Location-based Fast Recommendation Social Network

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Abstract. Location-based response to queries has the potential to improve the quality of recommendations. But in order to actually improve quality one needs in addition to location-based, also time-dependent evaluation of the basis for recommendation. We propose the usage of opinion-ontologies – a short and sharp loosely structured subjective ontology – that can be transmitted in real-time and be integrated with previously received opinion-ontologies. This approach has been designed and implemented into a system with wireless smartphone clients and servers supporting information integration, evaluation and recommendation formulation. The approach has been tested with a prototype composed of existing software packages playing the needed roles in the designed system.

Keywords. Location-based, Time-dependent, Opinion-ontology, Social network, Recommendation, Conflicting opinions Integration, Wireless Smartphone.

1 Introduction

Suppose that during a trip to a region in the north, one approaches dinner time. One needs to decide upon a convenient restaurant, and then find a hotel to spend the night, without forgetting about a gas station to refill the car tank. The old way to do that is to buy in advance a printed tourist guide of the area. The modern way is to ask other people that have travelled around, or are just on location, about a place to eat with a good recommendation.

But are the recommendations reliable?

One should be able to compare and evaluate different recommendations.

This work describes a system for location-based queries, with capabilities to integrate and evaluate the most fitting overall recommendation. The approach uses *opinion-ontologies* [6]. These are quite short, loosely structured subjective ontologies whose purpose is to express opinions that serve as recommendations. As these are very short, one swiftly transmits and manipulates them, to obtain results in real-time.

In this paper we describe a recommendation system based on the opinion-ontologies approach. It was designed and implemented with smartphone clients and a server supporting information integration and overall personalized recommendations.

Exman I. and Nagar E..
Location-based Fast Recommendation Social Network.
DOI: 10.5220/0005167600550062
In *Proceedings of the 5th International Workshop on Software Knowledge* (SKY-2014), pages 55-62
ISBN: 978-989-758-051-2

1.1 Related Work

Location-based approaches have been proposed and implemented in several specific contexts, one of them being crowdsourcing. Alt et al [1] and Bulut et al. [2] extend crowdsourcing to location-based problems. Mashhadi and Capra [11] discuss quality control for real-time ubiquitous crowdsourcing.

Mobility issues, especially related to social networks, called the attention of several researchers. Chow et al. [5] investigate location-based social networking services. Lenders et al. [8] deal with the issue of location-based trust for mobile user-generated content. Schuster et al. [13] develop a service-based mobile real-time collaboration application for social networks.

Opinion and ontologies have been discussed at length in the literature. Chang et al. [4] refer to reputation ontologies. They deal with "Trustworthiness of Opinion Ontology". Li and Du [9] research ontology-based opinion leader identification for marketing in online social blogs. Lu et al. [10] propose using structured ontologies to organize scattered online opinions.

Cambria et al. [3] describe a public semantic resource for Opinion Mining, called SenticNet. Sentic Computing enables analysis of very short documents, say one sentence. Zobel et al. [14] use a majority rule to merge conflicting knowledge bases.

In the remaining of the paper we introduce the domain of location-based recommendation (section 2), describe opinion-ontologies that are used in our solution (section 3), overview the software architecture and implementation of our tool (section 4), discuss case studies as a demonstration of the approach (section 5) and conclude with a discussion (section 6).

2 Location-based Recommendation

Location-based recommendation means that people who are or have been in a certain location express their opinion on a requested service or institution. The receiver of the recommendation, without being in the referred location, has to evaluate the recommendations, integrate them and take a decision on the action to be taken.

2.1 Locations: Acquisition, Storing and Display

Half of the problem has to do with locations. A location-based mobile recommendation system has to be able to do the following functions:

- *Acquisition* – of the recommender locations which entitle him to express his/her opinion; this certainly involves some kind of GPS functionality;
- *Storing/Retrieval* – the set of locations per recommender should be stored in some standard format; retrieval should be consistent with the storing function; the efficiency issue refers to what extent locality (the client) as opposed to a central server is important;
- *Display* – use a map with zoom_in/zoom_out capabilities.

2.2 Recommendations: Acquisition, Integration and Evaluation

Recommendations should be received from several people willing to express their opinions. Either the recommendation receiver or an automatic system or a combination of both should be able to evaluate the quality and reliability of the recommendation. An integration function should combine all the relevant recommendations to extract a single decision, or a ranked small set of possible decisions. In more details:

- *Acquisition* – a standard format recommendation should be acquired, stored and eventually retrieved from memory, locally or from a central server, similarly to the associated locations;
- *Integration* – the recommendation receiver or an automatic sub-system should take the individual standard format recommendations and obtain an integrated recommendation with the same format, thus facilitating decisions;
- *Evaluation* – a grading system, based upon an accepted but updatable scale, should associate a pure number with recommendations, either the individually received ones, or those which result from integration.

3 Opinion-Ontologies

In this work we adopted "opinion-ontologies" [6] as the standard format for recommendations. Its main motivation is integration of any number of opinions into a short data structure, to guarantee efficiency. Next, we shortly describe the standard format and the integration possibilities.

3.1 Structure for Efficiency

An opinion-ontology is a quite short – with a strictly limited amount of characters – loosely structured piece of information. An opinion-ontology has two kinds of terms: ***class terms***, with at most four letters and ***free-text words***. Class terms are not reserved words and are explained and systematically used within our application.

An example of an opinion-ontology regarding a coffee-shop is shown in Fig. 1. Its class terms are marked by italic-bold (here stressed in red color).

"***opinion-ontology** #17*: ***coff*** Maestro ***loc*** sea-shore ***food*** long sandwiches, sauce variety, perfect macchiato ***déco*** functional ***serv*** not so express."

Fig. 1. *Sample Opinion Ontology* – It refers to a coffee-shop named Maestro.

This opinion-ontology refers to a coffee-shop named Maestro, which is located near the sea-shore. The food served includes long sandwiches, with a variety of sauces and among its specialties one finds a perfect macchiato. The coffee-shop decoration is just functional. But, as a negative point, the service is not so fast.

A graphical schematic representation of the same opinion-ontology is seen in Fig. 2. Similar graphs can be obtained from ontology editor tools such as Protégé [12].

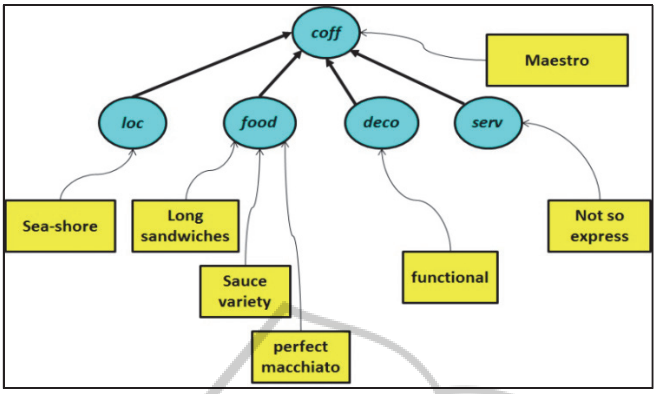

Fig. 2. *Sample Coffee-Shop Opinion Ontology* – In a schematic graph which has classes represented by blue ellipses, and instance values represented by yellow rectangles. Maestro is the name of an instance of a coffee-shop.

3.2 Integration

Integration should take into account two kinds of sometimes opposing concerns:

a. *Semantic Concerns* – such as mismatches caused by different terminologies, term ambiguities, contradictions;
b. *Size Concerns* – i.e. integration of opinion-ontologies without increasing size above the allowed number of characters, say by avoiding excess words.

Our fundamental integration principle is: whenever there is a conflict between semantic and size concerns, the size concerns are prevalent. If size may still accommodate expansion of opinion-ontologies, then semantic concerns may be taken into account differently from the case in which expansion is not possible anymore.

Here are some specific rules derived from the fundamental principle:

- *Reinforcement* – when two or more different recommendations reinforce the same opinion, use a numerical weight to express it, say *3 (multiplied by 3) means that the particular preceding free-text word appeared among three of the integrated opinion-ontologies;
- *Contradictions* – opposing opinions reflected in particular expressions and their negations, may be kept, if size allows it; if size does not permit, use a combination of positive and negative weights, say *-4 *6 (four negations and 6 affirmations) after the chosen expression;
- *Different Terminologies* – choose the most common term among the different ones; if this information is lacking choose one term arbitrarily;
- *Ambiguities* – disambiguate terms using the several opinion-ontologies before they are integrated;
- *Excess Words* – among the union of the sets of words of the individual opinion-ontologies, discard the less surprising (less informative) words.

4 Software Architecture and Implementation

In this section we shortly describe the system software architecture and its implementation.

4.1 Software Architecture

The system software architecture is schematically shown in Fig. 3. It basically has three upper modules:

1. *Central Server* – that controls communication with any client and stores recommendation information in a database;
2. *Location dedicated server* – that takes care of location related information;
3. *Client* – a mobile module carried by any user of the system.

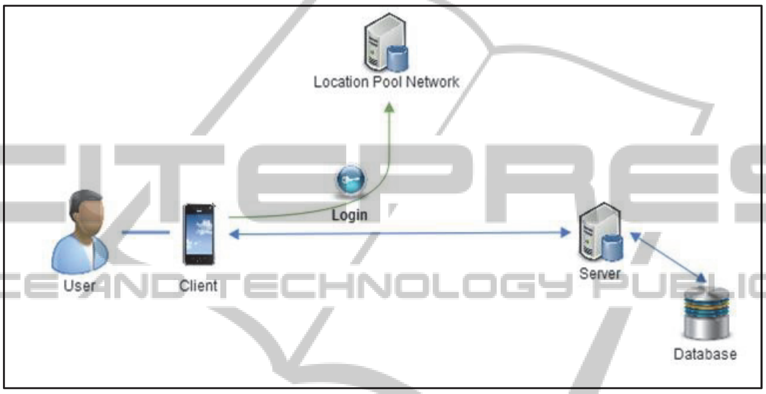

Fig. 3. *System Software Architecture* – It has a central server with a database, another server dedicated to deal with locations and a mobile client that may be replicated as needed.

4.2 Implementation

A prototype system was implemented by a combination of existing services and completely new coded software, to allow actual testing of the whole approach.

The location dedicated server is based upon the API of an existing social network service – Foursquare [7]. Users "check in" in venues they visited and the location information is saved for later use.

The central server manipulates opinion-ontologies for storing, retrieval, integration and evaluation. Communication with clients is made efficient by using GCM (Google Cloud Messaging).

The client is an application on an Android smartphone operating system version 4.2. Both the server and client were written in Java. Testing was done first on an emulator and then with real smartphones.

5 Case Studies

We have tested our system in a series of case studies. Two of them are presented here: the "theater show" and "automobile garage" contexts.

5.1 The Theater Show Context

Typical questions regarding temporary events, besides overall recommendation concerning quality and taste, are “did it start already?”, “are there available tickets yet?”. In Fig. 4 one sees the *Theater Show* opinion-ontology used.

“***opinion-ontology** #54*: ***Hous*** The Arena ***loc*** Broadway ***show*** comedy *4, bourgeois, light ***cast*** the troupe ***time*** no tickets left tonight.”

Fig. 4. A Theater Show opinion-ontology – It displays the theater house, location, kind of show, cast and timing notification. Four opinion-ontologies integrated into *opinion-ontology #54* stated that the show is a comedy.

If the only question of interest is “are there available tickets yet?” one can just use the relevant items as shown in Fig. 5.

“***opinion-ontology** #54*: ***Hous*** The Arena ***loc*** Broadway ***show*** - ***cast*** - ***time*** no tickets left tonight.”

Fig. 5. Theater Show opinion-ontology for “no-tickets” – It displays only the relevant class terms and respective information.

Although one could think that this is a waste of space and time – why not just send say an SMS with “no-tickets left tonight”? – an opinion-ontology has a fixed format that may be filled-in later and reused.

5.2 The Automobile Garage Context

Here the typical situation is as follows: one is travelling by car and unexpectedly appears a problem that allows one to continue the trip, but not for long. One needs assistance from a garage as soon as possible to repair the car.

Fig. 6 shows a generic opinion-ontology for the automobile garage context. It refers to professional specialization, types of vehicle and service quality and characteristics, besides the expected location.

“***opinion-ontology** #36*: ***Garg*** Peter’s Automotive ***loc*** 5 km north ***spec*** electrical, mechanics ***vehc*** cars, trucks ***serv*** on the spot, same day, unreliable”

Fig. 6. Generic opinion-ontology for car repair garage – It shows garage name, location, specialization, vehicle types and service considerations. In this particular opinion the service is unreliable.

Since the “unreliable” qualification is ambiguous – does it refer only to timing or to the overall quality of service – it could generate further inquiries from the receiver of the recommendation.

6 Discussion

This work proposes the direct use of short loosely structured opinion-ontologies, instead of completely free natural language text, for location-dependent and fast recommendations in mobile social networks. The idea is that with structured very short ontologies one may still make inferences in almost real-time.

The opinion-ontologies have a standard format, but it is loosely structured in the sense that there are no reserved keywords and the number of instance values for each ***class-terms*** is not fixed.

One of the interesting implications of making inferences upon opinion-ontologies is that one gets implicit opinions. For instance, in the coffee-shop opinion-ontology in Fig.1, the decoration is said to be "functional". There is no mention of pricing. But an inference rule could state that "functional furniture implies not-expensive", meaning that the referred coffee-house is not pricey. In general one should not expect recommendations to state negative or positive opinions just by means of explicit positive (nice) or negative (nasty) words.

Integration of various opinion-ontologies takes into account both semantic and size conservation concerns. Our fundamental principle is that when there are conflicts between semantic and size concerns, size concerns are prevalent. Specific integration rules are derived from this principle.

6.1 Future Work

The current system is a prototype. Once it is comprehensively tested, we may be able to build a second version, more mature system. System mobility and real-time capabilities should be tested for significantly larger quantities of clients and recommendation traffic.

Concerning opinion-ontologies, these are first tentative explorations of their possibilities. Extensive investigation of its various aspects – communication, storage and retrieval, inferences – is necessary to obtain a deeper and wider appraisal of their use.

6.2 Main Contribution

The main contribution of this work is the usage of short loosely structured opinion-ontologies for fast recommendations within a mobile social network.

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