Location Recommendation in Geo-Social Networks: A Human-Centric Agent-Based Approach

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Abstract. Many services in the world use recommendation mechanisms. Recommender systems make use of information about their users to provide accurate suggestions for them. Geo-social networks are a platform to share location and ideas with friends, a rich source of information about users and their behaviors. Therefore, they are appropriate places to utilize recommender systems. This paper presents a Belief-Desire-Intention (BDI) framework to model the users of a location recommender in geo-social networks.

Keywords. Location recommendation, Geo-social networks, Belief-Desire-Intention, Agent-based modeling

1. Introduction

Today, the use of recommender systems is almost ubiquitous. Online shops, online music streaming platforms, video sharing services and many others make use of one recommendation mechanism or another to provide their users with items which may seem interesting to them. In this context, spatial recommenders are those systems in which spatial aspects play a role in recommendations. Location recommendation is a research area which tries to provide the users some places to visit (Yu & Chen, 2015).

With the rapid growth of mobile technologies, such as positioning techniques and wireless communications, and web 2.0, revolutionized information about the behavior of users can be obtained. Among these, social networks are regarded as sources replete of information about their users. As an instance, take the situation in which a user has never chosen to watch a movie in a cinema in daylight time. This fact can be extracted from social networks and utilized in recommendation systems. A spatiotemporal case can be a situation in which a user often visits shopping stores located in a certain part of the city at weekends.

In recent years, various methods and techniques of recommendation, such as collaborative, demographic, and content-based filtering, have been proposed, some of which have been commercialized. Some studies have demonstrated that the use of agents in recommender systems yields better results than common approaches such as collaborative filtering (Good et al., 1999). However, little effort has been dedicated to model the users of a recommender system as an agent. In fact, the users are often regarded as atomic objects. The design of agents that are representative of social aspects, such as human beings, is still an open issue (Caillou, Gaudou, Grignard, Truong, & Taillandier, 2017). In this paper, we propose a Belief-Desire-Intention (BDI) architecture as a mechanism to model the users of a location recommender.

This paper is organized as follows. The next section introduces some notions of BDI agents. *Section 3* discusses about the applicability of BDI agents in a POI recommender. Finally, *Section 4* concludes the paper and provides some future insights.

2.   Belief-Desire-Intention: The Concepts

This paper proposes the use of three elements to model individuals participating in a recommendation environment. In other words, users of a recommender system are abstracted into their mental attitudes. *Figure 1* illustrates the architecture of a BDI agent. In this section, we briefly describe these elements and determine their role in a decision making procedure. For more information on BDI architecture refer to Rao and Georgeff (1995).

2.1. Belief

The first element in modeling users is their beliefs. Beliefs refer to a collection of propositions supposed, by the user, to be true. The correctness of the propositions does not matter as the recommendations are generated for a particular user with particular beliefs. In addition, beliefs are subject to change and evolution. Since beliefs are just some information about the world, both the interactions among users and the experiences gained by a single user, may cause some new beliefs to be created, some existing beliefs to be changed or eliminated. Consider a user who *believes* that the kitchens smaller than 10 m² are very poky.

2.2. Desire

Thomas Hobbes asserts that every action of a human, whether voluntary or involuntary, originates from endeavors. "This endeavor, when it is toward something which causes it, is called desire ... And when is fromward something, it is generally called aversion" (Hobbes, 2006). Desires are collections of affairs a user would wish to accomplish. The important point with desires

is that they may be sometimes in conflict with each other and, hence, it may be impossible to achieve all of them. Once again consider the earlier example. Now, the user *is going to rent a house* which *is at most 5 kilometers from the city center* (so he or she can go to the work on time), and *is located near a gym*.

2.3. Intention

Intentions are subsets of the desires which the user has commitment to achieve them. The main difference between a desire and an intention is that intentions cannot be self-contradictory. The commitment of the user to a particular intention implies that they should not easily ignore or abandon it, because the collection of intentions has been obtained after reasoning about different alternatives. Nevertheless the commitments should not be fanatical. For example, the amount of air pollutants near the city center might be far more than the standards for a user who suffers from respiratory diseases. In such a situation, the user should show more flexibility to distant areas and plan for an earlier wake up to arrive at his or her work on time.
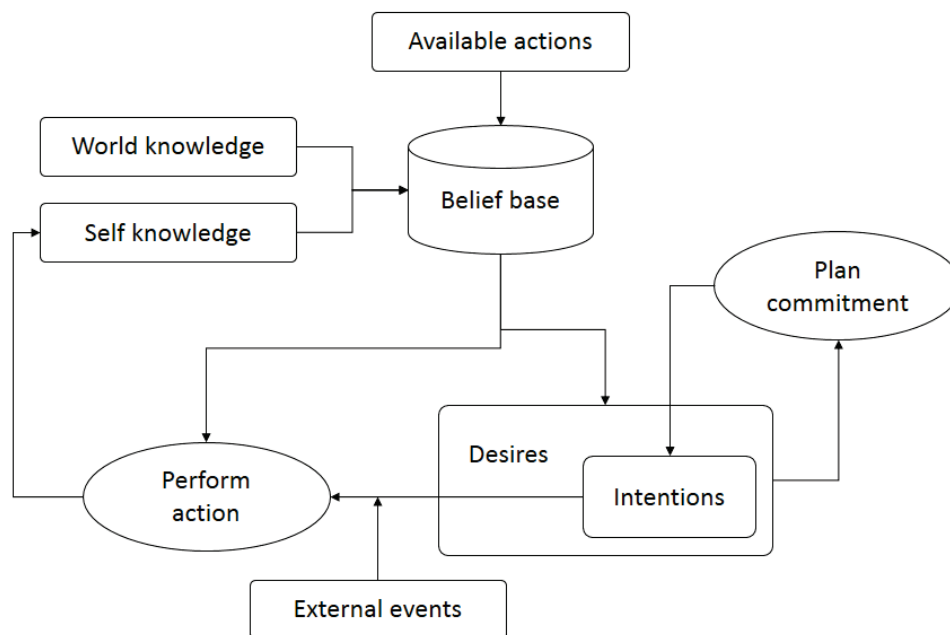
Figure 1. The architecture of a BDI agent.

3. Applications in Location Recommendation

Today, geo-social networks are omnipresent in people's lives. They are huge resources of information about their users. The information which can be extracted from geo-social networks can be classified into three broad categories: (1) The *location* (and spatial history) that users share with others; (2) The *content* (and content history) that users share with others; and (3) The *relations* (and relations history) that users establish with their friends. The nature of social networks is to some extent similar to that of agent-based systems. Particularly, as noted in the previous section, the behavior of users of these social networks and their decisions can be modeled via rational agents, namely BDI agents. So, each of the above classes of information would be participated in constructing beliefs and desires of the agent. People who are friends in social networks have some common interests and beliefs. Therefore, the beliefs of a user do have infuence upon others' recommendations. Formally, a user U is denoted as a set of beliefs B, desires D, and intentions I as follows:

$$U_i = \langle B_i, D_i, I_i \rangle$$

In addition to self-knowledge on which parts of beliefs and desires of a user are constructed, the user's friends (agents' communication) can also enter into the procedure of constructing beliefs and desires.

Proposition 1: The beliefs of a user's friends have impact on his/her own beliefs. However, a significant part of the beliefs may belong to what users have experienced themselves. In addition, the cultural views against a subject, which may not be the same in different societies, constructs play a significant role in belief-making. So, the set of beliefs of a user agent U_i can be written as:

$$B_i = \langle b_{exp}, b_{com}, b_{world} \subseteq \langle b_1 \dots b_n \rangle \rangle$$

where b_{exp} is the set of beliefs constructed by the user i via self-experience, b_{com} is the set of beliefs collected through communication between other users, b_{world} is the (local) world view on a subject, which will be injected into beliefs through the culture and education, and n is the number of the users' friends.

Proposition 2: The desires D of a user i may be originated from the desires of his/her friends.

$$D_i = \langle d_{own}, d_{com} \subseteq \langle d_1 \dots d_n \rangle \rangle$$

where d_{own} is the user's own desires, and d_{com} is what the user begins to desire resulting from communication with friends.

4.   Conclusions

This work-in-progress paper proposes the use of BDI agents in modeling the users of a recommendation system in geo-social networks. The similarities between users of social media and BDI agents are the driving force behind this idea. This way, the users of location recommendation system are not atomic objects, but they have three mental attitudes, namely beliefs, desires, and intentions. This research is being investigating by the authors to be implemented in a real environment.

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