Hunting Relics: A Collaborative Exergame on an Interactive Floor for Children

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Abstract
Exergames on interactive floors are appropriate to promote exercise and socialization in ludic environments. However, they lack of mechanisms to help children of early age to develop age-appropriate motor skills. In this paper, we present the design and development of an exergame to promote the collaborative exercising in young children (4-6 years old) using interactive floors. Also we take advantage of the socialization aspects catalyzed by interactive floors to promote collaboration among potential users. We close discussing design considerations, we argue an interactive floor exergame should incorporate to appropriately promote exercise and collaboration in young children.

Author Keywords
Exergames; interactive floors; motor skills; collaboration; children.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): User Interfaces - User-centered design; K.8 [Personal Computing]: General - games.

Introduction
In Mexico, around 34% of children are obese and overweight. During the last years, the incidence of

Figure 1. Observation of children during exercise session

Figure 2. Participatory design session. Children playing with the preliminary prototypes.

obesity and overweigh in young children (2 – 4 years old) is growing up [4], affecting individuals' quality of life and motor skills development. Motor functioning is important for young children to help them learn, explore the environment, gain body awareness, support self-expression and socialization [2].

It has been demonstrated that exergames on interactive floors are appropriate for young children (4–6 years old) and promote exercise, entertainment and socialization [6]. In this paper, we describe the design and development of Hunting Relics –an interactive floor exergame that incorporates mechanisms to develop motor skills and collaboration in young children. Hunting Relics supports exercising following a 3-steps model appropriate for children (warm-up, active exercising, and cool-down) according to a physical education session [1] and promote collaboration through three social mechanisms (i.e., transitions of turns, task division and work together).

Related work

Several projects have investigated exergames on interactive surfaces to support learning and movement (*e.g.* iGameFloor [3], Fish game [5], Stomp [6]). A promising application is the Stomp platform [6], this is an interactive floor that has a set of educational open-ended games for learning math and gross motor skills. This study shows that using exergames on interactive floor benefits exercise, socialization and cognition. None of the latter referred studies show how an exercise session to develop motor skills in young children must be done, and they do not promote the collaboration mechanism needed for the team work. Therefore, there is a research opportunity to design exergames to get the children practice collaborative exercise properly.

Design methods

To design our exergame, and determine a set of exercises, collaboration mechanisms and interaction model appropriate for young children, we followed a user-centered design methodology. We conducted a qualitative study at 2 kindergartens in Mexico. Our data inquiry process involves 6 semi-structured interviews, (with kindergarten (n=2), physical education (n=3) and art (n=1) teachers), 5 hours of passive observation of children when exercising (Figure 1), and 1.5 hours of passive observation of children using a commercial interactive floor with advergames. We used the results of the qualitative study to develop 2 high-fidelity prototypes running on the commercial interactive floor DEFI[1]. We conducted 3 participatory design sessions (Figure 2), that included a multidisciplinary team including children (n=7), kindergarten teacher (n=2), HCI experts (n=3), and designers (n=1). We used the results of our design sessions to define a low-fidelity prototype and re-design it before develop.

Hunting Relics

The results of the qualitative study indicate that an exercise session should have three phases to the adequate practicing of motor skills: warm-up, active exercising, and cool-down. We also found out role-modeling help children to adequately practice gross motor movements before exercising, particularly those exercises related to eye-foot coordination (e.g. track a line, avoid objects, jump on a target). We also uncovered the three collaboration mechanisms

[1] http://www.defi-interactive-projection.com/

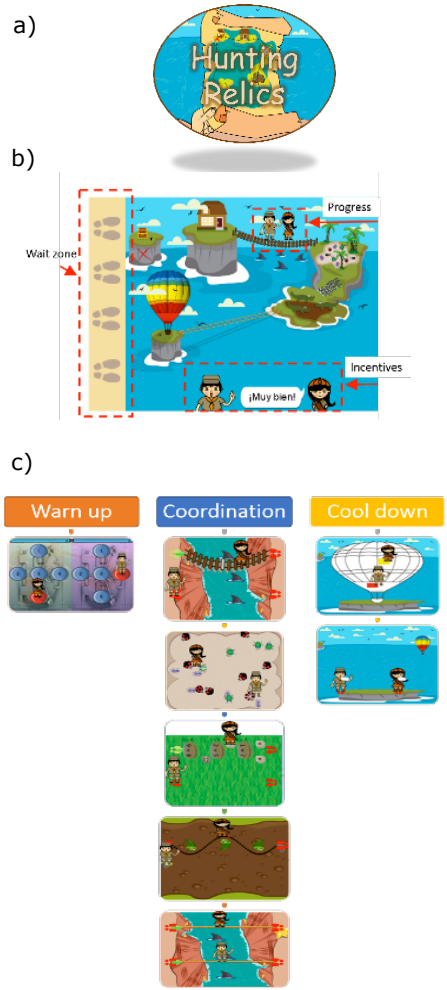

Figure 3. Hunting Relics screenshots. a) Logo. The game star with a short intro about the story; b) Interactive map to show the levels of the game, and awaiting zone to

appropriate to promote the collective exercising, including transitioning turns with waiting zones, task-division and work together to complete the level.

We used these results to design "Hunting Relics" (Figure 3a), an exergame where children practice different motor-exercises to help two scouts when hunting for their father's lost relics. To get the relics, the scouts should avoid obstacles practicing basic eye-foot coordination exercises. Children must help the scouts to go through seven levels (Figure 3c) available on an interactive map (Figure 3b). The scouts walk forward the map after completing a level. For each level, Hunting Relics provides a role-modeling tutorial about the exercises children should practice on each level, and the collaboration mechanisms.

In the first level, as a warm-up activity, children collaborate to help the scouts get the treasure map from a safe. To open the safe, all children foot-tap on the numbers corresponding to the safe's code. In the next five levels children need to practice basic foot-eye coordination exercises (Table 1). In the first coordination level children help the scouts to cross a swinging bridge to arrive to the adventure island. In this case, one child at a time cross the bridge while the rest wait for their turns in the waiting zone.

At the adventure island all children together stomp the bugs randomly appearing in the sand by foot-tapping on each bug. Then children solve math problems by stepping on the correct "stone" mimicking the game of hopscotch by turns. Next, children must walk through the marsh avoiding crocodiles by zigzagging in turns. Finally, children all together tightrope walk to reach the colors island.

Upon arrival, and as a cool-down exercise, children must color a white air balloon walking and then blow it to help scouts reach the treasure island. At the treasure islands, the scouts open the treasure and get the relic.

Developing Hunting Relics

Hunting Relics runs in an indirect optical sensing interactive floor.

Hardware

The interactive floor of 2x3m. of size (Figure 4), uses the Kinect sensor placed 1.80m. over the floor to infer the user's location and a DLP short-throw projector with a 0.3x0.3m mirror mounted vertically on a base placed 1.50m over the floor, connected via USB and HDMI respectively to a PC i7 with 6G RAM. The PC runs the gameplay scheme controlling the game dynamics.

Software architecture

Hunting relics uses the TSPS 1.3.7[2] library for getting the data captured by the Kinect sensor and inferring the location of the player. We used the Processing language to develop the multimedia interfaces, and the OSC protocol to send the information of the player from TSPS library to the Processing interfaces updated to portray the corresponding game effect. This effects are projected on the floor and including audio to complement the gameplay.

To promote scalability and maintainability we followed an oriented-object paradigm. The exergame has three logic layers: GUI, exergame logic, and calibration data. With this, the developer can develop more levels by

[2] http://www.tsps.cc/

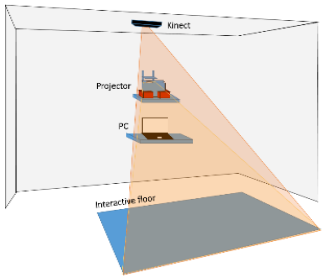

Figure 4. Interactive floor hardware

Exercise	Collaboration	Level
Warm up (Jumping)	Task division	Searching the map
Coordination (Track lines)	Shift	Swinging bridge
Coordination (Stepping)	Task division	Stepping bugs
Coordination (Jump on target)	Shift	Math stones
Coordination (Zigzag walking)	Relay	Marsh crocodiles
Coordination (Track lines)	Together	Tightrope
Cool down (Walk /breathing)	Task division	Colored island

Table 1. Hunting Relics levels

using the collaboration mechanism implemented, and extend the classes to provide information of the player (*i.e.* location), without affecting others levels, the GUI, or the calibration data. Both TSPS and Procesisng are multi-platform that enables flexibility.

Discussion: Design Consideration

As a result of the design and development of Hunting Relics, we identified the following design considerations and requirements:

- The exergame should have a background story to immerse children in the game dynamics, we found this is a strategy specialists use to keep children engaged when exercising. In our particular case children must help the scouts to hunt the lost relics.
- Instructions should be short and mimic role-modeling to help young children to understand the activity.
- The physical activity should have three phases: warm-up, active exercising, and cool-down.
- Collaboration mechanisms should involve a combination of taking-turns, task division and work together.
- The software architecture should promote scalability, maintainability and flexibility to enable the easy changes in the game dynamics.

Conclusions and Future work

In this paper, we showed the design and development of an exergame to promote the collective exercising in young children. The main contribution of this demo paper is to present a set of design considerations and developed prototype showing how an example scenario of an exergame supporting the collective exercising. So far we have explored the design space, however, we plan to conduct a study to assess the user experience of using the interactive floor and the collective use of the exergame.

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