# One Man Band: A 3D Gestural Interface for Collaborative Music Creation

Jared N. Bott* James G. Crowley† Joseph J. LaViola Jr.‡

Interactive Systems and User Experience (ISUE) Lab
University of Central Florida

## ABSTRACT

In recent years the popularity of music and rhythm-based games has experienced tremendous growth. However, almost all of these games require custom hardware to be used as input devices, and these devices control only one or two similar instruments. In this paper we describe One Man Band, a prototype video game for musical expression that uses novel 3D spatial interaction techniques using accelerometer-based motion controllers. One Man Band provides users with 3D gestural interfaces to control both the timing and sound of the music played, with both single and collaborative player modes. We further investigate the ability to detect different musical gestures without explicit selection of mode, giving the user the ability to seamlessly transition between instrument types with a single input device.

**Keywords:** 3D gestural interfaces, video games, music, Wii Remote

**Index Terms:** H.5.2 [Information Interfaces and Presentation]: User Interfaces—Auditory (non-speech) feedback; K.8.0 [Personal Computing]: General—Games; I.5.5 [Pattern Recognition]: Implementation—Interactive Systems

## 1 INTRODUCTION

Recently in the gaming industry there has been growing interest in music and rhythm games. Franchises such as Guitar Hero and Rock Band have sold over a million units, with newly released titles continuing to generate significant interest. These games offer the ability to simulate playing music by using custom input devices designed to emulate the instrument being played. Although it has been shown that such props can lead to a more immersive experience [6], these input devices represent an additional investment required of the player. Furthermore while these games may give the player the feeling of actually playing an instrument, there is almost no opportunity for individual musical expression. Instead, the user is relegated to using the input device to trigger a predefined sequence of notes. Thus, most games of the genre are more about matching rhythms than actually creating music.

We posit that it is possible to create a music game that gives players creative control over the music generated, and only requires a standard game controller to be used as an input device. To explore this idea we have created One Man Band, a prototype video game that uses 3D gestural interfaces to simulate a number of different musical instruments. Our prototype uses Nintendo Wii controllers, that utilize accelerometers, to identify gestures made by the players and translate them into musical notes or sounds. An important design goal in One Man Band was to enable musical novices to collaborate and create pleasing compositions.

*e-mail:jbott@cs.ucf.edu
†e-mail:jcrowley@cs.ucf.edu
‡e-mail:jjl@cs.ucf.edu

Figure 1: Four people playing guided mode.

## 2 RELATED WORK

Interactive music games have been developed and studied by both the academic community and the entertainment industry. Guitar Hero [1] and Rock Band [2] are just two recent examples of music-based games that have experienced tremendous success. For an excellent discussion of additional games and interfaces in this space see [4]. Although each of these games provide some collaborative and creative abilities, our work also gives the player a simple and powerful gestural interface for many instruments using only a single input device. Wii Music [3] is a recent title that focuses on using a simple interface to allow musical expression. This software uses an accelerometer-equipped input device to recognize musical gestures. However, Wii Music is limited with respect to melodic expression. Our work also uses simple gestures to implement musical interfaces, but additionally gives users creative control over exactly what melodies and rhythms they want to play.

## 3 IMPLEMENTATION

One Man Band uses a standard game controller in the form of a Nintendo Wii remote and nunchuk, a common accessory for the Wii remote. The Wii remote contain a three-axis digital accelerometer, an infrared camera, a directional pad, and a number of buttons. The nunchuk, which plugs into the Wii remote, contains the same accelerometer as well as a thumbstick and two buttons.

Our prototype provides six primary single-instrument gestural interfaces: drums, guitar, violin, bass, trombone, and theremin. These interfaces allow players to produce sounds by mimicking the way each instrument is played. The interfaces are designed to give the user an intuitive feel for how each instrument type should be used. This scheme allows for an interface that is easy, realistic, powerful, and expressive. We carefully chose the notes and sounds of the instruments so players can effortlessly play and combine sounds together in a way that is both musical and pleasing to the ear.

### 3.1 Gameplay

One Man Band provides two primary gameplay modes, a guided mode and a freeplay mode. In both guided mode and freeplay mode a metronome is used to help players keep time. The metronome can be configured by changing the time signature or tempo. In guided

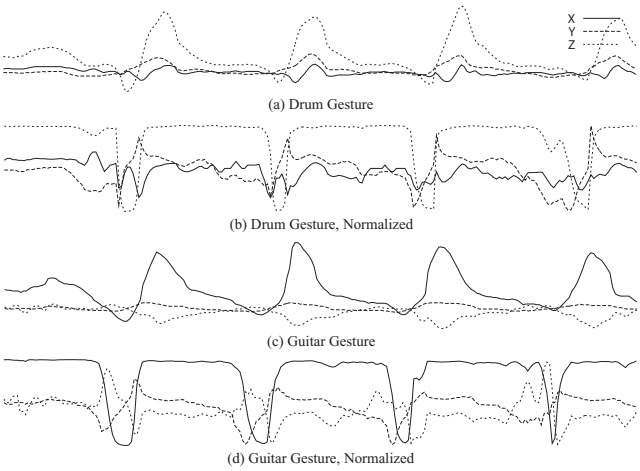


Figure 2: Accelerometer data for four drum and guitar gestures.

mode (Figure 1) we provide several songs of varying difficulty for players to choose from. The metronome is used to provide visual feedback in the form of scrolling lines representing beats in the song. Suggestions as to what might be played take the form of symbols that scroll on the prescribed beat. These icons give players a guide to playing the song, like sheet music; however, players are free to improvise as much as they would like and any melodies played will be heard regardless of what notes are suggested.

Freeplay mode allows up to four players to improvise using the provided musical interfaces. Visual cues can often aid inexperienced musicians in understanding what they and others are playing [5], so we provide players with a three-dimensional scene containing notes and geometric shapes representing the tones and rhythms played. When a player creates a note an object is added to the world and that object travels through the three-dimensional space. Each instrument has its own object type and each type has its own unique patterns of motion determined by the speed of the metronome. These objects help players to choose notes that interact with the other players' visual output. Each player is also given the ability to create repeated patterns of notes. Any sound the user plays may optionally be recorded and looped at an interval chosen by the user. This interval can be as small as a single measure, or arbitrarily large. Once the user has recorded one or more notes she can choose to quantize the recorded notes to the nearest beat or any subdivision of beats. We have found this ability to be particularly suited to novices who may have trouble playing accurate rhythms.

### 3.2 MIMI: Multi-Instrument Musical Interface

All of the previously mentioned gestural interfaces are chosen through explicit selection. A user plays one instrument at a time, although this instrument may be changed during play. However the gestures chosen are sufficiently different to suggest they may be able to be recognized without explicit mode selection.

We first tried to distinguish between only two gestures: a drumming motion, and a guitar strumming motion. These gestures are very similar except for the axis of motion. Keeping track of the last known orientation is simple, but requires the user to pause in the correct orientation since orientation can only be precisely determined when an accelerometer-based input device is stationary. This prevents the user from moving fluidly from one instrument to another. Instead we needed to develop a method of tracking both approximate orientation and motion concurrently.

Our classification function is implemented by passing accelerometer data through a series of mathematical functions. The magnitude of acceleration is not important to the classifier, as we are only trying to track the dominant axis of motion, so we first remove the dramatic peaks in the stream of accelerometer data by normalizing each accelerometer vector (Figure 2) such that:

$$\vec{a}_{norm} = \frac{\vec{a}}{\| \vec{a} \|}. \quad (1)$$

Once the data is normalized we pass it through an exponential smoothing function

$$\vec{a}_{current} = \alpha \vec{a}_i + (1-\alpha)\vec{a}_{i-1}, \quad (2)$$

using an $\alpha$ of 0.1 to remove jitter as in [7]. By using a second smoothing function with an $\alpha$ of 0.5 and carefully choosing which function to use, we are able to detect short, sharp movements, like a violin gesture.

To support a fourth instrument we leverage the fact that the thumbstick on the nunchuk is used when playing bass. We overload the guitar strumming gesture such that when the thumbstick is pressed it is interpreted as a bass; otherwise it is a guitar. Finally, we implement a fifth instrument type by banging the Wii remote and nunchuk together.

## 4 Conclusion

We have presented One Man Band, a prototype video game that uses 3D gestural interaction for simulating different musical instruments. Each gestural interface closely mimics a specific instrument in function and in sound, with gesture recognition performed using heuristic-based classification on Wii remote accelerometer data. We have also described a multi-instrument musical interface (MIMI) that operates without explicit mode selection that uses a combination of acceleration normalization and exponential smoothing to determine which instrument is played.

Although we have managed to differentiate between five instruments using a single device, we plan to investigate whether even more gestures can be added to the MIMI instrument. More accurate recognition might be possible by selecting different or additional heuristics, or more formal gesture classification techniques. A comparison between our method and current classification techniques with respect to accuracy may also be enlightening.

We believe that One Man Band shows that an array of peripherals is not required to provide a satisfying musical experience. Instead a simple input device can be used effectively to give the player the ability to create musical compositions. These compositions can be complex while still providing a simple interface to the user. We propose that such interfaces might be adopted in future interactive music applications to give users simple but powerful methods to express themselves musically.

## References

[1] Guitar hero, September 2008. `http://www.guitarhero.com`.

[2] Rock band, September 2008. `http://www.rockband.com`.

[3] Wii music, September 2008. `http://www.wiimusic.com`.

[4] T. Blaine. The convergence of alternate controllers and musical interfaces in interactive entertainment. In *NIME '05: Proceedings of the 2005 conference on New interfaces for musical expression*, pages 27–33, Singapore, Singapore, 2004. National University of Singapore.

[5] T. Blaine and T. Perkis. The jam-o-drum interactive music system: a study in interaction design. In *DIS '00: Proceedings of the 3rd conference on Designing interactive systems*, pages 165–173, New York, NY, USA, 2000. ACM.

[6] D. A. Bowman, E. Kruijff, J. J. LaViola, and I. Poupyrev. *3D User Interfaces: Theory and Practice*. Addison Wesley Longman Publishing Co., Inc., Redwood City, CA, USA, 2004.

[7] J. J. LaViola. An experiment comparing double exponential smoothing and kalman filter-based predictive tracking algorithms. In *VR '03: Proceedings of the IEEE Virtual Reality 2003*, page 283, Washington, DC, USA, 2003. IEEE Computer Society.