Virtual coaches for mission-based gamified smart communities.

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Virtual Coaches for Mission–Based Gamified Smart Communities

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Abstract
We propose a Virtual Coach for the gamification of participatory applications in complex socio-technical systems like Smart Cities and Smart Communities. In such participatory applications, the user community is an active and essential component. Users must voluntarily take up some tasks, in order to ensure the correct operation of the application according to its requirements and goals, which, in turn, delivers collective benefits to the community. In order to facilitate users, and support their sustained engagement in a participatory application, we use a *Missions* metaphor to describe those volunteering tasks. Our Virtual Coach is then responsible for selecting and recommending missions to users, based on a variety of factors, including the criticality of the corresponding tasks for the application purposes, the importance of the task for the individual user that should take it up, user profile characteristics, like personal preferences and skills, and the in-game incentives the user would earn by completing the mission.

Author Keywords
Virtual Coach; Missions; Gamification; Smart Communities; Participatory Applications

ACM Classification Keywords
I.2.1 [Applications and Expert Systems]: Games; H.1.2 [User/Machine Systems]: Human information processing

Introduction

Smart cities are a complex conglomerate of ubiquitous services, sensors, smart objects, devices, apps, and other ICT systems, which innerve contemporary urban environments; they pose new technological, governance and social challenges and opportunities. *Smart communities* extend the concept of smart cities with an emphasis on citizens who live and work in a territory, and interact with the technologies and services above, in order to cater to their collective interests, needs and goals. Smart cities and smart communities are pre-eminent *open environments*; they are very dynamic, since services, systems, agents and devices are heterogeneous, without central ownership or control, and can appear, disappear or change behavior at any time. Moreover, they are complex, large-scale socio-technical systems, where technology aspects of functionality and performance are inextricably linked with aspects of social behavior, governance, decision-making, and people-to-people as well as people-to-technology interaction.

We propose a *Personalized Gamified Smart Virtual Coach (PGSVC)* for the mission-based gamification of participatory applications in socio-technical open environments, like smart cities and smart communities. A participatory application supports community self–help; community members must take up specific tasks, so that the application can progress in its operation, and ultimately deliver some benefits and services to the community as a whole. Our PGSVC provides guidance in participatory applications, by presenting volunteer tasks as game-like *Missions* [12], and recommending to a user/player those missions that cater to her needs, while advancing the community objectives, and offering a fun competitive, or collaborative, experience. A PGSVC is particularly valuable in open environments, since – because of their dynamism, scale and complexity – a player may not have full knowledge of the whole domain, and the tasks that need to be done. A PGSVC can make dynamic decisions on the most appropriate missions for a player at a given juncture; its recommendations can be based upon multiple dimensions, including players' profiles and preferences, in—game incentives, or application state, including the collective goals and requirements of the community supported by the participatory application.

Related Work

A virtual coach is a visible or invisible assistant that supplies the player with direct or indirect suggestions on how to do well. Those suggestions may at times be tuned to the individual player with some form of personalization. Virtual coaches are used in many gamification domains. For example, in the automotive sector, virtual coaches are employed to support the exploration of a vehicle [3], or to guide drivers to eco-driving styles [3, 9] and to save fuel [8]. Richards [10] proposed to apply invisible coaches to exergames. Kulyk et al. [7] described guidelines for designing coaches for the gamification of physical and personal health activities. Buningh et al. [2] implemented a gamified system, with a coach, for stimulating company employees to choose sustainable means of commuting to work.

Some virtual coaches use the concept of missions to deliver their recommendations, but most domains that are gamified by using missions and a virtual coach are *closed environments*. Closed environments, such as regular information systems, or mobile and web apps, are pre–defined because their services, user interactions, goals, conditions and constraints mute rarely; furthermore, those changes do not happen at runtime: modifications to the system are made offline, which allows offline maintenance of the virtual coach as well. Our goal is to apply gamification to open environments like Smart Cities [11, 6], with their dynamic, large-scale user communities and ICT infrastructures.

There are some studies on the mission-based gamification of groups of people or communities. Fitz-Walter et al. [5] reported how, in the process of university orientation, supplying students with a mission–based gamified mobile app increases engagement and improves the experience. Dodero et al. [4] showed how a mission-based approach can be effective for groups of primary school children. However, those works do not consider the issue of recommending missions to community participants in an automated way by means of a virtual coach.

Motivating Example

We elucidate our proposal using the case of a smart community of citizens who self-help about the theme of Children Independent Mobility (CIM). CIM is important because being an independent and active road user is fundamental for the physical, social, cognitive and emotional development of children [1]. Unfortunately, most parents chauffeur by car their children, especially to school. This accounts for approximately 20% of the total daily traveling population in the EU, with implications on pollution and traffic. In addition, the traffic near schools creates safety risks for children who walk or cycle to school. A smart community for CIM requires several socio-technical services that help children becoming increasingly independent during the primary school years, for example services like *Walking Bus (WB)*, *Bike Train (BT)* and *Car–Sharing (CS)*. A WB is composed of volunteers that walk a group of children of age 6 to 8 to school. The route of a WB is made of stops near the children's houses. A BT is a group of children of age 8 to 10, who ride bikes to school together autonomously. CS is for parents who live far from school, who collaborate to chauffeur by car their kids to the nearest WB stop.

To operate CIM services effectively,many tasks of a participatory nature are needed. They require volunteering by parents, grand parents, neighbors, teachers, kids, etc. We propose to gamify these tasks as missions: e.g., "Propose a safe route for a WB", "Check if the proposed path is safe", "Preside over a dangerous crossroad". Missions can be co-dependent: e.g., for every WB route proposed , someone must check if the proposed path is safe for kids.

The technical components of CIM include smart bracelets, gateway sensors, smartphones, apps, etc. Smart bracelets track the movement of children . Gateways monitor other devices and interact with backend IT systems, such as school information systems, the CIM system and the gamification system. For instance: the school gateway monitors children arrived at school (via their bracelets), interacts with the school system to automatically fill the logbook, and with the gamification system for updating the game state and rewards (e.g. points) of all players for their mission completion. Mobile apps are used to coordinate community members with the CIM services.

Combining mission–based gamification of the participatory tasks with a PGSCV can encourage people to complete the necessary CIM activities in a fun way, while satisfying personal and community objectives. In the next section, we describe this idea in further detail.

Characteristics of the Virtual Coaches

A PGSVC is a software agent assigned to a specific citizen, its *owner*. A PGSVC that can successfully recommend personalized missions in a context like CIM – or a similar open-ended participatory application – must consider many criteria, which belong to the following three *dimensions*:

1. (like most virtual coaches) criteria that have to do with the state of the individual player within the game;
2. criteria that have to do with the state of the participatory application itself, and current community needs;

3. criteria that have to do with the user profile and preferences of the player,including the role(s) she can assume in the participatory application.

A PGSVC must also consider *mission characteristics*, i.e., meta-data about the participatory tasks, which may include time urgency, difficulty, dependencies vis-a-vis other tasks, roles, skills and resources required, etc.

The following example wraps up most of the previous considerations. Anna is a licensed WB volunteer, but she has the flu; she uses her CIM app to notify her absence from tomorrow's WB. The CIM system raises an issue because the WB does not have enough volunteers; this issue corresponds to (*dimension 2*) above. Sara, Mario, Luca and Paola are all WB licensed, so their PGSVCes consider their fit for the new mission M1: "Serve as substitute volunteer of the WB". Sara's PGSVC knows from her health profile (*dimension 3*) that she is injured, and decides that the mission is impracticable. Mario's PGSVC knows that he wants to win the badge of "Master of car–sharing" (gamification state – *dimension 1*); since M1 does not fit that objective, the PGSVC assigns M1 a low priority. Luca's PGSVC identifies him as a good candidate, but finds out that mission M2: "Manage the transit of a bike train in a crossroad" is more urgently needed right now (CIM context – *dimension 2*); since Luca lives near that crossroad (*dimension 3*), his PGSVC proposes to Luca mission M2.Paola's PGSVC knows she has a son (family profile – *dimension 3*) in the WB of M1, therefore keeping that WB operational, is critical to the organization of her day as a parent. Paola is proposed mission M1 and she accepts.

An additional aspect of PGSVC can be the calculation of personalized rewards for missions. For instance, if Mario were the only available volunteer to fulfill mission M1, the PGSVC could augment his in-game incentives, to induce the desired participatory response. For example, if points for M1 are accorded based on the length of the WB route, (*dimension 2*), the home location of the volunteer (*dimension 3*) and the number of families depending on the WB (*dimension 2*), Mario's PGSVC could decide to accord a 2-times multiplier for M1, so that Mario can achieve his goal with respect to the CIM points leaderboard (*dimension 1*).

In an open environment like a smart community, the elaboration of missions is challenging: missions can require multiple sub-steps and those steps may be dynamic. For example, the mission "Serve as substitute volunteer of the WB" of the example requires sub-steps like: make your way to the first WB stop; check in at the stop; check the list of children joining at that stop, etc. The PGSVC should be able to produce such a plan, and also change it during execution; for example, if a citizen notifies the CIM system that a section of the WB route is unsafe, that may require a change in the mission plan, the WB volunteer should be updated, and other missions may need to be created.

Conclusions

We introduced a *Personalized Gamified Smart Virtual Coach* for gamifying participatory applications in smart communities. We use the metaphor of *missions* to stimulate engagement in participatory tasks. Our PGSVC recommends appropriate missions to community members/players, by reasoning about multiple criteria related to mission characteristics, players goals, and the the smart community needs and objectives. We will implement this idea with a case study on *Children Independent Mobility* in the city of Trento (Italy).

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