

Chapter IX

Digital Sport:

Merging Gaming with Sports to Enhance Physical Activities Such as Jogging

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ABSTRACT

Recent advances in computing technology have contributed to a new trend that merges digital gaming with physical sports activities and combines the advantages of both; such as contributing a health benefit and supporting distributed participants. This chapter describes prominent examples, and their underlying theoretical concepts and perspectives. In particular, it presents a design prototype, “Jogging over a Distance,” which offers social joggers the opportunity to run together, although being in two different locations. This approach demonstrates the potential for the merging of computing gaming technology with sports activities, to offer combined effects that have traditionally been limited to each respective domain. Future work on enhancing existing sports and gaming activities will support novel experiences previously not possible. This exciting new field has the potential to enhance users’ lives by making positive health contributions.

INTRODUCTION

Digital computer games, from their early beginnings in arcades to the multi-million dollar titles of today, follow rule-sets; often allow for interactions; and are predominantly high-score focused. Furthermore, digital games encourage their players to improve upon their skills in a competitive fashion. Very similar characteristics are attributed

to sports. Also, gamers can become members of internationally organized clubs and participate in prestigious gaming tournaments, similar to the ones that exist in professional sports (Pedersen, 2002). Such activities have been labeled “online sports” or “e-sports”. Further, there is a voluntary characteristic associated with both sports and computer games, and both are believed to be motivated by a perception of fun (Wulf, Moritz,

Henneke, Al-Zubaidi & Stevens, 2004). It appears that physical sports and computer gaming have many aspects in common.

However, what differentiates computer gaming from traditional sports is its lack of support for physical exertion. Unlike sports, computer games do not encourage the use of gross motor skills, as their focus is mostly on fine motor skills. They do not intend to exert players physically, because they do not demand physical effort to reach the game's goal. This is very different to sport's focus on training and mastering the human body, which dates back to the ancient Greek's celebration of the body and its movements. Computer games involve predominantly the development of cognitive skills and neglect involving the body in its supported activities. Players are only required to press buttons on a keyboard/ game pad/ or mouse in order to control an avatar's movements, even though these avatars perform actions that, in reality, would require great strength and endurance. The mapping of users' actions is not proportional to the represented activities. This lack of inclusion of physical activities is characteristic for computer games, but that means gamers miss out.

Sports have many advantages, including physical, social and mental health benefits. From a physical perspective, sports can contribute to a healthier body by reducing the risk of obesity, cardiovascular disease and diabetes (Pate et al., 1995). From a social and mental health viewpoint, sport is believed to teach social skills (Morris, Sallybanks & Willis, 2003), encourage team-building, and support individual growth, as well as community development (Gratton & Henry, 2001). Some argue sport can foster social integration and personal enjoyment (Long & Sanderson, 2001; Wankel & Bonnie, 1990); provide opportunities to meet and communicate with other people; and contribute positively to self-esteem and well-being (Bailey, 2005). These are benefits that also contribute to the growth of social capital (Huysman & Wulf, 2004; Putnam, 2000). Sports activities can facilitate bonds between people, resulting in

loyalty and team spirit. Team sports, in particular, are considered to be character building. Sports clubs not only function as a place to exercise, but also as a social space (Putnam, 2000). International sporting events also demonstrate that sports have the ability to overcome the language barrier and bring people together from various cultural backgrounds.

In summary, sports offer many benefits. The health and social benefits are of particular focus here. Computer games share some of these concepts, but fall short in offering a fitness aspect, due to interaction mechanisms that focus on fine-motor skills. Their role in facilitating social support is ambivalent. However, computer game technologies have now emerged that allow for novel social experiences, such as participating in shared activities between geographically distant players.

The objective of this chapter is to introduce the reader to an emerging approach in the amalgamation of digital games technology and sports activities. By combining the unique advantages from computer gaming technologies (such as supporting geographically distant participants) and the health benefits of sports, new experiences can be facilitated that offer mutual benefits to users, previously only available in each area.

Computing technology has been used in sports applications before. However, such work has mainly focused on supporting performance enhancement of professional athletes. Less work has been undertaken on using computing technology to enhance the experience of very differently fit sports people, and to support the social benefits associated with sports activities. The work presented here aims to demonstrate that there is potential for computer gaming technology to support a wide range of sports participants with many different objectives, and even offer new experiences.

To highlight the feasibility of this approach, a system called "*Jogging over a Distance*" is described. It demonstrates how gaming technolo-

gies can be combined with sports activities, and in particular, how the benefits of networking advances can be utilized in sports settings to enable athletes to participate in shared sports activities, although being geographically apart.

BACKGROUND

From a computer gaming technology perspective, players recently have seen an increase in what has been labeled “exergaming”: a portmanteau of “exercise” and “gaming”. Computer games that make the player sweat have emerged, labeled exertion games. Game companies have discovered the potential of embracing physical activities in their games and using it to entice players to buy new hardware. Systems such as the EyeToy™ (EyeToy Kinetic, 2008) use advances in camera and vision analysis technology to detect body movements of the participants, who perform bodily actions in front of a screen to control an avatar. The Wii™ game console from Nintendo® comes with a controller that contains accelerometers to support physical activities in its games, and force-feedback is provided through subtle vibration in the controller (Nintendo, 2008a).

Exertion games are believed to be able to work against the prevailing computer gaming image of facilitating a modern world’s sedentary lifestyle. These games are attracting new audiences that have previously not been catered for, including novices outside the traditional “young and male” gamer demographic (Snider, 2008). It has also been reported that gamers have appropriated existing technology, such as Nintendo’s *Wii™Sports*, to supplement their fitness goals. However, without health progress reports, gamers have been using blogs and household scales to supplement their gaming equipment, in order to track their health improvements and combat obesity issues. New fitness products for the living room have emerged that promise more effective and motivating workouts through interactive status reports,

with personalized feedback and progress report functionality (Nintendo, 2008b).

The convergence of sport and gaming has challenged our understanding of what is a sport. The *Dance Dance Revolution®* game, which requires jumping on dance pads according to screen-based instructions, has been approved by the International Dance Organization as an official dance sport discipline named “machine dance” (IDO–MachineDance European Championships, 2006). *Dance Dance Revolution®* is probably the most successful exertion game worldwide; it has even been integrated into physical education curricula in the USA and fitness gyms (Behrenshausen, 2007).

Other commercial exertion game systems can be plugged into game consoles to replace the joystick or game pad interaction. Typical examples are stationary exercise bikes or treadmills with a connection to a computer. Sensors measure the speed of the wheel (or belt) on the fitness equipment, and the computer converts this data into commands typically performed with a traditional game console controller (Gamebike, 2008). So the faster the user pedals on the bike, the faster the car in the computer game drives. Other similar devices utilize existing exercise equipment, such as the Peak Training System Sensor Kit (2008) that can be retrofitted to any rowing machine or treadmill. Some of these interfaces take a simplistic approach to encouraging exercise: only if the user engages in physical activity (regardless of speed), the computer game becomes active and is controlled with a traditional game pad, but if the user stops exercising, the game pauses (Gamersize, 2008). The Bodypad™ (2008) supports exerting body activity as input control through pressure sensors that are strapped onto the hands and legs, replacing the button presses. The Powergrid (Interaction Laboratories, 2008) uses isometric force, in contrast to pushing and pulling weights most other exercise equipment affords. The user exhibits force against a sturdy metal pole, which does not move, however sensors

inside measure the applied intensity and convert it into game control commands. The exercise bike in “Virku” takes the exercise bike-systems a step further by adding a feedback channel: the digital world reacts to the physical effort the user puts in, but the virtual world also affects the exertion activity in return. By pedaling, the user travels through a virtual version of a rural park area. The pedaling speed affects the player’s traveling speed in the environment, but the game environment also affects the pedaling effort e.g. riding uphill increases the required pedaling effort and downhill decreases it (Mokka, Väättänen & Välikynen, 2003).

Academic prototypes and commercial products have been developed that consider social aspects in motivating users to exercise and aim to leverage people’s relations with one another for an enhanced experience. For example, websites such as Fitsync.com support athletes in tracking their exercise data, but also offer to share the results with other sportspeople for comparison purposes (Fitsync, 2008). Social networking websites such as Bodyspace™ aim to leverage the motivational power of social connections (Bodyspace, 2008). Sports that emphasize the visual appearance of the body, such as bodybuilding, can benefit from such sites, as they offer self-presentation capabilities: they allow members to upload pictures of themselves performing in their sport. However, these websites are limited by the existence of a temporal difference between the sports activity and its technological support. In other words, only after the workout is finished and the pictures taken can the body-builder upload the images and exchange messages with peers, usually hours later, in a different location and context. Fitsync.com allows for the use of PDAs and mobile phones during a gym workout to reduce the time between exercise and digital support mechanisms. However, there is still a conceptual separation between the exercise and the persuasive element, as the physical activity does not experience any technological augmentation, and the social augmented aspect

is, although influenced, not dependant upon the physical activity.

The Nike+ system (Apple, 2008) on the other hand offers a continuous augmentation of the physical activity: it adds entertainment technology to a jogging experience and combines it with a performance tracking feedback channel. A sensor in the jogger’s shoe tracks running pace and sends it to the user’s iPod®, where it is stored until it is synced with a computer. Through connection to a website, the results can be shared with thousands of other runners worldwide. Virtual runs can be arranged and other runners challenged for specific time or distance goals, offering a form of asynchronous running competition. However, the pace data is also available during the run, and the software in the iPod is programmed so that it uses this performance measure to influence the runner’s workout on-the-fly: the entertainment usually provided via music through the headphones fades out if the runner reaches a personal running record, and the recorded voice from Lance Armstrong compliments the jogger on reaching their goal. Pressing a button on the iPod® not only displays the runner’s speed; a voice, augmenting the entertainment channel, also informs the runner about the remaining time, distance and calories burnt, giving instant feedback anytime during the activity, or activated by context.

Other pace measurement devices exist that claim to be motivational through the use of peer support, or other computing technology. The *MPTrain* is a mobile device that monitors heart rate and speed of a jogger to select music, with a particular tempo delivered through headphones to encourage the user to slow down, speed up, or keep pace (Oliver & Flores-Mangas, 2006). Other prototypes that use social interaction to encourage walking or jogging include *Houston* (Consolvo, Everitt, Smith & Landay, 2006) and *Chick Clique* (Toscos, Faber, Shunying & Mona Praful, 2006). *Houston* is a mobile phone application that monitors step count and displays it alongside the step count of friends. *Chick Clique* is a similar mobile

phone application for sharing step count. This social peer pressure approach focuses on teenage girls and uses instant messaging to keep the social group connected and aware of each other's progress. *Shakra* (Barkhuus et al., 2006) supports physical activity awareness in a mobile setting, and the authors report on the beneficial aspect of competitive progress exchange as encouragement to exercise more. *Melodious Walkabout* is a head-phone based system that assists joggers in finding their way by using directional audio. It plays music files to guide the user in the right direction using GPS data (Etter & Specht, 2005). Another device that incorporates the user's activity to affect their audio is the "Are We There Yet?" system (Adcock, 2008), which modifies the playback speed of audio books according to how much travel time remains for the user. If the user increases his or her speed, resulting in the estimated time to destination to be sooner than anticipated, the playback of the audio book increases so that the read-out story ends just when the user arrives.

THEORETICAL FOUNDATIONS

The theoretical foundations for this merger of physical actions from sports with computer gaming technologies has been influenced by psychological investigations in emotional experience and bodily signs of emotion, which has been used to explain exergaming phenomena (Lehrer, 2006). One of the early questions under investigation in this field was whether emotions (such as fear and excitement) follow bodily signs (such as facial expressions and tears), or whether it is the other way round (Lehrer, 2006). Understanding this can inform the design of interactive physical experiences. A phenomenological approach to understanding the body's role has led to recent investigations in proprioception, suggesting a continuous bi-directional feedback loop between the mind and the body. Damasio (2000) calls it an "embodied mind", in contrast to the exclusively

embrained mind: a concept that emerged out of an earlier, rationalistic tradition of understanding interactive technology (Winograd & Flores, 1987). Merleau-Ponty (2002), in his investigations on phenomenological thinking, described the consciousness, the world and the human body as a perceiving thing that is intertwined and mutually "engaged". This view considers a correlate of the body and its sensory functions. Having a theoretical lens like this implies that a manager for exertion games should not ask one designer to be responsible for the gameplay, while another designer is assigned the interface, but rather these two tasks go hand-in-hand and should be considered as one entity.

Such an approach has further implications. "An emotion begins as the perception of the bodily change" (Lehrer, 2006). Therefore, moving around in an exercise activity can generate the perception of increased heart rate and sweating. This means in order to prepare a participant for an upcoming exertion interaction, the brain triggers a wave of changes in the physical viscera, such as a quickening of the pulse and the releasing of adrenaline. Once such a physical experience has started, these effects are exaggerated, because the muscles need oxygenated blood (Lehrer, 2006). Supporting this constant interaction or loop between brain and body is believed to create a more emotionally engaging experience for exertion games, compared to traditional screen-based games (Lehrer, 2006). Designers who are aiming for an emotional experience can leverage these findings in their designs. A more general recommendation is the inference that the mind-body loop calls for a more holistic approach in our understanding of combined sports and computer game experiences.

OPPORTUNITIES

An emerging research field has begun to leverage the advantages that can result from a holistic

approach to considering the body and the mind in computer based activities. Sports actions are augmented with pervasive computing technologies and borrow from computer game principles to help users improve their skills. Computer game activities are supplemented by involving bodily actions to control and immerse players in their environments, while simultaneously creating more emotionally rich experiences that have a significant impact on players' lives. This approach goes beyond adding an exertion component to existing computer games, but rather aims to create physical experiences that are not possible without the computer augmentation, similar to the "beyond-being-there" approach in videoconferencing. This work by Hollan and Stornetta (1992) realized that videoconferencing equipment, until then, was mostly designed with the aim of recreating a collocated experience as closely as possible. They proposed that an augmented tele-experience would never be as good as face-to-face, and therefore designers should not try to emulate this, but rather focus on creating compelling experiences that offer benefits "beyond" what is possible face-to-face. The same concept underlies the approach in augmenting exertion interactions: it is not designed to replace existing sports activities, but rather offer opportunities that are not possible without the technological addition.

This chapter argues that by creating awareness and sensitivity to the unique opportunities sports activities can offer, better interactive experiences can be designed. Novel experiences in augmented online environments can be offered, instead of trying to simulate existing ones. For example, researchers and practitioners have the opportunity to retain the benefits of physical exertion in interactive environments, but also capitalize on the ability of computer games to support geographically distant participants, through telecommunication advances. The chapter now turns to one example, an original prototype, which follows this framework of utilizing gaming technologies

and principles to support sports activities. It is a jogging support system for casual joggers who value the motivational and social benefits of jogging together, but are separated by distance.

JOGGING

Social Jogging

Jogging is one of the easiest ways of participating in sports activity in terms of requirements, because the jogger does not need any special equipment and running can be done almost everywhere. Jogging can also be a beneficial health exercise for participants of all levels. In particular, joining others to jog is often recommended to increase and sustain participation rates. Jogging in teams allows for socializing, and runners use each other's commitment for motivation. For example, joggers motivate one another to run faster and further by challenging each other's strength. This contributes to more effective exercise.

Ubiquitous computing technology to motivate joggers already exists. For example, heart rate monitors, pedometers and MP3 players are commonly worn by joggers to augment their experience. However, these devices focus on the individual and provide the individual a way of tracking progress. Here I present a prototype called "*Jogging over a Distance*" that offers experiences traditionally known from gaming such as distributed player support and spatialized audio, delivered via entertainment means, but applied to a sports setting. The conceptual themes and applied frameworks that led to the described prototype are detailed, along with the technological challenges faced in using gaming technologies for sports use. These included consideration of computing devices suitable for rugged outdoor use, programming efficiency and audio spatialization techniques for voice communication in un-tethered environments, as well as reliable acquisition and adequate tracking of

performance data in order to offer a satisfying augmented sports experience.

The system, *Jogging over a Distance*, is aimed at runners who want to run together but are geographically apart. It is facilitated by a ubiquitous distributed audio environment that retains the outdoor exercise experience, while aiming to support the social and motivational benefits. It is acknowledged that some joggers prefer running alone; however, in this work, the focus is on joggers who enjoy running with others.

Internet forums indicate that joggers often run with others (O'Brien, Mueller & Thorogood, 2007). A survey conducted with 77 joggers confirms this, with 57% of respondents stating they run with at least one other person. The top reasons for running with others include socializing (83%), motivation to run faster (78%), motivation to participate (53%), and to have fun (53%). Many social joggers value the ability to have conversations with their partners and use their exercise sessions as a way to stay in touch with their friends. One respondent noted,

About twice a month I run with some of the girls I went to college with. It's a great time to chat and catch up! Even though we see each other and chat regularly, we always seem to talk more openly while we run." Another participant gave an example of the benefits he received from running with a partner: "I ran on Sunday with another runner, and she wanted to add a little more distance to the route. We talked about it as we ran and agreed where to run. I ran more than I would have if I ran by myself. After the run, I was glad that I did the extra mileage. Also, my running companion ran faster than I would have in the early part of the run (I actually had to ask her to slow down a little for the first mile), and I think I pushed her at the end of the run. It was mutually beneficial.

A frustration participants have with social jogging is finding the "right" jogging partner: one

who can meet them at the same location and who jogs at roughly the same pace. This challenge of finding a partner often results when people move away, or when one partner becomes faster than the other due to training. One jogger explained that he only has one friend with whom he can run, but his friend moved across the country and "*now I know of no one my age who runs the way I do... many run longer and a lot run shorter... I still wish I knew people to run with to shake things up a bit.*" Another recently re-located runner stated, "*I run alone, [but] I wish I could find a couple of people to run with but haven't had much luck in finding a running partner since I moved two years ago.*"

For casual joggers, being able to hold a conversation can be an indicator that they are running at a suitable pace: not too fast and not too slow for an optimal health benefit. This is often referred to as the "Talk Test" (Porcari et al., 2002). While social jogging can motivate people to run faster and further than solo jogging, partners should have roughly the same physical capabilities in regard to both speed and distance. Some runners may run alone, simply because they have yet to find a jogging partner.

An important yet challenging aspect of social jogging therefore, is finding jogging partners who run at the same pace and who live nearby. An opportunity exists to overcome this challenge and enhance the sports participation of joggers.

Mobile Support

To support social communication between joggers, which is motivational for their exercise, a solution featuring an audio connection between the joggers was selected. An audio interface suits a mobile, outdoor environment: it is simple, lightweight, and allows users to visually focus on their environment. Furthermore, an audio interface supports outdoor running; unlike treadmill-based systems, our system is wearable and un-tethered.

Preliminary Experiment

To investigate the feasibility of an audio channel to support joggers and their social interactions, an experiment was conducted, in which a jogger was equipped with a small laptop in a backpack; a headset; and a wireless internet connection over a mobile 3G data network. The runner used Voice over IP (VoIP) to transmit his speech. The other person did not run, but sat in her office about 800 kilometers away, connected via the VoIP link. Of initial interest was testing the technical feasibility of the proposed setup; it was found that it is feasible to use a commercial wireless system to support a fast-moving jogger across a large area. But what was intriguing was the remote participant's report that she had a sense of sharing the other person's running experience, and through the conversation and noise from the outside environment, was able to visualize what the other runner was possibly seeing. This indicated that running with a remote person has the potential to be engaging.

Mobile Phone Experiment

In order to understand the experience joggers would have if they could communicate with a remote running partner through an audio channel (Figure 1), 18 volunteers were asked to go running at the same time, but in opposite directions, equipped with a mobile phone and a Bluetooth® headset (O'Brien et al., 2007). The vivid sense of presence the audio conveyed to the participants, confirmed the first experiment: participants not only mentioned hearing the other person's voice, but also the wind, the noise of the footsteps depending on the different ground surfaces, and the breathing of the remote jogger. As a result, the combined acoustical information created a social and enjoyable experience.

Considering the system was simply applying existing technology to a new context, it was surprising how much participants enjoyed their run. On a scale of 0-100 (with 100 being best)

Figure 1. Jogging with a mobile phone connection



participants ranked, on average, their enjoyment level of running alone as 55, their enjoyment of jogging side-by-side as 79, and their enjoyment with the mobile phones as 75. Although this is not a reliable measure, the high rating is promising.

One participant explained, *"There were times when I was just jogging along like I always jogged and chatting away like I always chat away and it was more or less exactly the same as running with someone."* Another participant stated, *"It had the advantage of running with the other person and I could run where and how I wanted to run [...] you had almost the same experience because you were constantly communicating with them."*

Knowing how fast they and their partner were going was important for half of the participants. For one participant, this kept her running. She explained, *"There's some pride that you don't want to stop. I thought about stopping a bit today, and that would have been easier, because [my partner] wasn't there, but I didn't know if she could tell over the phone, so I didn't try."* One participant suggested the partners could carry some tracking devices and then verbally tell each other their speeds, which he felt would greatly improve his experience. Participants seemed interested in knowing their partner's pace in order to help them endure the distance of the jog, by either cheering

them on to go faster, or motivating them to keep going. By notifying the joggers of their paces, such a system could better support motivation.

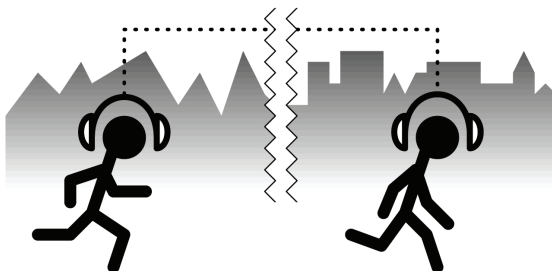
These results prompted the development of a prototype to push further the idea of jogging “together” with geographically distant partners. This system is called “*Jogging over a Distance*”.

JOGGING OVER A DISTANCE

One possible solution to finding social jogging partners is to enable people to jog with remote friends and other remote joggers (Figure 2). With *Jogging over a Distance*, jogging partners could live in opposite parts of the world, yet share the experience of jogging together. By meeting at the same time in separate locations, long distance friends could become, or stay, social jogging partners.

The prototype created not only supports conversation, but also uses audio to communicate pace. The *Jogging over a Distance* system therefore supports the motivational aspect of being able to compare each other's pace. Similar to jogging side-by-side and adjusting pace with one's partner, the *Jogging over a Distance* prototype transforms the conversation into spatialized audio to simulate hearing one's partner in front, to the side, or behind. The idea is that the information can contribute to an increased awareness of the other person's presence, hence creating a shared sportive experience.

Figure 2. Jogging together although geographically apart



Design Goals

The prototype aims to allow two joggers to experience a run “together”, similar to the experience of jogging side-by-side. The design is focused on the following points:

- To retain the experience of jogging, including its health and social aspects, the system is mobile and can be used outside. The workout as well as the social experience is greatly enhanced by being outside. Indeed, participants in the experiment indicated they jog outside, many to experience nature.
- One aim was to keep the technology as non-intrusive to the jogging experience as possible, and therefore to build a system that, if commercially deployed, could take the form-factor of a mobile phone or MP3 player. The current design is heavier than an iPod® and uses larger headphones, however, future technology advances will allow for the functionality to fit into a mobile phone. This way the user would have to carry only one device plus the headphones.
- The decision was made to restrict the modality to an audio-only experience, based on the fact that many joggers are familiar and comfortable with taking an MP3 player on their run. The participants will therefore experience a social run delivered through an audio-only channel, not distracting their visual focus by requiring them to look at a display.
- Joggers already exert themselves physically and their mental focus is occupied with a strenuous run, therefore it is important the experience does not require any button presses. In fact, the interface should be controlled explicitly, not implicitly. Therefore, the decision was made to let the jog become the Exertion Interface (Mueller, Agamanolis & Picard, 2003) to enhance the experience.

Adding Pace Awareness

By increasing the sense of presence of the other person, it is possible to enhance the experience of jogging together for geographically distant jogging partners, beyond the previous audio-only approach (discussed earlier). Adding pace awareness could be beneficial for an increased sense of presence between the jogging partners, which in turn could contribute to the motivational and social effects of jogging together. A mobile audio system was therefore designed that connects two joggers over a distance, supporting their conversations while using spatialized sound to communicate pace awareness.

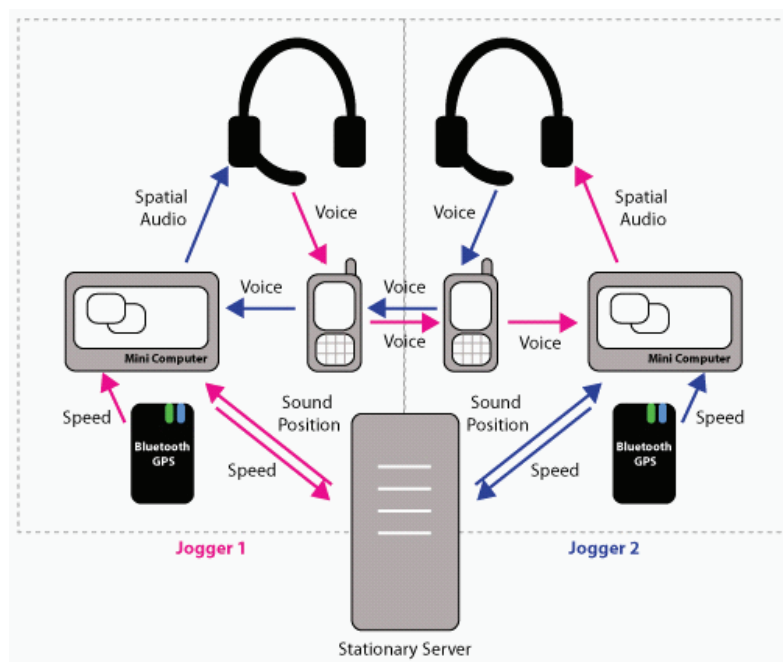
Experience

In the current design, the two joggers, who run in different locations, wear microphones to speak to each other. They also have headphones that deliver the conversations exchanged with the remote partner, but the audio is positioned on

a virtual 2D horizontal plane around the user's head. While they jog, speed data is collected and used to position the audio of their conversations and environment in a 2D sound environment. As one jogger speaks, their partner hears the localized audio and is able to detect whether the other person is going faster, same pace, or slower, and thus is in front, to the side, or behind. Similar to a colocated setting, the audio cues runners when to speed up or slow down in order to “stay” with their partner. This approach supports joggers' desire for socializing and motivation to keep pace, as indicated in the survey and forums. The joggers can discuss running routes, encourage each other, or simply listen to the environment noises of the other location.

The system is per default optimized for a condition in which the two jogging partners run roughly the same pace: the joggers should experience the other person's voice sometimes coming from the front, sometimes coming from the back, but mainly coming closely from the center position. If one jogger is constantly faster than their

Figure 3. Technical implementation



partner, the sound would always appear coming from the back, which might therefore seem not to be very reactive. For this kind of scenario, an offset in the code can compensate and adjust the two joggers' speeds virtually. This enables two joggers to jog together although they would not enjoy jogging together side-by-side: one would be too exhausted trying to keep up, the other frustrated by the slow running speed. Finding a partner that has the same jogging speed is a frequent problem reported by participants, but *Jogging over a Distance* can help accommodate these joggers.

Jogging over a Distance consists of two identical systems, each with a miniature computer; a Bluetooth® GPS device; a wireless modem; a mobile phone; and a headset (Figure 3) (Muel-ler, O'Brien & Thorogood, 2007). Each system is carried in a small, close fitting bag while the user jogs (Figure 4).

The mini PC runs Java™ and Processing software, which determines the participants' speed from the GPS data. Each computer is

connected to a commercial wireless broadband service, which covers the major urban parks where joggers run. Speed and time data from the GPS device is received by the mini computer via Bluetooth®. The computer then transmits this data wirelessly over a 3G network to a server, which calculates the speed difference and adjusts for GPS inconsistencies. The server determines how fast each jogger is running in relation to his or her partner. As a result of this, an algorithm calculates a sound position value for each jogger. As each jogger talks, their voice is picked up by a microphone and the audio is transmitted via a conventional mobile phone. VoIP technology was initially used, as in the preliminary experiment, but the lag and reliability was insufficient for the current purpose. Before routing the incoming audio from the remote jogger's mobile phone to the headphones, the mini computer applies a spatialization algorithm to the sound source. The mini computer uses the sound position value received from the server to transform the audio data into spatial 2D audio by placing the sound source onto an imaginary plane around the jogger's head, delivered via the headphones. The result is that the jogger hears their partner's voice coming from a certain direction.

The localization effect is enhanced by high-quality headphones, however it is acknowledged that such headphones are often bigger in size than conventional headphones and, therefore, may not be liked by all joggers. Smaller headphones have also been tested, and while not as superior, they still deliver an adequate spatial sound experience.

Sound Spatialization

In order to develop *Jogging over a Distance*, it was important to find an audio setup in which users could clearly detect where the sound is coming from. Unfortunately, without the use of visual cues, it is difficult for people to differentiate between front and back sound sources, in contrast to left and right (Burgess, 1992). In

Figure 4. The prototype



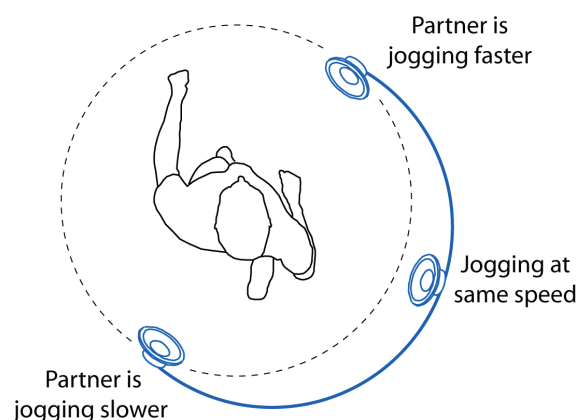
addition, mobility has been found to decrease audio target accuracy by 20 percent (Marentakis & Brewster, 2006). Fortunately, target accuracy for the current application does not need to be very precise. However, the user needs to be able to clearly differentiate if the other person's voice is coming from the front or the back. To find a solution for communicating sound location while in a mobile environment, different headphones and audio spatialization implementations were evaluated.

In an informal experiment, five participants were recruited to jog on a treadmill at a public gym, while listening to spatially positioned audio cues with various headset models. These headsets were off-the-shelf surround sound headphones, internally designed surround sound headphones, and regular headphones. Some of the spatialization implementations used HRTFs (head related transfer functions), while others relied solely on filtering frequency. Jogging makes sound localization difficult due to the participant's exhaustion level and the moving around of the body and the head. An intensification approach for the prototype was therefore adopted. Instead of positioning the remote sound on an imaginary axis from 12 o'clock to 6 o'clock (from a bird's-eye perspective, with the person being in the center of the clock, looking at 12 o'clock), it is proposed that the sound is positioned on an axis from 1:30 to 7:30 (Figure 5). This exploits a person's ability to easily distinguish between left and right audio sources, while simultaneously conveying an experience of hearing sound appearing from the front or back. Initial experiments confirmed that this design greatly improved the sound localization ability of participants, while still creating the impression that the other person is talking either "from behind or in front".

Limitations

In its current implementation, the system does not take into account any elevation data and assumes

Figure 5. Bird's eye view of spatialized sound



that both joggers run on a flat surface in order to effectively compare pace data. Also, the joggers should ideally run for the same amount of time and start simultaneously.

DISCUSSION

Jogging over a Distance targets social, casual joggers who enjoy jogging with others and like to converse during their runs. Not all joggers talk during their exercise: six percent of surveyed joggers who run with others replied that they do not talk while running, and some enjoy the tranquility of running alone. However, the design of *Jogging over a Distance* is based on feedback from participants who claim they jog with others for social and motivational reasons. *Jogging over a Distance* is also not aiming to replace the traditional social "jogging together" experience. Rather, it provides a novel experience and enables an activity that is not possible without the technical augmentation, for joggers who want to run with friends or family but who are located elsewhere. Furthermore, the ability of processing pace data via computational means before delivery to a sports partner allows for modification to improve accessibility. By adjusting exercise intensity data to a suitable level for the involved exercise part-

ner, it is possible to create sports experiences that compensate for different skill levels between the participants. In *Jogging over a Distance*, runners of different speeds can run together, because their exercise level can be computationally adjusted before being utilized on the remote end, thereby providing an enjoyable experience for both joggers. Such a situation in which the participants have different physical capabilities can often be unsatisfactory in a collocated environment. The joggers can wear weights or other equipment that limits their capabilities, or deliberately decrease pace to that of the slower partner, but these experiences are often associated with feelings of not being challenged enough by the faster runner, and notions of inadequacy and over-exhaustion by the slower one. *Jogging over a Distance* could also modify the baseline variables on-the-fly based on the players physiological conditions. This adjustment could occur concealed from the participants to facilitate implicit motivational support. For example coaches could use this to push their athletes as part of a training plan to reveal the athlete's limits.

In further work, my colleagues and I want to conduct a comparative study to measure whether spatial audio delivery has an effect on the perceived presence of the other person. Furthermore, we are interested in investigating if a greater sense of presence can serve as a motivational tool to encourage people to run faster, further and more often. The results of this research will inform future designs that aim to support social interactions between geographically distant participants.

FUTURE WORK

Although prototypes and even commercial products have emerged that combine computer gaming technologies and sports, this field is only in its infancy and far from having achieved its goals. Although exertion games have been shown to offer physical health benefits (Lanningham-Foster et al.,

2006), their cardiovascular energy expenditure is often limited, and has therefore been compared to only moderate traditional activities such as brisk walks (Maddison et al., 2007). Incorporating more strenuous activity to support richer health benefits will therefore be one of the next challenges to consider in future games that are aimed at addressing the obesity issue. Furthermore, although it is acknowledged that exertion games can help attract new audiences (Bianchi-Berthouze, Kim & Patel, 2007) to participate in fitness exercises, they are generally considered to be only facilitators for future participation in sports clubs and gyms, as opposed to being distinct sports activities on their own. Turning such exertion games into distinct sports experiences could be a rewarding opportunity for future research.

Future designs and evaluations of new prototypes will help uncover the potential computers can contribute to the sports domain, and in which ways athletes, from the beginner to the professional, can benefit from computer game technology advantages. Creating a conceptual framework around the topic is a remaining issue. Such a theoretical model could provide guidance for the development of future systems. In particular, it should be able to consolidate conceptual themes from the two core areas – digital play and sport – and hence has potential to contribute towards a beneficial balance that considers the benefits of each domain in this merging field.

Many technological advances have been supporting professional athletes in recent years, however the market for hobby sportspeople has a growing commercial potential. With an increasing awareness of the health issues our sedentary lifestyles support, people could become more self-conscious and more involved in sportive activity. Supporting these amateur, but passionate sportspeople has created a growing financial market, and might be an increasingly important area for future developments. In particular, the design of cheap, robust technology that can support health goals will be a central challenge.

Technology can supplement participants' motivational efforts by providing them with social support mechanisms through their peers. Empirical investigations should be undertaken to investigate how these mechanisms need to be designed for maximum effectiveness. In regards to the previously outlined design issues, a few elementary questions emerge. First, can technology be an influencing factor when it comes to the size of these social support networks? Do these networks have the same opportunity to scale effortlessly, as is seen in digital games? Does the communication support need to be synchronous, or what effect does an asynchronous channel have? Finally, does a high degree of anonymity facilitate or hinder social support mechanisms? Knowledge from online communities in social network games could contribute insights here. Answering these questions will benefit designs in the merging area of digital games and sport.

CONCLUSION

With this contribution, selected aspects of a growing trend in merging digital game technology with physical sports activities have been highlighted. In particular, the goal of this chapter was to sensitize the reader to the many opportunities offered by the application of digital gaming technologies to bodily activities. This approach is exemplified by describing a system that offers advantages known from computer gaming (i.e. supporting players in geographically distant locations by utilizing networking technologies) to engage users in a physical activity together, despite being apart. It has been shown how this system, called *Jogging over a Distance*, can address the issue of finding the right jogging partner: one that is roughly running at the same pace and available at a mutually convenient time. This is often difficult to achieve in a traditional, collocated setting. Other research prototypes exist that augment sports with digital technologies to support performance enhance-

ment, and prominent examples were described. Commercial systems have already entered households across the world, and users have appropriated them for their health goals. However, many of these systems that have their origin in a gaming tradition offer only limited support for energy expenditure. With a simple example of using mobile phones for jogging activity, this chapter shows how technological advances can support traditional sports activity, while being accessible and affordable to the recreational athlete. This study showed how powerful existing technology can be when applied to a new context such as sport, as indicated by the enthusiastic comments from participants. It is hoped this inspires more work in the area.

This work on networked sports activities should not suggest that the benefits of introducing digital gaming technologies to fitness applications are limited to supporting distributed participants. Offering enhanced training effects; supporting teams with players of different capabilities; and allowing athletes to work out with others at different times are all scenarios that could be envisioned by the utilization of technological advances. Computer gaming technologies can also serve as persuasive tools to motivate people to start a healthier, physically active lifestyle and thus address a growing obesity issue. On-line systems often in combination with smart sports equipment, has demonstrated this. Users benefit from such approaches by being offered more engaging experiences, and they can use these systems to support a healthier lifestyle, as well as increase their mental, social and physical well-being. However, participants also need to be aware that some of these advances cannot and should not replace traditional sports activities. For example, participating in sports clubs has many advantages beyond the obvious health benefit, such as contributing to social capital, and users should not forget that technological solutions might not be able to support all of these aspects equally well. A sportsperson should always weigh up the

advantages and disadvantages a new technological advance offers. It might be helpful to consider these opportunities as complementary to existing sports opportunities, instead of as a replacement. Also, some design solutions offer experiences that are not just simulations of existing activities, but rather aim to go “beyond” by enabling functionality traditionally difficult or impossible to obtain. *Jogging over a Distance* exemplifies such an approach by supporting sportspeople of different physical capabilities. The consideration of such opportunities in design will enable athletes to participate in sports activities that offer exciting possibilities for their well-being in the future.

Digital gaming in combination with sports activities now has the potential to work against its past criticism of supporting a sedentary lifestyle and diminishing physical fitness. Instead, it is making a significant leap towards contributing positively to health effects and enabling novel well-being experiences previously difficult to achieve. Seizing the opportunities is a task that lies ahead for all of us in this area, whether we are designers, researchers, developers, practitioners, decision makers or users, and collectively, a rewarding contribution can be achieved that contributes to the well-being of many people worldwide.

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