

# Lost In Space: Indoor Localization for Virtual Environment Exploration

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## ABSTRACT

Lost In Space is a project utilizing Bluetooth Low Energy beacons in tandem with mobile devices and 3D panning on the web to overlay virtual sound arrangements onto a physical location in which users can listen through their phones and tablets. The virtual environments are distributed through a website and are populated with virtual sounds and speaker locations. Users activate the Bluetooth on their mobile devices to scan for beacons. User location navigates the corresponding location in a virtual environment. Moving around the virtual environment probes the soundscape. The project also touches on issues of unreliability of Bluetooth tracking indoors, the state of BLE-based project development, and the need for Web Bluetooth development to enable these types of projects.

## INTRODUCTION

The Web Audio API allows for complex processing and routing of audio on the web [1]. Tone.js is an interactive music framework built on the Web Audio API. Artists and developers can take advantage of these interfaces to create applications and pieces for mobile devices. Mobile performance pieces built with the Web Audio API can attempt at localizing each participating mobile device. Lost In Space uses indoor localization techniques with Bluetooth to allow users to explore a virtual environment analogous to their physical space.

Bluetooth Low Energy beacons transmit signals that are scanned by mobile devices. With enough beacon data, a user's indoor location is tracked. By tracking physical location, a virtual analogue is positioned on the web.

## METHODS AND MATERIALS

BLE Beacons/Bluetooth 4.0 are used for indoor localization. Lost In Space's website is built with HTML, CSS, and JavaScript to comply with web standards. The JavaScript portion relies on the Web Audio API and Tone.js to create virtual speaker nodes. Android Studio is used to build a mobile application to access mobile devices' Bluetooth in combination with a WebView to share Bluetooth data to the JavaScript in the website.

Bluetooth Low Energy (BLE) beacons are placed around a room or large space. The user opens an app on their mobile device that scans for these specific beacons. Based on data such as Received Signal Strength Indication (RSSI), an approximate distance from the mobile device to the beacon is calculated. This data is sent to the Lost In Space website's JavaScript. When the website has the proximity to at least three beacons, trilateration is used to find the user's location relative to the beacons [2]. The user's location is then mapped to the virtual sound environment built in Tone.js. The virtual sound environment is a series of virtual speaker nodes scattered about a virtual environment analogous to the physical space in which the app is used. When the user gets near virtual speaker nodes, the nodes become audible through the mobile device's speaker.

## DISCUSSION

Fine tuning the Web Audio portion of the project is necessary to adapt to each physical space in which the project is deployed. Mono output is used because tracking orientation of users for output based on head-related transfer functions is too complicated where devices may only have one speaker.

Bluetooth is not incredibly reliable when judging distances by signal strength, as interference from other devices, people, or walls can cause fluctuations. New options to perform indoor localization are being worked on that rely on fingerprinting and polynomial regression models instead of signal strength that could improve accuracy of tracking users [3].

## CONCLUSIONS

Bluetooth based indoor localization methods are adequate for tracking users and are becoming sophisticated. BLE beacons are great for traveling, room-scale tracking projects. Mobile device speakers are adequate for indoor distributed performances, but lacking in large-scale outdoor performances. Android applications are versatile, but there is a need for web Bluetooth.

Ideally, this project will work entirely in a browser with no need for an Android application to access mobile devices' Bluetooth. Unfortunately, Web Bluetooth API is highly experimental and unstable currently. It may be in its infancy now, but Web Bluetooth will replace the Android application architecture once the Web Bluetooth API becomes stable and more features are incorporated. Placing the project entirely in the browser eliminates the need for users to download external applications, instead allowing them to use the browser with which they are already familiar. This approach attempts to make Lost In Space an inclusive experience.

## REFERENCES

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