# Curball – a prototype tangible game for inter-generational play

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## Abstract

*Older people have been the focus of research for ubiquitous computing applications. While many of these are understandably focused on health and aging in place issues, there is also considerable opportunity to support more playful aspects of life as an older person. We report here on a prototype collaborative game that can be played between an older person and a child. The game is based on a bowling game and makes use of tangible devices, sensors and augmented reality components. We report on the iterative development of this inter-generational play prototype and initial user feedback.*

## 1. Introduction

The world population is aging; the proportion of older people will continue to increase. To give an example[1]: in 2002 33.5% of the UK population were over 50 and this is expected to increase to 37% by 2031. Hence, it is not surprising that older people (defined by UK National Office of Statistics as 50 and over) are receiving more attention as a focus for ubiquitous technologies research. This can be seen in a number of areas: the extensive offering of conference workshops which bring practitioners and researchers together such as "HCI and the Older Population" [3]; the shift of industry research, e.g., Intel's Proactive Health research project[2] which looks at "helping the elderly age gracefully at home"; and the allocation of research funds, e.g., the EU FP6 call on 'ambient assisted living' which aims to "To extend the time elderly people can live independently in their home environment with the support of ICTs"[3].

Many applications in the field of technologies for older people concentrate on the health domain and aim to support aging in place. For example "The CareNet Display" by Consolvo et al enables remote family member to keep "an eye on" their older relatives [1]. Other areas receiving considerable attention are activity monitoring e.g., [10] and Alzheimers support e.g., [9].

However, the potential space of applications for older people is much larger than just health monitoring. What about people who are still well? What about other aspects of life, especially those that contribute to quality of life, such as interactions with friends and family, engaging in hobbies and leisure activities and so on? While there is some attention being given to supporting communication between older people and their families, as above with [1] and other examples such as the messageProbe [8], games and more playful activities have received less attention. Yet research suggests that games might be well received by older people, given their current level of activities with computers and with games.

Datamonitor[4] identifies the over 55 age group as the fastest growing online population in the US with 22% of people of retirement age with internet access; similar patterns have been identified in the UK (e.g., "Silver Surfers day targets the over 50s" , The Register, 21 May 2004). Jimison et al ., [9] in the US context report that over a third of internet users over 65 play online games. Goodman et al [4] also found that of the over-55 people online in their study, 47% played computer games; further, while the use of the internet and email decline with increasing age the use of games did not. Our experience based on informal interviews with older people revealed that communication and collaboration are an important driver for using computers.

Hence, a potential application area for ubiquitous and tangible technologies is to support older people having fun and staying in contact with other people. One opportunity to combine having fun and interacting with others is given by distributed collaborative games that can give older people a possibility to make

[1] http://www.national-statistics.org.uk/cci/nugget.asp?id=874
[2] http://www.intel.com/research/prohealth/
[3] http://www.iserd.org.il/ist/2.6.3AmbientAssistedLiving.htm
[4] http://www.nhionline.net/products/datamonitormr36.htm

creative, playful and social use of their leisure time. In particular, there is an opportunity to support play between an older person and their grandchild. In exploring older people's use of leisure time, Tarling [11] found that much of older people's interest in games was around the opportunity they provided to spend time with grandchildren. They would report stories of playing simple games repeatedly and for hours on end because of the incentive of quality time with the child (time that the child is less willing to give if it were for 'pure conversation'). Playing however involves in most cases a lot of communication which is only in parts to facilitate and coordinate the game.

This paper presents the iterative development process, from the initial idea to an in-lab trial, of a prototype for a collaborative ubi-comp game to be played between an older person and a child. The game we report on is called 'curball' and is based on the notion of a bowling game where a tangible ball with embedded sensors is 'thrown' by an older person, which sets the ball virtually rolling on tangible augmented-reality (AR) tagged obstacle board at the home of another e.g., grandchild. Both parties have to collaborate to enable the virtual ball to successfully roll to the end of the board.

The structure of this paper is as follows. First the idea-finding process with initial user feedback is described. The next section explains the original game idea. This is followed by a description of the three development iterations. Finally the conclusions of the in-lab trial after the last iteration are discussed and a view on further work is given.

## 2. Concept Generation

This work took as its starting point the research by Tarling [11] that suggested that playing with grandchildren is an important incentive for older people to play computer games. Collaborative aspects and the opportunity for informal communication are of importance for such games. This set an initial requirement that a game should be exciting for a child and of interest to the older person. Another requirement that we set was to use objects which are already known by the people to lower the initial effort for learning.

With this in mind, we conducted brainstorming meetings, to explore possible connections between items you have in a household, and already-existing games. Based on the ideas of the brainstorming meetings, we decided on five game ideas: Mastermind, Hot and Cold, Distributed Bowling, Darts and Augmented Pets.

We developed concept sheets with short descriptions and sketches of these game ideas and showed them to two potential players to get their feedback. We also gave them demonstrations of how sensors can work to help bring the ideas to life a little more. For example, an early prototype of a ball as an input device illustrated a kind of a bowl game in which one ball can be "thrown" with a sensor. The demonstrations were realised with phidgets[5] [5] and ECT toolkit [6].

The participants were a couple in their mid fifties who had two grandchildren living 30km away. Both participants were familiar with computers. After exploring the games ideas with them, they provided specific comments on each of the games for how they thought it could be improved and who they could imagine playing it with. What was more interesting than their specific comments was what they said around the games, confirming the findings from Tarling [11]: *"I'm not a games person, I've never touched a game; to me a computer's a tool…yet today […] I can see a lot more. It's an interaction thing, as much as the game […] It's using the technology to be able to make contact, to communicate, to me that's the important aspect of it. The actual game that you're doing, I guess that is important, but that's only part of the picture for me."*

Following further discussion with them, it was decided to focus on two of the ideas, hot and cold and the bowling game. The participants could see that both games are cooperative in nature and they expected that they generate a lot of conversation. Furthermore it was appealing that they seemed easy to learn. They also had suggestions for how the games could be further developed in terms of game motivation and rules. Here we focus on the bowling game that was developed through to interactive prototype. The following section describes the bowling game, which we call 'CurBall', in more detail.

## 3. CurBall – Concept Overview

On the basis of the feedback received, we developed the bowling game concept into 'CurBall', a combination of Curling and Bowling. In this game tangible objects as input devices are used. The senior player plays with a physical ball (Figure 1 left). The junior player has a game field with a starting area and a finish area (like a bowling alley) and physical obstacles, which he distributes over the field (Figure 1 right). The goal of the game is to let a virtual ball roll from the starting to the finish area without touching

[5] http://www.phidgets.com/index.php

any of the obstacles. To be successful the players must communicate and collaborate successfully.

Both players have to work together because the senior player sees the game field, the obstacles and the ball on his screen, but he cannot move the objects. The junior player has only the game field with the obstacles and does not see the ball. He is reliant on the other's commands, which tell him the obstacle he has to move so that the ball does not touch it, but the obstacles have to stay on the field.

**Figure 1. Senior Equipment: the ball and a computer (left). Junior Equipment: the game field with the colored objects (right)**

The senior player starts the game by performing a "throw gesture" to decide how fast and in which direction the ball should roll over the field. The ball is bounced by the side walls, so that it always stays in the game. If the ball touches an obstacle, the round is over and the players get points for the distance covered. If the ball reaches the target area they get the full points (see Figure 2).

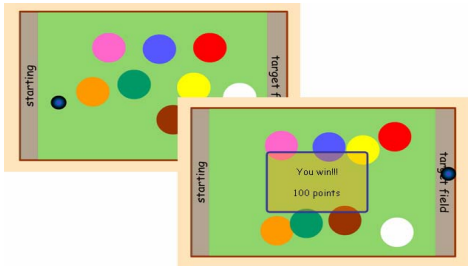


**Figure 2. One game round – brief after the start and the successful end of the round**

## 4. Prototype Development (first iteration)

During the development of the prototype we tried to involve the user as often as possible to get early feedback, so that we were able to adapt the games to the user's wants and wishes.

All in all the final system architecture consists of three components: the game, the ball and the objects component (see Figure 3) which were developed in three iterations. After each iteration user tests were conducted. The prototype consists of two parts CurBallSenior for the senior player and CurBallJunior for the junior player.

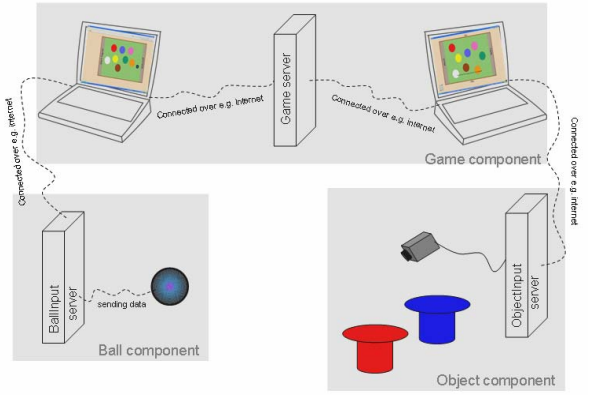


**Figure 3. System architecture of "CurBall". The two game parts CurBallSenior and CurBallJunior are connected to the game server to exchange the game information. In the ball component the sensed ball data are processed and sent to CurBallSenior. The objects' positions are recognized in the Object component and also sent to CurBallJunior.**

In the first step we desinged the game UI which is developed with Flash MX 2004 (Actionscript 2.0).

The game component is responsible for the course of the game and the game communication. For the communication between the two game parts the ElectroServer from Electrotank[6] is used.

CurBallSenior is responsible for the game control of the ball and the collision detection. For collision detection CurBallSenior needs the obstacle positions from CurBallJunior. At any time during the game the junior player can move the obstacles and the new positions are sent in real time to CurBallSenior. If the ball collides with one of the obstacles, sound plays and a message is shown to both players telling them that the game is over and their score.

In order to have a rapid prototype and to test the game component, we decided to develop a computer based version of CurBall. The "throw gesture" in the senior part is replaced by a Drag and Drop movement of the ball to determine the speed and the direction of the ball. The junior player also sees the game field with the obstacles on his screen and moves them via Drag and Drop over the field as if they are physical objects.

Before participants were invited to try these early prototypes they were tested by colleagues from the lab. Their feedback suggested that the idea and the course of the game was understandable. We decided that further user tests with this prototype do not make

[6] http://www.electrotank.com/electroserver/

sense. The real hardware -the ball- is needed to get meaningful feedback from them. Without having a real tangible interface people's feedback was focused on the GUI and hence the value for the final concept was of limited value.

## 5. Prototype Development (second iteration)

A ball for the senior player was designed and the new "Ball component" with the Java program BallInput is described in the following discussion.

The original idea of using the ball is to simulate a throw similar to that which bowling players do to start the rolling of a bowling ball. To make the input easier for the senior player, a push/throw gesture is made (see Figure 4); thereby the ball always stays in the player's hand.


**Figure 4. Throw gesture to the left side, straightforward and to the right side. In the left picture also the x- and y-axis are shown with the calculated angle.**

This push/throw gesture determines the speed and the direction of the ball on the screen. For example, if the player pushes the hand with the ball slowly forward the virtual ball rolls slowly straight forward. Quick movements to the left result in the ball rolling fast to the left and correspondingly to the right.

For the ball, we used a foam ball. For the hardware inside the ball, a particle from Teco[7] was chosen. Particles are small and wireless sensor nodes and thus they are well qualified for applications for ubiquitous computing. More details can be found at [2].

The particle senses the acceleration along the x- and y-axis (see Figure 4 left picture) and forwards that to BallInput. This program calculates from the row data a direction (left or right), the speed and the angle α and sends this results to CurBallSenior and starts the rolling of the ball on the screen with it.

BallInput is not only responsible for the calculation of the speed and the direction. It also affords the TCP connection to the Game Component, exactly to CurBallSenior. All calculated values: direction, speed and angle are sent to CurBallSenior for the further processing.

We then conducted user tests with two people of the right age around the university. The tests showed us that the ball as an input devise was accepted by the participants although one man said that he need more practice to get a feeling for the ball. However, the results showed that CurBall has potential, we will have possibilities to make new levels and to make it more interesting.

The results meant for us, that we could focus on CurBallJunior in the further development. It was necessary to develop the tangible input for the junior part.

## 6. Prototype Development (third iteration)

For the application to support the junior player, the Object component with physical objects and the program ObjectInput are recruited to connect the physical objects to the game component. The Object component and the physical objects are described in the following discussion.

To make the obstacles on the game field tangible we had to find a cheap and easy way to determine the object's position, preferably without needing to aquire new hardware. A good opportunity is described in the paper "Using ARToolKit Markers to Build Tangible Prototypes and Simulate Other Technologies" from Hornecker and Psik [7]. The ARToolKit[8] delivered the necessary information, and the only additional hardware required was a webcam, because it is based on visual detection of optical markers.

For the design of the physical objects it must be considered that the required AR markers have to attach on the top of the object and that during the game the markers are not covered by the player's hand otherwise tracking of the object is not possible. For this reason, our objects consists of a cylinder to make it easier for the junior player to grab the object and we placed a flat round cap on the top with the AR marker (see Figure 5 left picture).

In addition, a game field with a start area and a finish is needed on which the objects can be distributed (Figure 5 right picture). The corresponding visualisation is displayed on the senior player's screen. The fruits on the side walls help to make the interaction between the two players easier, especially for the child. Thus, the senior player has the opportunity to give the instruction "Move the blue object to the apples" instead of "Move the blue object to the left" so there should be less misunderstandings about direction. Overall the game was designed to require collaboration and communication between both

[7] http://particle.teco.edu/

[8] http://www.hitl.washington.edu/artoolkit/

players. But as the setup was distributed it was essential minimize the chances for confusion.

The game field is also equipped with four markers, one in each corner. They are necessary to calculate the width and the height of the field to determine the positions of the object.


**Figure 5. Physical object and how to grab it. (left). Game field with eight phsical objects (right).**

The ARToolKit Framework (which is freely available with many examples on the internet) enables an easy binding to our existing components. An existing example program, which recognizes multiple markers was augmented with our requirements to BallInput.

The camera pictures are analyzed by ObjectInput. Each movement on the field is recognized and sent to the game component. To achieve a relative positioning the distance from each object to one specific corner is determined in percent. CurBallJunior converts the received position values to its coordination system and the corresponding object can be updated.

For the communication between BallInput (Programming language C) and CurBallJunior (Programming language ActionScript) a TCP connection is used. BallInput starts a server and CurBallJunior connects to this server and sends a start command when the game is started. After this the position of the coloured circle on the screen can be updated with the real position of the object, so that there is always an exact match between the real and the virtual "world" (see Figure 6).

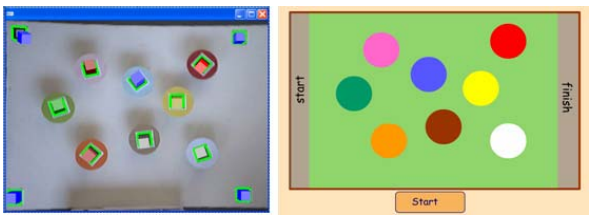


**Figure 6. Camera picture and the corresponding presentation in the game.**

## 7. User Study

A user study was designed to collect information about the acceptance and the handling with the game. Furthermore, we are interested in constructive feedback including other ideas based on the presented idea and suggested improvements, so that we are able to adapt our games to the player's wants.

For our study we recruited two older people (age of 56 – 65) and one child (8 years old). The older people were both female and do not have grandchildren of their own. Both have a computer with an internet connection and described themselves as advanced computer users. Our junior player was a boy who frequently played computer games.

The study had the following structure. At first the junior player was initiated in the game so that the focus during the game explanation and the playing was on the senior players. Each woman was then familiarised with the game before playing six or seven rounds with the junior player. After the rounds the senior player was interviewed. After each of them had played the game, we conducted a final group discussion.

The tests showed that the high communication factor was embraced by both women. But the communication during the game was more on the senior player side "Quick, move the brown to the apples, brown to the apple, browns to the apples". It seemed that the child was too busy during the game with moving the objects over the field to say something.

They saw potential in this game to make it more interesting. It was easy for them to think about new levels, such as making a slower or faster ball, and more or less objects or even different objects, "so that is actually quietly teaching the child" - "Maybe you can use two balls". There were also suggestions to change the game field, e.g., to change the fruits on the walls in each round so there is another challenge to make new arrangements for the new game situation.

The observation as well as the commentaries from the women showed that this game needs more practice to play it, especially relating to giving the right and sufficient instructions for the child. The instructions should be clear so that the child knows what to do. One suggestion was to give the fruits a number, so that you can say "Move the blue object to banana two".

In contrast to the problems with giving instructions, the input with the ball was quickly grasped. They understood quickly how to control the speed and the direction of the ball on the screen. It seemed as if they were familiar with the ball from the first moment: "Yeah it was easy to throw it".

One woman mentioned the problems older people often have in controlling the cursor with a mouse, so that it might be easier for them to use the ball instead of the mouse. But both pointed out the mobility problems older people sometimes have. This aspect should be considered.

One interesting improvement, mentioned from both, was that it might be easier to match the throwing direction from the physical ball to the ball on the screen if the ball rolls from the bottom of the screen to the top instead of from left to the right (as shown in Figure 6).

To add also one child's observation, it seemed to be exhausting to run around to move the object. But this was the aspect that pleased the woman much, to know that the child is active and engaged.

Additionally to the controlled experiment in the lab we demonstrated the system at the University of Munich at the 5th November 2005 after a public lecture. Overall visitors immediately understood the game concept and the user interface. Informal feedback collected from about 10 people suggested that collaborative tangible games are promising especially for games where there is collaboration between older and younger people.

## 8. Conclusion and further work

This paper presented the development, from the generation of ideas to implementation to an in-lab trial, of one ubi-comp inter-generational game possibility.

Ongoing plans are to develop CurBall further into a prototype that we can take into people's homes for an in-home study. The improvement suggestions from the participants in the user study should be taken up so that, for example, the game field will be rotated so that the ball rolls from the bottom to the top instead of from left to right. Different levels of engagement will also make the game more interesting. They will also make the game easier to learn, enabling people to practice, e.g., with a slow ball and fewer objects, so that the players can get a feeling for the game and can also work out how best to coordinate their activities together. A way to then make levels more challenging would be to deduct different points when the ball hits different objects.

Related to the mobility problems which older people may have, we should consider creating the ball to support different levels of interaction with it but we will need to explore if it is possible to control the ball with a small movement of only 2 or 3 cm, so that the game could be also playable by people with handicaps.

During the user tests the participants were inquiring and open-minded about the new input alternative. Thus, with these games there is also a possibility of introducing them to ubiquitous technologies and making them comfortable with other future possibilities that might also support "aging in place" and health monitoring concerns.

Generally our experiences with the prototypes showed that there is significant potential for ubi-games for older people if the focus is on playing with the grandchildren and having the ability to communicate, it makes sense for the field of ubiquitous computing to not only concentrate on needy people. The ludic and lucid people should not be neglected. The games can give them a possibility to make creative, playful and social use of their leisure time.

## 9. References


[1] Consolvo, S., Roessler, P and Shelton, B. The CareNet Display: Lessons Learned from an In Home Evaluation of an Ambient Display. *Proc Ubicomp2004*, Sept 2004

[2] Decker, C., Krohn, A., Beigl, M., Zimmer, T. The particle computer system. In: IPSN Track on Sensor Platform, Tools and Design Methods for Networked Embedded Systems (SPOTS), *Proc of ACM/IEEE 4th International Conference on Information Processing in Sensor Networks*. (2005)

[3] Goodman J., Brewster S., HCI and the Older Population – Workshop at HCI 2004, Leeds, UK (2004)

[4] Goodman, J., Syme, A. and Eisma, R. Older Adults' Use of Computers: A Survey. *Proc HCI 2003*, Bath, UK (2003)

[5] Greenberg S., Fitchett C., Phidgets: Easy Development of Physical Interfaces through Physical Widgets (2001)

[6] Greenhalgh, C., Izadi, S., Mathrick, J., Humble, J., Taylor, I. ECT: A Toolkit to Support Rapid Construction of Ubicomp Environments. *Proc UbiComp'04* (Demonstration) Nottingham (2004)

[7] Hornecker E., Psik T., Using ARToolKit Markers to Build Tangible Prototypes and Simulate Other Technologies. *Proc INTERACT 2005* Rome. (2005)

[8] Hutchinson, H., Mackay W., Westerlund B., Bederson B., Druin A., Plaisant C., Beaudoin-Lafon M., Conversy S., Evans H., Hansen H., Roussel N., Eiderback B., Lundquist S., Sundblad Y., Technology probes: inspiring design for and with families. *Proc CHI2003*. Fort Lauderdale, FL

[9] Jimison, H., Pavel, M., McKanna, J. and Pavel, J. (2004) Unobtrusive monitoring of computer interactions to detect cognitive status in elders. In *IEEE Transactions on Information Technology in Biomedicine*, Vol 8, No 3, 248-252.

[10] Tapia, E.M., Intille, S. and Larson, K. (2004) "Activity recognition in the home setting using simple and ubiquitous sensors," in *Proc PERVASIVE 2004*, vol. LNCS 3001, Berlin Heidelberg: Springer-Verlag, pp. 158-175.

[11] Tarling, A. Older People's social and leisure time, hobbies and games. Masters Thesis. Uni of Sussex (2005)