Model Recommendation System for Guided Tours based on Ubiquitous and Context-Sensitive Computing

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Abstract: - The proposed model in this research, intended to work in a guided tour context, is based on developing the tourist ontology in Python using the Owl-ready library, and describes the entities of the guided tour model. The ontology allows us to apply the concepts of ubiquity and represent context sensitivity in three ways, with geographical, temporal and environmental context. For the guided tour, the user's profile, preferences, emotional state and evaluations of the visited places are considered, as well as the profile, itinerary and site characteristics, the user's transportation preferences and the site's transportation characteristics. An ontology language was used to model the concepts and characteristics of the guided tour system, which allows inferences to be made with rules using the SWRL language with the Pellet reasoner. All models were evaluated using the RMSE metric and the accuracy, recall and F1 score metrics have been used to evaluate the predictions. This paper concludes that, among the recommender system models with collaborative filtering, the hybrid model obtained the best results for RMSE and the other metrics of accuracy, recall, and F1 score. For this reason, it is one of the most widely used recommender models in the industry.

Key-Words: - Context sensitivity, Guided tour, Recommendation model, Sentiment analysis, Ubiquity.

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1 Introduction

This research aims to look for new ways to use the information provided by mobile technologies in information systems, to expand the range of possibilities and actions by using the information of the context in which the user is located and on which the device where the system operates. People can make use of environments that are conditioned to support wireless network technologies, [1], not only to connect with mobile devices but also to take advantage of the benefits and novel aspects of ubiquitous computing and artificial intelligence approaches that are planned to be integrated into the model of this research.

In recent years new approaches have emerged that propose using a greater number of features and properties that consider context information, as is the case of ambient intelligence that aims to create intelligent spaces where the environment adapts to the demands and needs of people, [2]. The information that comes from data sources such as context has an intricate relationship that can be puzzling for people, recommendation systems are very useful information filtering tools to help in a personalized way discover the information that may be of interest within a space of possible options, which facilitates the decision-making process, [3].

Mobile technologies allow people to be freely in many connected places accessing various services, this has become part of the spaces that we normally attend and use daily. There is a paradigm called context-sensitive computing that takes advantage of this feature of the devices by taking information from the environment surrounding the device, which is constantly changing, to adapt it according to the location of use, according to information from nearby objects and people, and considering the changes of these objects over time, [4]. The information captured is known as context information and is important because it allows the discovery of new opportunities for the use of mobile technologies as elements that can be integrated in different contexts collaboratively and intelligently.

These new features offered by mobile technologies are part of a very interesting behavior that aims to make the interaction of the person with the device and the system invisible, which changes the way of seeing and using such devices. This behavior is known as ubiquitous computing, [5].

Context-aware computing applied to information systems is an object of study that covers a wide multidisciplinary research space that has turned it into a tool to understand and create system models that adapt to the needs and profiles of users to provide adequate services to the user within a dynamic environment. Additionally, these models can be applied transversally to various domains of interest in systems that make use of the advantages and features offered by mobile technologies in a personalized way.

With the approaches and paradigms mentioned above, belonging to mobile computing and artificial intelligence, we seek to integrate them to propose a recommendation model for guided tours that improve the interaction of people with the surrounding context, seeking that the system adapts to the environment and the user in real-time and responds intelligently and adaptively.

With the model of this proposal, we plan to develop functional prototypes applied in the search for solutions to problems of different categories of interest, such as guided school visits to museums oriented to learning, guided tours that need to orient the motivation of visitors by showing sites and information different from the exhausted traditional tourist product such as the rich heritage, architecture and landscape of the place and that differentiates it from other sites. It is proposed to address the issue of the management of procedures in a service provider institution, since managers claim that management can be facilitated and improved, through the use of cell phones and e-mails, the assignment of appointments and resources to users promptly.

2 Problem Formulation

One of the many possibilities for people to interact with information systems is in the area of education. When mobile technologies are available and ubiquitous, students can access, share and build knowledge easily in various places with different adaptations. It is necessary to design and create new models that facilitate this new way of learning and that are different from the learning acquired with traditional systems used in desktop computers. Ubiquitous computing is an alternative to provide a notion of learning motivated by mobility, ubiquity and context sensitivity supported by the use of mobile technologies.

This form of learning happens in a specific context and fosters deeper and more meaningful learning. There is a lot of promise and potential of mobile and ubiquitous computing applied to the area of learning, but this field is still little studied. In terms of implementation, there is still a lot of ground to cover, also in terms of reducing the barrier to adoption and sustained use in learning practices, as well as possible, [6].

Mobile devices are common in our daily lives, but using them for education and learning may still take a long time in our environment. The task of a recommender system is to offer the user only what is relevant to him and the concept of relevant information has a relationship between the user's profile and the content of the object of interest, [7]. It is difficult to determine what is relevant to the user and for this, some measures or factors must be defined to help determine that relevance, for example, the most searched and updated information of the object of interest, specific information of the object of interest, such as the lowest cost and best quality, information of an object that belongs to another person with similar characteristics to those of the person who is looking for the object and information of a similar object that the user has already tried to search for in the past.

The problem here lies in the need to make many decisions to arrive at a good recommendation. It is at this point where the integration of ubiquitous and context-sensitive computing with Artificial Intelligence techniques is useful to obtain information from the person and the context, and not only from a set of data based only on the person's preferences and profile.

2.1 Hypothesis

The possibilities of interaction that people have with information systems can be expanded and enhanced through a recommender system model using mobile technologies and artificial intelligence techniques that facilitate the decision-making process by using context information based on ubiquitous and context-sensitive computing to capture data, create models and infer knowledge to reason and act according to people's goals and needs.

2.2 Objective

Develop a ubiquitous, context-sensitive personalized recommender system model for guided tour decision-making. In the context-sensitive component of the proposed model, for the user, the context related to the user's preferences and emotional state was considered; for the context of the environment, the functionalities and features found in mobile devices and their incorporation in the acquisition of context information were considered. A recommendation system model was created for guided tours that apply context-sensitive computing on mobile devices.

The model has a customization component based on the user model and the model of the sites of interest. The prototype testing considered two or three test cases applied to guided tours in the educational, tourism, or service sectors. The functional prototype of the recommendation system based on the context-sensitive model personalized to the user and the points of interest was implemented. A performance evaluation of the prototype was performed based on metrics applied to the case studies.

The proposed model did not consider aspects related to the planning of routes to recommend them in the tours of a guided visit, it only recommends points of interest that match the information of the context and the user in a personalized way. In the context-sensitive component of the proposed model, for the user context, the context related to the dynamic behavior and physiological state of the user was not considered. In the context-sensitive component of the proposed model, for the context of the environment, the application of computer vision techniques and the Internet of Things was not considered. In the recommender system, aspects related to user privacy management were not considered.

3 Proposed model

This section presents the characterization of the entities and concepts that are part of the model of the recommendation system for guided tours such as the user, their generic preferences, the user's reviews about a site of interest, the site of interest and the schedule of activities that are done at the site of interest. In this characterization, we will expose the user model and its personalization, the place model (point of interest POI), [8], and the context model applied to the contextualized guided tour model. Then, the tourist ontology is presented, which forms the set of concepts and categories in the contextualized guided tour model indicating their properties and relationships, in addition to the definition of inference rules that validate the ontology in the proposed scenarios.

From the ontology developed, several models of recommender systems are shown that are based on simulated data that starting from the ontology are adapted to data models in pandas to be processed in Python to be applied in the different approaches of recommender systems addressed in the proposal. In this work we will consider the application of the model in several recommender system approaches, such as; user-based collaborative filtering, knowledge-based filtering using user profile information, filtering using a K-means algorithm and filtering based on singular value decomposition and finally filtering in a hybrid recommender system.

The model offers the possibility of using user reviews in the machine learning technique of sentiment analysis to determine the level of user acceptance of the site of interest. Finally, we will expose the metrics used with the results obtained that allow us to validate the model.

3.1 Model of the recommendation system for guided tours

This situation shows the need for tourism systems to know the needs of users and be prepared to receive them with a variety of personalized and updated services according to this characteristic, [9]. Responding to this need, we intend to make a representation of a model for visits that, in addition to considering the place and the user, considers the user's preferences and the characteristics of the place, such as the schedules of its events, so that they can be considered in a more personalized recommendation according to the user's needs. The proposed model considers the following elements as a starting point:

Generic preference: Constitutes the general preferences of the user to represent his itinerary since it constitutes the time he would like to leave, the money he is willing to spend, the time he would like to return and the date of such preference. For each Generic Preference, it is necessary to clarify that this is different for each day, so the date must be defined.

User: This concept represents the user's information; it also indicates the current location of the place where the user is. The user can make many reviews and ratings of each place visited.

Location: Represents the point of interest, in addition to its basic data it considers the sum of all the ratings made by all the users, as well as the total number of users that have voted. This data is used to calculate the metrics of the best-rated places to show them in the recommendations. It also has a textual overview for use in collaborative filtering using an algorithm that calculates the distance between the places that have the most similar overview to recommend them according to that characteristic.

Schedule: This concept contains the properties to represent an event or an activity performed in a place. A place can have many schedules. It is important to clarify that in this model we consider whether an event can be attended by minors with underage property. Fig. 1, shows the initial model for the recommendation system model for guided tours. This model makes it possible to represent the places that are outside in the open space, inside another larger place, and the places that represent a service inside an organization. It is necessary to clarify that, to model the user and the way to personalize it, this work will deepen in the representation of their preferences that include their emotional state, their social state with their company to travel, their preferences to transport themselves to a place, the topics of interest to visit a particular place and the preferences of the context.

Likewise, to model the place and how to adapt it to the user, this work will include the characteristics of the place that are shaped by the transportation preferences to get to the place, the topic of interest that labels the place, and the information of the current context at the time of visiting the place.

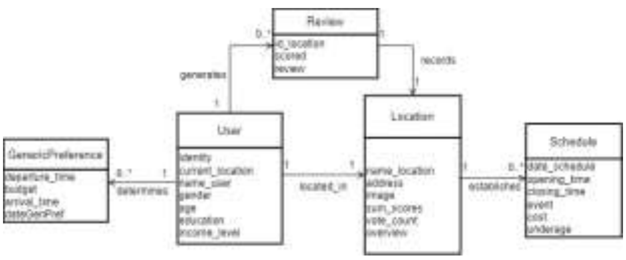

Fig. 1: Model of the recommendation system for guided tours.

3.2 User model and its customization

Mobile applications allow access almost anytime and anywhere, to the user's information and preferences, as well as their location, this information can be used and filtered avoiding congestion in the process of accompaniment during all the activity related to a visit to a particular place, [10].

This model seeks to represent the user's preferences, considering his emotional state with the Emotional State concept, his social state with the Companion concept, to represent the transportation preferences with the Transportation Pref concept, to know the user's topic of interest to search for a place that has this topic, this is represented with the Topic concept and finally to represent the context which can be geographic, temporal and environmental, represented in the concepts; Geographical, Temporal, and Environmental respectively as shown below.

These concepts will allow to personalize the user's recommendations, to have a more complete profile, which considers both their availability and their emotional state, as well as their interests and preferences to move and the environmental conditions of the places they wish to visit at a given time. As mentioned in the previous model, it allows the user to rate and generate reviews of the places visited. All this enriches the proposed model and allows the application of recommendation systems and machine learning techniques.

The user model and its customization are shown in Fig. 2. Each of its concepts and attributes are detailed below. Starting from the concepts previously explained in the previous section, namely; User and Generic Preference, which have already been mentioned.

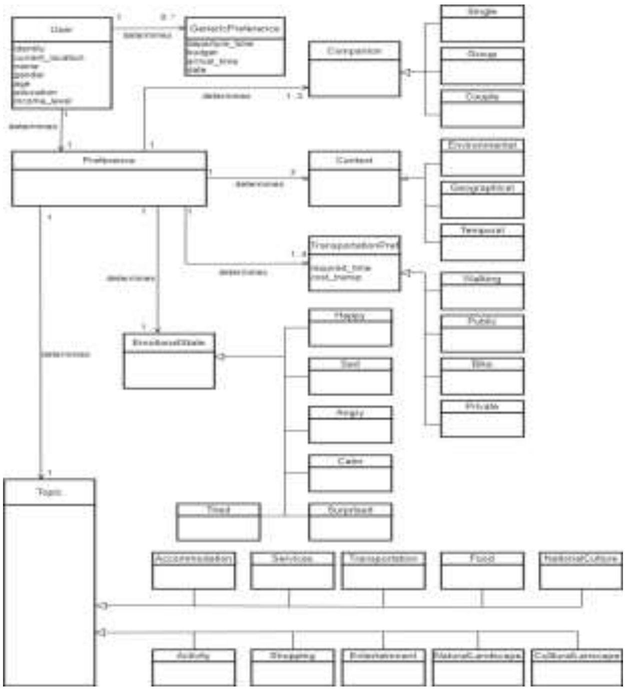

Fig. 2: User profile model.

Preference: This concept represents the user's preferences which can be; Companion, Context, Transportation Pref, Emotional State and Topic.

Companion: This concept is used to indicate the social status of the user in his surrounding environment, this can be divided into three types; Single, to indicate that he is traveling alone, Group to indicate that he is traveling in a group, and Couple to indicate that he is traveling as a couple.

Context: This concept represents the context information. It is divided into Environmental, Geographical and Temporal.

Transportation Pref: This concept is used to indicate the user's preferences to travel to a place. It has as properties; required time, to indicate the time he is willing to spend to get to a place and cost_transp to indicate the amount of money he is willing to spend on transportation. This concept has the following types of means of transportation to get to a place; Walking, for walking, Public to indicate that you would like to travel by a public means of transportation, Bike to indicate that you would like to arrive by motorcycle and Private to indicate that you would like to travel by a private means of transportation.

Emotional State: Indicates the user's emotional state, and is divided into the following types; Happy, Sad, Angry, Calm, Surprised and Tired. This model allows adding new emotional states such as Normal.

Topic: This concept is intended to be managed as a label to identify places of interest and is divided into the following types: Accommodation, Services, Transportation, Food, National Culture, Activity, Shopping, Entertainment, Natural Landscape and Cultural Landscape. It is possible to add new topics.

3.3 Model of the site and its adaptation

Modern smartphones offer very interesting functionalities that allow taking advantage of location-based services or LBS, which determine the user's location to provide personalized services based on that location, [11]. This indicates that it is very important to have location information not only with its location but also with information that enriches a better adaptation with the user. In the proposed model, an adaptation of the place is presented according to a set of characteristics that are concentrated in the concept called Characteristic, and that correspond with the user's preferences to allow obtaining a better recommendation, that is to say that the user's preferences are considered in terms of transportation and topic preferences of the place and the context information that corresponds with that of the place and the user to better adapt such personalization. Let's look at the components that make up the place model, see Fig. 3. Each of its concepts and attributes are detailed below. Starting from the concepts previously explained in the previous section, namely; Location and Schedule, which have already been mentioned.

Location: In addition to considering what has already been explained in the initial model about this concept. It is added that this concept can be of three types; Inside, Outside and Service.

Characteristic: This concept represents the characteristics of the place which can be; Context, Transportation Pref and Topic.

Context: This concept represents the information of the context of the place. It is divided into; Environmental, Geographical and Temporal.

Transportation Pref: This concept is used to indicate the characteristics of arriving at a place. It has as properties; required time, to indicate the time required to get to a place and cost_transp to indicate the cost to get to that place using the selected means of transportation. This concept has the following types of means of transportation to get to a place; Walking, for walking, Public to indicate that you would like to travel by a public means of transportation, Bike to indicate that you would like to arrive by motorcycle and Private to indicate that you would like to travel by a private means of transportation.

Topic: This concept is intended to be managed as a label to identify places of interest and is divided into the following types: Accommodation, Services, Transportation, Food, National Culture, Activity, Shopping, Entertainment, Natural Landscape and Cultural Landscape. It is possible to add new topics.

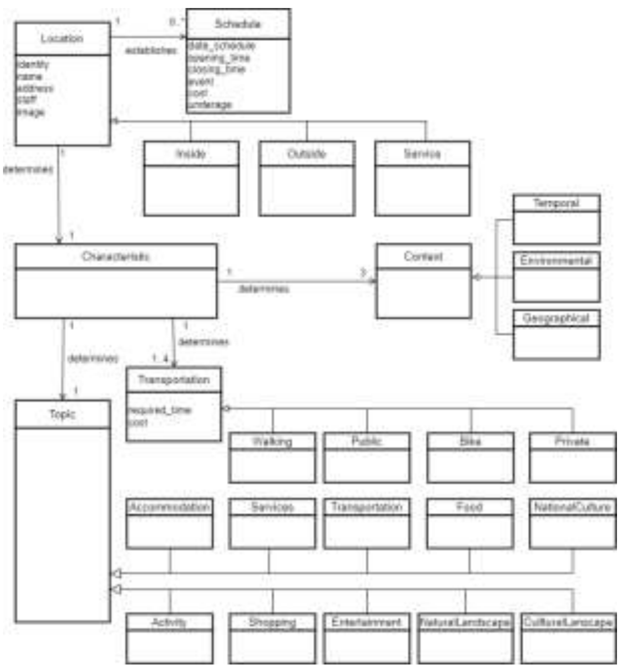

Fig. 3: Model of the site and its adaptation

4 Ontology

The conceptualization of the proposed ontology consists of the following activities: construction of the glossary of terms, construction of the taxonomy of concepts, construction of the diagram of binary relations, construction of the dictionary of concepts, description of the binary relations in detail, description of the instance attributes in detail, definition of rules, and definition of instances. Table 1 presents the concepts belonging to the domain of the recommendation model for guided tours and composes the ontology.

Table 1. Ontology concepts

Category	Concepts
User	User, identity, current_location, name_user, gender, age, education, income_level, GenericPreference, departure_time, budget, arrival_time, date, Review, id_location, review
Location	Location, name_location, address, image, sum_scores, vote_count, overview, Schedule, date_schedule, opening_time, closing_time, event, cost, underage, InsideLocation, OutsideLocation, ServiceLocation.
Preference	EmotionalState, Happy, Sad, Angry, Calm, Surpriced, Normal, Tired.

The knowledge representation of the proposed system was given the name of tourist ontology (Fig. 4), and represents the knowledge in detail, to relate it with its defined elements and reason about this knowledge, in this case, Owl ready was used and 2 classes were created to manage the user, 3 classes to manage the user's history. 7 classes were created to manage the types of tourist places. 2 classes were created to manage the scheduling of the events of the places.

2 classes were created to represent the user's preferences and the characteristics of the place. 8 classes were created to manage the user's emotional state. 4 classes were created to manage the social profile of the user. 5 classes were created to manage the user's transportation preferences. 13 classes were created for the accommodation topic.

12 classes were created for the Services topic. 17 classes were created for the Transportation topic. 9 classes were created for the Food topic. 9 classes were created for the topic of National Culture. 9 classes were created for the Activity topic. 40 classes were created for the Shopping topic. 25 classes were created for the entertainment topic.

21 classes were created for the natural landscape topic. 43 classes were created for the Cultural-Landscape topic. 5 classes were created to manage the geographic context. 2 classes were created to manage the temporal context. 34 binary relationships were created between all the defined classes. 37 object-property and datatype-property properties were created. The implementation of the ontology can be seen in the annex. The implementation of the ontology can be seen in, [15].

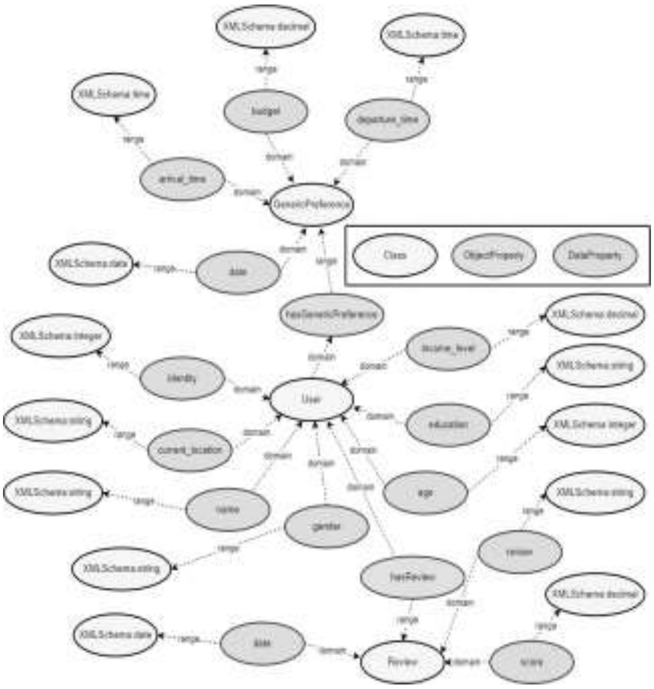

Fig. 4: Tourist ontology

Fig. 5 shows the results of applying the 5-fold cross-validation technique for the hybrid model composed of a content-based recommender system and a collaborative recommender system using singular value decomposition, we obtained a mean RMSE value of 1.2478, which exceeds that obtained in the model using singular value decomposition with an RMSE of 1.2490, and which had been the best so far. In addition, in fold number 3 an F1-score of 0.96 was obtained, the best of all and which corresponds to an RMSE of 1.1936, thus it can be concluded that the filtering model based on hybrid recommender systems outperforms all previously seen models and for this reason, it is one of the most used in the industry.

$$RMSE = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(yo_t - ym_t)^2} \qquad (1)$$

$$MAE = \frac{1}{n}\sum_{t=1}^{n}||yo_t - ym_t|| \qquad (2)$$

$$MSE = \frac{1}{n}\sum_{t=1}^{n}(y_t - \bar{y_t})^2 \qquad (3)$$

Evaluating RMSE, MAE, MSE, FCP of algorithm SVD on 5 split(s).

	Fold 1	Fold 2	Fold 3	Fold 4	Fold 5	Mean	Std
RMSE (testset)	1.2616	1.2970	1.1936	1.3086	1.1783	1.2478	0.0531
MAE (testset)	1.0295	1.0605	1.0078	1.1129	0.9279	1.0277	0.0612
MSE (testset)	1.5916	1.6821	1.4246	1.7125	1.3884	1.5598	0.1318
FCP (testset)	0.4912	0.4667	0.3883	0.5238	0.5576	0.4855	0.0574
Fit time	0.01	0.01	0.01	0.01	0.01	0.01	0.00
Test time	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Fold 1	Fold 2	Fold 3	Fold 4	Fold 5
Precision:	0.815556	0.844792	0.947619	0.904762	0.816667
Recall:	0.970000	0.916667	0.985714	0.908163	0.760417
F1 Score:	0.886098	0.879263	0.966291	0.906459	0.787539

Fig. 5: 5-fold cross-validation technique.

5 Conclusion

This research proposes a recommendation model that can be applied in the field of tourism for guided tours, which can be used in tours for visits to tourist centers with places open to the outside, closed places such as museums, and in tours in places that offer several locations with services that involve search and decision making by the user, such as a shopping mall.

The model allows making use of the user's information and preferences, the information and characteristics of the place, as well as the information of the context at the time of the tour so that the model makes use of ubiquitous computing, and can also be adapted in models of recommendation systems that work with collaborative filtering to recommend places of interest.

The proposed model presents as one of the main contributions the modeling based on ontologies and proposes the tourist ontology for guided tours that allows representing the knowledge related to the user's profiles and preferences, the profiles and characteristics of the place and contextual information. The ontology allows considering the emotional state, social and transportation preferences of the user, as well as the topics of interest to label a place to visit. Likewise, the ontology considers the characteristics, events and transportation preferences of the place. The ontology also considers context information for both the user and the place; temporal, geographic and environmental context.

Ubiquitous computing frees users from the limitations of time and space, providing opportunities for users to access and enjoy the services offered in places no matter where they are physically by accessing the technologies that allow mobile devices, all these possibilities can be exploited with the ideas presented in the proposed thesis model to develop systems that depending on the current location of the user, automatically displays information about the different places nearby, their services and events. As well as recommending other places of interest according to the topics selected by the user and having the advantage of knowing the information of its context to get better recommendations.

As an artificial intelligence technique to personalize recommendations based on the user's context, profile and preferences, a knowledge-based recommender system model has been used to obtain intermediate recommendations of places by querying datasets containing relevant information obtained from the user either as a query or using an application interface. In this way, the system searches through the data, preferences and profile information to return results that match a set of rules or guidelines on how the results should be, or an example of a recommended place.

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The authors have no conflicts of interest to declare that are relevant to the content of this article.