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Providing Emotional Support to Children under Long-Term Health Treatments

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Abstract**—**Patients under health treatments that involve long stays at a hospital or health center (e.g. cancer, organ transplant*s and severe burns*), tend to get bored or depressed because of the lack of social interaction with family and friends. Such a situation also affects the evolution and effectiveness of their treatments. In many cases, the solution to this problem involves extra challenges, since many patients need to rest quietly (or remain in bed) to their being contagious. Considering the weak health condition in which usually are these kinds, keeping them motivated and quiet represents an important challenge for nurses and caregivers. This article presents a mobile ubiquitous game called *MagicRace*, which allows hospitalized kinds to interact socially with one another without putting to risk their sensitive health conditions. The game does not require a communication infrastructure at the hospital, but instead, it uses a mobile ad hoc network composed of the handheld devices used by the kids to play. The usability and performance of this application was tested in two different sessions. The preliminary results show that users experienced positive feelings from this experience.

Keywords**—**Ubiquitous game, children's emotional support, social isolation, mobile collaborative interactions.

I. Introduction

HOSPITALS and many other healthcare institutions count on isolated areas to accommodate children who require specific medical treatment. Typically, these rooms are decorated and set up especially to host children. The patients requiring long-term treatments (e.g. for cancer, organ transplants, severe burns or chronic kidney disease) are located in special rooms, often in isolation. Their compromised health condition increases the risk of being infected by others whom which they are in contact. Usually, physicians and nurses working in these areas, and also personal caregivers, are the only people in contact with these children. Many children experience severe boredom, and often become depressed. As many have to spend a long time in bed, the problem is exacerbated and challenging. It is well-known that the patient's mood affects their immunological system, in turn, affecting their ability to take well to a treatment and their illness in general [1]. In this scenario, promoting a good mood and feelings of well-being seems to be the best practice.

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This research project takes advantage of the fact that the kids' rooms are usually situated close to one another and also to the fact that most of them are able to use technological solutions. Based on this, we have developed a ubiquitous game called MagicRace, which embeds collaborative features as a way to allow social interactions among kids, and thus, improve their mood. Because these kids typically undergo similar types of treatments, they become more open to social exchange of comments about experiences and end up supporting others that eventually suffer depression. Moreover, most periodically attend healthcare centers, not only to receive treatments, but also for periodic checkups. This allows both kids, and caregivers, to get to know each other where caregivers can become part of a patient's informal community, which usually plays a positive role in treatment protocol [2].

MagicRace takes advantage of this situation and enhances these social links among the kids. The game runs on handheld devices (particularly PDAs and smartphones) and uses a Mobile Ad hoc Network (MANET) [3] to support the communication among these devices. Since the communication is wireless, the patients can interact with each other from their rooms, thus avoiding risk of possible contagious contact.

Next section presents the related work. Section III discusses the main requirements and design decisions that guided the development of game. Section IV describes the developed application and its main components. Section V shows and discusses the preliminary results. Finally, Section VI presents the conclusions and the future work.

II. Related Work

Several studies support the idea that social networks and social interactions may enhance the quality of life of older adults and also children [2], [4]-[6]. Some social applications have shown to be useful at addressing the isolation and anxiety that some feel when they are undergoing long treatments in hospitals and also at home. An example of these applications is MEK (Mobile Exchange of Knowledge), a software tool that helps detect, in a ubiquitous way, patients or relatives with similar interests [7]. After that, MEK allows these people to exchange particular knowledge, e.g. treatments or experiences. Another example is ePortrait -- an ambient display that allows family members to share pictures [1]. The application was designed to connect elders (e.g. grandparents) with the rest of the family; therefore its user interface requires a low cognitive load. Sharing pictures, family members help boost the elder's mood, positively affecting their overall mental health condition.

In the same context, other researchers have studied the relationships between Internet technologies and the emotional and social support for hospitalized patients. For instance, Barrera-Ortiz et al. [8] present a study about how to support chronic diseases using ICT social tools. Eysenbach [9] discusses the role of the Internet as an information source for patients with cancer. Felset al. [10] propose a system based on smartphones for helping hospitalized children to be connected with their respective schools.

There are also several volunteer-based organizations that try to address this challenge. For example, "Magic by a smile" (www.magiaxunasonrisa.com) is volunteer-driven initiative created by students of several health programs at the University of Chile. The mission of the program is to visit hospitalized kids and perform magic shows as well as balloon modeling sessions. Although this way to address the problem is highly effective, these sessions can be done just during pre-established times and they cannot involve kids with weak health conditions. For that reason, we have developed MagicRace, as a way to compliment activities performed for these kids. The proposed game allows children to interact and have fun at any time, and we intend to contribute to ways of boosting and maintaining their fragile moods.

III. Software Requirements and Design Decisions

The first step in the *MagicRace* conception was the definition of the game goal and its main characteristics. In that sense we established that the game should be able to increase the interaction between users and include social components. Since these children spend long periods at hospitals, the game should involve several levels to allow users play for a long time, and also to advance according their own expertise.

The game should be attractive and collaborative to keep the interest of the users and also allow children to socialize with one another, as they form teams through such interaction. It must also be able to automatically detect potential players connected to the gaming space, and thus to facilitate the users participation.

It was also considered as an important requirement that the application consumes few computing resources, to ensure that the game would run in mobile devices with limited hardware capacity, such as PDAs. This constraint will allow volunteer organizations supporting these kinds to collect outdated devices and recycle them to be used with the stated purpose.

The application should be as ubiquitous as possible to allow kids to play the game in a transparent way and independent of the place where they were located. Therefore, we decided to use a Mobile Ad hoc Network [3] to support interactions among the players, to avoid thus, the dependence on pre-existing communication infrastructure and also the use of the hospital resources. The MANET should have routing capabilities to ensure that kids located on non-contiguous rooms can play together.

The target population for the game was kids between 4 and 12 years old. With these requirements in mind we try to figure out which gameplay should be the most appropriate to reach the stated goal. Several existing games were analyzed and finally, two possible options to implement our gameplay were selected. These games were "Taxi Gone Wild" and "Backyard Sports: Sandlot Sluggers Mini Game", which are available at the Yahoo Web site for children (http://kids.yahoo.com). In "Taxi Gone Wild" the player drives a taxi and he/she must drive safely to complete a certain distance in a certain time. The game is simple and allows a player to advance to more complex driving scenarios, depending on his/her previous performance. Although the game is interesting, it is not collaborative or ubiquitous.

In "Backyard Sports: Sandlot Sluggers Mini Game", the player is the batter in a baseball game. As the player improves his/her performance, it is possible to advance through various game levels. These two games inspired the design of the gameplay of *MagicRace*, a car race that includes several “magic objects” and that allows players to participate in teams.

In order to manage the game design appropriately, we separate the design concern in four components: *User Interface*, *Gameplay*, *Interaction Support* and *Local Data*. The result was the layered architecture shown in Fig. 1.

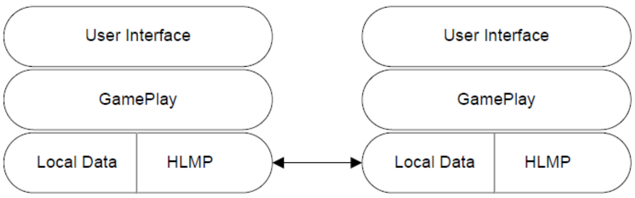

Fig. 1 Magic Race basic architecture

The *user interface* should be simple, as it must be addressable by devices with constrained hardware resources. After evaluating several alternatives we decided to use bitmap tiles as the components of the user interface. This strategy to compose and manage the user interface allows the game to store the tiles required to build the game scenario in real time, eliminating the need to build the tile on the fly and then showing them on the gaming scenario. This reduces the resources consumed by the game. Moreover, the tile change was addressed by analyzing, tile by tile, in real-time. Here, tiles did not require unnecessary changing. This also helps minimize the use of the hardware resources used by the game.

The technique used to redraw the bitmap tiles that need to be changed is known as “Off Screen Bitmap Technique for Painting” [11]. The technique allows the creation of a bitmap out of the screen, building the graphics to be shown and finally showing the resulting bitmap on the right position of the user interface.

The *gameplay* is the component that controls all actions performed by the game. This component embeds and manages the logic of the game and its objects (e.g. car movements, changes in the gaming scenario, avatar behavior, teams and their scores. The game play is described more in-detail in the next section.

The interaction among players is supported by middleware called *HLMP* API [3]. This middleware automatically creates a

MANET with the devices that are physically close and also manages user connections and disconnections ubiquitously. Therefore, users do not have to be concerned with networking issues. HMLP provides several functionalities, which have been used by MagicRace, e.g. the users' identification, the ubiquitous management of the MANET, message routing, file transfer, session management and a chat. The use of this middleware as support for user interactions allows us not only to simplify the game development process, but also to address challenging requirements, such as the ubiquity of the game and its capability to run on devices with constrained hardware resources.

Finally, the *local data* component stores the circuits and tiles required to play the game in a local repository without requiring external support. Therefore, just the actions of the players are transmitted through the MANET in real-time. Since such information is lightweight, its communication among the nodes participating in a race does not produce an important impact on the response time perceived by the users.

The local data component is also used as a temporary repository by the gameplay to keep all information related to a race (e.g. participants, circuit, complexity level, cars relative position, location, scores and energy). This component also stores the history of races and participants, allowing a player to recognize other players when they are connected to the MANET where they can eventually interact with them through a new race or just using the chat.

IV. The Gameplay

This game involves several players and several stages depending on the drivers' expertise. The players can participate as independent drivers and also in teams. When they play in teams, each player receives points according to his/her final position in the race. The team members points obtained in the race are computed as part of the team score and the team that obtains the highest score is the winner. Therefore, it is important that the participants have a team strategy to race, thus, increasing their chances of winning the race.

Four teams were predefined in the game and they were identified by the color of the cars (teams blue, green, red and orange). Each team may have many participants. All cars participating in the race start the competition with a certain amount of energy, and as the car moves it can gain or lose energy depending on the driver's actions. For example, every time the car goes off the road or moves in the opposite direction, it loses energy. On the contrary, if the driver does not make mistakes for a certain time period, the energy of his/her car increases until reaching the maximum. The amount of energy determines the maximum speed that a car can reach.

During the different stages of a race, certain "magic objects" appear on the circuit. When the car passes over one of these objects, its behavior changes. Therefore, these objects can help or harm, not only the player, but also the team. The game considers four types of magic objects depending on the effect these objects produce: personal positive, personal negative, team positive and team negative. Objects in the first two categories affect just one player and those in the last two categories affect the whole team. Fig.2 shows the positive personal magic objects.

Fig. 2 Magical objects in the "positive personal" category

The stars increase the speed of the car. The ghost makes the player invisible to other players for five seconds. The fruits allow a car to recover part of the lost energy. The first-aid kit lets you recover all lost energy. These magic objects appear randomly during the race, therefore making every race different from the previous one, even if the same circuit is used. The objects appear more frequently in later stages of a race, and in particular, the positive ones appear more frequently than the negative ones. The current prototype has 30 different scenarios or circuits. Fig. 3 shows an example of the interface of the prototype.

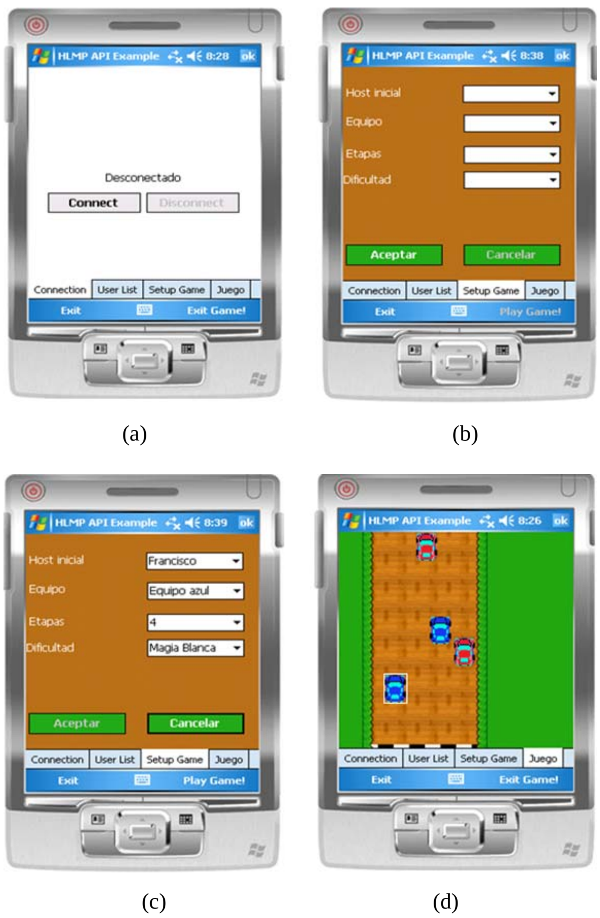

Fig. 3 The MagicRace game interface

The game user interface includes four tabs that are shown at the bottom area of that interface: *connection*, *users list*, *setup* *game*, *play*. These tabs group functionality or services provided by the game.

The first tab (Fig. 3 (a)) includes the functionality that allows potential players to connect to a MANET. The MANET represents the shared space where the users can see each other and interact via a chart to organize the racing teams, agree to circuit use in a race and discuss racing strategies with teammates.

The second tab of the game user interface shows a kind of "buddy list", where all users currently connected to the MANET appear. The buddy list also indicates the quality of the connection between the local user and the rest of the people. Such quality is determined by the number of hops required to reach a certain user. Through the buddy list the users can perform point-to-point interactions and also share files.

The parameters of the game can be configured using the functionality shown in the third tab (Figs. 3 (b) and (c)); e.g. the teams that participate, the stages involved in the game, and the complexity level of the game. The last tab (Fig. 3 (d)) is for starting the game. In that screenshot we can see two teams participating in a race, and the white square indicates which car is being controlled by the local user.

The position of a player during the race is updated as it passes through certain checkpoint. The checkpoints are represented by orange cones. Each race consists of several laps around the circuit. The difficulty of the game is directly related to the speed at which cars move.

The first user who joins a particular race becomes the host of that race. The rest of the users connected to the MANET can choose to create a new race or join an existing one. The host user is the only one able to configure the race.

V. Preliminary Results

The game was evaluated using two instances. The first one evaluated the application usability involving children without health problems. The second evaluation was focused on the application performance and it involved computer science students from the University of Chile. The following sections present and discuss these preliminary results.

A. Usability Evaluation

This evaluation involved a group of five children ranging between 9 to 14 years old. The objective of this pilot experience was to evaluate the gameplay and also the user interface.

One important aspect to evaluate was the meaning of the icons representing the magic objects. Therefore, it was validated in order to determine if the users assign the same role to the icons as do the game designers. Therefore, the first step was to know if the icons represented something positive or negative to the children. Then, we had to assess whether the icons affect a single user or the whole team, according to the icons' role described in Section IV.

In order to evaluate this aspect of the game, cards with the used icons were delivered to the children. We then asked them to order the images from "good" to "best". After that, we asked them to separate icons affecting a team, from those affecting a single player. The result of this first assessment indicated that 80% of the icons fulfilled the objective; i.e. the roles assigned by the users were the same than those assigned by the game's designers. The remaining 20% of icons required minor modifications to reach their design goal.

The assessment of the gameplay required the children to play in pairs for approximately 20 minutes using PDAs, and then they were interviewed. The opinions expressed were highly satisfactory. As was expected, the children did not care that the devices were old-fashioned or that the graphical quality was not the best. The most important issue for them was the possibility to play with friends at the same time, which is (according to them) "much more entertaining than playing alone". This confirms the research findings indicating that the most important thing in the development of video games is the gameplay and not the user interface. A fun, well-designed gameplay, is much more important for the game success than a good GUI. For instance, Prensky [12] states that "great games are about gameplay". The graphical interface (called "eye candy" in the videogames design context) is very important, and recent technology advances allow for the creation of interfaces that are as realistic as those of a TV program. However, the most important part of a game is the "gameplay", which refers to the semantic of the actions done by a user while playing.

Another aspect evaluated in this experience was the need to include sound in the game. To evaluate this aspect we asked the children if they considered sound to be important for *MagicRace*. None of them had noticed that the game had no sound, but everyone responded that they would like *MagicRace* to have sound, despite the fact that they did not consider that sound much affected the game attractiveness.

The users also suggested that circuits should have arrows to indicate the right directions to follow. They also suggested increasing the complexity of the races while it advances through the different stages.

B. Performance Evaluation

The performance of the game was tested using PDAs as a way to ensure the application response time is acceptable on handheld devices with constrained hardware resources. We also evaluated the message routing capability of the process as a way to indicate how far two users that decide to interact using the game can be.

Two settings were used in this evaluation process. The first one (see Fig. 4) involved five PDAs located in a line, and the second one used the same topology but involved six nodes (i.e. it included the node with dashed line in Fig. 4). Every node was not able to reach non-contiguous nodes. The evaluation was done at the facilities of the Computer Science Department of the University of Chile.

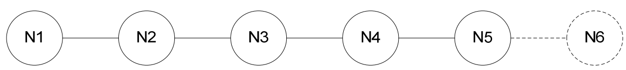

Fig. 4 Settings of the performance evaluation process

The PDAs where located in several rooms simulating a hospital, and the users (i.e. computer science students) played the role of hospitalized kids. The distance between PDAs was approximately 20 meters; therefore there were 80 meters approximately between the nodes N1 and N5, and 100 meters in the second setting. All devices were the same HP IPaq Hw6515, which have a CPU of 312 MHz, a ROM of 64 MB and a RAM of 64 MB.

The evaluation process involved two races by each setting. The first setting involved 2 teams composed of two players each. Nodes N1 and N4 played against N2 and N5. Node 3 was used just as an interim point to support the communication process. In the second setting nodes N1 and N5 participated as a team against nodes N2 and N6. In this case, nodes N3 and N4 acted as intermediaries.

During the each game, we have monitored the eventual nodes disconnection to try identifying the limits of the communicationinfrastructure. After participating in each game setting, a discussion ensued to exchange opinions and mainly get user feedback. The main issue to evaluate was the response time perceived by the end-user.

The obtained results show no node disconnections in the first setting and only one disconnection in the second setting. Since HLMP automatically tries to reconnect any device after a disconnection, the connection was reestablished after 10-15 seconds. The main consequence was that the local user was not able to visualize the position of the other players during such a time period. Although they were not part of the target population, all users found the game entertaining.

The participants mentioned that the response time of the game is acceptable in both settings; however, they perceived that the car positions of remote participants were not updated in real time. This feature was perceived more clearly in the second setting, which is probably the maximum distance attainable by this application. In this sense, further evaluation will be required to determine the limits of this application. We do know that the game can be played at least in areas where the kids' rooms are near or contiguously located.

VI. Conclusions and Future Work

Hospitalized kids are usually affected by changing moods due to their social isolation produced by treatments; particularly when these treatments are drawn out over time or the kids must be remain in his/her room. Their mood affects body defenses, hence the importance of promoting healthy mood boosting environments.

To deal with this issue, this article proposes the use of an ubiquitous game, called MagicRace, that runs hardware constrained devices connected through a MANET. The game allows social interactions among hospitalized kids through various mechanisms: playing, chatting and sharing file (e.g. pictures). The usability and performance of the game was evaluated in two different scenarios. The obtained results are still preliminary and they are not enough to draw strong conclusions. However, these results indicate the game is ready to be used in a real setting involving hospitalized children. This is exactly the next step of this initiative. We expect that this collaborative ubiquitous game could serve as an emotional support for these kids.

We are also continuing the process of evaluating and improving the game performance; particularly the network communication support, to extend the physical scenarios in which this game can be used.

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