

SONOS

Sensing and Locating the Active Listening Area for an Outdoor Loudspeaker

UCSB ECE Capstone Project

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Introduction

Sonos is the wireless Home Sound System that fills as many rooms as you want with great-sounding music, movies and TV. Stream via WiFi. Play whatever you're craving. And amp up every moment with intense, pulse-pounding sound. The real power of a Sonos system kicks in when you add more speakers. Suddenly you're playing different songs in different rooms. Or grouping all your speakers together to blast one big jam to every room at once. With Sonos, the songs stream from your WiFi network (not your phone), so there's never any of the dropouts, delays or interruptions associated with Bluetooth. Sonos plays everything – the most popular streaming services, on-demand Internet radio, your favorite podcasts and audiobooks, your go-to collection of downloads – whatever you love to listen to.



Figure 1. Sonos Home Sound System

One of Sonos' key differentiating features is "Trueplay" – it lets you calibrate Sonos speakers according to their position and makeup of the room, so that the sound isn't compromised by being obstructed. Because the sound quality is so important to us, we'd like to extend this idea to an outdoor area.

Background

The tonal quality of an outdoor loudspeaker is affected by its surroundings perhaps to a greater degree than for an indoor loudspeaker since there is no sustained reverberant sound field to distribute the sound more evenly. Outside, the modification to a loudspeaker's sound by reflections from nearby surfaces (including the ground) which do not form an enclosure is dependent on the combined geometry of the speaker, the reflecting surfaces, and, central to this project, the listening location with respect to the speaker and its surroundings. If, as we expect

will often be the case, there is a single listener, or most of the listeners are clustered in a relatively small area relative to the loudspeaker, opportunities for tonal correction or other features for enhancing the sound experience are increased, but only if the location of the listeners relative to the loudspeaker can be determined.

Project Definition

Using a microphone array which could be built into a Sonos product, along with signal processing techniques and algorithms, develop a system which can determine the location of the listener(s) in both direction and distance from the loudspeaker (the microphone array). The system should work well for distances in the range of 0.5 to 3 meters distance, with an area accuracy of about a square meter – this is not a precise specification, but a guide to the expected useful performance. Precisely how to accomplish this is up to the project team, but it is expected that the solution will rely mostly on sounds created by the listeners either deliberately (voice commands or conversation) or incidentally, such as furniture moving or creaking, clothing rustling, or tableware clinking. Possible additional information might be obtained from reflection of the music emitted by the loudspeaker by the listeners, but it must be recognized that there will be strong reflections from nearby walls or objects, so any reliance on reflections will have to depend on additional characteristics, such as movement within a limited area, to distinguish listeners with a meaningful location from passive objects.

Additional Details

The solution should be based on an array of 6 microphones arranged in a horizontal circle about 70 mm in diameter. Such arrays are available (usually with an additional 7th microphone located in the center, which preferably is not used by the project solution) from several sources, often combined with/connected to a Raspberry Pi or similar processor, which can be used as the signal processing platform. It is suggested that analytical techniques, such as common direction-finding algorithms, estimation of distance based on loudness or reflection signatures, or other techniques identified after a suitable literature search, be explored first, but machine learning can also be explored if the initial exploration identifies a promising feature set.

What SONOS Will Provide

1. Engineering guidance / mentorship.
2. Access to SONOS labs for specialized testing / fabrication.