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# Context Aware Serious Games Framework for Sport and Health

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***Abstract –*** *Serious Games for Sport and Health are a promising chance to help people to improve their health. In this paper, we address the challenges of adding context awareness to Serious Games for Sport and Health. We propose a framework for social networks and web services that is specialized in capturing temporal and spatial context as well as vital parameters of a user. Our framework dynamically maps necessary e-Health services such as exergames. In this way, we assist a user to find the most appropriate health services according to his/her needs at anytime and anywhere. We present our initial proof of concept implementation of the framework, which includes new sensor based Serious Games for Sport and Health as well as our test results.*

***Keywords*** *– Serious Games for Health, Exergames, Context Awareness, Social Networks, Web Services, Sensors, Personalization.*

## I. INTRODUCTION

Nowadays, a lot of attention has been given to cardiac diseases, obesity, diabetes, and muscular atrophy or misbalances. These health issues occur due to the abundance of calorific food, lack of movement, and misbalanced exposure. Eating less and exercising more sounds like a simple solution to these problems. However, in reality it is hard for many people to follow this guideline. This is where Serious Games for Sport and Health come into play [1], [2], [3]. Serious Games for Sport and Health motivate people to participate in sports, include exerting activity in their gameplay, or teach people about health issues. Most of the well-known exergames are commercial games such as Dance Dance Revolution or Wii Fit. Although these games are not primarily developed to improve health, positive effects can be constituted [3], [4]. Besides research prototypes such as [5] exergames are very rarely included in exercise equipment (e.g. Concept2 Indoor Rower[1]). Capturing user context and providing appropriate exergame services is envisioned to address many of the health issues raised above.

Previous researches show that extracting user context from from body sensor network (BSN) and multimedia information contained within heterogeneous Internet services [6], [7], [8], [9], [10], [11], [12] is a challenging task. For the former case, accessing live sensory data from BSN and for the latter case, deducing user context from multimedia information contained in the form of email messages, RSS feeds, web services data messages, text messages, IMs, content management systems, to-do lists, calendar events, blog messages and other online sources poses a challenging task [13], [14]. The author in [13] presents a framework for building context-aware services, called SocialAware. The framework has been tested with two proof-of-concept applications. The first one, called SocialAwareTunes, is a context-aware music jukebox player that plays music, which reflects the preferences of a group of co-located users. The second application, called SocialAwareFlicks, is a context-aware video system that plays movie trailers, which reflects the preferences of one or more users watching a video display together.

The research and development efforts in context-aware service selection systems are still quite immature [18]. Some systems assume that the set of services is determined a priori [19]. Frameworks like [12], [20] provides context-aware mechanisms to identify appropriate services. This solution provides mechanisms to discover Internet-based services. However, none of them, even though exhibiting potentially interesting features, have yet been applied to support context-awareness.

Recent advancements in multidisciplinary research domains such as wireless sensors, smart phones, high speed personal area networking, social networks, and mobile communication (3G or 3.5G) have contributed to a new era of context-aware computing. For example, various wired or wireless sensors can capture different physical context such as heart rate, blood pressure, glucose level, and sweat condition. In addition, activities such as walking, sleeping, driving, falling, running, talking, and in a conversation with a friend could be captured, as well as environmental parameters such as humidity, temperature, location, altitude, etc. In [16] we proposed a second dimension of capturing user context by introducing a novel ubiquitous stack that can intelligently follow user mobility and utilize user context coming from both sensory media and diversified Internet-based services.

In this paper, we present the integration of a set of Serious Games for Sport and Health and we make them context aware by the use of our framework. The rest of the paper is organized as follows. Section II details the framework design while section III shows the implementation details and preliminary test results are presented in Section IV. Section V concludes the paper.

[1] http://www.concept2.com/us/motivation/games/default.asp

## II. SYSTEM DESIGN

Extracting user context from sensory data and multimedia information contained within heterogeneous services poses two challenges. First, it requires live extraction of multimedia content from heterogeneous services and from BSN for context analysis. Second, employing appropriate logic to extract contextual information from the available social network and sensory data, aggregate and then store them to a repository to be used for dynamic selection of relevant serious games and health services. For better representation of the concept, we describe the framework with three logical modules. The first module deals with the extraction of multimedia data from different services over the web and live sensory data from one's BSN. The second module takes care of deducing context primitives from the extracted content. The third module dynamically portrays the context-aware serious games and other e-Health services to a visualization interface. The high level architecture of the proposed system is shown in Figure 1. Next, we elaborate each of the logical modules.

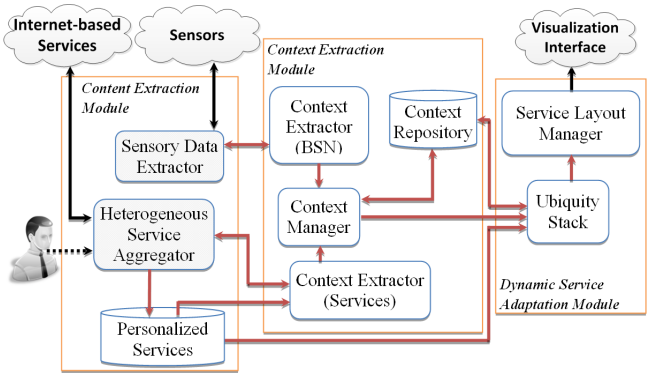


Fig. 1. High level components of context-aware serious games service selection system

### A. Content Extraction Module

This module takes part in the actual content extraction process from heterogeneous Internet-based services and body sensor network. It first collects a list of subscribed services from each subscribed user. *Heterogeneous Service Aggregator* is designed to collect content from popular multimedia services such as audio/video conferencing, video streaming, communication, instant messaging, email, serious games, social network, event and calendar services, to name a few. *Sensory Data Extractor* embeds the logic of extracting sensory data from different sensory media [17]. *Personalized services* database stores one's subscribed services from which context is extracted.

Each type of content extractor encompasses a wide variety of methods that are necessary to request content payload of a particular Internet-based service provider and sensory media. It also includes data formatting, range checking and data validation, algorithmic computation and normalization, augmentation, and interpretation of low-level sensory and social network data into higher-level information that complies with the subsequent phases of context processing modules. For example, an event extractor scans through the calendar services of a user and if one or more new exercise event(s) are within a pre-defined threshold of time, it is subjected to a context checking process. Finally, all the services with new message content are tagged and subjected to pass through the following context treatment process.

### B. Context Extraction Module

This module employs the MVC[2] design pattern to find context value of a service. Both the *Context Extractors* i.e. BSN and Services (see Figure 1) employ the controller, which receives live content from sensors and Internet-based services as a payload and passes the content and the metadata of each service to the appropriate model components. Model components employ algorithms and domain specific knowledge of extracting context from each service, details of which can be found in [17]. For example, a Twitter message containing a calendar event message is passed to the calendar parser module and current outside weather data is passed to the weather inference module. Table I shows some sample content extracted from three services that carries important contextual information of a user. The *Context Manager* aggregates raw context primitives and combines them for compound contexts, which is stored in *Context Repository* for further higher layer service selection process.

TABLE I. RECEIVED CONTENT FROM MULTIMEDIA SERVICES AND SENSORS AND CORRESPONDING DEDUCED RAW CONTEXT DATA

| |
|---|
| (*Accelerometer:StatusMessage*)→No movement for the last two hours |
| (*Weather-Message:WeatherService*)→Heavy snow this morning, outside jogging is not recommended |
| (*Calendar:CalendarService*)→Tuesday doctor's meeting has been cancelled |

### C. Dynamic Service Adaptation Module

The compound context primitives are used by our earlier developed social network portal called SenseFace [16] to dynamically map to a subset of serious games and/or health related services. The role of *Ubiquity Stack* is to provide a ubiquitous overlay network, which is unique for each person. This stack provides the needed logics, protocols and algorithms to extract services related to Sports and Health information from *Personalized Services* database. This stack supports higher layer concepts such as ontologies to define the context, and medical and physiological constraints. On that basis, we calculate in our

[2] http://en.wikipedia.org/wiki/Model_View_Controller

implementation which games we propose and which exertion level we suggest. The *Service Layout Manager* dynamically checks any new state of the user context and updates service visualization user interface with new exergames and health related services.

## III. IMPELEMENTATION

We have developed a proof of concept framework, which utilizes the ubiquity stack (see Figure 1) to integrate our previously developed Serious Games for Sport and Health to the user [21]. *Heterogeneous Service Aggregator* leverages different layers of open stack, which is implemented using open source protocols and APIs. Because all of the layers of open stack can be implemented with existing PHP libraries, we have deployed them within a PHP framework called XAMPP[3], which acts as a web server. We have configured PHP modules as a XAMPP service cron that can be configured to automatically run at a specific interval to discover any update to a user's chosen service list. Some of the developed services are third party web services and some are developed as part of this research initiative. The third party web services' clients use either proprietary or open source APIs.

The Visualization Interface has been implemented using open source web portal iMoogle[4], which uses PHP and JSON to dynamically control the layout and content of each portlet. iMoogle portal is based on JavaScript and the number of portlets, their layout, spatial location and the size of each of them can be dynamically changed by server side PHP script. The portal uses two metaphors; one is grid-based and the other is based on a sliding window. We provide an authoring interface to facilitate a user in associating a service with context(s).

Our implemented system leverages the previously recorded vital parameters and the information [17], [15], [21]. As sensor we added the EZ-430 Chronos Sports Watch and the Daum 8008 TRS 3 ergometer bike. With these two devices we can measure the activity of a person in real time. The EZ-430 measures acceleration, temperature and height of a person and together with a chest belt, we can measure the heart rate variability and the speed. The advantage of the watch is that it is generally worn for the whole day at the same part of the body. During our previous tests with the smart phone, we had the problem that we were not able to record accurate acceleration data [15], [15], since some people preferred to put it on the table or in their jacket. We implemented a RESTful Interface to transmit the acceleration data in real time [15]. In this way we detect longer periods of calm work and suggested suitable Serious Games, such as our Y-Move Game [21]. This Game is a simple car racing game which is controlled by the movement of the player's head. The movement is recognized via real time face detection. The aim of this game is that the player moves his back.

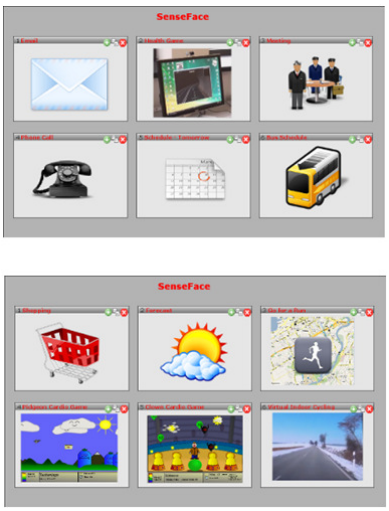


Fig. 2. Visualization interface showing different services, according to the context of the use: top-at work and bottom-at home.

To follow our previously mentioned scenario, we used the acceleration, temperature, and height to calculate a "stress-level", and depending on the calculated value we suggest different games as shown in Figure 2. The top screenshot shows the interface during the context 'at work'. The user is proposed to play the Y-Move game after reading one important email. It is enough time left to play the game until the meeting starts. After the meeting, he has to do a phone call, update the schedule for the next day and needs the bus schedule for his way back home. The bottom screenshot depicts a situation at home. He/she has to do shopping first and then he/she should check the forecast to decide if he/she feels comfortable to do outdoor sports. We do not want our games to be seen as a substitute for 'real sport', rather we take weather forecast and actual time to suggest outdoor activities if possible. Since he did not perform cardio training yesterday, the user is proposed to go for a run (a track is suggested with the assistance of a web portal), or to play one of the cardio exergames.

The dynamic visualization module employs the ubiquity stack explained in [17] to dynamically map a set of services based on the most recent user context available from the context extraction module. It also uses a dynamic *Service Layout Manager* component that can adapt the user portal as soon as user context changes. We implemented a RESTful interface to include the measurements during the ErgoActive Game (see Figure 3) in the calculation which game to suggest next time. For our approach the interface does not need to be real time,

[3] http://www.apachefriends.org/en/index.html
[4] http://www.moonkiki.com/imoogle/

but now multiplayer functionality or tele-medical assistance is possible. If the user did some exercises the day before, he/she is suggested to go for a walk or to play Yoga or Pilates games or cardio games on a lower intensity level.

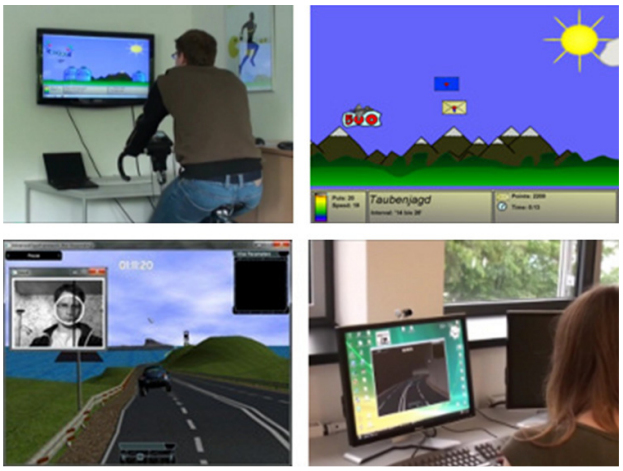


Fig. 3. ErgoActive (top) and Y-move (bottom), two of our previously developed Serious Games [21] which are now Context-Aware.

## IV. TEST RESULTS

To evaluate the effectiveness of the proposed system we conducted a subjective evaluation test, which is based on a sample of 95 test persons with about 25% female users, which was conducted between May 15, 2010 and November 30, 2010. The majority of the users belong to an age group older than 25 with 45 users under 25 years. All the test subjects used various internet based services in different scale in the past 4 to 6 years. About 20% of the test subjects are non-technical and they use the Internet sparingly only at their home desktops or laptops. Every user was requested to test the framework at different locations and time for duration of their choice. The user's satisfaction was measured with an online questionnaire which was based on ISO 9241-11[5]. To facilitate the testing process, we created demo accounts for each of the services and kept it operational for about a year prior to this usability test so that users can see the content of each service. However, some users were kind enough to provide their login information, with the assurance that current testing infrastructure would not store any personal or login information in the server.

Around 70% users on the average strongly accepted the notion about importance of user context, 25% users showed their positive view and the rest were undecided. Around 65% of the subjects strongly supported the idea of incorporating sensors to monitor different vital parameters and to suggest activities based on their contexts. 30% of the subjects showed a positive tendency towards the above and 5% did not have any clear opinion. Moreover, some users raised the privacy issues while others were concerned about the prices of those sensors. Some showed pessimism to carry them always to get those services. Additionally, users were presented with several services as proof of concept to demonstrate the usefulness of extracting live content that might carry important context information such as weather data, location, and addresses in maps, events from calendar and sensory data, to name a few. User feedbacks show encouraging prospect of the concept that contents pulled from services may carry important information that users are interested about. The idea of dynamic service suggestions, such as the most fitting Serious Games at the right time was strongly accepted by 65% of the users, 30% gave their consent and 5% were unsure.

[5] http://en.wikipedia.org/wiki/ISO_9241

## V. CONCLUSION

In this paper, we presented a framework to add user context with Serious Games for Sport and Health. We successfully demonstrated that it is possible to design such a framework by leveraging different technologies together and our previously designed ubiquitous social network stack. We showed that the system is accepted by the user and we found open issues for our scenario. The amount of existing games is small, only a few of them are configurable and provide accessible interfaces.

We exploited the open stack of Internet and added an overlay on top of it to make Serious Games for Sport and Health context-aware. We conclude that sensory data coming from body sensory network can provide us with rich contextual information in addition to user context coming from social networks such as calendar, to-do list, weather networks, and historic context profile. Using off the shelf hardware, social network application programming interfaces (API) s and open source tools, we were able to build a prototype context-aware system through sensory data input from a personal body area network and multimedia information from social networks and applied it in the e-Health domain.

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