Sping 2018 CS755 Project Report Acoustic Sensing

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ABSTRACT
More and more IoT devices emerge into our daily life, aiming to ease our living style. Those devices such as smart TV, smart fridge will have more functionality to provide a better user experience. A traditional controller that uses buttons cannot meet the expectation of the usage. In this paper, we implement AAmouse [1], a system that tracks the device using acoustic sensing. It enables users to use their mobile devices as the controller to draw freely in the air. AAmouse adopts inaudible sound wave and Doppler shift effect to track the device movement. Human being cannot hear the sound wave frequency above 17kHz. However, these frequencies are supported in commercial devices. AAmouse takes advantage of this unused frequencies. Also, AAmouse does not require specialized hardware to operate. We implemented AAmouse in two platforms, PC and Android tablet. To refine the tracking result, we applied maximum ratio combining and signal smoothing filter. Then we conducted the evaluation experiment. The actual error is larger than the AAmouse paper. We also discussed the possible reason of the error. In addition, the difference between our implementation and the original work is discussed in this work as well.

Keywords
AAmouse, acoustic sensing, inaudible sound wave

1. INTRODUCTION
In this work, we implemented AAmouse, a system that utilize acoustic signal and Doppler shift effect to track the device movement. AAmouse uses inaudible sound wave that operates above 17kHz. Researches indicate that human being cannot hear the sound wave above 17kHz. However, current commercial speakers support those frequencies. The unique property of AAmouse is that it can operates in our daily devices and it does not require any specialized hardware.

The original AAmouse uses STFT, Doppler shift, maximum ratio combining (MRC) Kalman filter, and particle filter. Our system is different than the original work with minor changes.

Our system sends the sound wave and analyze the received signal using Doppler shift effect. The frequency shift will give information to calculate the velocity. We then used the velocity to calculate the distance that the device traveled. To refine the tracking result, we further apply MRC and signal smoothing filter.

We implemented the system in PC using matlab and in Android using Java. Some technical details we are using are different than the original paper, but the overall concepts are the same. During the experimental evaluation part, we observed that the actual system has larger error than the original paper. We provided detailed reasoning to explain what the potential causes are and what are the potential solutions.

The rest of this paper is organized as follows. Section 2 introduces some related works in this area. Section 3 provides some possible applications of this work in the future. Section 4 summarized the contribution of each group member in this work. Section 5 provides an overview of the project, compared to the original work. Section 6 includes all the technical details of the implementation. We evaluated the system in section 7.

2. RELATED WORK
State of the art techniques in literature, and how they are related to the work youâĂŹve done. This should not exceed half page

3. APPLICATIONS
IoT devices becomes more and more popular nowadays. Some appliances such as smart TV, smart fridge offer more functions than we ever had before. Merely using a remote controller with buttons cannot meet the expected user experience offered by those appliances. A mouse has been on of the best design for controllers. It enables a high level of freedom of controlling the devices. There are recently mouse developed for smart TV.

A traditional mouse requires a smooth surface to operate, which is feasible for a typical PC. However, when it comes to the smart TV or smart fridge, it is not suitable to have a flat

surface near them and it is not suitable for user to maintain a fixed position when using the appliance. For example, an user may want to control a TV on couch, on desk, or on the dining table. Having a mouse in each one of the location is not feasible in real world. Our system can be applied in this scenario by enabling a mouse in the air on the go. User would be able to control the appliance wherever they want with rich control options.

4. ROLES AND COLLABORATION

We discussed the project implementation details together, including what we should implement, what the time line would be, what the issues are, and what we should do to solve them. For each technical concept we need, such as MRC, Kalman filter, STFT, Doppler Shift, and the particle filter, we discussed the implementation procedure, potential issues, and the possible solutions.

Mingrui Han: Implement the system in Android tablet. Review and discuss matlab code. Research and implement third party tools which java does not have.

Joshua Lilly:

5. PROJECT OVERVIEW

This section should provide an overview of the project, especically compared to the original work. Please include below subsections. You are free to add or reorder sections, but should not remove any.

5.1 Original Work

Briefly summarize the original work. You may use your critique but please adjust to fit into the project context. Should not exceed half a page

5.2 Project Summary

Summarize what you have achieved in your project, especially compared to the original work. What parts were and were not implemented, performance gap from the original work, etc.

6. DESIGN AND IMPLEMENTATION

This should be the main part of the report. It should include below subsections. Feel free to add (do not remove) subsections and reorder them.

6.1 Setup

Scenarios and setup of your implementation, including location, hardware, software, and so on. If possible, include pictures and figures to be illustrative. Compare your setup to the original paper, and explain why you did so

6.2 Technical Details

All the technical details related to your project should be placed here including, but not limited to, techniques and methodologies involved, theories behind thee, how they were implemented, what was the difference from the originial paper, what was not mentioned in the paper and how you overcame it, and so on. Be specific.

6.3 Lessons learned

What are the knowledge obtained from this project? Clearly state what you have learned from this project, beyond what is on the original paper. This includes practical issues youâĂŹve faced, how you were able to troubleshoot them. Even if you could not fix it, describe what you have tried, why you were unable to solve it, and your hypothesis on what would be the cause. If you were not able to implement the entire system in the originial paper, explain why.

7. EVALUATION

Performance evaluation and potential improvement. Should include below subsections. Feel free to add (do not remove) subsections and reorder them.

7.1 Performance and Analysis

Be illustrative with graphs and figures. However, donâĂŹt just simply enlist the results, but explain them and provide anal- ysis/insights obtained from the implementation and exper- iments. For example, why does your project performs bet- ter/worse than what is reported in the original paper? Why does it perform differenty under various scenarios? Any un- expected results are found, and why

7.2 Potential Improvements

From your experiment experience, what do you think can be done to improve the performance. Please justify

8. REFERENCES

[1] S. Yun, Y.-C. Chen, W. Mao, and L. Qiu. Turning a mobile device into a mouse in the air. In *MobiSys*, 2015.