

MusicPad Final Report



Inaz Alaei-Novin - Programmer

Narges Norouzi – Programmer

Word Count: 1920

Table of Contents

1. Introduction	2
2. Overall Design	3
2.1. Movement Manager	3
2.2. Instrument Manager	4
2.3. Bluetooth Manager	4
2.4. Internal application Storage	4
3. Statement of Functionality	5
3.1. Application Launch	5
3.2. Connect	6
3.3. Record Movement	9
3.3. Note Selection	9
3.4. Recorded Movements	10
4. Key Learning Experiences	11
5. What we do differently?	11
6. Contribution by Group Members	12
6.1. Inaz Alaei-Novin:	12
6.2. Narges Norouzi:	13
7. Future Work	13
8. Commercialization Potential	14
9. Useful Links	14
10. References	15

1. Introduction

Conventional music application categories fall into one of the four categories of music education tools, music toys and games, music tools that provide instrument tuning, and virtual music instruments. As modern day mobile devices come equipped with powerful processors and accurate sensors, all of which allow the device to participate in a real time interaction with users, MusicPad was created to add a new concept in virtual musical instruments applications.

For the MusicPad project, our aim was to develop an application that would use an iPhone smartphone as the central sensing and communication unit for creating and playing sound tracks. The overall goal of the MusicPad application was to create a more realistic way of playing musical instruments' notes and to open a new way of communication with users on mobile devices. So, instead of either touching the screen or pressing buttons (like what we had in conventional virtual musical instruments), the app requires players to assign a signature movement with the iPhone in her hand to a special note or a combination of notes. In this way, by having multiple users and considering that each user is capable of making certain sounds with her specific assigned movements, a group of people will be able to create music with movement of their iPhone devices. By capturing the sounds and sending them to a central speaker they will be able to hear the music that they all make together.

We envision that the MusicPad would be a starting point for making music applications more social, and would lead to new innovations in music applications for smart phones.

2. Overall Design

The overall design of the application is broken down into four major subsections as shown in Figure 1: the movement manager in purple, instrument manager in orange, Bluetooth manager in red, and an internal application storage.

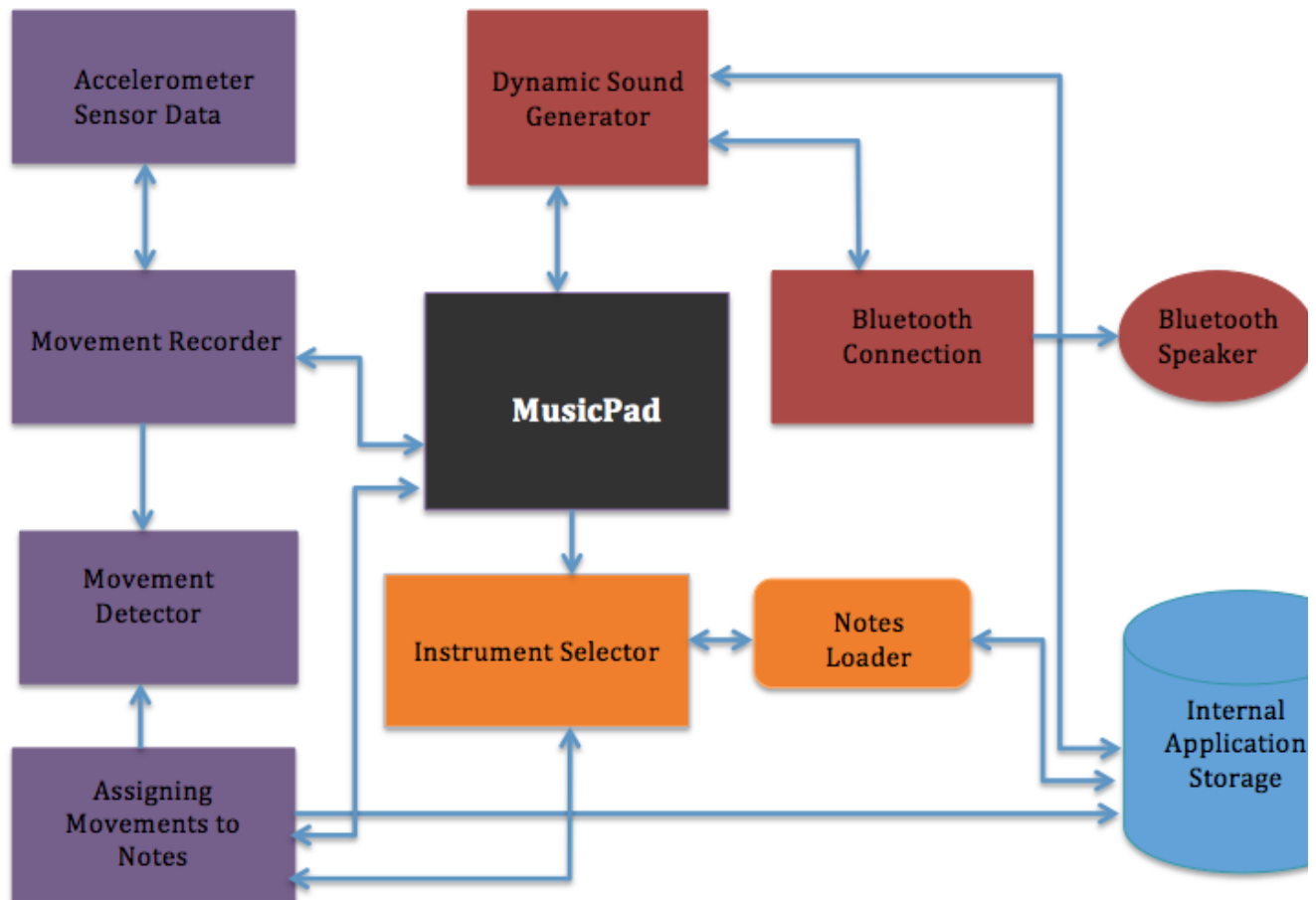


Figure 1. MusicPad Block Diagram

2.1. Movement Manager

Movement manager consists of four main modules. In order to handle incoming data (from iPhone's Accelerometer sensor) we read accelerometer data through movement recorder module. Movement recorder module continuously provides input to the movement detection module in order to listen for the occurrence of the signature

movement. At the end, this manager is also responsible for assigning specific note to each movement.

Furthermore, in order to make a real-time decision on the occurrence of special movement, movement detector module continuously computes Auto-correlation between the signature movement and currently recorded movement.

2.2. Instrument Manager

Instrument manager deals with providing flute and piano notes to users to choose from and assign the selected notes to their movements. The note loader module will load notes related to the instrument selected by user in the instrument selector module.

2.3. Bluetooth Manager

Creating and maintaining Bluetooth connection between the currently running applications on different iOS devices and to the central Bluetooth speaker is done by Bluetooth manager. This manager will dynamically listen for any data to be transmitted between the mobile devices or to the central speaker and will transmit the data.

2.4. Internal application Storage

Internal application storage contains flute and piano notes and also the accelerometer data from the recorded signature movements. This database is configured in a way that we are able to add more instruments for future development and hence it gives us the capability to extend our code easily.

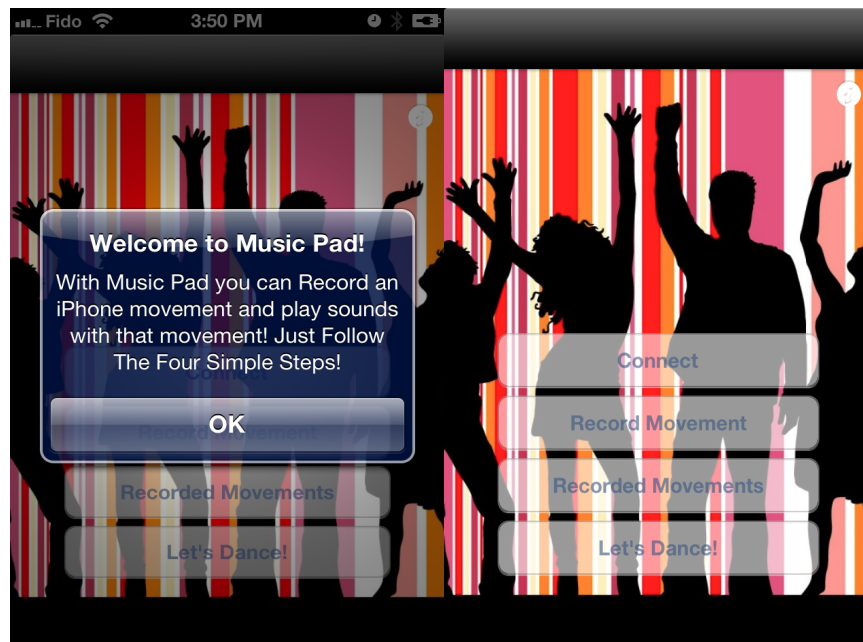
3. Statement of Functionality

The working features of our application can best be demonstrated through an illustrated walkthrough:

3.1. Application Launch

Upon application launch, user will see the screenshot in Figure 2.A which shows the welcome alert. The welcome message gives users a basic idea of the functionality of the application. After pressing 'OK' user will see the main page of the application which is illustrated in Figure 2.B. In the first page users will have the options to:

- Connect to other devices and central Bluetooth speaker in order to dance and make music with other players.
- Recording signature movements.
- Review the list of recorded movements and select movements for dancing
- Start dancing



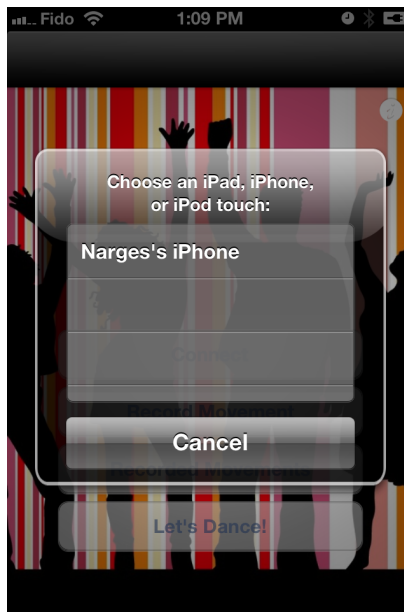
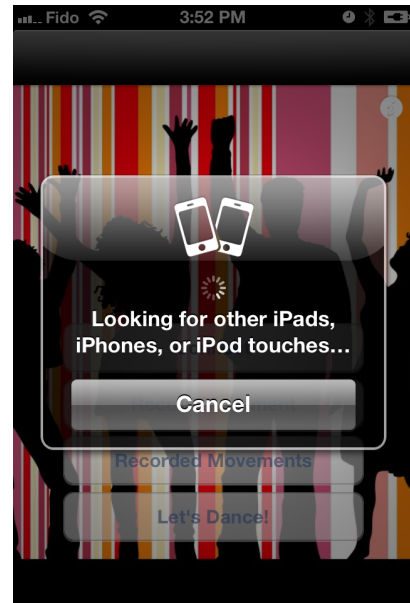
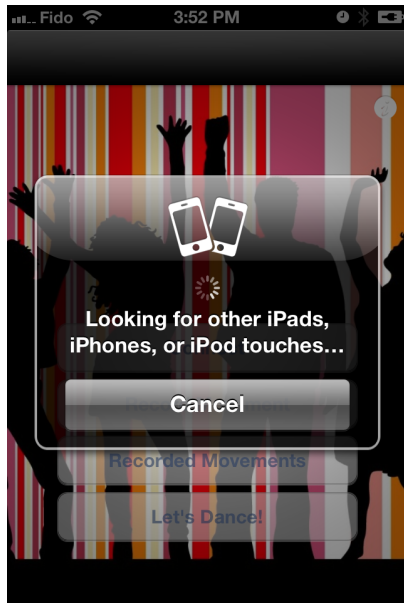
A) Welcome page

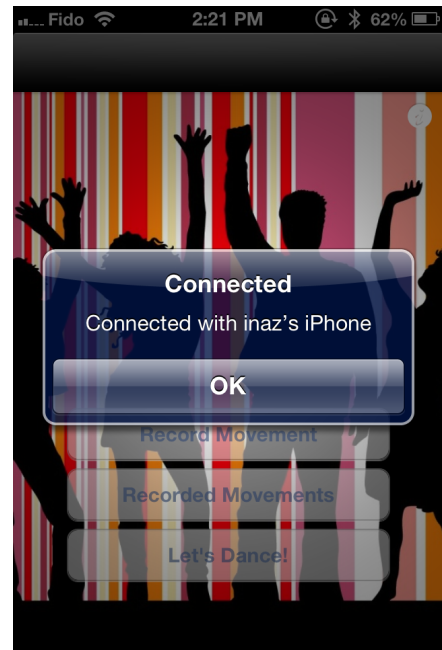
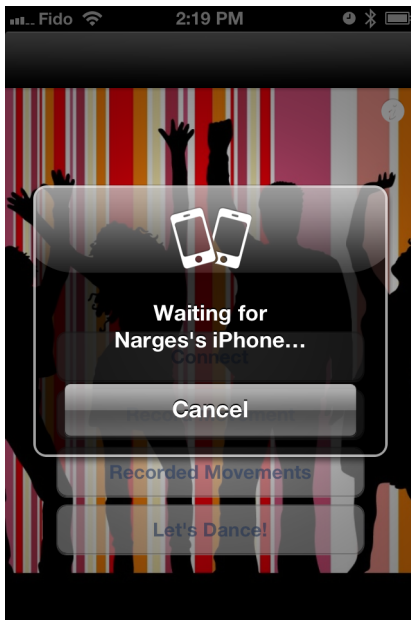
B) Start Page

Figure 2. Application Launch

3.2. Connect

Upon selecting 'Connect' in application launch page, user will see figure 3.A.1 which shows that the device is looking for other devices. When the device finds any other devices which are ready to connect, it will show the user list of available devices (figure 3.A.2). User can initiate a connection to other devices by selecting the device's name from the list. After selecting a device to connect the user will wait for the other device's response. This flow is shown in figure 3.





User 1

User 2

Figure 3. Bluetooth Connection Flow for 2 users

In case that there is no other running the application, user will see the empty list and will look for the Bluetooth devices to connect to. You can see the screenshot in figure 4.

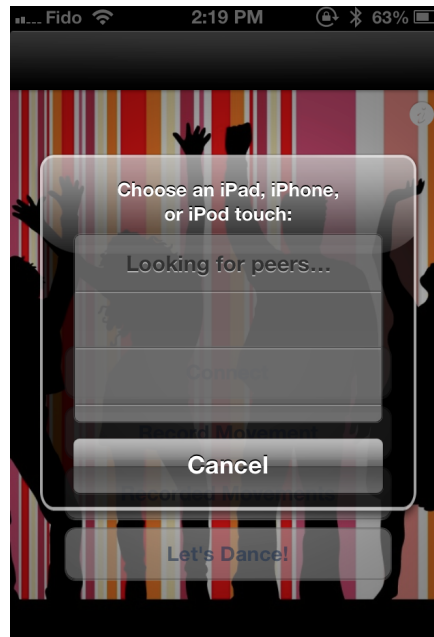


Figure 4. Looking for other peers

If one user declines to connect to the other device, the message below will pop up.

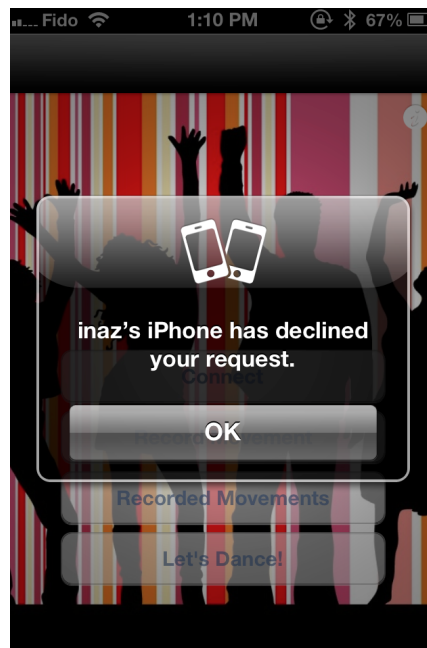


Figure 5. Decline message

3.3. Record Movement

Upon selecting 'Record Movement' in Application Launch page user will see the screenshot in Figure 6.A which explains to user how she should record her iPhone movement. By pressing 'OK' user will see screenshot in Figure 6.B in which she can select her musical instrument. After selecting the notes (explained in 3.4) user can record her movement by pressing 'Record' Button and then 'Stop' to stop movement recording. By pressing 'Stop' user will see screenshots in Figure 6.C in which she can save her recorded movement.



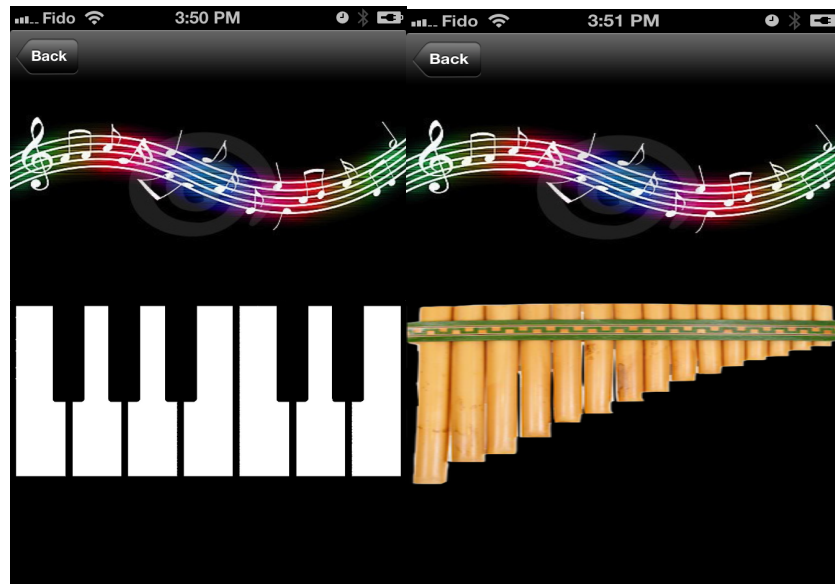
A) Record Movement welcome page B) Instrument Selection
C) Save movement

Figure 6. Instrument Selection

3.3. Note Selection

Based on the musical instrument that user selected, user will see the screenshots in Figure 7 in which she can select the notes for her movement.

After selecting notes user should press 'Back' to go to previous page (shown in Figure 6) in which she can record her movement.



A) Piano

B) Flute

Figure 7. Note Selection

3.4. Recorded Movements

Upon Selecting 'Recorded Movements' in application launch page, user will have the option to select from her recorded dances for her current dance session which is shown in Figure 5.

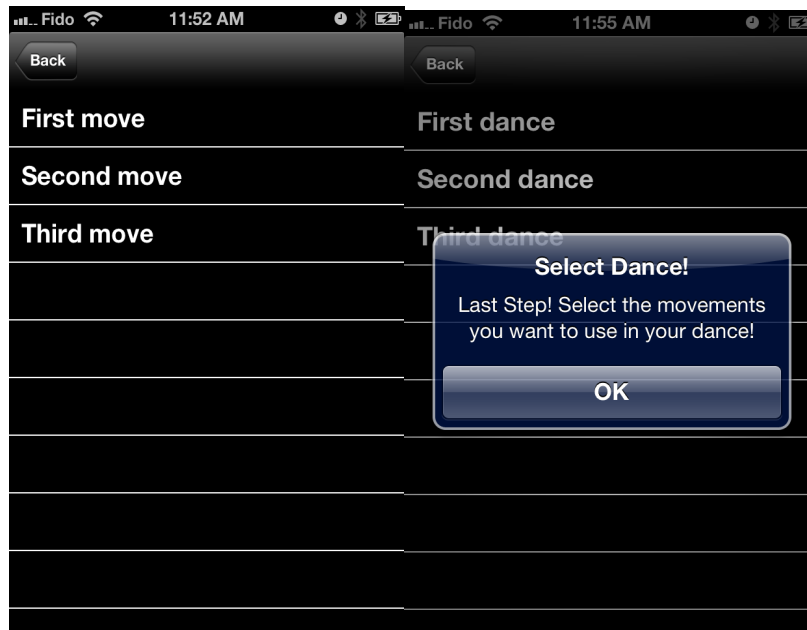


Figure 5. Select from Recorded Movements

4. Key Learning Experiences

Over the course of developing this app, our team had the great opportunity to learn how to work with many interesting and unique aspects of iOS application development. We have learned a lot about application development for iPhone devices using Objective C. We have been able to explore and set up in app communication between devices using Bluetooth interface, access the sensors data from the iPhone and utilize that data to detect user movements.

Developing a functional and aesthetic user interface using design principles for mobile devices was one of the learning experiences as well. Time management and getting something working within the deadline was also another insight acquired in the course of the project.

Furthermore, we acquired digital signal processing background and we used fundamental digital signal processing skills in a practical application.

5. What we do differently?

As both of us are programmers and we did not have any experience in designing user interface, we would put more effort on designing user interface if we had more time.

The main problem we faced during the development process was the limited access to accelerometer data. We spend a lot of time to find out how we can get velocity of the movement from the acceleration data. Finally we changed our implementation and now we are using pattern matching of acceleration data to detect signature movements. If we know this limitation we would spend more time on the accuracy of our detection algorithm.

Furthermore, we could also implement Wi-Fi connection to see which of the Bluetooth and Wi-Fi connection would work more reliably.

6. Contribution by Group Members

We started working together on planning the architecture of the application. We also did task estimation and initialized the mockups together. Once we had plan, tasks and mockups, we both did the fair share of research on movement detection algorithms and virtual musical applications, report writing, and preparing presentation. we divided tasks between two of us and were continuously merging and consulting to each other about the progress. In detail, you can find our main contributions bellow:

6.1. Inaz Alaei-Novin:

1. Movement Detection
2. Writing the skeleton code
3. Writing the audio feedback
4. Designing and refining UI and producing in-app special effects – manipulation of alpha/transparency, drop shadows and help menus .
5. Adding Bluetooth connection to the application for the spiral 4: integrated Bluetooth communications into the game that allows automatic discovery of other running applications.
6. On-device database for spiral 2.
7. Reprogramming the event detection logic for spiral 4.
8. Developed DSP algorithms for preprocessing, movement detection, and data analysis.
9. Coding user interface and back-end support.
10. Presentation graphics.
11. Performed app usability testing, sensitivity testing, and error determination

6.2. Narges Norouzi:

1. Movement Detection
2. Writing the access to the accelerometer data
3. Providing musical notes for internal application storage
4. Researching on the functionality of the virtual music applications
5. Adding Bluetooth connection to the application for the spiral 4: integrated Bluetooth communications into the game that allows automatic discovery of other running applications.
6. On-device database for spiral 4.
7. Event detection logic for spiral 2.
8. Developed DSP algorithms for preprocessing, movement detection, and data analysis.
9. Coding for user interface and back-end support
10. Assembled presentation graphics and slides
11. Performed app usability testing, sensitivity testing, and error determination

We both have been participating in presentations and reports creation and demos on the spiral delivery dates.

7. Future Work

For future development, we would propose the following changes or additions:

•Resolving distance restriction between users

Currently, users can produce sound tracks together if they can via Bluetooth. So, for future development, it would be great to use a web server as a communication mean for sending and receiving data. In this case users can connect together and play with application without distance restriction.

•Adding more complicated notes and user-defined sounds

One interesting idea is to add user-defined sounds like tapping on a surface or the sound of wind to the application. Furthermore, the application currently is unable to play notes with different timings, i.e. we cannot play notes with specific time interval in between. So, it would be great to give the users more control on the time interval between the notes.

•Add more instruments

This application has a potential to be used as a collection of virtual instruments. So, as a further development we would like to add more instruments.

8. Commercialization Potential

We are interested in making MusicPad more accurate and commercialize it. As we believe MusicPad has the potential to open a new era in virtual musical instrument applications, if someone in a business field can see a broader view in commercializing the application we are ready to continue its development and extending it to a commercial product.

9. Useful Links

- [Musical Instruments Sounds](#)
- [Bluetooth Connection Tutorial](#)
- [Audio Player Tutorial](#)
- [Accelerometer data access example](#)
- [Virtual piano](#)
- [Virtual Flute](#)
- [Virtual Guitar](#)
- [Apple Gamekit Bluetooth integration tutorial](#)
- [Virtual Drum \(1\)](#)

- Virtual Drum (2)
- Background Pictures for Demo
- Background Design of main page of application
- WiTap : in app Wi-Fi connection
- iPhone socket programming tutorial
- TableView innovative design

10. References

[1] GOUZOUASIS, PETER, and DANNY BAKAN. "The future of music making and music education in a transformative digital world." *The University of Melbourne refereed e-journal 2* (2011).