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MobZombies: A Wearable Sensor For A Playground Style Electronic Game

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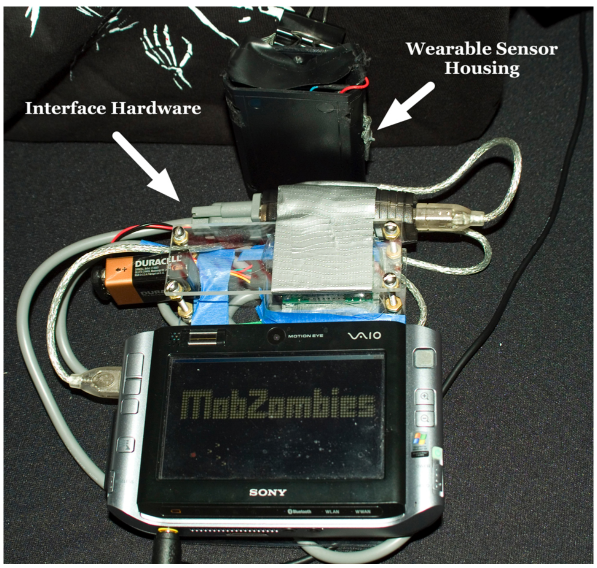

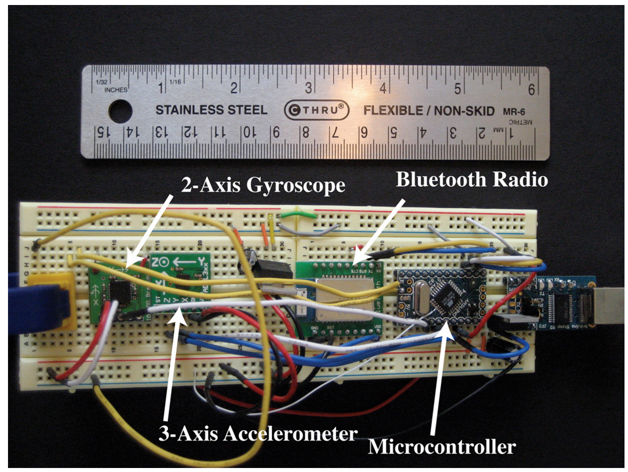

Abstract

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1. Introduction

MobZombies is an electronic game that uses the player's physical body movement to control the game avatar. [1] In the game, the player's avatar is chased by a mob of zombies that must be evaded in order to survive. The player must run and turn in order to control their avatar's forward movement and turning movement. Through the use of a wearable sensor, the player's running and turning are translated into avatar movement. We investigate three successive wearable sensor designs and report on their suitability for this unique style of electronic game.

2. Research Objectives and Motivation

Our project is based on the general assumption that electronic games are largely a sedentary form of entertainment. Creating electronic games that require broad physical movement is a unique opportunity for the wearables community. On this basis, our project is motivated by the possibility of creating electronic forms of play that mix traditional pre-digital playground activities with wearable, portable electronics and sensor technologies.[7] The goal is less to advance instrumental aspects of wearable computing, and more to investigate how wearable technologies and sensors can create an "opportunity space" for new forms of electronic play that encourage or support more physical style game activities.

3. Prior Art

The typical video or computer game entertainment scenario is quite sedentary. In this way, most computer games are disconnected from physical, body-based movement. But in some specific cases, computer games have explored the use of various wearable or hand-held sensors to translate physical, body-based movement into a component of the game play.

The Nintendo Wii is today's canonical sensor-based video game console. The sensor apparatus is composed of a hand-held game controller that uses a 3-axis accelerometer and IR sensor.[3] This game controller enforces a play design that couples the player's physical motion with the action of the player's avatar on screen. It is possible to speculate that, on the basis of the Wii's success, future, more physically active forms of electronic play will become increasingly acceptable to the game playing public.

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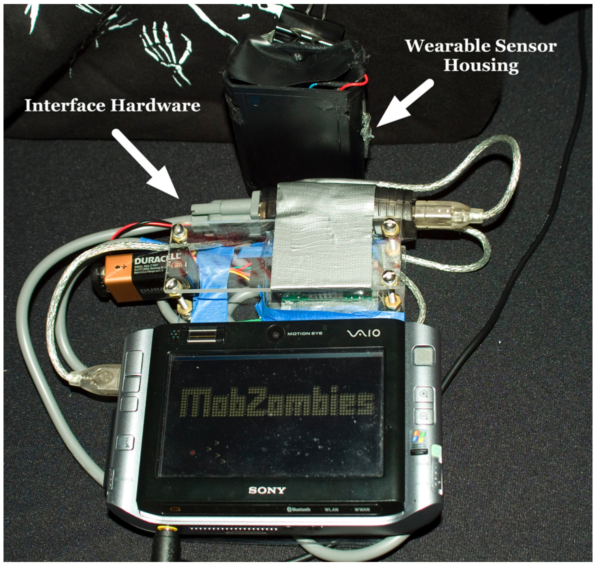

Figure 1 Prototype wearable sensor consisting of magnetic compass and accelerometer, interface and hand-held computer

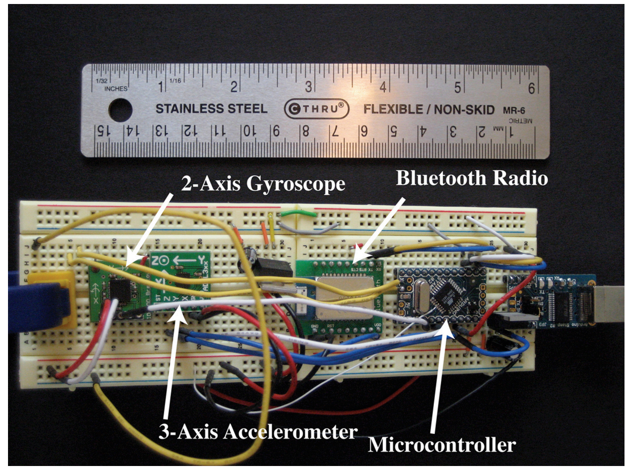

Figure 2 Prototype of gyroscope-based version of the wearable sensor.

In addition to these unique, physical sensor mechanisms for console games, mobile games have begun to leverage wearable peripheral devices to use a player's motion data as an integral part of the gameplay.

For example, Teku Teku Angel is a Japanese language Nintendo DS-Lite application that includes an electronic game and accompanying Tamagotchi-like pedometer.[2] In the Teku Teku Angel game, players manually enter their current number of steps as indicated on the pedometer display. The game then shows a real-world geographic map which indicates the distance between known geographic landmarks, such as cities, that the player would have walked had they been walking a straight path.

Pirates! is a game constructed to evaluate how traditional game play can be integrated with computational game elements by using the physical world as the game's arena.[4] Through the use of proximity sensing and wireless communication, the game allows players to physically wander the game board — an area of physical space — using handheld computers to connect to the game engine. This game investigates how the social elements of more traditional board games, such as your proximity to objects or other players, could be used in a virtual-physical hybrid game.

4. Description

MobZombies takes some of the physical movement sensing characteristics of the prior art and extends it in two ways through the wearable sensor, described in detail below. First, it extends the envelope of significant movement to include full body translation and rotation. Second, it provides this extended envelope of sensing in a package that allows it to be used in "untethered" usage contexts. In other words, it is mobile, portable, and battery-powered and thus can used in a variety of settings. For us, a significant motivator was very much the image of fairly unstructured, adolescent playground action and the challenges of creating an "interface" for that kind of physical activity.

All of these unique characteristics were determined to be requirements built to achieve the design goal of creating a pre-digital playground style sensibility in an electronic game.

4.1 Game Scenario

The game scenario is a typical avoidance and attack scenario. An endless horde of zombies are on the loose, searching for you, the last non-zombie in town. Your character must evade the zombies by running away from the attackers, or lure them into approaching small explosive parcels. Your character slowly loses its energy and humanity with each attack. "Power up" parcels allow you to regain some strength. The objective of the game is to sustain yourself for as long as possible through a combination of avoidance, counter-attack and power-up. The game is scored based on the amount of time you maintain your humanity, and how many zombies you're able to eliminate.

The game is viewed from a top-down perspective. The player controls the movement of the game avatar by walking (or running) forward. Turning left or right changes the direction of movement of your avatar. In order to enhance the effect of you actually controlling the avatar and to avoid disorientation, the avatar is actually fixed in relationship to the player and always remains in the middle of the screen.

The game was developed using the Processing development environment, a wrapper around Java.[8] We chose Processing because it offers a rapid development environment and offers a relatively easy facade around the Java graphics framework.

4.2 Sensor Technical Design

Three versions of the wearable sensor were created. These three sensor platforms were created to compare the advantages and disadvantages of each with respect to their ability to create game play suitable to the goal of a quick-movement style game.[9]

The first sensor framework uses a hand held GPS device. The second sensor framework uses a digital magnetic compass and tri-axis accelerometer. The third sensor framework uses a MEMS integrated two-axis micro-mechanical gyroscope and tri-axis accelerometer.

In the first GPS-based platform the player's relatively large translational movements in the real world — several meters based on the accuracy of the GPS — control where the avatar appears on the game grid. The GPS recorded latitude and longitude was used as a way to determine the relative location of the player's avatar from an arbitrary starting point.

The second platform uses a PNI Vector 2Xe 2-axis digital magnetic compass and a Freescale MMA7260Q tri-axis accelerometer. The magnetic compass is used to capture the direction the player is currently facing. This direction data is correlated to the direction the player's avatar is facing within the game world. This then determines the direction the player's avatar moves.

The third platform uses an InvernSense IDG300 two-axis gyroscope and an Analog Devices ADXL330 three-axis accelerometer. The IDG300 can resolve up to +/- 500 degrees per second, which makes it very responsive given the speed of rotation that players will likely achieve. The gyroscope angular rates are captured to determine how quickly the player turns either left or right. This angular rate of change is correlated to how quickly the player's avatar turns either left or right.

In the second and third platforms, movement is correlated to agitation of the accelerometer according to a simple algorithm that captures the motion of walking or running.

All three platforms were sufficient to make the basic game mechanic work with varying degrees of success in attaining the goal of a quick-action physical game.

The first sensor platform proved to be a good learning experience in that it revealed aspects of GPS sensing that can impair the continuity of quick-movement style game play. In this case, the variable accuracy and time latencies of GPS make it difficult to construct a "real time" game of the sort described here. Although suggestions have been made as to how to resolve such issues when determining location for "real-world" pervasive games, we were less concerned with geospatial location and more with relative motion, uncorrelated to any physical objects or landmarks in the world.[6]

The second platform proved much more accurate both in determining translational movement and avatar direction. This version improved upon the previous platform by allowing the player to move quicker than the previous platform. Using sensor readings from an accelerometer to infer forward motion resolved that motion much quicker than using a consumer GPS. On the other hand, we found that the digital magnetic compass' ability to lock a direction lagged a small amount, but enough so that there was the sense that the game was slightly behind the player when they were turning.

The third platform uses a MEMS gyroscope to determine angular rates — change in direction — as a way to control how the player's avatar turns. This approach was initially explored as a result of the slight lag presented by the digital compass, but also because of some electrical design problems. The magnetic compass proved to be sensitive to the local radio frequency energy generated by the Bluetooth radios which were used to interface the sensor to the hand-held computer. Also, the noisy RF environment of the handheld computer impeded the accuracy of the compass. It was difficult to come up with a compact printed circuit board design that isolated the radio from the compass without hampering the performance of one or the other. While we were initially reluctant to use the gyroscope, this approach offered an unexpected interface advantage by providing an easier way to measure rate of direction change when compared to the digital magnetic compass. This way the game could require that the player turn quicker as they moved up in difficulty levels, further increasing the game's challenge.

The first platform was tested on a small, light-weight Toshiba tablet computer, while the second and third platforms were tested using a Sony UX hand-held computer. The third platform is also being developed for use with a J2ME compatible mobile phone.

4.3 Game Design

The usage scenarios for so-called wearable and portable computers pose a number of practical design challenges. We focus on one very specific challenge, that being ways in which broad, embodied movement as captured through a wearable sensor can be used for electronic games that require physical activity.

In the spectrum of the user-interface syntax, there is a taxonomy of significant interactions — those manipulations of a specific user-interface that result in some sort of action. In the case of computer user interfaces, such actions are often logically or semantically coupled through a careful design of the interface.[5] Conventional buttons, such as keyboard keys, are one of the most common computer-human interfaces. With this interface, the key press is directly connected to a very specific, precisely defined result of the key press action.

The limits of a user-interface dictate the possibility space for the usage scenario. In most cases, the possibility space is limited to a simple, short translational movement — a "button push" — creating some effect instrumentally linked to that the user's action. The possibility space for interaction in this case is constrained to things that are semantically relevant to a keyboard key being pressed. In this example a key press, as a computer-human interface, does not lend itself to controlling a game through broader, more robust body movement.

As sensor and other techniques for capturing broader actions are developed, more and more of the human body can become part of the computer-human interface framework. Wearable computing, specifically sensors used in the context of wearable computing, are "worn", hence they are able to capture specific body movements and articulations, widening the possibility space and context for new kinds of computer-human interaction.

In the case of the present research, we focused on sensing body movement, particularly change in momentum. By measuring angular rates, as in the third platform described above, we are correlating our data to angular momentum. Similarly, translational acceleration is related to change in the player's body's momentum. For our research objectives, the precise direction in which the player is facing, as well as the precise speed at which they walk or run is much less important than creating a sense that the player is manipulating the avatar roughly according to their motion. We found in observing players that they were deeply engrossed in the actual game itself and less concerned that their movements correlated precisely step per step, or degree of rotation per degree of rotation with the action depicted on the screen. Our speculation is that the fact that the game is "heads down" and has a deliberate low-resolution visual design mitigates the requirement for one-to-one correlation between player and avatar movement.

5. Future Directions

We are presently working on a version of the sensor and game that is better suited toward wider distribution. The new version will use a smaller and lower cost sensor platform, based on the third, gyroscope-based design. It will use a Bluetooth radio to communicate sensor data. The application code will be designed using J2ME so as to run on less expensive, more readily accessible mobile phones. Future possibilities include a physical version of the canonical mobile game "Snake" or a version of the traditional playground game "Capture the Flag."

6. Acknowledgements

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