BISCT

Blind Interactive Simulation for Cricket Training

Final Report

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Executive Summary

This project came about because of a need to provide support for blind students on a sports coaching course at London Metropolitan University and so was a needs driven endeavour. Using a personal surround sound space (3D audio through head phones) and a Wii controller for haptic interaction, the project set out to create an immersive simulation of the blind cricket game . Blind cricket exists in the real world and is not dissimilar to conventional cricket but with a ball that rattles. The technology needed for the simulation had already been developed elsewhere as part of other projects so the main aim here was to harness the technologies for this specific simulation and to assess its usefulness.

Interactive audio spaces are challenging. This is an area which we have wrestled with for sometime. Earlier work indicates that precise feedback improves user cognition. Haptic response to virtual ball impact with the virtual bat seems to have been effective. None of our users were cognitively challenged by this. In the event the project created a batting simulation which has been evaluated. It was found to be suitably playful without particular cognitive challenges but not necessarily a realistic simulation of blind cricket in the same way that Wii tennis does not particularly emulate the experience of actual tennis.

This report contains a description of the team journey including issues related to a description of technical and user centred design, pedagogy and usability coupled with a description of on-going potential.

Background

This project was a joint submission from London Metropolitan University (lead partner) and Nottingham Trent University. Each party had separately been developing innovative software applications for blind learners prior to its inception.

Previous projects developed by Gamelab London (part of the Faculty of Computing at London Met) included a full Maths learning application in conjunction with BBC (project value £350k) employing an innovative 3D personal audio environment - an environment originally developed for the defence industry in which using head related transfer functions the listener can experience a full special surround sound through the use of head phones and for which no other hardware is required; the outcomes from the project were initially disseminated at a JISC meeting in Birmingham in March 2010 and will be more widely reported at …in October 2010. in The interactive tools developed for that project were flexible in their use and Gamelab sought to bring what had been learned to the development of the Blind Interactive Skills for Cricket Training (BISCT) project. Given what had already been achieved, most development work was in creating a suitable user interfaces layer.

Simultaneously, but separately, Nottingham Trent University had been developing Wii mote access for blind users as well as various interface concepts developed for the serious games domain – the virtual cane being a particular application for blind users.

The BISCT project represented an opportunity to build on these two separate innovations to create an immersive blind-centred virtual space. There was a specific demand for training in Blind Cricket at London Metropolitan University and for the creation of a usable interactive virtual audio space. Further, it was explicitly intended that the space would be sufficiently flexible to allow for adaptation to other applications beyond cricket. Based on the track record of the two partner institutions and the real progress that has been made through BISCT, we are excited by the potential for further development and expect our work to be more widely adopted across HE in the UK and beyond.

Aims and Objectives

This project creates a bespoke digital interactive practice and coaching space for Blind Cricket.

- It offers players and coaches an unprecedented autonomy in their control of practice times, access to facilities for practice, and the design of coaching drills and applications.
- The potential for the development of individualised performance is complemented by access to the collective norms and standards for skill-development and matchplay which are embedded in the environment along with opportunities to work with coaches and other players, thereby consolidating Blind Cricket as a community of practice.
- The creation of a digital environment with lean but flexible architecture and established Wii UI to a personal 3D audio environment allows for technology transfer nationally, internationally and to other blind sports.

Evidence from trials suggests that the opportunities for skills practice presented by the BISCT environment are complemented by an equally significant cultural dimension. In that it clearly has the potential to be a focus for young players of blind cricket as a way to signal their aspiration and commitment to becoming full members of this community of practice. Young blind and partially-sighted cricketers are as attuned to gaming environments as any other young people and based on the field trials, they were probably more excited by the potential to have their own, shared bespoke gaming environment as by the potential for skill development through repetitive drill and practice. We believe that the emphasis on the meaning of BISCT as a “cultural environment” for the young people outpaces its instrumental potential as a coaching “tool”.

There is an analogy to be made with the way in which other, more familiar cricket gaming environments (such as Brian Lara Cricket, or even pre-digital games involving dice etc.) are engaged with by players. They serve more as a point of collective identification for membership of cricket culture than as a means to skills or tactical development – they are a way in which players can confirm with each other their membership of the community of practice.

It was also clear that the loosening of space-time-organisational constraints facilitated by the virtual environment appealed to players – they gained greater control over when, where and with whom they practiced.

Methodology and Implementation

Modelling of Reality

In order to model blind cricket and construct the simulated environment it was felt necessary for developers to learn to play the game for themselves.

Development team 'in training'

We accordingly organised a two hour session under the guidance of Andy Dalby-Walsh, a regular player for the England Blind team and senior coach for disabilities' cricket with Cricket for Change – our key blind cricket partners in this project. Software developers and project coordinators were shown how to bat and bowl with both the domestic ball and action and the international ball. The domestic ball is a size 4 rubberised football with noise-makers inserted via the air valve. This ball is bowled in a more conventional overarm style because and exhibits sufficient bounce. The international ball is the same size as a mainstream leather cricket ball and is made of high-impact white plastic. This ball is not particularly bouncy and tends to skid through; hence it is usually bowled underarm. It too has noise-makers inserted into it at the moulding stage. The logical form underlying the transaction of a game became more obvious through this modelling exercise. Through it developers gained an enhanced understanding of batting or bowling techniques as embedded responses to the challenges presented both by that logical form and the characteristics of the equipment used. This was essential to the subsequent virtual modelling of the game. It also served to build and consolidate team confidence and working relationships.

Richard England batting as Andy D-W bowls the domestic ball

User Centred Design

The blind cricket game has rigorously followed an iterative approach to its development to ensure its objectives were met.

The development team has allocated few months in field studies to get a better understanding of the mechanics of blind cricket and an insight of the key factors that make the gameplay and user experience fulfilling.

Focus groups have been held with blind cricket players to identify the mental model players have of the relationship between bowler, ball and cricket bat in an audio space. This information is fundamental in order to create a 3D audio environment that mimics their user experience on the field.

Professional blind cricketers have acted as advisors throughout the development by testing and providing feedback on each iteration of the prototyping lifecycle.

The application of a User Centred Design approach ensured the development team was immersed into the gameplay from a blind perspective.

Personas were developed after having experienced playing the game blind-folded and conducted field studies.

Novice and more experienced blind cricketers were involved in the testing of the prototype at key stages.

Once the mechanics of the game were implemented, there were several iterations of testing and refinements to ensure the sound of batting and of the ball, in domestic and international mode, was mimicking as much as possible the real objects. Small variations in the sound objects carry or in audio feedback on actions can make the difference between good gameplay and frustrating user experience.

Key factor in designing an audio game is to provide users with the same clues, feedbacks and environment sound richness as when designing a visual interface.

There were three key measurements that each iteration of prototype testing was checking against: 3D cognitive model of game; level of engagement; replayability. The latter was particularly important, as the main objective of the blind cricket game for Wii is to motivate players to train outside the main weekly teaching hours in order to improve their performance. ~~As a piano student would practice 3 hours a day the routine taught by his/her teacher, so blind cricketers can practice at home. Only by extensive practice any discipline's performance can be improved.~~

Creation of Simulation

A series of experiments were created in order to establish the means of creating and controlling a sound-based, three-dimensional virtual environment with the Wii controller. The steps consisted of:

1. Implementing a physics engine (Nvidia PhysX plugin used with Director/Shockwave 3D). The PhysX engine can detect and control events in the 3D world through collisions and control of “rigid bodies”.

2. Applying the dimensions and physics of a real blind cricket environment (virtual world consisting of a cricket bat, a cricket ball, the ground, and wicket)

3. Means of throwing the ball in the virtual environment (using a combination of scripting and the physics engine) together with force, collision and haptic feedback (e.g. rumbling controller upon “hitting” the ball) to enhance the experience.

4. Implementing existing “binaural” 3D sound code libraries in conjunction with the physics engine.

5. Connecting the Wii Controller via standard Bluetooth wireless connectivity. The controller can be connected to any computer with Bluetooth technology available.

6. Establishing a means of getting usable accelerometer (motion) data from the Wii Controller (using Flash and an intermediate server socket layer). This means that Wii controller data can be received from the controller. The initial test file returned the SensorX, SensorY, SensorZ, pitch, roll and yaw data from the controller as it was moved and rotated.

7. Testing Wii controller feedback and response through a simple Flash application.

8. Getting Wii controller data from Wii controller, via Flash/server, to 3D virtual environment in order to apply it to the environment.

9. Applying Wii motion data to a 3D object using Director’s scripting language, Lingo.

10. Understanding the limitations of Wii controller data in the form of accuracy and delay.

11. Using Infrared motion data to enhance motion data and improve the simulation.

User Trials

A series of field trials were held throughout the development of the environment and the connections built with cricketers should facilitate ongoing work.

1. Trial one: basic test of coordination of the environment with a sighted young cricketer.

2. Trial two: extended trial with two players of Blind Cricket – Faraaz Vadiwala, LondonMet student community sports coach categorised as B1 (totally blind) and Andy Dalby-Walsh, Head Coach for Cricket for Change and England player in B2 category (partially sighted). These trials were filmed and interviews followed. Both players found the environment challenging but playable and recognised the benefits in being able to control the delivery of the ball and therefore hone their response as batters. They found the simulated domestic form of the game (using size 3 football and with bouncing delivery) more accessible than the international version. However, both said that the environment was convincing in its approximation to real batting conditions. Each player subsequently took the software away for extended practice.

3. Trial three: with young players at Cricket for Change headquarters, Plough Lane, Carshalton. Cricket for Change run regular monthly practice sessions for promising young players and welcomed an opportunity for a trial of the environment. The trial was eagerly awaited by the players. Several players tried the environment and there was general approval of its authenticity and entertainment value. It was at this trial that the potential for BISCT to become embedded in the cultural world of this group became much clearer and, as serious recreational gamers, they felt that this was something that could bring their sporting and social interests into closer alignment.

4. Trial Four: formal structured tests with experienced blind cricketers. The full report is contained within the appendices. The null hypothesis that the simulation does not improve batting skills was born out for experienced players. However there would seem to be some benefits which are considered elsewhere.

Implementation

The different technologies used for this project were already well established but required integration that both technically and cognitively would provide a simulation for blind cricket which fulfilled the requirements of the university blind cricket coaching course. To achieve this the work packages were broken down in the first instance into parallel streams – namely technology integration on one hand and UI design on the other.

The technology integration required that the synthetic binaural stereo audio technology could be triggered by the Wiimote technology and vice versa. Initial 'ball hits bat' trails were speedily implemented and it was the subtlety of the UI that provided the greatest design challenge.

The audio technology provides a very large range of audio manipulation tools. The audio spaces needed to be developed iteratively with repeated user trails to reach levels of acceptability. Here we used both sighted and blind users. Integration too of a physics engine into to the virtual space required careful tuning to user models. The virtual 3D space was tuned to user perception so that the sense of 22 yards (the length of a cricket pitch) did not correspond to an actual physical dimension approximating to 22 yards. The duration of a ball travel does correspond to the duration of ball travel during a bowl. The acoustics were then adjusted to provide an appropriate sense of space.

System feed back is a key feature in interaction design. The feedback elements here were both audio and haptic. Success in hitting the ball is provide both with a 'hitting' sound , a haptic rumble, a voice indicating direction of hit and occasional applause from the virtual crowd. Failure would be audio only.

Having achieved a working proof of concept prototype Trials were conducted to establish a measure of usability and to help define parameters for a fuller game/ learning experience.

Output and Results

- Simple batting activity
- international and national ball simulation
- may not improve cricket per se
- provides additional opportunity
- effective as immersive space

The developed interactive application developed so far represents a simple batting activity and provides a social focus among blind cricket players. It does not improve batting skills per se but does seem to raise levels of engagement.

The applications simulated both the international and national ball – the national ball seemed to have been preferred among players.

One significant feature which may have wider application is just how immersive the gameplay turns out to be – an audio virtual reality immersion. In conventional video games virtual space remain outside the user on a screen whereas in the audio space the user becomes the centre of the audio sound scape.

Outcomes and Impact

We believe that BISCT has demonstrated the potential that exists for the development of new spaces for learning and for learning in virtual space. Opening of new territory is particularly important in this context because this is a game that is played in space and success depends on the control of space by players. However, beyond this, the virtual environment greatly relaxes the powerful constraints that space, time and organisation exert over the opportunities for sustained and regular practice that all sport players experience. Even when fully developed, it certainly does not, nor could, take the place of playing real matches against opponents in real space, however, it offers opportunities for directed physical activity and regular practice that do not realistically exist without it. Furthermore, as we have suggested, there are cultural and social dimensions to the development of the environment that may be at least as significant as the potential for repetitive drill and practice – even though this is a vital element in the development of sporting prowess and should not be dismissed. This sort of environment exists in gaming formats (that don't develop skill beyond that format) for mainstream forms of many sports (viz. Brian Lara Cricket etc.), however, very few have been developed with sound as the dominant spatial medium. Learning in sonic landscapes will not only support people who are blind and partially-sighted, but has wide potential application. We believe that this work represents a highly significant first few steps towards the development of richer learning environments and enhanced ways of knowing through virtual technologies.

Conclusions & Recommendations

As a proof of concept we are satisfied that the system developed is cognitively convincing. We expect now to develop the simulation further to with scoring systems measuring performance . Additionally, we would enhance the Wii mote controller interface to provide better response to ‘ bat action’ for use in training and in educational contexts.

Implications for the future

A natural extension of the project is to develop fuller gameplay such that the Blind Cricket becomes a fully working audio game – maybe with multiple player including bowling as well as batting as an activity and placement of fielder as an gameplay stratagem.

Migrating to other platforms also is a consideration eg Wii or iPhone.

Finally we consider this environment could have other applications where ear/ hand coordination combined with haptic inteface would be beneficial.

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User evaluation of Gamelab's Blind Cricket game – report

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1. Introduction

Gamelab's Wii based version of blind cricket (Gamelab, 2010) has been developed in order to enable blind cricketers to practise more easily than they are able to in the real world, where it is necessary to book nets and to have a bowler available. The aim is for blind cricketers to be able to practise more easily and at their own convenience, facilitating access to and participation in the sport. Blind cricket is popular with members of the blind community. There have been three world cups so far, with the next one due in 2010, and there are various domestic competitions around the world. It is a version of the sport adapted for blind and partially sighted players. The sport has been played since the 1920s; it is based on the standard rules of cricket, but uses a larger ball which contains ball bearings. The wicket is also larger, and various verbal signals are used by umpires and players (BlindCricket, 2010; Wikipedia, 2010).

The Wii version of the game mimics the real version to some extent. The bowler shouts "ready", the player indicates they are ready by pressing the trigger button on the Wii remote (hereafter Wiimote), the bowler shouts "play", and a ball is bowled. There is usually a double bounce, but the fate of the second bounce is determined by the position and pace of the ball. The rattling sounds of the bearings within the ball have been recorded and from this the sound of the ball created for the various types of ball in binaural form. Balls can be bowled at slow, medium and fast pace, and to the left, centre and right of the batsman. The batsman attempts to hit the ball using the Wiimote, and if the attempt connects and the swing is of sufficient force, hears the sound of the ball hitting the bat. A "good" hit gets a cheer from the crowd. The direction of the ball is hit in is given verbally using clock position; a more detailed verbal description is available. A cry of "out" is given if the wicket is hit (along with applause) and "missed" if the ball is missed. There are two modes of play, club and international. The size of the ball, the rattling noise and the style of batting are distinctly different in the two modes.

The present study aims to establish whether or not training with the Wii game produces effective improvement in ability to hit the ball. Whether or not this improvement transfers to play in the real world is an important consideration which may be addressed in a future study.

The Wii game could be a significant addition to the small but growing number of accessible games available to the blind and partially sighted community. Most mainstream computer games cannot be played by those who are blind or partially sighted. In the past, games designed for blind and partially sighted players have not been inviting for sighted players. In both cases the situation contributes to exclusion. Terraformers is one game which breaks this mould; the Terraformers game is playable by players who are blind, who can play the game against sighted opponents (Westin, 2004). Terraformers offers auditory navigation and game information, which blind players can use successfully to navigate its virtual environment and to play the game. It also has a graphical format (which can be turned off for economy), so that blind players can play with sighted opponents. Consequently, blind players, are, for once, included in the virtual world occupied by the sighted. Other developers have also produced accessible games. The Human Computer Interaction laboratory of ICS-Forth research, design and develop universally accessible games (e.g., see Grammenos and Savidis, 2006). Two notable examples of universally accessible games by them are UA-chess and space invaders. It is easy to see that the blind cricket Wii game could be played by both blind and sighted players, so that they could play against each other, and both groups could use it as a practise tool.

Enabling users who are blind to operate in virtual environments (VEs) has many potential benefits. Skills such as navigating around the real world, travelling and crossing the road are major challenges for the blind. Applications of VEs have been developed for training in basic skills, for travel training, for learning to cross the road and for route planning, for people with a range of disabilities (e.g., Brown et al, 2005). Such applications would be of great benefit for people who are blind. Notably, the Wii Cane (Battersby, 2007; Evett et al, 2009) has been designed and developed to enable users who are blind to navigate around a virtual environment. The target application for the Wii Cane is as a navigation aid for blind users, so that they can learn to navigate around a virtual version of a real environment on their own and in their own time, making them less dependent on trainers. Access to other VE applications, such as those mentioned above, would also be of benefit.

The current study is concerned with evaluating the effectiveness of the Wii blind cricket game as a training tool for blind cricketers. The first stage is to establish whether or not players can reliably hit the ball using the cues available from the game, and if they can improve their performance using the game. The next stages would be to establish if any skills obtained effectively transfer to the real world, and to evaluate the system as an accessible, inclusive game.

2. Proposed Method

a. Players

The players for this initial study are two computer literate profoundly blind players. Both have some experience with Wii technology.

b. Design

It is difficult to get significant numbers of suitable players together very quickly, so for this initial study, the two players will each take part in a single subject experimental design. Zhan and Ottenbach (2001) describe a number of possible designs for such studies. It is proposed to use an ABA design, where A is the "baseline" and B is the "intervention". In this case, the two subjects will take part in a set of test trials to evaluate their initial success in hitting the ball. There will then be a series of training trials, followed by another set of test trials. Performance in the two sets of test trials will be compared. Zhan and Ottenbach (2001) detail several approaches to analysing such data – visual, split-middle trend line and running median. Visual inspection will of course be carried out. Relevant statistical tests will be applied: it is envisaged that a sign test will be used to compare trial by trial, and trial by trial by ball type, and the Wilcoxon matched pairs signed-rank test will be used to compare performance overall across ball types. It is hoped that additional data will be collected as it becomes possible to do so, to improve reliability and generalisability. It is hoped that future studies will investigate competitive play and transfer to the real world. The null hypotheses are no change in performance between the two sets of test trials, no change in performance over time, and no difference in performance for the different ball types.

Table 1: Initial proposed design in table form:

Trial type	order	pace	left	centre	right
TEST	random	medium	20	20	20
TRAIN	ordered	slow	10	10	10
	ordered	medium	10	10	10
	random	medium	10	10	10

TEST	random	medium	20	20	20

c. Results

Performance will be compared across the two test sessions: trial by trial; trial by trial for each ball type; overall hit rates for the different ball types in the two test sessions. Changes over time, between the two test sessions and overall changes in hit rate will be examined.

Visual inspection of the two test sessions and over the training sessions will be carried out.

Player comments will be collected and analysed.

3. Informal user testing I

10/3/10; Present: LJE, Allan, Zaf, Simon, Patrick

After informal initial testing, it was clear that players aren't really able to work out how to hit the ball, rather judging the time of the swing; if timing is correct, the bat may hit the ball. The bat is horizontal in International (Int) mode, vertical in club mode; as well as the directional differences of the bat in the two modes, international has rattle and a (quiet) first bounce, club has bounce and a "rushing" noise accompanies the ball. Verbal feedback gives ball direction in clock position; more detailed feedback on the hit is an option (although this is in an MS narrator voice that nobody liked, and found difficult to understand). The crowd cheers a "good" hit. However, if the system doesn't register the swing of the Wiimote, there is a long time out delay until the verbal feedback is given. The significant delay is very disruptive for the player, and the development team could not fix the problem. Initially it was thought to only occur in Int mode, it was thought it might not be possible to test in this mode, so only some exploratory testing was planned for this mode. Both modes have binaural sound – however, it is not really possible for players to use this information to direct motion of the Wiimote (even seeing the ball doesn't help much); players can only affect play by judging the timing of their swing, so the effectiveness of the binaural information for positioning the Wiimote cannot be tested in the current set up. Bowler warning ("play") and bounce are probably most effective for timing the swing.

Additional problems identified were:

1. Bounce hardly heard in Int mode
2. Wiimote doesn't always rumble on contact
3. Contact between bat and ball not very clear
4. Long delays for verbal feedback at times
5. The voice used for the detailed verbal feedback is unclear

A well as clearing up these problems, it was felt that the following would improve the system:

1. A much clearer, more systematic and predictable relationship between the movement of the Wiimote and movement of the bat in the game is needed. Particularly we need a batting mode in which timing and position of, and swing direction of the Wiimote, all contribute to the success of the hit. Some measure of confidence in the system's ability to accurately track the Wiimote's position is necessary.
2. Clearer and more distinct sounds for bounce and for bat hitting ball, Wiimote to rumble on contact more consistently, clearer detailed feedback, and avoiding the long delays are all desirable.

4. Informal user testing II

16/3/10; Present: lje, Allan

The issues identified could not be addressed in the timescale available, so formal testing is planned with the system as it is. However, a number of details needed to be clarified, and the results of today's informal testing have led to some changes to the design. The version which recorded play was downloaded, which did seem a bit different to the version tried previously (**WAS IT?**). Today's informal testing clarified a number of issues and perhaps raised some more.

Motion/hitting issues – most fundamental to the success of the game:

1. The relationship between the motion of the Wiimote and the motion of the bat in the system is not natural, predictable or understandable. This makes it difficult, if not impossible, for players (sighted or otherwise) to work out what to do.

Feedback issues:

2. In both modes, it says "missed" when the ball is missed and "out" when the wicket is hit. There is only a sound of the ball hitting the bat when the Wiimote has been moved with sufficient force for the system to pick it up. However, the sounds for bounce, hitting the ball, ball hitting wicket or ball hitting the back are very similar, it would help if hitting the ball stood out more distinctly.

3. In Int mode, sound of bat hitting ball and of bounce are relatively quiet – when turned up to make clear, can make other sounds too loud. In both modes, and particularly Int mode, the relative sound levels of the audio/verbal cues varies a lot, so getting some at the desired level may be to the detriment of others.

4. Wiimote rumbles for hit when swing sufficient for system to pick it up, sometimes – this feature is very erratic.

5. The voices used within the system are OK; Microsoft voices used at other times were disliked and difficult to understand (NB there are some good new MS voices).

6. The clock direction feedback sometimes corresponded to the visual direction of the ball and sometimes didn't seem to; not an issue for blind players but would be an issue for partially sighted players and for mixed playing, if that was ever developed further, and it does contribute to the general uncertainty. The system must take account of the needs of the partially sighted. While teams may all be blindfolded in matches, they wouldn't be when practising and playing informally. The UK blind cricket site says (BlindCricket, 2010): "…..the major adaptation is the ball, which is significantly larger than a standard cricket ball and filled with ball bearings. **The size allows partially sighted players to see the ball** and the contents allow blind players to hear it. The **wicket (stumps) is also larger, to allow partially sighted players to see** and blind players to touch it in order to correctly orient themselves when batting or bowling" (as paraphrased in Wikipedia, 2010), so the visual cues are important, especially since total blindness is rare.

Technical issues:

7. The instructions state "Press A to toggle a "helper" tone sound. This is intended to help the user centre the Wiimote in front of the wicket". In fact this did not work. Pressing A did not initiate the sound, rather it was mapped to 1, the same button used to switch through the bowling options. The sound was either on or off, and appeared sometimes and not others. So this feature could not be used.

8. Left handed/right handed could be toggled, or changed by the way up the Wiimote was held (buttons up/buttons down, sort off) but did not seem to relate to play at all.

9. Long delay for hit feedback can occur in both modes.

10. There are delays between the motion of the Wiimote and the motion of the visual bat; contributes to difficulty in working out what to do, and could be difficult for partially sighted players, and for mixed sighted/blind playing, if that was pursued.

11. Using the sensor bar made no noticeable difference and so wasn't used.

Testing issues:

12. Perhaps, instead of the straight random mode, it would be better from a testing point of view to have a set of balls from the training options and then to choose from that without replacement but with some constraints – more control over the balls in the random sequence would make transfer from training more straightforward?

13. Testing would be easier and more reliable if the run of trials could be set up in advance for each player.

14. Because of 1, even if the binaural sound could be used to reliably place the ball, it wouldn't help hit rate – it's difficult to modify motion of the Wiimote to improve hitting even when the ball can be seen, so it's impossible to assess the effectiveness of the binaural cues. Consequently, all testing was done using speakers, as this made it much easier to monitor play and get feedback from the players.

5. Final Design

The following design was decided on for the formal testing on 17/3/10. The system was run with long verbal description of hit off, because it was disliked and difficult to understand. Both players had 5 random balls to start, in order to check the volume.

Mode 1:

1. Player to return to a comfortable starting position after each hit
2. 20 random bowls
3. 5 of each left, centre, right at medium pace[1]
4. 20 random bowls

Mode 2:

1. Player to return to a comfortable starting position after each hit
2. 20 random bowls
3. 5 of each left, centre, right at medium pace
4. 20 random bowls

Compare 2, 4 for each mode, compare modes, analyse data for 3, and collect player feedback

[1] For the first run through, there were 5 of each type for each pace. This was changed to just medium pace since it took too long and seemed more frustrating to the player than anything. Each player took about 40 minutes for the whole thing including feedback.

Players:

Player 1: club mode first, then Int mode
Player 1 is 54, and is profoundly blind. He can distinguish between light and dark. He did have sight until his 30s, although he has always had vision problems. He has some experience of using Wii technology from his involvement in the Wii cane project, although not of playing Wii games.

Player 2: Int mode first, then club mode

Player 2 is 22, and is profoundly blind, from birth. He can distinguish between light and dark. He has played real blind cricket once. He plays Wii tennis on a regular basis and can beat his sighted cousins.

Both players are computer literate.

Instructions:

“There are two modes of play, club and international. In both modes you will hear the bowler say “Ready”, you pull the trigger when you are, and the bowler then says “play” and bowls the ball. You will hear the ball bounce, sometimes once, sometimes twice. This can depend on the pace of bowling (slow, medium, fast). In some cases, related to pace, the second bounce will be too late to attempt to hit the ball, so it’s best to judge your swing according to the bowler and the first bounce. The ball can pitch to the right, centre or left. If you hit the ball, you will hear bat on ball, except sometimes if the system hasn’t picked up any movement of the Wiimote – it needs to detect a swing to pick it up. If it’s a good hit, the crowd will applaud. There is verbal feedback as to the direction of your hit (in o’clock). If you don’t hit the ball it will say “missed”, unless it hits the wicket when it will say “out” accompanied by applause. The Wiimote should rumble when you hit the ball, although again this depends on detection of a swing and seems a bit erratic.

You will start with a random series of balls in one of the modes. This will be followed by 5 left, centre and right balls in slow, medium and fast pace. You well then get another random serious of balls. This will all then be repeated in the other mode.

The main difference between International and club mode is that, in International mode the ball can be heard to rattle; in club mode there is no rattle, rather a rushing sound. Both of these sounds can help you to judge the approach, speed and position of the ball. The motions of the bat are different in the two modes. It’s difficult to describe these differences except to say that their actions with respect to hitting the ball will be noticeably different in the two modes, and you may well find that you play on more often in International mode and that the ball is more difficult to hit.

I will be asking you for feedback at the end of the session, and recording any comments you have during play. Please keep your comments short during play.”

6. Results

a. Player feedback:

Player 1 preferred to play with rattle (Int mode), but mainly because he really disliked the “rushing” sound in club mode which for him masked the sound of the bounce. In both cases he did not think that the sounds helped him identify the side of the ball at all. He automatically tried to adjust his play to what he thought the feedback was telling him, but found it frustrating that the feedback didn’t seem to give him any reliable cues. Quite a few times he felt he’d got it, only to find that doing what he thought would produce a good hit actually failed. Player 1 noticed the Wiimote rumbling, but not often and he felt it was very erratic.

Player 2 preferred to play with the “rushing” sound (club mode), which he thought was more like the real thing. He has played the real thing at club level and this sound is meant to mimic that sound, so this was successful. However, he thought the bounce is much more prominent in the real game than it is in the system, and he felt he used the bounce mainly to direct his hitting. Player 2 also didn’t think either of the sounds gave any idea about the side of the ball. Player 2 didn't notice the Wiimote rumbling at all (did it stop doing it?). During player 2's session, the lining up sound came and went and couldn't be turned off as it had been for player 1. The player found it annoying. Player 2 wanted the sound of hitting the ball to be more distinct and realistic, and to vary with the type of hit, as in the real game.

Both players thought the game had potential but found it frustrating how little they were able to improve their success in hitting the ball by modifying their behaviour. They would like to be able to play it against sighted players (as player 2 does with Wii tennis). Both players found the "out" sound indistinct, and queried what it was the first few times they heard it.

b. Performance data

The various problems, such as the lining up noise, the erratic rumble etc, and the fact that the number of balls had to be counted for every stage (and some mistakes were made) will affect the reliability of the data. Table 2 shows the hit rates in the various conditions.

Table 2: Pre and Post test hit rates (%) for each mode by player

	Player 1		**Player 2**	
	Club (1st)	**Int (2nd)**	**Club (2nd)**	**Int (1st)**
Pre test	60	56	44	53
Post test	60	45	35	70
Average:	60	50.5	39.5	61.5
Av. overall:	55		51	

Overall hit rates are not much different from a chance level of 50%, although they do vary by condition (Table 2), and by the pitch of the ball (see Table 4). Player 1 is better in club mode, and player 2 is better in Int mode, contrary to both their expressed preferences. These are the initial modes for both players, and the main effect would appear to be a decrease in hit rate over time – see table 3.

Table 3: Hit rate (%) by order of sessions for each player

	Sessions by order			
	1	**2**	**3**	**4**
Player 1	**Club pre**	**Club post**	**Int pre**	**Int post**
	60	60	56	45
Player 2	**Int pre**	**Int post**	**Club pre**	**Club post**
	53	70	44	35

These results suggest that play tends to get worse over time; this is consistent with the observation that the players got more and more frustrated that their efforts to improve their hitting came to nothing. Comparing hits for each player for pre and post sessions for each mode, and first and last sessions, no differences were found to be significant using a sign test, so the null hypotheses of no differences between them cannot be rejected.

Figure 1: Hit rate (%) by order of sessions for each player

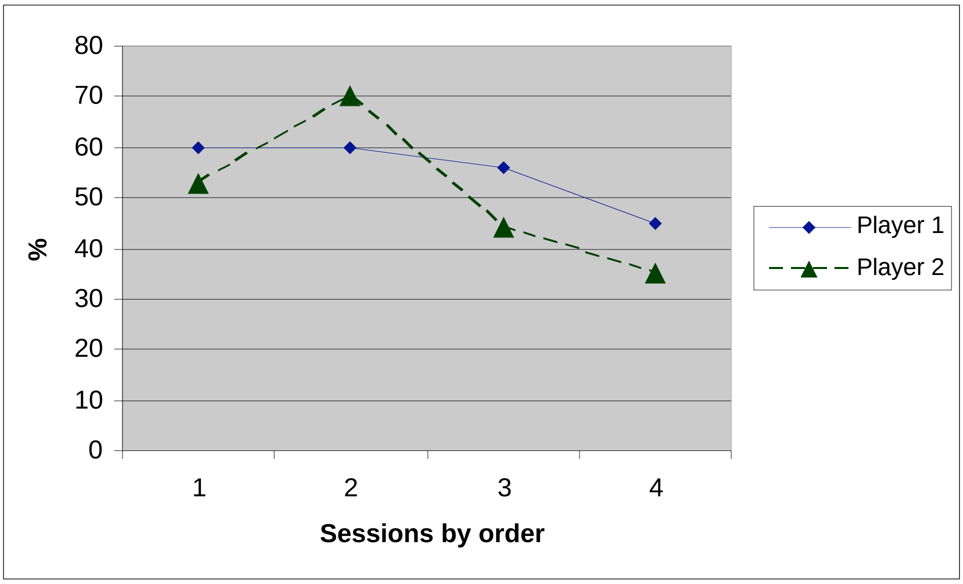

Table 4 shows the hit rates for the training sessions. Both players hit all the centre balls, but struggled with the balls to the left and the right. Differences between the test sessions could be purely due to the selection of types of balls in the random runs. In random bowling, how far to the left or right of centre the ball is pitched, and the speed of the balls are chosen at random, within certain limits (X 1100 max; Z max 22000).

Table 4: Hit rates in the training sessions (out of 5) by direction of ball

		left	**centre**	**right**
Player 1	**Club (1st)**	0	5	0
	Int (2nd)	3	5	2
Player 2	**Club (2nd)**	0	5	2
	Int (1st)	4	5	2
Average		1.75	5	1.5

Looking at the information on the balls in the data files, the types of balls in the random sessions cannot easily explain the decrease in performance across the sessions. Left and right pitched balls have an X value of ±1100 from the centre, where X= 0. From Table 4, balls at this pitch can be considered to be hard to hit, and centre balls easy. Table 5 shows the number of hard (>±700 X values) and easy (≤±50 X values) balls for each of the sessions.

Table 5: Number of easy and hard balls in each of the sessions

	Sessions by order			
	1	**2**	**3**	**4**
Player 1	1 easy, 0 hard	1 easy, 0 hard	1 easy, 0 hard	0 easy, 0 hard
Player 2	3 easy, 2 hard	4 easy, 0 hard	0 easy, 0 hard	1 easy, 0 hard

This data suggests that the ease/difficulty of the balls is not responsible for the decline in performance over the sessions, although the 4 easy balls in session 2 for player 2 may be the reason his score went up in that session.

7. Discussion and recommendations

The main result is that it does not appear that players can improve their hit rate with practise. In fact, their performance tends to deteriorate over time. This would appear to be because of frustration over the lack of effectiveness of their attempts to use the cues to improve their performance. This effect does not seem to be due to a greater number of difficult balls occurring in the later sessions.

The players felt the game had potential, but it is clear that the main improvement that needs to be made is to make the relationship between the motion of the Wiimote and the hitting of the ball more natural and predictable. Once this is achieved, a number of things can be done to improve the cues, and the effectiveness of binaural cues could be assessed. Both players thought that the sound of the bounce would be the more effective cue. Both players wanted the sound of the bounce to be more distinct, and player 2 wanted the sound of hitting the ball to be more distinct and realistic, and to vary with the type of hit, as in the real game. Detailed recommendations are given in section 4. As well as the motion and feedback issues, some technical problems, such as with the delay, and with the rumble and lining-up features need to be resolved, all batting options should be seen on the screen, and play should be halted until the applause dies down. More detailed control of ball types in random mode is required, and the ability to set up a run of balls would facilitate testing.

All the necessary elements and features would appear to be present in order to create an effective and engaging game. There needs to be some adjustment of the various parameters, and, most importantly improvement in the relationship between the players' movement of the Wiimote and the hitting of the balls. This relationship does not need to be exact, just better than it is. One of the players here reports that he regularly plays Wii tennis, and with some success. Comparison of the blind cricket game with Wii tennis could be revealing. Some evaluation of Wii tennis is planned.

Once issues identified are addressed, the system could be evaluated again, and its effectiveness for blind cricket practise and transfer of skills to the real game assessed. Extensions to make an accessible, inclusive competitive game could be considered.

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Appendices

Appendix 1 – Data

		Player 1				Player 2		
		Club		**Int**		**Int**		**Club**
	Test:							
1	random	hit		out		error		hit
2	pre	hit		hit		miss		hit
3		hit		miss		miss		miss
4		hit		hit		miss		miss
5		hit		hit		out		miss
6		hit		hit		miss		miss
7		hit		hit		hit		out
8		miss		hit		hit		hit
9		miss		hit		hit		out
10		miss		miss		miss		hit
11		hit		miss		hit		miss
12		miss		miss		miss		hit
13		hit		out		hit		hit
14		miss		hit		out		out
15		out		miss		hit		out
16		hit		hit		hit		hit
17		hit				hit		
18		miss				hit		
19		miss				miss		
20		hit				hit		
	12/20	60%	9/16	56%	10/19	53%	7/16	44%
	Train:							
1	left med	miss		hit		hit		miss
2		miss		hit		hit		miss
3		out		hit		hit		miss
4		miss		miss		miss		miss
5		miss		miss		hit		miss
6	centre med	hit		hit		hit		hit
7		hit		hit		hit		hit
8		hit		hit		hit		hit
9		hit		hit		hit		hit
10		hit		hit		hit		hit
11	right med	miss		hit		miss		hit
12		miss		miss		hit		hit
13		miss		hit		miss		miss
14		miss		miss		hit		miss
15		miss		miss		miss		miss

		Player 1			**Player 2**			
	Test:							
1	random	hit		miss		out		out
2	post	miss		out		hit		hit
3		hit		hit		hit		miss
4		hit		hit		miss		hit
5		hit		hit		out		out
6		hit		out		hit		miss
7		miss		miss		miss		out
8		hit		miss		miss		hit
9		miss		hit		hit		out
10		hit		out		hit		hit
11		miss		hit		hit		miss
12		hit		miss		hit		out
13		hit		hit		hit		hit
14		miss		out		hit		out
15		hit		hit		hit		hit
16		miss		out		hit		hit
17		hit		hit		hit		miss
18		hit		miss		hit		miss
19		out		hit		hit		miss
20		out		miss		out		miss
	12/20	60%	9/20	45%	14/20	70%	7/20	35%

Session:

	1	**2**	**3**	**4**
Player 1	60	60	56	45
Player 2	53	70	44	35

In the random sequences, X values were between 0 and ±1100; 11 balls were ≤ ±50 and 2 balls were ±1100, otherwise all were < ±700 and > ±50. Z values were between 15045 and 19870, apart from 2 at 24000 where the player hit the change bowling button accidentally.

For the options, Sides: Z = ± 1100; Pace: slow Z = 16000, medium Z = 20000 or 22000, fast Z = 22000

Appendix 2 – Instructions

default is random however ball follows bat. ?

(Press 1 - on Wii controller OR b on keyboard to switch through the various bowling options, directions and speed).

All controls listed below

The Wiimote controls are:

* Press TRIGGER (B) to bowl (after batter asks "are you ready")
* Swing the Wiimote at the required force to hit the ball.
* Press 2 to change mode between International and Club. The difference being the way the bat is held (vertical or horizontal) and the ball size (large or small).
* Press A to toggle a "helper" tone sound. This is intended to help the user centre the WiiMote in front of the wicket.
* Press 1 to switch through the various bowling options, directions and speed. Default is a "random" ball
* Press + to take control of the mouse (if using an infrared bar).
* Press HOME to toggle visuals on/off.

The keyboard controls are:

* Press SPACE to bowl a randomly aimed ball towards you (the listener).
* Press ENTER or V to simulate a Wii controller swing (it will apply a random amount of force to replace the swing force/direction it expects rom the Wii controller). Time it right and you will be able to hit the ball (you'll hear a batting noise).
* Press M to change mode between International and Club. The difference being the batting position (vertical or horizontal) and the ball size (large or small).
* Press T to toggle a "helper" tone sound. This is intended to help the user centre the WiiMote in front of the wicket. This movement can also be simulated by moving the mouse to place the bat. The tone will be centred when the bat is centred. If the bat is to the left or right then the tone will be heard from that direction.
* Press B to switch through the various bowling options, directions and speed. Default is a "random" ball
* Press C to toggle "full report" mode (this reads out the direction and the distance the ball went).
* Press X to toggle visuals on/off.

NB: we requested: “The button for the beeping sound to tell you that the bat is in front of the wicket is mapped to the same button as the change bowling type button - could this be changed?”

NB: there are some issues with the default/international mode that I've noticed (mainly to do with bat/ball collisions not always being registered properly occasionally for some unknown reason). You will know this has happened when there is a long pause before the direction of hit / miss is read out. I should be able to fix this by next week.

Appendix 3 – Data Collection

Username for session (user is asked to enter name upon startup)

Date/Time of session

Bowling data

- Bowling/Batting mode (International or Domestic)
- Bowling type (random or direction/speed)
- Bowling force/direction (3d vectors)
- Time of bowl

Hit information

- "Hit", "Miss" and/or "Out"
- Hit to angle (360 degrees)
- Hit distance (cm)
- Swing strength

BISCT

Blind Interactive Simulation for
Cricket Training

GameLab London

The project aims

to offer players and coaches increased autonomy in planning and regulating their skills' practice regime

to remove constraints of time and place for practice through the provision of portable virtual environment

to supply an environment that supports the design of bespoke coaching drills and applications

to create a digital environment with lean but flexible architecture and established Wii UI to a personal 3D audio environment.

GameLab London

Projected Project Outputs

Integrated Wii driven 3D audio space

Playable download

Trials for Blind Cricket simulation

Understanding of cognitive boundaries and usability issues

Use cases for scaling to full applications and domains other than cricket

GameLab London

Expected Project Outcomes

A specific Blind Cricket orientated exemplar of a scalable learning space applicable across HE in a range of contexts where kinaesthetic learning styles and ear / hand coordination may be appropriate.

A ‘space’ that can be integrated into regular learning environments and e-learning contexts.

GameLab London

Technology Functionality

- **Physics engine**
- **The dimensions and physics of cricket**
- **Throwing the ball**
- **3D sound –** simulated binaural audio (stereo output)
- **3D sound working with the physics engine**
- **Connecting the Wii Controller**
- **Data from the Wii Controller**
- **Wii controller feedback and response**

GameLab London

Technology Demonstration

GameLab London

Observations from Initial Trials

- affirmation of 3D cognitive model
- high level of engagement
- high motivation towards performance improvement
- issues in relation to the reality of the simulation

GameLab London

Current State of Play

Formalising UI issues within HCI lab conditions

Technology limitations

Identifying cognitive boundaries

Define usable parameters for Cricket training

GameLab London

Future

Extend training environment to:

Fuller game

Other contexts

Also extend technology for space as well as time based training