Agent-based knowledge management system for urban social space

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1 Introduction

In this paper we propose a methodology for knowledge management systems (KMS) as support of local communities, a social knowledge management systems (SKMS). The goal of SKMS is to enhance the citizens awareness of their neighbourhood providing tools to discover, create and use information about their shared close environment. In order to expose the requisite of this systems and to expose the differences with existing, we consider a case study about a web platform for geographical social information about the neighbourhood. The platform should also providing a simplified and intuitive access to local information aggregating public open data and information from social networks, public portals and other websites.

The general question we try to address is how to provide a knowledge management service about social knowledge that is incomplete, about multiple topics, from multiple perspective, for multiple purposes without a domain specification. In other words when the domain definition is missing and there is not a correct way to reason about the information the basic assumptions of KMS are missing. In this contribution we start to address this question, in particular we discuss: the general problem and the methodology we use, the use of meta-ontology for social entities to represent social space, the use of a semiotic model to represent the user's point of view.

The rest of the paper provides a brief discussion about related works, and some concluding remarks about open issues and future developments.

2 Scenario

People sharing the same close environment that do not also share interests, ideas, goals or other relation. In this scenario the citizens' common ground is made of some basic notions about the neighbourhood. For instance where the schools are located, when the stores are open and closes, the lack of night bus or traffic jam. Citizens have opinions grounded on fuzzy, tacit and imprecise knowledge of their neighbourhood. Neighbours should be able sharing their opinion and partial knowledge to aware of the neighbourhood activities, of the shared problems, and the mutual needs in order to self organise creating and strengthening their social relations.

We consider a web platform that should be able to support:

- the users' perspectives of social spaces such as when it was done, how it was made, who made it, why was made, how can i access, how it is when there is such an such, and so on..,
- time and times of urban space: periodicity of public and services, events, evolutions of the urban space, etc.
- multiple potential uses of social information like city journalism, reviews, crowd funding, community of practice, event organization, etc.
- relations among compositions of public/private functions (e.g. health care) and locations (e.g. malls, campus)

An increasing number of open data about cities are being produced by public administration. There are three aspects that involves directly the citizens: finding relevant information inside the huge amount of public portals, the evaluation of the quality and reliability of information and the lack of feedback mechanisms.

At the same time, the crowd is producing more and more information everyday life, including things of public interest. Socially produced information can be complementary to institutional data if a mutual connection is established. However, social contents are also shattered across platforms, represented in custom formats and with the same issues about accountability, correctness, privacy and licence of use. In this scenario, citizens have to crawl the web searching for information. Moreover, users do not have a simple, direct and reliable way to give a feedback and share public relevant information with all possible interested auditors.

Information about neighbourhoods is a paradigmatic example. Daily, citizens ask to other citizens assistance about their activity though forums, groups, social networks and blogs. Given this request of information exchange many actors started to propose dedicated web platforms focused on a specific topics, "way of living", gender issues, task or the question-answering model. The idea behind the vertical systems is based on the long tail that can be summarized as the certainty to find someone sharing the same interests with you at the global level. This model do not apply at local level, it is unlikely to create a self-sustained community about minor things at the local level. Common things in daily life are usually minor, we don't buy pc, go to restaurants, travel to exotic beach every day. Following, a social knowledge management system for daily life in a neighbourhood has to be general in order to generate enough information to be useful and used.

A web-based SKMS has to integrate institutional data on geographical base and provide functionalities of a social network. Citizens should be able to find, annotate, and share existing information, and create new entries. The system do not handle domain knowledge but it is an *intermediary* between users. In particular, the system needs to provide:

- a way to express a clear perspective about the content, reducing the ambiguity and giving the means users to correctly interpret the information
- a multi-facet recommendation system for the different activities of the users.
- an intelligent interface able to adapt to the user's current goal

The main entity of the system has to be the result of the relation between place and function. For instance a school as the place where children are educated is one of the possible relation between a building and a function. The school presidency is the result of the relation between another function (the presidency) and the same building.

In this contribution we focus on a model of "urban social space", on a model for the social value of urban space and a agent-based query system interface.

2.1 Requirements

Information about neighbourhood are related each other because their local relevance and not because about some specific topic (multiple topics). From a citizen perspective neighbourhoods are not strictly defined but overlapping areas. Similarly, the concept of proximity changes according to contingent goals of users (multiple purposes), we are willing to move more or less according to what we want to do. Furthermore, the social information produced about the neighbourhood cover as many point of views as the aspects of real life (multiple perspectives). For instance we can be interested to a public services and the way we can access to it, to the history of a place or an event taking place somewhere. The system need to handle multiple topics, purposes and perspective of the social urban space, the knowledge that needs to be represented has multiple facades.

The knowledge we should collect is about the social perspective of urban space. As previously introduced it is not possible to treat such information as usual: citizens are not experts that agree or can agree to a common theory. Information are ambiguous but it can be understood by others, information convey an imperfect knowledge about something that is shared (the urban space). Now, considering the urban space from this perspective, the knowledge about a neighbourhood should be as follows:

- The basic entity is the "space"[1], a space has a location, it can be composed with other spaces, it has a lifecycle and a referent (group, community, institution) recognising its existence. A space has many properties, in this contribution we consider its specificity[2]: it can be specific, semi-specific or unspecific, in other words can be more or less related to the hosted activities (or possible to host).
- Spaces usually host activities, we refer to the activities that have a social relevance as functions. A space can contain one or more functions. A function needs to be hosted in a space, it has a lifecycle, it can be composed with other functions and it has a referent that do not to be shared with the hosting spaces[3]. Functions are categorised in communities (productive activity, public service), and according to the given category the citizen perception can drastically change [4].
- Both space and function have different degree of importance that are addressed in urban planning with hierarchical categories (primary, secondary, tertiary) and importance categories related to their public relevance (public/private, specific/semi-

[1] It is not a location but a generalisation of building, squares, streets, etc.

[2] The specificity can be saw as the degree of the connection with existing and potential activities. It answer the questions what the space is designed for and how we can use it for.

[3] It is possible to have communities valuing the space and other the function hosted inside that are not aware of each other and of the other values.

[4] For instance for many reasons we demand much more from a public services than from private services, the impression about the value and the quality of a service can change knowing if it is public founded or not.

specific/unspecific)[5]. We consider categories that can help to express the citizens' perception, that we can use to express the assumptions behind. Following, the relations among categories and the hierarchies are local, we expect major differences between linguistic and cultural communities[6].

Now we present the approaches we use to address some of the most relevant aspects of the presented scenario.

3 Methodology

As previously discussed we cannot rely on a specific domain ontology. Given this constrain it is possible to rely on an upper ontology such as DOLCE or SUMO to represent locations, people, actions, time and all the main concepts we need. In this contribution we consider a different approach based on the theory of social objects[1]. Social objects are entities between concepts and physical objects. A social object has physical aspects, life cycle, physical inscription or 'body" which is the media of a 'message" (a social object is a physical communicative act). The object meaning can be retrieved through interpretation of the message relying on common social models. A retrieved meaning can be one of the possible contents. Social objects are at the same time subjective and shared (grounded into the society common ground).

We developed a meta-ontology[7] for social objects[2, 3] that can be used to represent the traces left by agents during the process of creating social artefacts. The ontology is inspired by the theories of social objects[1] which considers a social artefacts a third category of objects between ideal and physical objects. A social object and models of social objects can be represented using the meta-ontology in figure 1.

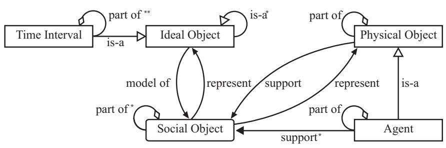

Fig. 1: Social ontology.

A model of urban social space based on the discussion in the previous section is an instance of the meta-ontology including the following components (Figure 2):

[5]Those ontological categories are related to theories about urban planning but we consider a citizen-centric perspective, their semantic can differ greatly between communities.

[6]Pilot projects and living labs are planned specifically in order to catch the local features and customise the system.

[7]It is not an upper ontology because it is not general purpose but focused on processes of creation of social artefacts.

– "Space" is the root component of social urban space, it is the class of social objects representing buildings, local and any physical space. Spaces are social objects, they must represent at least a physical place described with its geographical information (location and shape). Spaces can be composed.
  - "Function" is the component of the urban social space representing the activities that take place within a space. A function must represent one or more functional concepts (in an external ontology).
  - "Description" is the component of the urban social space representing the content of the social object about a space/function. A description can represent one Value (an external ontology of values which are described). It is an abstraction of a semantic network or other representations representing the description semantic.

Figure 2 shows the structure of the social object and the relations with the physical objects representing the "Geo Information" and other concepts like "Function", "Value", etc.

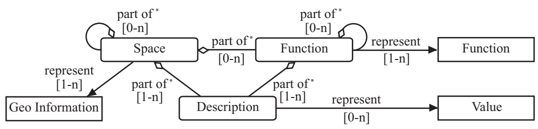

Fig. 2: Model of social urban space.

The knowledge base is the network of social objects, instances of the model for urban social space. The single instances are graphs connected together through agents, physical objects and concepts nodes. In other words the external ontologies of concepts and physical objects work as pivots connecting the social objects graphs together. Querying the network is a combination of graph traversing and a policy to select and exclude nodes (node aging, mutual exclusion, etc.) The knowledge base can be implemented as a metadata graph above a relational database using RDF and SPARQL or OWL.

3.1 Exploring the urban spaces

The knowledge base as previously described grows fast. Furthermore the social object graphs can be different from each other, a model as described is not an entity-relational diagram or an RDF Schema. The flexibility of the knowledge model we use need to be mitigated with a mechanism to assist users in content creation and retrieval. The knowledge base is more like a solution space that needs to be explored rather than a database to query. We propose an agent-based query system to translate the users' queries in actions to explore or modify the search space. In this contribution we discuss only the general approach and the main related.

First we propose to distinguish between two types of possible users' interactions: "methods" and "actions". With methods we refer to the methods in the object oriented approach: a method is a functionality provided by the object. We consider methods external functionalities related to a resource. For instance a museum can be an entity providing some functionalities like "contact", "give a feedback" or "book a ticket". With actions we refer to functionalities that are specific of the relation between an object and an agent. We refer to a cognitive phenomenon of perception called "affordance"[4], an action available on an object/agent because the specificity of the agent or in other words, an action is a property of the relation object/agent. In other words, an affordance is what a object "offers" in term of perception of possible interactions to specific kind of agent.

Example 1. A museum has specific properties related to the visit time and access rules for most of persons but there are other special case when a museum can be very different like: for a common person it has restricted access time and condition (for instance ticket); for a national archivist a museum is an archive accessible in any working time without any need of specific permission; for a student it can be the same if it can manage to get a specific authorization from the manager.

As in this scenario we do not have a domain theory we also do not have a definition of what is possible in term of interactions. Considering the theory of affordances we want to design a solution that can be flexible enough to represent emerging interactions. We consider the following assumptions: affordances (just action from now on) should not be represent as properties of objects or agents; an action becomes available when both the condition of entities and users are fulfilled; actions are global, do not belong to specific context but the context features can be a prerequisite for the action. Given those assumptions we consider affordances as a special case of actions as usually defined in artificial intelligence with two sets of agent and object preconditions.

As in other systems we should consider atomic and composed actions. An atomic action can be generalised as follows:

- Preconditions (A_g, O_b), a duple of propositions: A_g for the acting agent and O_b for the object.
- Procedure (a_i, o_j), an algorithm to build a new object o_k, from properties of the agent and object matching the preconditions, and the list of update to a_i, and o_j.

This approach goes in the same direction than Di Caro et al. approach to affordances[5]. The authors present a model to build dynamically the interaction ontology from the social network analysis.

Atomic actions involve one object at time and be much more complex than update or insertion.

Considering the system requirements and the complexity of composed actions, we propose to represent a system action a cognitive agent. Complex actions may require strategies made of many several actions and may have many outputs according with the time given. An agent can pursue the user's goal finding and executing a complex plan. An agent can be instantiate from a general template with the user's parameters and being left running as long as the user what to perform an action. The validity of the information created is in this way bounded to the agent run, the information validity correspond to the agent lifecycle.

3.2 A framework for social valorisation

Users can describe a social space for many reasons or having in their mind specific goals. What the system should avoid is to enforce a specific theory of urban space. Users should be able to create and retrieve content respecting their own perspectives about the urban space. In figure 2 we introduced a node named "Value" representing a meta-ontology specific for the dynamic of social valorisation. We are planning on developing an interface based on narratives to enable users to annotate the content themselves.

The meta-ontology in figure 3 is based on a model called semiotic square[6]. The semiotic square has been used to study narrative and advertise[7, 8]. The semiotic square represent the logical articulations of a duple of opposite values. We instantiated the semiotic square with the utopian and practical values of the urban space.

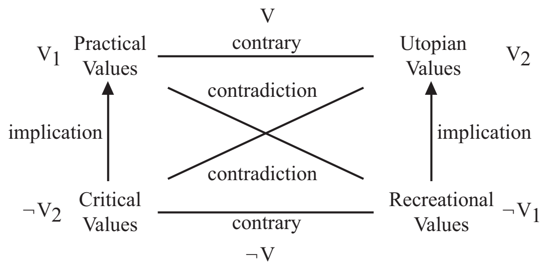

Fig. 3: Possible social valorisation of objects.

The semantic square describe the following relations:

- Contrary $V = V_1 + V_2$ and $\neg V = \neg V_1 + -V_2$ (V complex axis, $\neg V$ neutral axis)
- Complementary: $\neg V_2 + V_1$ and $\neg V_1 + V_2$
- Implication: $\neg v_2 \rightarrow V_1$ and $\neg V_1 \rightarrow V_2$

This methodology will be used to develop a general framework to reason about values. This framework will be used to describe more perspective of urban spaces during living labs. Furthermore, this solution, as component of the system agent's reasoning system, responses to multi-aspect requirement.

3.3 System agent

A system action is a cognitive agent that can generate permanent and that can be used as model for users' custom agents. Among the several models of cognitive agents we consider one of the most used, the belief, desire, intention (BDI) model[9]. A BDI agent is characterised by a belief knowledge base about the state of affairs, a desire KB collecting the agent's and the current intention, what the agent will actually pursue.

A BDI agents are being widely studied, there are many implementations and extensions. In order to give the intuition of how the notions we presented can be used, we "trivialise" the concept of BDI agent and show in the following scenario how the concepts interacts:

- The belief component corresponds to the knowledge network. Agents can access to the network and explore it anytime.
- The desires component corresponds to the user's goal. A goal is a partial description of a desired status.
- The intention component corresponds to the output of the agent reasoner. The reasoner solve goal conflicts giving a priority, it decides plans and the intermediate steps to reach the goal.

An agent has a knowledge base of possible actions (that in our case can be dynamically populated). Our agent works on the knowledge network, it is the agent environment, with other agents. An instance of the system agents requires: a set of permitted actions, a subset of the system atomic actions, a policy for the planner and the user's goal. In this contribution we do not address the goal representation, for now we assume that any user has one specific goal for each agent.

4 State of the art and concluding remarks

The presented scenario is being partially addressed with different techniques. Mainly, we can mention geographical system and social networks with geographical information. We can consider the following approaches:

1. oriented to the physical aspects (GIS) for research and documentation purpose,
2. navigation systems for cars, scouting, sailing, etc. (TomTom)
3. map-based search engines (Google maps, Bing maps)
4. map-based social networks (Foursquare, Localflow)
5. social networks with geographical information (Twitter, Facebook, G+)
6. geographical systems with social network tools (Weeze, BlaBlaCar, TripAdvisor)

In general, geographical systems are oriented to the physical aspect of space. A geographical entity is a duple location/shape plus categories[10, 11], there an objective perspective to geographical information that comes from the formal theories of geography, urban planning and other fields interested in geo-data. The first three approaches are examples of this approach. Among the hybrid systems, the last three approaches, we have: (a) topic-oriented systems (TripAdvisor, BlaBlaCar), (b) social-relation oriented systems (G+, Facebook, Twitter) and (c) application-oriented systems (Weezer, Foursquare, Localflow).

Those last systems are candidate solutions to the presented scenario. The platform addressing some aspects of the scenario are vertical solutions, and as previously discussed in the vertical approach seems to not work on local level. The generalist systems are oriented to communities of interest (groups, pages) and to user networks (cicles, groups, fiendship, followers). We need to merge some elements of the vertical solutions, in particular the contribution of strangers with geographical systems. Plus, it is missing a mechanism to handle the information relevance without relying on friendship and communities. Forsquare is an interesting solution but it is based on a competitive mechanism to be "expert of a place" that does not fit with the collaborative environment we want to build.

The connections between geographical systems and social networks go in the direction of the crowd source or participatory design[8]. As example we can recall the partecipatory ontology design[12], ontology alignment[13, 14] and also geographical systems[15].

Looking to the artificial intelligence perspective, the use of agents in tasks of information retrieval is not new. There are several proposal and projects based on agent technologies, just to cite some of them we can recall the remembrance agent[16], an agent for continuous retrieval, agents Letizia developed in the MIT to enhance web search[17] and MELISSA, an an ontology-based agent for the medical domain[18].

Respect our proposal we can recall two similar projects:

- Wawa (Wisconsin Adaptive Web Assistant) system implement a framework to build information retrieval agents and information extraction agents on the base of users' a priori knowledge. This system generates agents from users search parameters, then agents learn from retrieved document. The system can be used also for web search. The machine learning component are used to overcome the lack of semantic annotations.
- The authors of 'Discovering SemanticWeb Services using SPARQL and Intelligent Agents"[19] propose the use of rdf graphs, agents and SPARQL (graph query language for RDF) to explore and discover Semantic Web Services (SWS). An SWS is described with preconditions and postconditions. The author use SPARQL to evaluate the precondition for the service applicability, build the post condition and check if the postcondition are compliant with the agent goal.

Knowledge management system see nowadays a large use of semantic web technologies on pair with reasoners and agents , our proposal goes in the same direction. The novelty of our approach can be found in the overall approach that tries to address complex scenarios using models from social science rather than fixing a specific domain.

4.1 Concluding remarks

We presented a general approach to knowledge management for a geographical social network. The main question addressed in this proposal is how to provide a knowledge management service about social knowledge that is incomplete, about multiple topics, from multiple perspective, for multiple purposes without a domain specification. We proposed a general approach and some solutions inspired on theories from social studies. The proposal aim is to enable new features close to the social conception of space and deal with the complexity of the described scenario.

About the evaluation this kind of problems do not allows correct answers, the strategy is to provide for each component what can be considered a result. The most important aspect of the evaluation is still the users' feedback, we are planning living labs, sessions of participatory design and other strategies to involve the users in the process.

[8] Solutions used also in many other fields related to knowledge systems like natural language processing, ontology design and ontology disambiguation.

The future works will be focused on formally define the system agent, on an automata-based semantic for the meta-ontologies, and an argumentation framework to reason about the knowledge network.

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