The spatial knowledge representation of players movement in mobile outdoor gaming

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Abstract — This paper describes an innovative approach for developing a spatial knowledge representation based on the existence of multi tier spaces as a mental construction of human movement. The three "spaces" paradigm has been proposed to support the reasoning process in terms of sensing, symbolic, and social spaces. The spatial knowledge representation was implemented as a computational ontology in Protégé, and it has been applied to provide new insight about the actual behavioural patterns of players within a recreation site, accordingly to checkpoints and similar players´ interactions. This first experiment consisted of an educational game in Amsterdam using mobile phones and GPS-technology for 200 students having the age of 12-14. The results demonstrate that different types of inferences play a different role accordingly to what a recreational planner needs to infer, that is, the location of interactions among players and the environment.

Index Terms — Recreation planning, mobile outdoor gaming, spatial knowlegde representation, ontology.

1 Introduction

In the planning of recreation space, the aim is to provide a range of functional and aesthetically pleasing environments for outdoor recreation [1]. Mobility is an integral part of the process of recreation planning. However, most of the approaches to planning for leisure and even those that utilise spatial principles have not been developed to handle the sense of mobility of players and its significance to recreation development.

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The term mobile game typically stands for an isolated interactive game on a mobile device which does not utilise location and movement of the player. The availability of positioning technology such as GPS, together with more powerful mobile devices, and mobile networking infrastructures can allows us to develop mobile location-based multimedia games.

Existing mobile games that introduce location in their application context often go into the direction of augmented reality, using extensive hardware and software. Integrating the location, such games bridge the real and the virtual world. Some examples include Pirates! [2], which uses additional proximity sensors to locate the players and hence is not very suitable for an (ad hoc) outdoor game. With GPS drawings [3] we find systems that use GPS to draw a picture in the virtual world by physical movement, however, have not life game momentum.

We are particularly interested in understanding the movement of players and

foreseen possible new riddles of a mobile outdoor gaming. Our approach is to develop a spatial knowledge representation about these movements by developing an ontological formalism within which not only definitions (concepts) but also a supporting set of axioms must be true in every possible location of a player. Our effort should not be considered of a simple simplification of particular epistemic states, but as a basis for causal inference that enables the understanding of what we call movement. In fact, we are searching for the explanation of the spatial patterns (e.g. flows) of the actual trajectories followed by players, not only the starting and ending points.

2 THE NOTION OF DIFFERENT SPACES IN MOBILE OUTDOOR GAMING

The first theoretical assumption is the existence of multi tier spaces as a mental construction of movement. Movement is conceptualised as “motion” or “translation” of a player over time. This excludes the rotation, parts-of-body motion, or internal motion of a player. Knowledge about movement arises from the reflective and abstract conceptualisation and representation of seemingly distinguishable types of spaces, interacting causally with concepts in a common space and time [4].

2.1 Sensing space

The concepts are related to the general picture of movement in space and time that can be interpreted as a simply one of concrete and discrete units, such as node, stop, move, vector and flow. In fact, each concept represents the analytical perspective of movement, because they represent the logic-geometrical and topological understanding of movement which can be seen or sensed at one place and one time. They also provide a basis for interpretation of measurements and observations of the actual trajectories of the players.

2.2 Symbolic space

The conceptualisation of movement is not divided into discrete units, but instead, it involves the distinct semantics of movement as a crucial precondition of explicating the logic-semantic structure of the movement in space and time. The symbolic space represents the essence of movement, that emphasises the underlying continuity and not the separation of things, even though the continuity might in some sense be conceptualised in terms of the discrete concepts, for example, the generalisation of flows through the conceptualisation of attractors.

2.3 Social space

It is connected with what has happened or is going to happen. Movement needs to be associated with intentional behaviour and therefore, it needs to be represented directly to social and economical behaviour. This space is NOT a generalisation or abstraction of the previous ones. Some examples of concepts include actor (i.e. player) and his actvity involved in solving a riddle.

3 THE MOBILE OUTDOOR GAMING

Paper chase (also known as scavenger hunt) is an old children’s game in which an area is explored by means of a set of questions and hints on a sheet of paper. Each team tries to find the locations that are indicated on the questionnaire. Once a place is found, they try to best and quickly answer the questions on the sheet, note down the answer, and proceed to the next checkpoint (CP). Based on this game idea, a mobile outdoor game was developed to evaluate the proposed spatial knowledge representation of the different spaces in mobile outdoor gaming (Fig. 1).

The game mainly consists of a set of georeferenced checkpoints associated with multimedia riddles. With the mobile game client a player logs in to the game server, receives a map and the player has to find during the game.

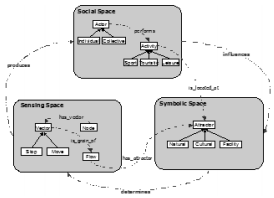

Fig. 1. The spatial knowledge representation of multi-tier spaces developed for the representation of the movement of players of a mobile outdoor gaming. It was implemented as a computational ontology in Protégé, using OWL DL that allows the maximum expressiveness while retaining computational completeness.

Each of the checkpoints is geo-referenced by a Gauss Krueger coordinate which is transformed into a screen coordinate and drawn on the map. The player's device includes a GPS receiver which continuously tracks the current position of the device. As the checkpoints are proximity-aware an event is raised and the server is contacted, whenever a player physically approaches one of the virtual checkpoints. The server responds by sending the information about the corresponding riddle, which is presented in a hypermedia presentation to the user.

Each riddle has associated resources like an image or other additional (media) information that are needed to solve the riddle with the respective interaction(s). The player tries to solve the riddle not only correctly but also as quick as possible, because the time needed to solve all the riddles is accumulated and added to the overall score. The answer to the riddle is communicated to the game server. It is possible for the player to interact with the system but also with other players.

3.1 The experiment: frequency 1550

In the Frequency 1550 mobile outdoor game, students were transported to the medieval Amsterdam of 1550 via a medium that's familiar to this age group: the mobile phone. The pilot took place in 2005 from 7 to 9 February and was supported by KPN Mobile's UMTS network (Fig. 2). The Waag Society educational staffs worked with the school to make sure the mobile game experience fits with the traditional curriculum. Apart from adding to historical awareness and knowledge the pilot was meant to enhance communication and collaboration skills (game tactics) and educational abilities (interpreting historical sources and references). Through this pilot, the game was focused on whether actively experiencing history through the immersing qualities of a (location-based) game and the creation of your own media (pictures, sound, video) adds to the understanding and appreciation of the city and its history.

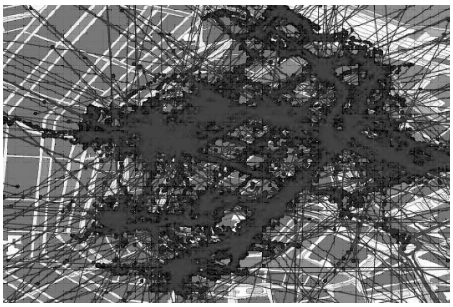

Fig. 2. The GPS data set collected during the Frequency 1550 Mobile Outdoor Game.

4 REASONING ABOUT MOVEMENT

Reasoning allows the encoding of knowledge about specific domains and often includes ontology languages that support the processing of that knowledge. Among all the ontology languages, the Web Ontology Language (OWL) is a well known standard from the Semantic Web and it is now a W3C recommendation [5]. An interesting feature of OWL is that it relies upon a family of languages known as Description Logics (DL) that provide an inference system based on a formal well founded semantics [6]. The basic components of DL are *concepts*, *roles (properties),* termed as TBox, and *individuals,* termed as ABox. Concepts describe the common properties of a collection of individuals and roles are binary relations between concepts. Furthermore, a number of language constructs, such as intersection, union and role quantification, can

be used to define new concepts and roles.

OWL currently has three sublanguages of increasingly expressive power that are: OWL Lite, that is the syntactically easiest version, that can define hierarchies and simple constraints; OWL DL that allows the maximum expressiveness while retaining computational completeness, corresponds to Description Logics. Finally, OWL Full allows for maximum expressiveness and the syntactic freedom of RDF with no computational guarantees.

In this paper we exploit OWL DL for the formalisation of the concept ***STOP*** and the reasoning about movement patterns rather than a particular trajectory of a singular player.

Concept 1. **STOP** represents the suspension of movement of a set of players. It is defined as the spatio-temporal relation between a high density and low velocity of players within a specific region (Fig. 3).

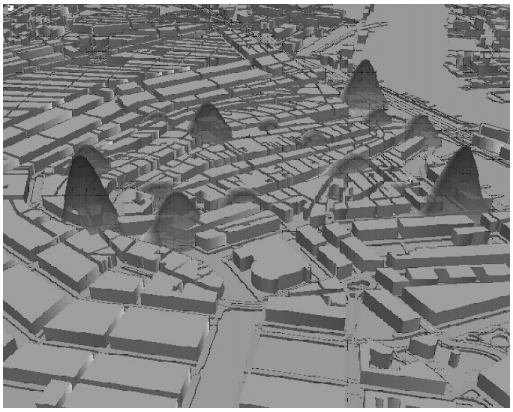

Fig. 3. A snapshot of the location of places with the highest density of players during the entire game.

Therefore, the characterization of an **ATTRACTOR** during the game can be infered using the **STOP** concept, as well as a-priori knowledge about the location of checkpoints of the game (Fig. 4).

ATTRACTOR ≡ HasRegion some (hasDensity some HIGH) and (hasVelocity some LOW)

ATTRACTOR ⇒ is_at some STOP

Fig. 4. The results from processing the inferred ATTRACTOR concept based on the suspension of movement of players. An interesting finding is that a large number attractors have ocurred during the game and they were located at the bridges.

This example, despite its simplicity, shows how OWL axioms allow to perform automatic reasoning over the movement of players taking into account additional background information, such as geographical and application-dependent knowledge.

5 CONCLUSIONS

Three main findings can be drawn from our research described in this paper. They are:

1. Mobile devices, linking the real and virtual worlds could change your perception of your surroundings. *They* will gather *event driven data* which will incorporate real-time observations collected upon players requests from mobile multi-sensor networks. Most of the gaming processes will move away from the post-processing step, which is today very time consuming, due to the fact that raw data from orbiting satellites and in-situ observations are collected in such a volume that varies from place to place and time to time.
2. Mobile location-based outdoor games will create new cultural, social, and virtual landscapes, which will require the development of a knowledge representation *of* different notions of spaces, with attractors, activities, and processes potentially taking context information everywhere.
3. The impacts and implications on *privacy* in the sense of preventing the disclosure of sensitive data, both explicitly

(e.g., providing individual's identity) and implicitly (providing non-sensitive data from which sensitive information can be inferred).

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