.

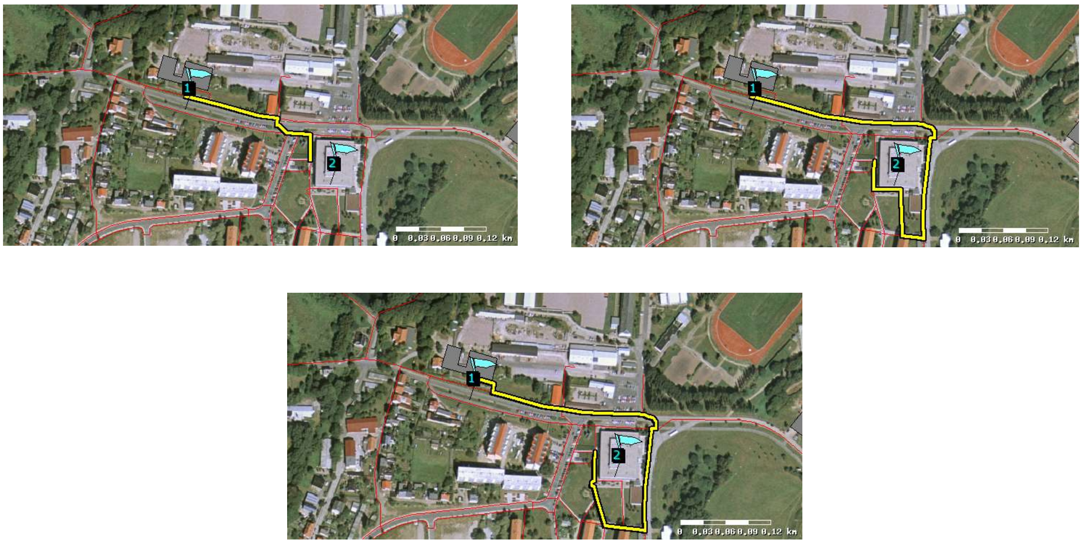

Fig 1: *Different calculated routes for different users.*

Figure 1 shows three possible results of the route planning for different users. The starting point of all routes is a lecture hall of the Technical University Ilmenau (flag 1), the end point is the nearby cafeteria of the university (flag 2). Different real obstacles are placed on the map, like a heavy traffic crossway in the northwest of the cafeteria and a small stairway at the southern terrace of the cafeteria.

The picture at the upper left shows the route for a user without any physical limitations. The algorithm selects the direct connection between the start and the end point. The picture at the upper right shows the route, calculated for a seeing impaired user. The algorithm avoids passing the cross-way and directs the user to the slightly longer, but much safer path. The last picture at the bottom shows the route for a wheelchair driver. Not only the cross-way is avoided but also an alternative way for the stairs is used. Note that the cross-way could be included in the routes if the alternative way would be to long and the risk at this cross-way would not be too high compared with the necessary detour.The stairs on the other hand would never be included into the route for the wheelchair driver. To achieve this behavior, the stairs are rated with an infinite value at the H_{walk} module if the user selected a wheelchair driver profile in the survey. The cross-way is rated with a high, but not infinite value by both, the H_{walk} and the H_{see} value.

4. FIELDS OF APPLICATION

While the project has the background of accessible tourism, the proposed enhancement to pedestrian route planning can be used in a broad field of possible areas. Not only bodily-impaired people might benefit from a personalized route planning, but also families with children and baby carriages, elderly people or even athletes are possible user groups. To include personal interests in the route planning, a module $H_{interest}$ might be implemented to weight the “touristic value” of the route.

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