Kinetic Particles Synthesizer Using Multi-Touch Screen Interface of Mobile Devices

Yasuo Kuhara Daiki Kobayashi
Department of Interactive Media, Tokyo Polytechnic University
1583 Iiyama Atsugi Kanagawa Japan 243-0297
kuha@t-kougei.ac.jp m0724044@st.t-kougei.ac.jp

ABSTRACT
We developed a kinetic particles synthesizer for mobile devices having a multi-touch screen such as a tablet PC and a smart phone. This synthesizer generates music based on the kinetics of particles under a two-dimensional physics engine. The particles move in the screen to synthesize sounds according to their own physical properties, which are shape, size, mass, linear and angular velocity, friction, restitution, etc. If a particle collides with others, a percussive sound is generated. A player can play music by the simple operation of touching or dragging on the screen of the device. Using a three-axis acceleration sensor, a player can perform music by shuffling or tilting the device. Each particle sounds just a simple tone. However, a large amount of various particles play attractive music by aggregating their sounds. This concept has been inspired by natural sounds made from an assembly of simple components, for example, rustling leaves or falling rain. For a novice who has no experience of playing a musical instrument, it is easy to learn how to play instantly and enjoy performing music with intuitive operation. Our system is used for musical instruments for interactive music entertainment.

Keywords
Particle, Tablet PC, iPhone, iPod touch, iPad, Smart phone, Kinetics, Touch screen, Physics engine.

1. INTRODUCTION
Various musical video games such as Namco's Taiko Drum Master, Konami's Guitar Freaks, and Nintendo's Wii Music have been developed because of the requirement to play music with instruments. However, with these games, a player cannot perform his/her own music, but passively operates the controllers according to preloaded music. On the other hand, some portable synthesizers such as Korg's Kaossilator and Nintendo DS's DS-10 and M01 have been developed for musical performance. Also, Yamaha developed Tenori-on as a music pad that creates music visibly by a finger touching interface. However, it takes a long time to learn how to play music on these portable synthesizers because of the difficult interfaces. Therefore, there are many precedents [1] in the NIME community related to investigating controllers oriented towards musical experience. Furthermore, various smart phones such as iPhone and Android devices are in widespread use, and are highly evolved as application devices beyond simple mobile phones. The new field of mobile music emerged at the intersection of ubiquitous computing and portable technology for a musical expression [2]. Many musical applications for the smart phone such as MoMu [3] have been developed and distributed on the web site.

In this paper, we proposed a simple sound generator using multi-touch gestures by fingers, which is familiar to those who have experience of operating popular smart phones or mobile PC devices. Most of them have a three-axis acceleration sensor, which enables the user to operate by tilting the device. Accordingly, they are useful for a novice for composing and performing music easily. We aimed to develop a mobile synthesizer suitable for musical performance with a touch screen that is able to generate attractive music while keeping the operation simple, which makes it possible for everyone to enjoy performing music.

We used a moving particles model as a sound generating unit. Many sounds in the natural world are made from an assembly of simple sound components, for example, rustling leaves, falling rain, babbling streams, ocean surf, forest sounds, and crowd applause. We regard a particle as such a sound component, which is the source of sound synthesizing. Each particle moves in the screen via the kinetics, sounding by synthesizing its own physical properties. A player can operate particles by touching the screen and tilting the device, and totally all of the particles generate music sounds.

2. METHOD
2.1 System Configuration
Our system is on two platforms: tablet PC and iPhone/iPad with a touch screen. For PC, we use Windows 7, and FlashDevelop software [4], which is a free ActionScript source code editor that generates Flash movies. For iPhone/iPad, we use Apple computer's iOS SDK. In both of platforms, we use Box2D [5], which is a free physics engine that can calculate the physical dynamics of a large number of particles. The iPhone/iPad has a three-axis acceleration sensor and a player can move particles by tilting the device.

2.2 Sound Synthesis
Our system synthesizes sounds using the parameters related to the motion of particles in the screen, which move in accordance with the law of kinetics. When a player touches a screen, a particle is generated in the touched place of the screen and begins to move. The particle is continuously moving and frequently collides with other particles or some stable walls initially located in the screen. The kinetic motion and collision cause the sound synthesis. Consequently, our system composes music of moving particles in the screen. Some demonstration movies are shown on our website [6].

2.2.1 Kinetic motion

A particle works as an oscillator of an analogue synthesizer, which generates tone by self vibration such as sine wave, square wave, and saw wave. Particles move and spin by their kinetic properties such as linear and angular velocity. When a particle is generated by the player touching the screen, it has their initial value.

Each kinetic parameter is related to a sound synthesis element (see Table 1 and Figure 1). Linear velocity is used for the amplitude of tone, and angular velocity is used for pitch, which is the frequency of tone. The particle shape is related to the wave of the oscillator, for example, a circle is for a sine wave, and a rectangle is for a square wave.

Table 1. Particle kinetics and sound synthesis

Particle dynamics	Sound synthesis
Linear velocity	Amplitude
Angular velocity	Pitch, Frequency
Shape	Oscillator waveform
Collision	Percussive sound

2.2.2 Collision

When a particle collides with others or wall objects, a percussive sound is generated. Each particle has its own percussive sound of collision assigned in advance. When a player shuffles the device, it acts like maracas, because many particles make sounds by the collision effect.

The friction and restitution are related to the activity of the motion of particles. At the point of the contact, the friction decreases the kinetic energy. If a player sets a larger friction parameter, it is easier for the motion of particles to be inactive. As a result, the music becomes quiet. In contrast, the restitution provokes the rebound to a particle at the collision, which increases the kinetic energy. Consequently, the motion of particles becomes more active and the music is more aggressive.

2.3 Performance

At first, there is no particle in the screen, except preset walls, which are optional. A player performs music by touching the screen to generate moving particles. If the number of particles is few, the music is quiet. On the other hand, a player can generate one particle after another by continuous streams of touches on the screen. A large amount of particles, which means many oscillators in the screens, makes the music loud. If a player touches the particle by finger, the touched particle is erased, while touching a void space in the screen causes generation of a new particle. A player can adjust the loudness of music by controlling the number of particles.

In our natural environment on Earth, all objects are influenced by G-forces as acceleration of gravity. When a player tilts the device, particles are forced to increase the velocity to the tilted direction by the working of the three dimensional accelerometer. As a result, motion or collision of particles is promoted, and it causes the sound to be more active. If a player shuffles the device, the motion of particles is more active, and the music may become more aggressive.

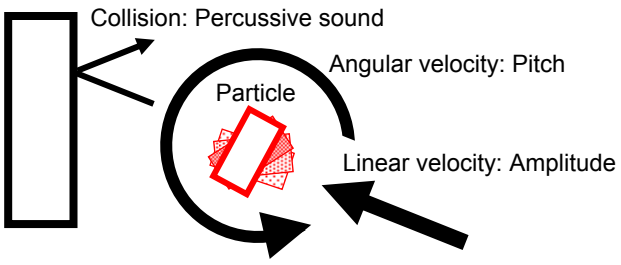

Figure 1. Particle kinetics and sound synthesis.

2.4 Graphics

A particle is drawn with the frame color according to its kinetic energy calculated from linear and angular velocity. The order of coloring graduation corresponds to the hue cited sequence, which is similar to Newton's sevenfold, gradually changing from red, orange, yellow, green, blue, indigo and to violet. Additionally, some textures are able to be attached to the face of the particle like patterns of tops. Players can enjoy a visual variety of particles moving and coloring while they perform music (see Figure 2).

3. DISCUSSION

This system works as both an analogue synthesizer and percussive instrument. A player can adjust the balance of these two musical aspects. If a larger collision sound is set, a player can perform rhythmical music like using percussion instruments. By setting stable walls or fences, more varied collision and motion occur, which promotes musical and visual attraction.

On the other hand, if a large oscillator sound is set, a player can perform the ambient music of an analogue synthesizer. By a large amount of particles, which are oscillators, various frequency waves are mixed and complex sounds are generated.

This system has a simple operating interface of touching and tilting the device. It enables everyone to perform music. In the demonstration, children enjoyed this system as a musical toy by touching the screen and shuffling the device.

4. CONCLUSION

We developed a simple analogue synthesizer and percussive instrumental sequencer using the multi-touch screen interface of a mobile device. Using this system, people who do not have musical skill can perform interesting music. In the near future, we will improve this system for playing more varied instruments and enjoying the ensemble of sounds and images, while keeping the operation of the multi-touch screen simple.

5. REFERENCES

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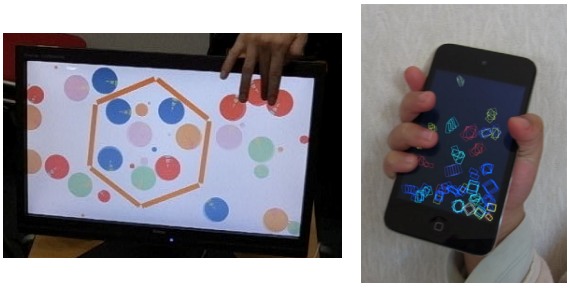

Figure 2. Example of kinetic particles synthesizer.