

# Integrating Awareness in User Oriented Route Recommendation System

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**Abstract**—Development of recommendation systems are now gaining importance in variety of fields ranging from multimedia content on web sites to travel guides or online product buying to help and guide users in finding out relevant information from the vast pool of information generated everyday. The research in the area of information retrieval, data mining, marketing or e-commerce shows that integration of contextual information into recommendation system would further improve the efficiency and capability of recommendation system for individual users. In this work the conceptual framework of an user oriented pedestrian navigation system with the capability of integrating context awareness in route recommendation is proposed. A very small pilot study is undertaken to measure the effectiveness of the recommendation system with incorporation of context awareness.

## I. INTRODUCTION

Development of recommendation systems are increasingly becoming popular in variety of fields ranging from music, movie, reading material selection from a large pool of websites to travel route selection in unfamiliar environment or buying products from online markets. Due to the overgeneration and overloading of information in every sphere of life, finding out the most relevant information is getting time consuming and difficult. Recommendation systems are efficient tools that help overcoming this problem and provide the users with the most relevant contents. Traditional recommendation systems generally focus on recommending the most rated items to the user and ignore the various contextual information relevant to the particular user. For example, while recommending products to its potential buyers, the majority of recommendation systems consider the rating of the product in the market assessed from the comments of the other buyers and the buying behaviour of the customer, and put less emphasis on other peripheral information such as the location, condition, situation and personal preference of the user. However in many applications, contextual recommendation is much more meaningful and extremely important. For example, using the weather or time of the day context, a travel route recommendation system might provide different routes. Similarly the recommended route for a pedestrian navigation system should differ depending on the user's age, physical condition, objective of travel etc. In the case of personalized content delivery on a website, it is also important to decide what contents to be delivered to the customer and when.

The utility value of a recommendation system is judged by the degree of satisfaction of its users which depends on the accurate prediction of the consumer preferences. The incorporation of the relevant contextual information in the recommendation process would undoubtedly improve the capability of the recommendation system for providing better service to its customers. In [1], the authors argued that contextual information does matter in recommender system and provided an approach for modelling context awareness in recommendation process. Context Aware Recommendation Systems are now receiving growing attention by researchers and various mechanisms for incorporating awareness in the recommendation mechanism are developed [2] [3] [4]. In the field of marketing and data mining, context aware modelling of customer behaviour is found to be important for developing personalized applications [5]. Recently sophisticated mobile devices are being developed rapidly and the need for new services are emerging. In [6] a new scheme for providing recommendation service of multimedia contents to mobile users has been proposed. Other recommendation system applications related to mobile devices are reported in [7], [8], [9].

Route recommendation is an important functionality for pedestrian navigation systems in unfamiliar environment. The growing need of user oriented route recommendation for diverse users in modern society with variety of demands gives rise to the development of personalized user aware pedestrian navigation systems. The development of computational framework for subjective preference based route selection in pedestrian navigation system by the author, has been presented in [10] [11]. In this work, the framework of integration of awareness in developing user oriented route recommendation for pedestrian navigation system is studied. The next section describes in brief the current state of route recommendation in navigation systems and means of integrating contextual information in route recommendation. In the following section, the framework of the proposed context integrated user oriented pedestrian navigation system is introduced. The next section describes the computational algorithms and a very small pilot study followed by the conclusion in the final section.

## II. ROUTE RECOMMENDATION IN NAVIGATION SYSTEMS

Car navigation systems are now widely used for quite a long time. Due to rapid advances of mobile and GPS

technologies and computerization of maps, the motivation for the development of efficient pedestrian navigation systems is increasing. Route selection and recommendation is one of the main functionality of a navigation system. Traditional navigation systems usually show the shortest path from the given origin to destination. Newly developed car navigation systems provide a wide choice of routes to cater different requirements and preferences of their users [12] [13]. Unlike car drivers, pedestrians form a highly diversified group, with respect to abilities and preferences. Hence, the need for user oriented route recommendation to satisfy diverse users' specific needs and desires, becomes obvious. Moreover, route requirements of pedestrians are not strictly bound to designated routes like car drivers. The lack of systematic information regarding the roads and environment to support pedestrian navigation imposes a harder challenge in developing such a system catering the diverse population from children to elderly or disabled persons.

Commercial efforts in pedestrian navigation is pioneered by Japanese companies such as mobile route planners EZ-Naviwalk by KDDI, Do-Co Navi by NTT DoCOMo etc. But none of them incorporates user's personal preferences in route selection. Specially aimed systems like persons with visual or physical impairment, tourists or business man are also designed [14] [15] [16]. But flexible pedestrian navigation systems to provide routes considering user's physical ability or personal preferences in different contexts are yet to come. In [17] [18] research works to incorporate user's subjective preferences in route selection for pedestrian navigation system have been reported. In [19], the authors proposed a personalized pedestrian navigation system in which the route selection is done according to the highest subjective satisfaction degree of the user based on Road Evaluation Model set up by users.

#### A. Integration of Awareness in Route Recommendation

Current pedestrian navigation systems are able to retrieve the current position of user automatically from GPS. With the information of map, they are able to provide route based on static road information according to user's choice in a limited range. Due to the availability of mobile services, dynamic road information, weather information and other contextual factors are now easy to access. Incorporation of these additional contextual factors are needed to develop user oriented and context or situation aware route recommendation. In [20], the authors conducted survey from users to rate the importance of different criteria to be included for context awareness. The result shows that preference of individual users are different and do not depend on other user's recommendation. These findings point out that choosing the contextual information relevant to the individual user is also very important.

Thus it seems that to incorporate context awareness in route recommendation system, it is necessary to identify the features that influence the user's current situation and it might vary from user to user. In this work, a preliminary study to identify the features to define context awareness for several group of users have been done and a framework have been

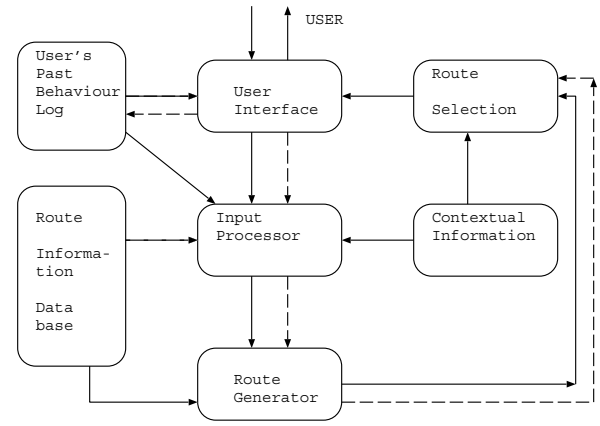


Fig. 1. Block diagram of Context Aware User Oriented Pedestrian Navigation System

developed for integration of the context features to improve our earlier proposed pedestrian navigation system. In the following section proposed framework of context integrated user oriented pedestrian navigation system is presented.

### III. FRAMEWORK FOR CONTEXT AWARE USER ORIENTED PEDESTRIAN NAVIGATION SYSTEM

The block diagram of the framework for user oriented Pedestrian Navigation System(PNS) incorporating awareness of contextual information is shown in Fig. 1 which is a modification of our proposed system in [11]. The dotted line represents the feedback path. The system consists of seven basic components, the functionalities are described below.

- 1) **User's Interface:** The user inputs his/her request of desired routes through the interface in linguistic terms (within some limited vocabulary) in addition to the start and destination locations. For example, "Please provide me a wheelchair friendly route" , "Please provide me a scenic route" , "Please provide me comfortable route " etc .The system also return a set of routes related to user's preferences and will show the characteristics of the routes. User either selects one of them or if he/she is not satisfied with the provided routes, he/she can fine tune the system by feeding back his/her comments through interface.
- 2) **The Road Information Data base:** This data base provides information about road, traffic or environment. The information is stored in form of a graph with weighted edge. The design and development of the data base is described in the next section.
- 3) **Contextual Information:** This data base contains the contextual information related to the route recommendation for a particular application.
- 4) **Input Processor:** This module processes user's request with the incorporation of road information, user's past behaviour and contextual information to design the multiobjective criterion function for route generation.

- 5) Route Generator: This module uses computational algorithms to generate a set of optimal routes with different characteristics from start to destination with the criterion function generated by the previous module.
- 6) Route Selector: This module ranks and selects a predefined minimum number of preferred routes and informs them to user via user interface. If the user is not satisfied with the options, he/she can ask for other options by feeding back comments through user's interface.
- 7) User's past behaviour log: This module logs individual user's choice route after the user uses the system. This helps in selecting the user in his/her future interaction with the system.

#### IV. COMPUTATIONAL FRAMEWORK FOR PILOT STUDY

The main hurdles of developing user oriented pedestrian navigation system incorporating context awareness proposed in the previous section are the following:

- 1) Information collection of walking routes and the environment and their assessment on the basis of subjective preferences of the user to design road information data base.
- 2) The processing of semantic content of the subjective expression of user's requirement and match them to the objective characteristics of the route segments in the route information data base to design the proper criterion functions for route selection.
- 3) Identification of relevant features from the several contextual information that influence the individual user's current situation and acquisition of those relevant contextual information.
- 4) Generation of a set of near optimal alternate routes according to the user's preference and context.

The design of road information data base, method of semantic processing of user's requirement and generation of multiple optimal routes are developed based on earlier work in [10] and [11]. The identification of context information and its integration into the system is newly proposed in this work. The computational steps are briefly described here.

##### A. Design of Road Information Data base

For the design of the database, the roads from the road map is divided into some connected segments of homogeneous characteristics and converted into a connected graph where each road segment represents the edge/link between two nodes. The objective characteristics of the road segments as the distance, inclination, width, curvature, has tree or not, through park, segment of main road etc. are considered as the features of the road segment and attached to the link as a n-dimensional vector ( $L_{ij} = [l_{ij1}, l_{ij2}, \dots, l_{ijn}]$ ).  $L_{ij}$  denotes the link representing the road segment connecting node i and node j. The road parameters i.e the elements of the link vector can have continuous or discrete values.

In this work the following parameters are considered as the components of link vector with their value type in braces .

- 1) road length (link length)( continuous )

- 2) road width (continuous)
- 3) road inclination (continuous)
- 4) road curvature (continuous)
- 5) turn or straight for the next segment (L, R or S)
- 6) tree or no tree (binary)
- 7) through park (binary)
- 8) segment of main road i.e. more than one lane road (binary)
- 9) footpath available (binary)
- 10) average number of people crossing the road in a day (continuous)
- 11) is there any stairs? (binary)

The road information is stored in the data base in the form of a graph with nodes and link vectors. For a route selection problem, nodes in the graph corresponding to the starting point and the destination point on the map are noted as the start node and the goal node in the graph. Any possible path from the start node to the goal node via other nodes is a possible solution for the route. However looping in the path is avoided.

##### B. Processing of User's request

The user requests for the desired route via user's interface in addition to the starting point and the destination point. In doing so, the users are allowed to use linguistic fuzzy terms from a limited vocabulary to express his/her subjective choices as well as objective choices with properly defined terms. In this work we considered the following choices of words in characterising the desired route: 1) shortest route 2) scenic route 3) comfortable route 4) easy to remember route

Processing unit computes the request as follows:

- 1) Processing unit interprets the semantic content of the user's desired route and express them in terms of a fuzzy rule.

For example, comfortable route can be expressed as the following rule:

*if the road is wide and more or less plain and straight and no stair case and not crowded it is comfortable*

The linguistic terms in the rule such as 'wide' or "more or less plain" are manually tagged with a fuzzy membership function while binary terms (crowded or not crowded) are taken as 0 or 1.

- 2) The route segments are evaluated according to user's subjective preference from the objective information stored in the data base.

The degree of evaluation is calculated by processing the "if" part of the rule. The antecedents in the rule might contain fuzzy variable or crisp variable. In case of fuzzy variables, membership functions are designed to assess the fuzzy variable by matching them to the nearest objective information in the data base. Using the concepts from fuzzy set theory, the consequence of the rule can be calculated by fuzzy min, max rule.

For example, if the rule is " IF A and B and C THEN D" with A, B, C and D fuzzy sets, then degree(D) is calculated as

$$\text{degree}(D) = \text{Min}(\alpha * \mu_A, \beta * \mu_B, \gamma * \mu_C)$$

where  $\alpha$ ,  $\beta$ ,  $\gamma$  are small random control parameters which can be varied in a limited range to fine tune the concepts and are used for generating multiple criterion functions.

For example, to evaluate the road segments according to the fuzzy rule generated above for degree of comfort the “if” part of the above rule is processed. The variables used are a) wide, b) more or less plain and straight c) existence of stair case d) crowded of which a), b) and d) can be represented by fuzzy set matching the terms with road width, road inclination and curvature and number of people crossing the road in a day respectively in the road information data base. The variable c) is binary variable and can be directly accessed from the data base.

- 3) The evaluation function for the generation of the set of alternate near optimal routes is designed. Now the proposed rules are used as the evaluation function. The degree of evaluation of the road segments are summed up to calculate the total value of the criterion function for the entire route. The control parameters are varied a little to generate a group of evaluation functions. Genetic algorithm is used with the group evaluation functions to generate a group of alternate walking routes. The algorithm is represented in the following subsection.

### C. Multiple Route Generation

Multiple alternate route generation with the criterion function designed above has been done with genetic algorithm. The details are presented in [11]. The basic steps of the algorithm for finding out a set of solution containing ‘m’ alternate near optimal routes according to ‘m’ fitness functions is as follows:

- 1) Initial population is formed by random selection of paths (chromosomes) from the entire solution space.
- 2) The individual chromosomes are evaluated multiply by the different fitness function corresponding to different choices of control parameters in criterion function and ‘m’ group of chromosomes are formed by ranking corresponding to ‘m’ alternate selection. Any particular chromosome may belong to two groups. ‘m’ different groups are then subjected to genetic operation as follows:
  - a) For each group, the first few chromosomes (number to be selected according to the problem) are retained as it is (elite selection) for the next generation.
  - b) For other chromosomes in the group crossover operation with probability  $P_c$  has been done with parents selected by Roulette selection with the group specific fitness function. The crossover position is selected at the place where the node numbers of the parents match.
  - c) Mutation with a very small probability  $P_m$  at a random position is done to generate new population in the group.
  - d) All the groups are then put together to form the next generation of population. The new population

is then checked for duplicate chromosome and looping of path.

- 3) The new population is then ranked again by evaluating with the fitness function with different values of the control parameters and the procedure is repeated.
- 4) The stopping criterion is decided beforehand as a trade off between the availability of computation time and goodness of the produced solution.
- 5) The best route of each group ‘m’ after final iteration is selected to form ‘m’ alternate solutions.

Now due to randomness in the process, there is a small possibility of generating non-existent solution paths. Those solution are discarded eventually as they do not contribute to the fitness function.

### D. Route Selection Incorporating Context Awareness

The final route selection and recommendation to the user is done here with the incorporation of contextual information. The identification of the contextual features for a particular application with relation to the user’s current situation is a challenging task. In this work heuristics are used to identify the features. For a small scale pilot study, the contextual features used here are the age group of the user, the physical strength and capability of the user, the season and the time of the day.

Age group parameter has values : *Child, Young, Aged, Old*

Physical strength parameter has values: *Weak, Strong and Disabled*

Weather has values: *Winter, Rainy, Summer*

Time of the day has values: *Morning, Noon, Night*

During the final selection of the routes, multiple routes generated in the previous stages are ranked. For ranking, the weight of the individual solution is changed according to the contextual parameter values. For example for calculating “comfortable path” the weight would be higher if the user is in old group than in the young group. For “scenic path”, the weight of the different factors in calculating “scenic” will change according to the time of the day and the rank of the scenic path will be lower in night than in morning.

### E. A very small scale pilot study

The computational framework for pedestrian navigation system proposed earlier has been tested by a pilot study. Our university campus (Iwate Prefectural University) is taken as the test bed. The campus consists of roads circling the buildings, parking lot, play ground, park etc. The roads segments have up and downs, some are for cars and some for pedestrians. A graph is manually generated which resembles the roads and environment of the test bed. The road information data base is also manually generated. The link vectors contain eleven parameters mentioned in earlier section. In future we are planning to propose techniques for automatic generation of the road information data base by automatically converting the road map to a graph and automatically acquiring the road information to design the data base. The generated graph contains 187 nodes and 256 edges/links.

For route selection, the start node and the goal node is selected and four types of preferences, such as 1) comfortable and fast route 2) scenic and walking route 3) routes with ups and downs 4) crowded route, are used in our experiment. The number of alternate routes are set to 3. The generated routes are checked with the graph and the information data base to evaluate whether the desired routes are found or not. Now the experiment has been repeated with the incorporation of contextual information mentioned in the earlier section with virtual users and other contextual information generated randomly. The generated routes are checked with the actual map. It is found that integrating context awareness leads to better route recommendation in some cases. Though the experiment is still going on and it is needed to be done with a larger data for any concrete result.

## V. CONCLUSION

In this work a conceptual framework of a context aware route recommendation system associated with pedestrian navigation is studied. Identification of contextual information for designing user aware route recommendation system is investigated. Context awareness is added to the previously developed framework of a pedestrian navigation system with subjective preference based route selection. The proposed framework is tested with a very small scale pilot study. The proposed work is intended to be used to design pedestrian navigation system needed by the people visiting a new place or tourist spot. At this stage, the system includes only static information of the routes and environment and the user is supposed to plan his/her route before starting to walk.

To design an useful and practical system, the main hurdle is to design the actual road information data base. The automatic acquisition of information and semantic processing is also needed. For establishing the effectiveness of adding awareness to the recommendation system, we need to identify accurately the features of contextual information relevant to the user in the current application. Also a bigger test bed is needed for meaningful study. The very small scale study in this work indicates that the integration of proper context awareness might lead to more satisfactory route recommendation to the user.

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