# Mobile Localization for Augmented Reality

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## 1. Introduction

We live in a world of increasingly ubiquitous computing. All around us there are devices we can interact with digitally, ranging from mobile phones to wearables to everyday devices such as key chains. However, interacting with these devices often requires that we first identify their digital location: some non-physical way to interact with them.

There are many instances where a device's physical location is known, while its digital location is not. For example, if I wanted to send a message to a phone next to me, I would first have to learn the phone number of that phone. As another example, if I wanted to connect my phone to a smart appliance (such as a TV) I would first have to find that device from a list of devices that are near me.

I propose a system such that any two (or more) nearby devices can communicate with each other and determine each other's position. A user with access to one of these devices, a mobile phone in this case, will be able to find all other nearby devices. Furthermore, the user can quickly open a digital interface with any nearby device knowing only its location. I plan to implement the identification of nearby devices by augmenting a live image of the real world with the devices information.

For the purposes of this project I will only consider the case of two mobile devices. I will attempt to determine their relative location by using ultrasonic pings and changes in each device's location, measured by accelerometers on each device. After that I will have each device show a live image of the world as seen through its camera, and overlay the other devices name onto the live image in the location of the second device. An example of the ideal end result is given in Figure 1.

## 2. Related Works

There has been much work already in the related field of localization for mobile robots. Many ultrasonic sensor systems such as [1] and [2], can accurately localize a mobile entity with the aid of stationary nodes in know location. Obtaining the relative location of different entities without nodes of known location has considerably less research, but has been accomplished with varying accuracy [3]. One improvement my methods will have over [3] is the use of ultrasonic range-finding as opposed to the RSSI of Infrared signals.

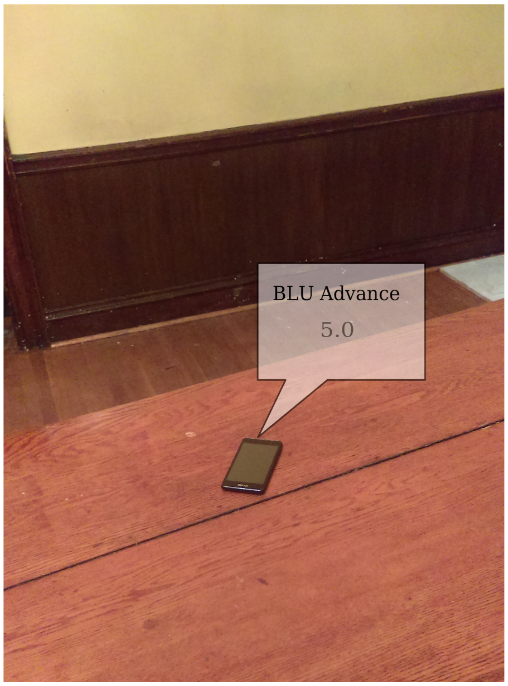


Figure 1: An idealized example of the desired behavior of the finished project. A semi-transparent identifying bubble overlays the real world in the location of the second device.

There has also been research aimed at combining different types of location data to get a more accurate estimation for the relative location of devices. One additional type of location data that is often used is dead reckoning, or calculating a devices new position by integrating data from an acceleration sensor [4]. Research conducted at Yahoo Labs went further to combine dead reckoning, ultrasonic range-finding, and RSSI of Bluetooth signals. This study was able to obtain localization accuracy within a few percentile [5], albeit at a relatively close range (< 2m). I will attempt to use similar methods to those used in this paper, while extending the range to that of a room or hallway.

# 3. Methods

The emphasis of this project will be on getting a functional project, not necessarily with the strategy I describe in this proposal. As such, I am not committed to the methods and strategies I describe here, and if convenience dictates I will switch to something more practical. For example, if I can not communicate between devices via BLE, I will switch to another communication method such as WiFi.

## 3.1 Hardware

I will be testing my implementation with two different devices: a HTC Desire 626s and a BLU Advance 5.0. These devices were chosen as low-cost mobile devices which have all the hardware functionality needed for the methods I intend to use. These devices were also chosen for their shared operating system (Android) in order to expedite the development process. The hardware I will be using on these devices include the speakers, microphone, acceleration sensors, compass sensor, camera, and BLE communication hardware.

## 3.2 Steps

I have split my work into ten discrete objectives for the purposes of this project. I intend to do one of these objectives each week for the duration of this project. This will give me a few buffer weeks at the end of the semester if one step ends up taking more than one week to complete. The steps are detailed below:

1. Make an Android app that sends an ultrasonic ping every second.
2. Have the app listen and record these pings from other devices.
3. Create a BLE connection between two devices running this app.
4. Calculate the distance between two devices by using the difference in time of arrival between the BLE signal and ultrasonic signal.
5. Use acceleration sensors to calculate an approximate displacement for each device.
6. Send this displacement information to the other device via the established BLE connection.
7. Integrate the displacement information from both devices with the ultrasonic range-finding to find an approximate location for the other device.
8. Refine the location of the other device by using a Kalman filter.
9. Convert the location of the other device into the corresponding location to be displayed on the screen. For example, if the phone is facing North and the other device is North, then the location will be in the center of the screen.
10. Overlay a virtual object representing the other device onto a live feed from the phone's camera.

# References


[1] Sewan Kirn; Younggie Kim; "Robot Localization Using Ultrasonic Sensors", Proceedings of IEEEIRSl, September, 2004

[2] Do-Eun Kim; Kyung-Hun Hwang; Dong-Hun Lee; Tae-Young Kuc, "A Simple Ultrasonic GPS System for Indoor Mobile Robot System using Kalman Filtering", SICE-ICASE 2006 International Joint Conference, October, 2006

[3] Jim Pugh; Alcherio Martinoli, "Relative Localization and Communication Module for Small-Scale Multi-Robot Systems", IEEE International Confrence on Robotics and Automation, May 2006

[4] Bong-Su Cho; Woo-sung Moon; Woo-Jin Seo; Kwang-Ryul Baek, "A Dead Reckoning Localization System for Using Inertial Sensors and Wheel Revolution Encoding", Journal of Mechanical Science and Technology, November, 2011

[5] Haojian Jin; Christian Holtz; Kasper Hornbaek, "Tracko: Ad-hoc Mobile 3D Tracking Using Bluetooth Low Energy and Inaudible Signals for Cross-Device Interaction", Proceedings of the 28th annual ACM symposium on User interface software and technology, November, 2015