

**iBand Version 2.0 -
Music Visualization on Mobile Devices**

by

DENG Churan, Charis
(20292075)

Supervised by
Dr. David Rossiter

An Independent Project Report (CSIT 6910; 3 Credits)

HONG KONG UNIVERSITY
OF SCIENCE AND TECHNOLOGY

November, 2015

ACKNOWLEDGEMENT

I would like to express my great gratitude towards my supervisor, Dr. David Rossiter, who had given me invaluable advice to this project, and for his constructive comments during the development of the project.

TABLE OF CONTENTS

| | |
|--|----|
| ABSTRACT..... | 4 |
| 1. INTRODUCTION..... | 5 |
| 2. METHODS AND IMPLEMENTATION..... | 6 |
| 2.1 <i>Position Converting</i> | 7 |
| 2.2 <i>Water Effect</i> | 8 |
| 2.2.1 Simulate waves..... | 8 |
| 2.2.2 Transparent Surface Ray-Tracing..... | 10 |
| 3. CONCLUSION..... | 12 |
| References..... | 13 |
| Appendix..... | 14 |

IBand Version 2.0 - Music Visualization on Mobile Devices

by

DENG Churan, Charis

MSc in Information Technology

HONG KONG UNIVERSITY

OF SCIENCE AND TECHNOLOGY

ABSTRACT

This paper focuses on how to build a music visualization that simulates the water effect on iOS devices. The first version of “iBand” is a Musical Instrument App on iOS devices, which can play piano and drum synchronously at different iOS devices. At the second version of “iBand”, music visualization is added. The piano sounds liquidly, the visualization of piano sound is simulating the water been touched.

Keywords: Music, Visualization, Water Effect, iOS, Mobile Devices

1. INTRODUCTION

Music takes an increasingly important role in the society, and there are a lot of ways to feel the magic of music. People could just listen to music, play the music, and even create their own music. Also, people can play the music in many different forms, for instance, they can play the instruments individually or with a group of people. They can play the music with the real instruments or with mobile devices. However, music is far beyond the beautiful melody and clear rhythm that can be heard, it can also saw by eyes.

Music Visualization is the real-time music video that create based on the playing music. In this App, it will visualize the piano sound into the touched water. There are totally 88 keys on the piano. Each note has its own position corresponding on the screen. The higher pitch of the note, the closer to the right-bottom corner. What is more, the visualization feature requires iOS 9.0 or higher on iPhone or iPad.

In short, in “iBand”, users not only can play the piano and drums together, but also can enjoy the real-time music video.

2. METHODS AND IMPLEMENTATION

“iBand” is an entertaining iOS App that let users play instruments together through Wireless LAN. Currently, it consists of two instruments, piano and drum. All joined devices exchange their sound information through WLAN so that they all have the same sound effect. Also, music visualization is implemented on this App.

For the music visualization part, the system should get the note that users are playing. Then, convert the note caught into the corresponding position in the screen base on a rule. Finally, create a water effect for each note with the given position.

Figure 2.1 shows the main steps of “iBand Version 2.0”.

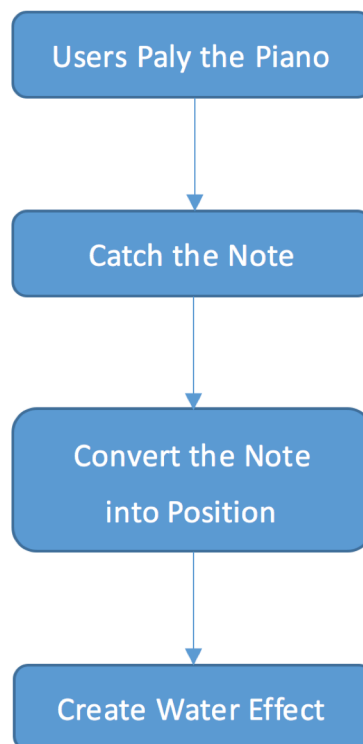


Figure 2.1 Main Steps

2.1 Position Converting

After the system has caught the note that users are playing, it will send the name of the note and call the function in visualization view controller. Then, the position can be converted by the note.

The idea of converting the note is based on the pitch of the note. The same X-axis represents the notations in the same octave; the right-most point has the highest pitch. The same Y-axis represents the same notation in different octaves; the bottom point has the highest pitch. Figure 2.2 shows the position converting in the screen.

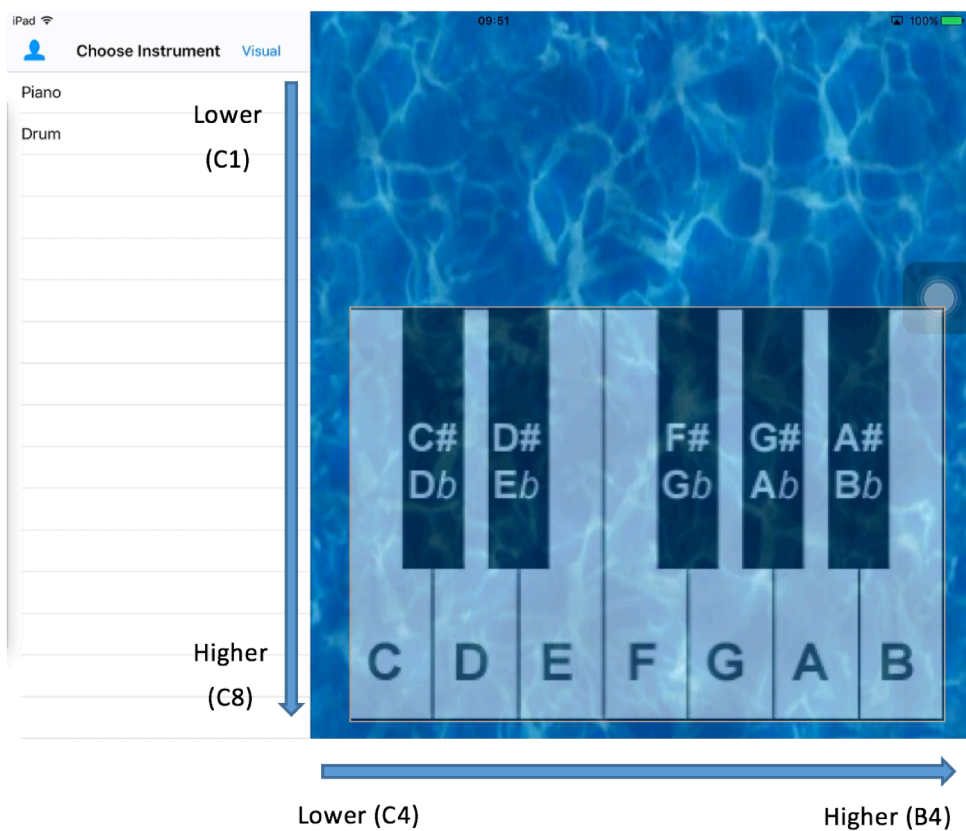


Figure 2.2 Position Converting

2.2 *Water Effect*

2.2.1 Simulate waves

Area Sampling uses commonly in computer graphics. In a two – dimensional diagram, point (x, y) is affected by the points around it, such as $(x+1, y)$, $(x-1, y)$, $(x, y+1)$, $(x, y-1)$. For example, in a simple blur, blurring the map is to get the average value of the surrounding points. So $\text{ResultMap}[x, y] = (\text{SourceMap}[x, y] + \text{SourceMap}[x+1, y] + \text{SourceMap}[x-1, y] + \text{SourceMap}[x, y+1] + \text{SourceMap}[x, y-1]) / 5$.

Similarly, to create a wave simulation is to calculate the value of (x, y) in a different way, which is in three dimensions. Obviously, to calculate the wave simulation, the state of previous values have to know. In this case, $\text{ResultMap}[x, y] = (\text{SourceMap}[x+1, y] + \text{SourceMap}[x-1, y] + \text{SourceMap}[x, y+1] + \text{SourceMap}[x, y-1]) / 2 - \text{SourceMap}[x, y]$. In this result, twice the average of the surrounding points subtracts the previous point is got. Figure 2.3.a and 2.3.b show how this affect the wave. In the figures, the horizontal line represents the average height of the wave, which is not the x-axis. The vertical direction shows the ups and downs along with the time. If the previous value at (x, y) was lower than the average, then the wave will rise towards an average level, as shown in figure 2.3.a. if the previous value at (x, y) was higher than average, the wave will drop towards an average level, as shown in figure 2.3.b.

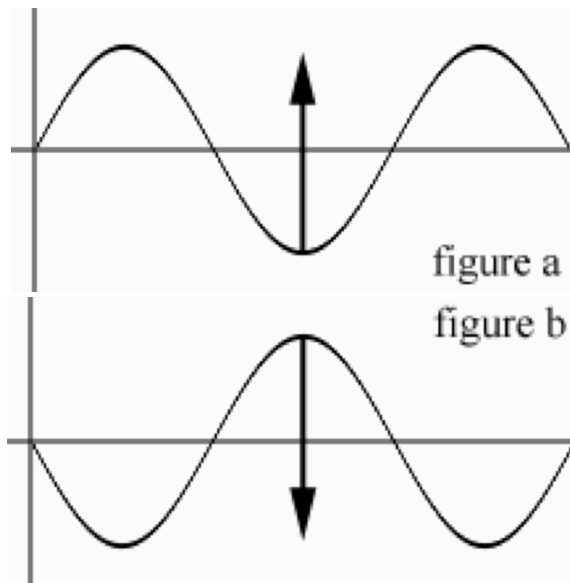


Figure 2.3 Effect to the Wave

Damping is an influence within or upon an oscillatory system that has the effect of reducing, restricting or preventing its oscillations. In physical systems, damping is produced by processes that dissipate the energy stored in the oscillation. Every time a wave moves up and down, its energy will spread in an extended area. It means that the amplitude of the waves will decrease to zero, which indicates that the water is back to still. The damping factor can be used to simulate it. This factor decreases quickly in a high amplitude, it decreases slowly in a low amplitude and becomes zero finally.

Lowering the values in the wave map makes the wave move. A wave can be created by picking a random location and changing its value. A higher value indicates a bigger wave.

2.2.2 Transparent Surface Ray-Tracing

Let a wave irradiated vertically through the surface of the water. Since water has a higher density than air, refraction will occur at the surface. Figure 2.4 shows the refraction of the light.

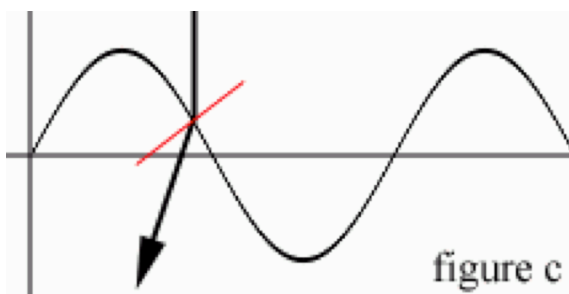


Figure 2.4 Refraction

The red line in the figure represents the surface normal. The vertical black line represents the incoming light. The line with an arrow is the refracted beam. So the angle between the refracted beam and the surface normal is smaller than the angle between the incoming light and the surface normal.

To ensure the angle of incoming light, measure the difference between (x, y) and $(x-1, y)$, (x, y) and $(x, y-1)$ is necessary. In figure 2.5, triangles have a base of 1; the angle equals to $\arctan(\text{height difference} / 1)$, or $\arctan(\text{height difference})$. Alpha in figure 2.5 is the angle between the surface normal and the incoming light. After rotating the red triangle 90 degrees counterclockwise, it's obvious to find the hypotenuse is parallel to the surface normal. The tangent of alpha is $1/y$ (the base of the triangle is 1).

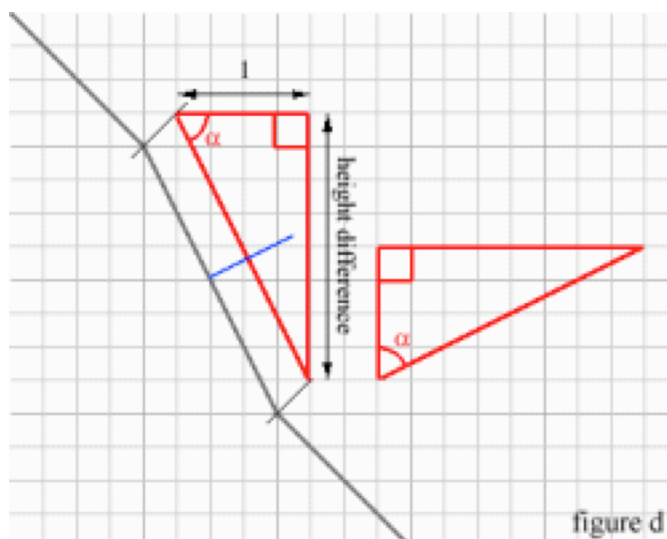


Figure 2.5 Angle of Incoming Light

Next, the refraction needs to be calculated. As known in physic, *refraction index* = $\sin(\text{angle of incoming light}) / \sin(\text{angle of refracted light})$, so $\text{angle of refracted light} = \arcsin(\sin(\text{angle of incoming light}) / \text{refraction index})$ is got. Finally, the position that the refracted beam hits the image, so $\text{displacement} = \tan(\text{angle of refracted beam}) * \text{height difference}$.

3. CONCLUSION

This paper has focused on the “iBand” Version 2.0 – Music Visualization on Mobile Devices. “iBand” is an entertaining iOS App that let users play the piano and drums together through Wireless LAN. The sound of the instruments uses WAV audio files. The audio files are played efficiently using ObjectAL library. All joined devices exchange their sound information through WLAN so that they all have the same sound effect. Also, users can see the music video real time, which simulates the water effect.

This project requires different areas of knowledge and the strong programming ability. Meanwhile, the implementation of instruments makes use of the advantage of Object-Oriented Programming so that it provides good extensibility.

References

- [1] QIAN, Li. (2013, May). *iBand - Musical Instrument App on Mobile Devices*. Retrieved December 4, 2015, from http://home.cse.ust.hk/~rossiter/independent_studies_projects/ios_music_system/csit6910_ios_music_system.pdf
- [2] Willemse, R. (2000, February 15). The Water Effect Explained - Graphics Programming and Theory - Articles - Articles. Retrieved December 4, 2015, from http://www.gamedev.net/page/resources/_/technical/graphics-programming-and-theory/the-water-effect-explained-r915
- [3] Dalrymple, M., & Knaster, S. (2009). *Learn objective-C on the Mac*. Berkeley, CA: Apress.
- [4] Kochan, S. (2011). *Programming in objective-C* (3rd ed.). Upper Saddle River, NJ: Addison-Wesley.

Appendix

Minutes of the 1st Project Meeting

Date: Monday, 18 September 2015

Time: 11:00 AM

Place: Room 3512

Attending: Prof. Rossiter, Charis DENG

Absent: None

Recorder: Charis DENG

Approval of minutes

This is first formal group meeting, so there were no minutes to approve.

Report on Progress

Charis explained her ideas, discussed with Professor, and decided the topic of the independent project.

Discussion Items and Things To Do

- Find out the way to implement the program on iPhone & iPad .
- Get the code of the first version's program and get start it.
- Design the way of visualization.

Meeting adjournment

The meeting was adjourned at 11:20 AM.

Minutes of the 2nd Project Meeting

Date: Tuesday, 13 October 2015

Time: 10:30 AM

Place: Room 3512

Attending: Prof. Rossiter, Charis DENG

Absent: None

Recorder: Charis DENG

Approval of minutes

The minutes of the last meeting were approved without amendment.

Report on Progress

Charis showed the program running on the iPhone with icon changed, and explained the idea of what is the visualization.

Discussion Items and Things To Do

- Get the note that playing and show on the screen

Meeting adjournment

The meeting was adjourned at 10:50 AM.

Minutes of the 3rd Project Meeting

Date: Tuesday, 27 October 2015

Time: 2:00 PM

Place: Room 3512

Attending: Prof. Rossiter, Charis DENG

Absent: None

Recorder: Charis DENG

Approval of minutes

The minutes of the last meeting were approved without amendment.

Report on Progress

Charis showed the program that already got the note, but contained a bug.

Discussion Items and Things To Do

- Solve that bug.
- Complete the water effect for the visualization.

Meeting adjournment

The meeting was adjourned at 2:40 PM.

Minutes of the 4th Project Meeting

Date: Tuesday, 17 November 2015

Time: 2:00 PM

Place: Room 3512

Attending: Prof. Rossiter, Charis DENG

Absent: None

Recorder: Charis DENG

Approval of minutes

The minutes of the last meeting were approved without amendment.

Report on Progress

Charis showed the water effect which happened while touching the screen.

Discussion Items and Things To Do

- Combine the water effect and the original program.

Meeting adjournment

The meeting was adjourned at 2:15 PM.