Multimedia Mobile Motion

Augmented Handheld Mobile Device for Motion Control

Matt Benatan, Ian Symonds, and Kia Ng
ICSRiM – University of Leeds
School of Computing, School of Electronic and Electrical Engineering and School of Music
Leeds LS2 9JT, United Kingdom
mobilemotion@icsrim.org.uk, http://mobilemotion.leeds.ac.uk

***Abstract*— As the popularity and capabilities of mobile devices increases, there are many more opportunities arising for innovative applications on the mobile platform. Over recent years a trend has emerged with the majority of handsets utilizing direct user interfaces such as touch screens. However, more current mobile platform developments have also resulted in the incorporation of a number of on-board sensor systems, such as accelerometers. This project looks to augment these existing on-board sensor technologies to facilitate user-centric motion detection, and from this develop a comprehensive gesture-based motion control system for the mobile platform. This paper discusses position detection techniques for the mobile platform utilizing additional sensor augmentation, and presenting a comparative study with a computer vision-based motion tracking technology to analyze the motion data.**

Keywords- multimedia; sensor; accelerometer; ultrasonic; augmentation; interactive

I. Introduction

There are a number of existing technologies that have been augmented to facilitate motion control. Many of these, such as Sony's PlayStation Move [1] and Microsoft's Kinect [2], have been developed for commercial gaming platforms. This level of commercial investment demonstrates that there is currently a significant interest in motion-control interaction.

Motion-control interfaces, such as the game controllers mentioned above, and professional motion capture systems like Vicon [3] require static hardware units to measure the subject's movements. By definition, static reference points are not an option for mobile applications. Hence mobile devices typically use accelerometers to sense changes in movement, but not to acquire positional data.

Through this project, an add-on has been developed that utilizes ultrasonic sensors to enable a mobile device to measure user-relative positional information. This has been used as the foundation for a portable motion control interface.

There are a number of critical requirements that needed to be met in order for a successful solution to be developed. These were broken down into three primary groups:

- Portability: the resulting system would have to be portable, and not inhibit the mobile nature of the augmented device.
- Responsiveness: the system would have to function at low latency, in order to provide an optimal user experience.
- Accuracy: the system would have to accurately and consistently interpret user gestures.

II. Existing Motion Control Technologies

To date there have been few developments involving mobile device augmentation. However, there has been an interest in this area for a number of years – with systems such as Tanaka's augmented PDA [4] being developed in 2004, before mobile devices began to increase in popularity. Outside of the mobile platform, motion control technologies are widely utilized within console gaming, such as with the Nintendo Wii, PlayStation Move and Microsoft Kinect. The approaches used by each of these systems were surveyed during the development of the mobile motion control interface.

A. Nintendo Wii

The Nintendo Wii [5] is an excellent example of a multi sensory motion control system, utilizing both accelerometers and infrared to detect user gestures. The controller is able to determine its position through the use of tracking sensor technology developed by PixArt. This technology uses an infra-red camera to detect the location of two infrared beams projected by the Wii's sensor bar (serving as the static reference). The Wii console then calculates the Wii remotes position through triangulation. The infrared tracking system can then be couple with the controller's accelerometer, which provides data on the forces acting on the Wii remote, resulting in a multimodal gesture control mechanism.

B. PlayStation Move

Unlike the Wii, Sony's PlayStation Move relies on visual light, rather than infrared, for its tracking mechanism. The system tracks an orb of colored light attached to the 'wand controller', which is held by the player. As the orb is of a known size, its position can be tracked, simply by analyzing the size of the received orb image. The system is also capable of dynamically changing the orb's color to allow consistent tracking against a variety of backdrops, and in a range of different lighting conditions. The Move also incorporates a 3D accelerometer, rate sensor and magnetometer. These are used, as with the Wii, to monitor forces acting on the device and provide gesture data. The magnetometer enables the device to correct for cumulative error through calibrating its orientation against the earth's magnetic field.

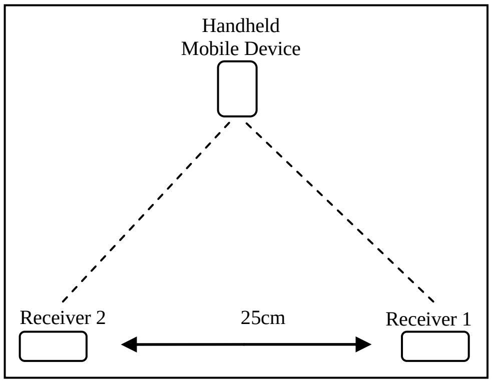

Figure 3. Ultrasonic sensor setup.

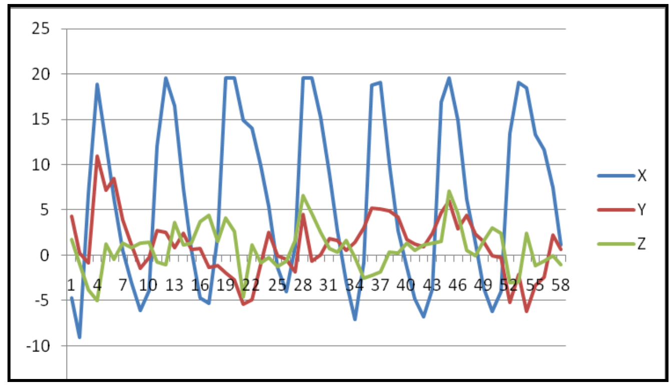

Figure 5. Graph depicting accelerometer data during conducting gesture.

B. Mobile Device Sensors

The device's onboard accelerometer was used to provide data from the forces acting on the phone. This provides three-dimensional information in the form of x, y and z force data from the accelerometers three axes. To use this information within the system, a custom Android application was developed (Figure 4). The application, Sensor Control, accesses the phone's sensors and transmits the data via wifi, allowing it to be used for system testing and prototyping.

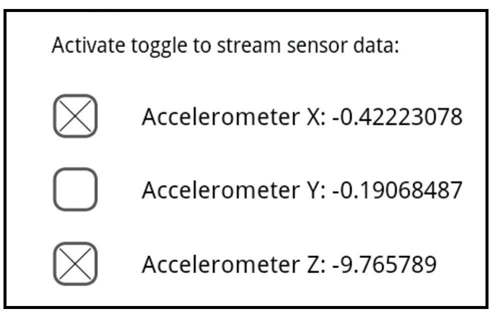

Figure 4. Sensor Control Android application.

1) Hit Detection

One of the first test-cases of multimedia feedback to using the motion-based interface is to use the mobile device to virtually play a percussion instrument such as a drum or a xylophone. For the system to trigger audio samples in response to the user's movement, a hit detection technique was developed. This allowed samples to be triggered dynamically in response to user gestures.

As Figure 5 demonstrates, percussive gestures have very distinct patterns. The maximum force of the gesture produces a distinct feature when compared to the resting force on the axis. Due to this, it can be measured and exploited to allow for more dynamic feedback. This is done by comparing the maximum force to a number of threshold values. Different audio samples are then triggered according to the range of values the accelerometer falls within; resulting in more realistic, dynamic feedback.

As well as velocity-sensitive playback, the hit detection process also utilizes the ultrasonic positioning information. Using this, the system is able to select the correct sample set according to the device's position – moving up in pitch towards the right, and down towards the left, just as with a real xylophone.

The multi sensory approach opens a wide range of multimedia mapping strategies; enabling simple one-to-one mapping to many-to-many mapping using different types of measurements and analysis to control different output parameters [11].

IV. UNDERSTANDING GESTURES

A custom application was developed to validate the accelerometer sensor as a form of capturing gesture data. This program uses Microsoft's Kinect to compare the computer vision data with the accelerometer output. Through correlating this information, it is possible to compare the performance of the accelerometer with a widely used commercial motion control system.

The application is programmed to track the user's hand position in 3D. This allows the data to be compared with the device's accelerometer output.

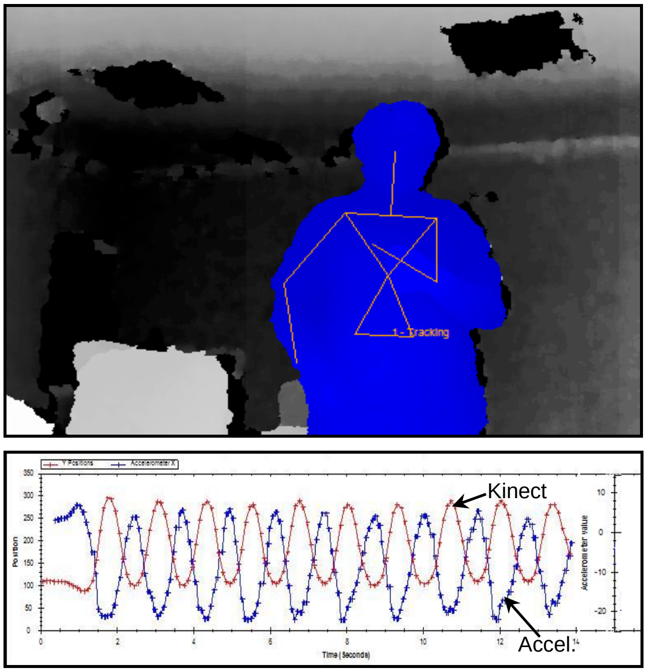

Figure 6. A syncronised view of the Kinect (vertical position coordinate only) and accelerometer (corresponding axis) output.

Figure 6 illustrates one of the dimensions as measured by both sensors, in this case using the vertical axis. It shows a logical correlation between the accelerometer and computer vision data sets. The acceleration increases with the downward movement (decreasing vertical position), and vice versa. The acceleration can also be seen to decrease as the user approaches the apogee or perigee of the gesture before the change of direction.

The correlation between the data shows that the device's onboard accelerometer is capable of providing detailed gestural information. To fully utilize this, cluster analysis algorithms have been developed to provide more detailed gesture recognition. As well as increasing system accuracy within the xylophone application, the enhanced pattern recognition algorithms have also broadened the potential applications of the system giving it the functionality required for use within a wider range of gesture-based applications.

V. Conclusion and Further Direction

This paper proposes a motion control interface for the mobile platform by augmenting an existing mobile device with additional sensors. It describes the needs of a user-relative positioning system, discusses related works and presents the design and development of the system. The paper also proposes a system that integrates ultrasonic sensors to provide time-of-flight-based positional data within a mobile setup.

The system is currently undergoing validation, and recent results prove promising. Comparing the system's performance directly with a commercial motion control unit has shown that this approach is capable of capturing complex gesture data.

Beside optimization, current works in progress include longer range ultrasonic sensing. This capability does not have significant impact on the device's main functionality; though improving the coverage area will broaden potential application domains.

Mobile Motion demonstrates that a portable solution to motion control can be developed and refined for use in a range of applications. These could include game development, alternative forms of device control, musical interfaces and gestural research applications. The system could also be further expanded to utilize other technologies, such as GPS, to enable the development of combined user-relative positioning and global positioning systems.

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