Paint with Music

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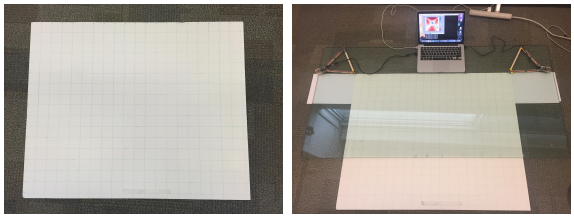


(a) 1 meter by 1 meter grid (b) array placement

Fig. 1: Setup for circle movement localization

***Abstract*—The abstract goes here.**

I. Introduction

II. Experiment

To test localization accuracy, an one meter by one meter grid was set up and the arrays are placed at the top left and top right corners of the grid. Fig 1 shows a picture of the setup.

A total of 32 positions are chosen uniformly in this region where microphone data is recorded. To test how accuracy varies with window size, the algorithm is fed with recorded microphone data with different segment length. Fig 2 shows how accuracy changes with window length for three GCC algorithms. The error lowers as window size increases and plateaus after window size exceeds around 10 milli-second. The lowest error achieved is 2.53 centimeters. It is achieved when window size is set to 12 millisecond and GCC_PHAT is used to estimate difference of delay

Although accuracy improves with window length, the calculation time also increases with window length. The part of calculation that depends on window length is using cross correlation to estimate difference of arrival time. cross correlation can be calculated with FFT and the runtime is of order $O(N \log N)$. We measured how the computation time varies with window length and Figure 3 shows the result. The runtime increases approximately linearly in the window size region of interest.

We also calculated the localization error for each tested point in the region. Figure 4 shows a heatmap of the error distribution inside the grid. The error is below 3 cm for most areas inside the region. There is one error spike in the mid-left region and we contribute this to audio source placecment error becuase the error is fairly low and consistent around that spike region.

To test how well the arrays track movement, we mounted a rotating disk 40 centimeter in diameter onto the grid at $(x = 0, y = -0.3)$. Fig 5 shows a picture of the sestup. A sound source is placed on the edge of rotating disk and the arrays localizes the sound source as it rotates in a circle.

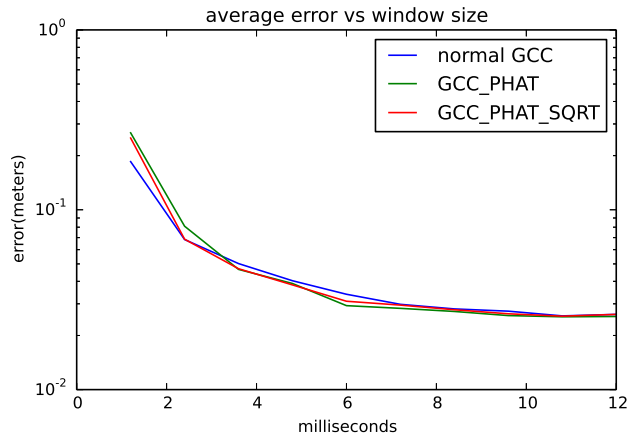


Fig. 2: accuracy versus window size

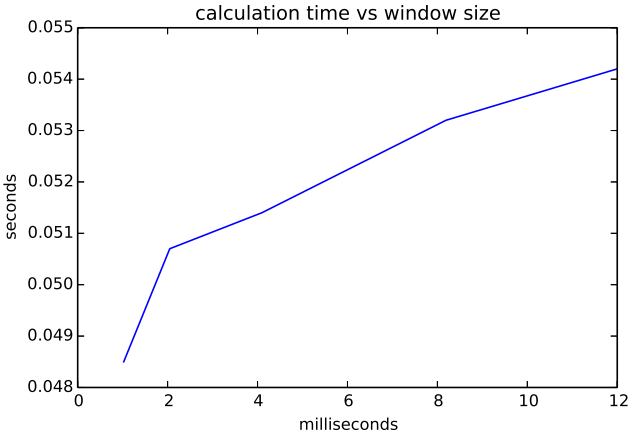


Fig. 3: speed versus window size

Parallel to the analysis performed on point localization, we analyzed how accuracy changes with window size for movement tracking. The result is presented in Fig 6. Fig 7 shows localization results for a few different window sizes. The trend is similar to that in point estimate where accuracy improves with window size and plateaus after the window size exceeds around 10 milliseconds.

To test how different sound sources affect localization quality, three trials were performed with three different sound

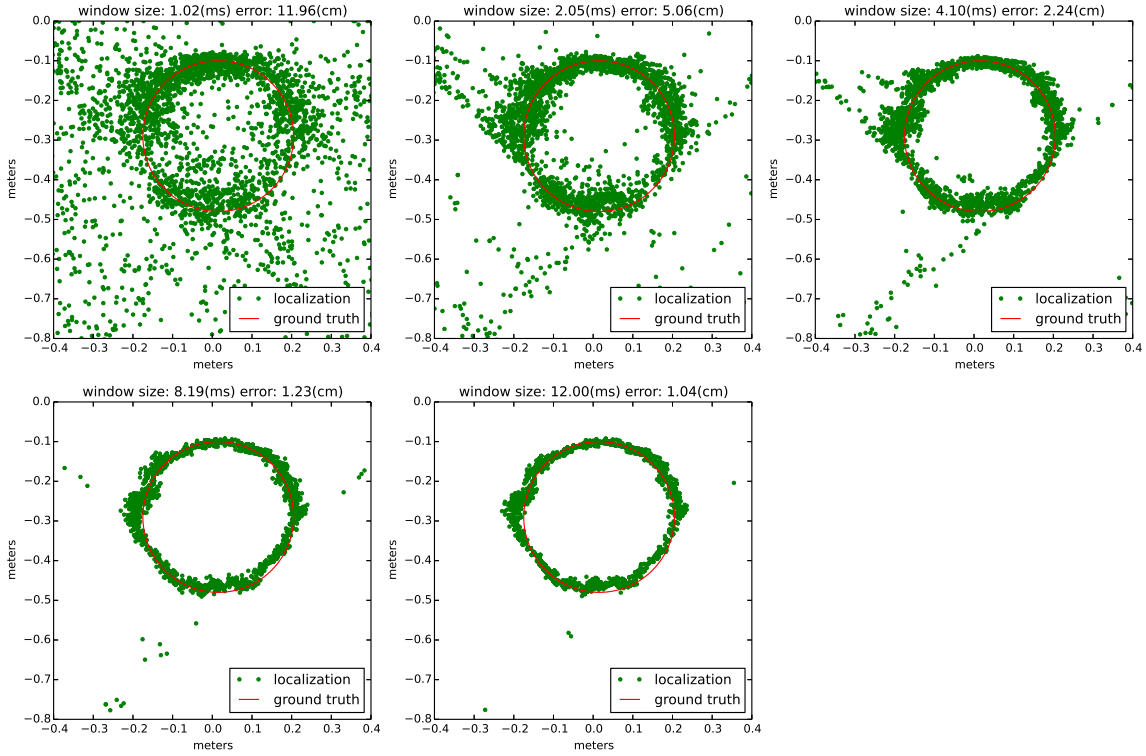


Fig. 7: Localization of circle movement with different sound sources

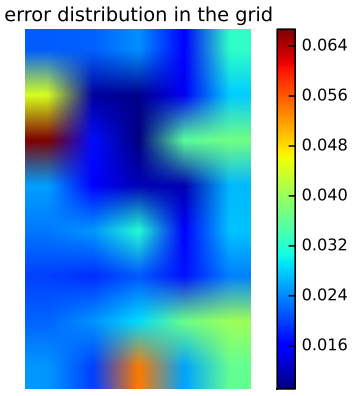


Fig. 4: error distribution in the grid

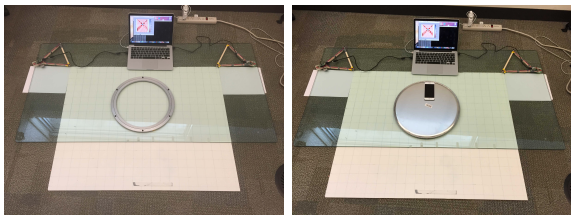


Fig. 5: Setup for circle movement localization

sources. In the first trial, white noise is used to set a baseline for audio sources, since our understanding is that white noise performs the best under GCC_PHAT. In the second trial, a randomly picked music is used. In the third trial, a music that contains low amplitude segments is picked to reflect real life situations. Fig **??** shows the result for all three trials. From the result, white noise does perform the best and the localized shape matches well with the shape of the rotating disk. There exists a bit of jiggling, but can be improved with filtering. Fig **??** also shows the result with averaging filtering and Kalman filtering.

For the music A, the array still localizaes correctly and the output represetns a circular shape, but the localizaed points are more spread out with more jiggling. This is because music does not have components in all frequency bands and GCC_PHAT estimate is less accuracy with such audio sources. Similar to the white noise case, we can improve the raw tracking estimates from the array with filtering.

For music B, the music has a low amplitude section and it is also shown in the traced result. The ”blank” region in the output corresponds to the low amplitude segment in the audio.

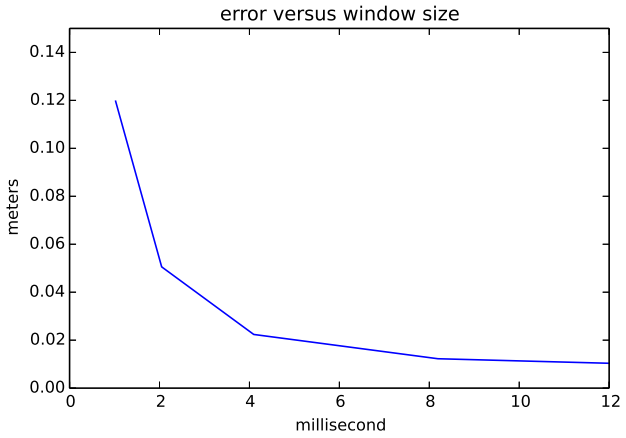


Fig. 6: Localization error versus window size

The general tracking quality of this music is not as good as that with Music A due to these low amplitude audio segments.

III. Conclusion

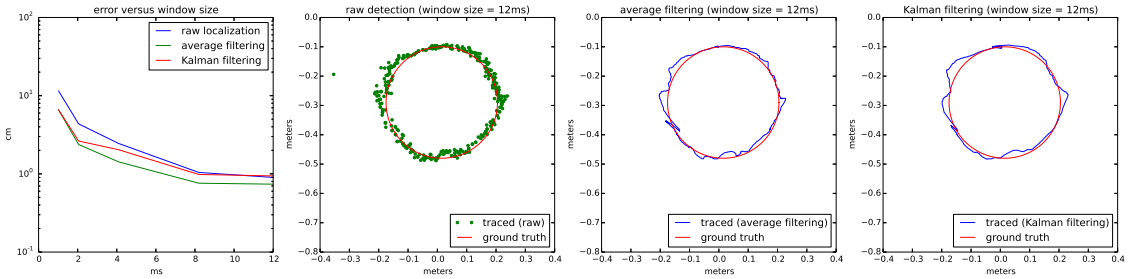
The conclusion goes here.

Acknowledgment

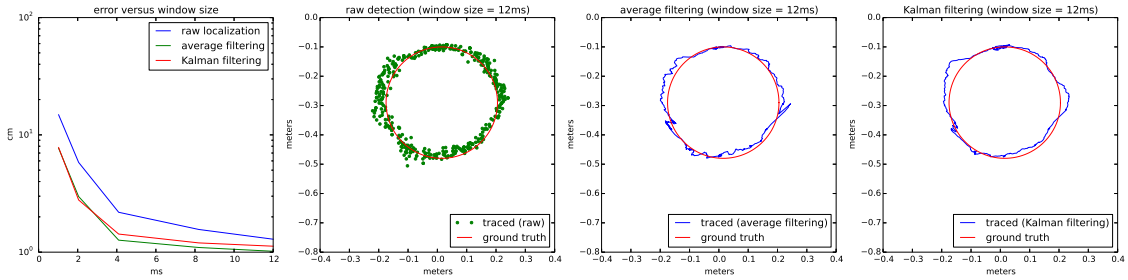
The authors would like to thank...

References

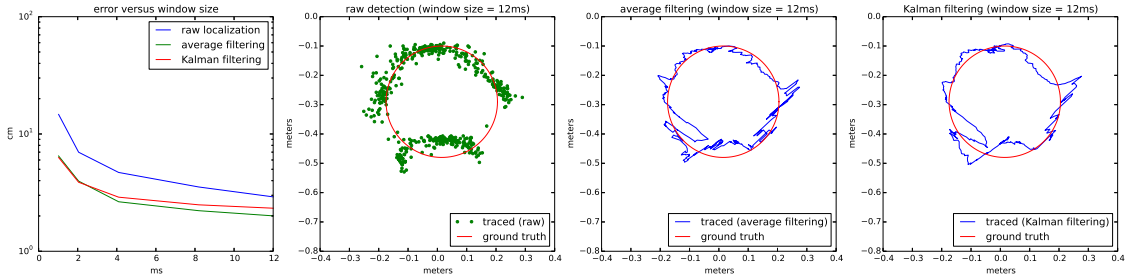
[1] H. Kopka and P. W. Daly, *A Guide to LaTeX*, 3rd ed. Harlow, England: Addison-Wesley, 1999.



(a) white noise

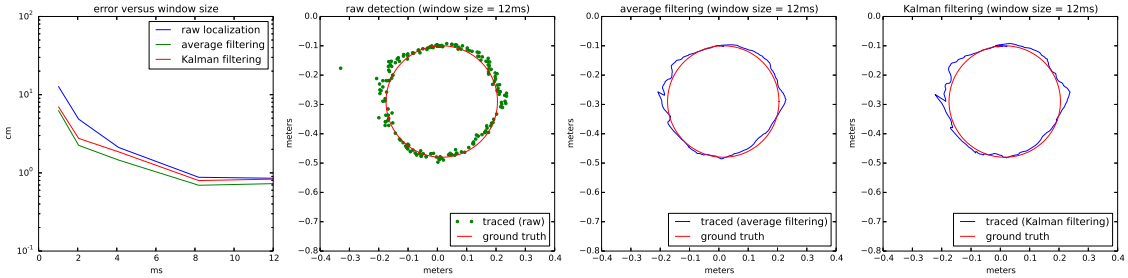


(b) music A

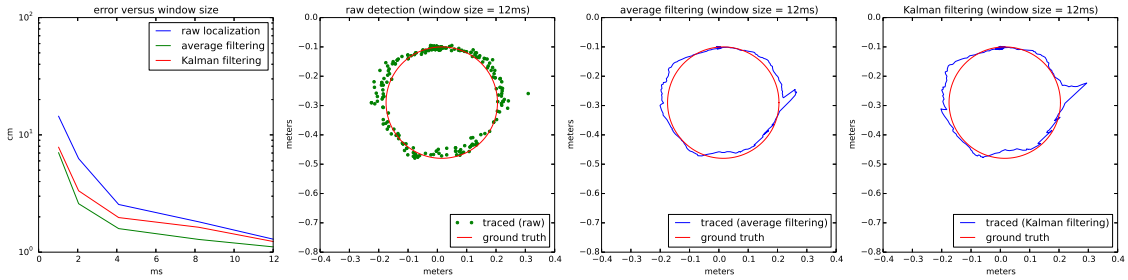


(c) music B

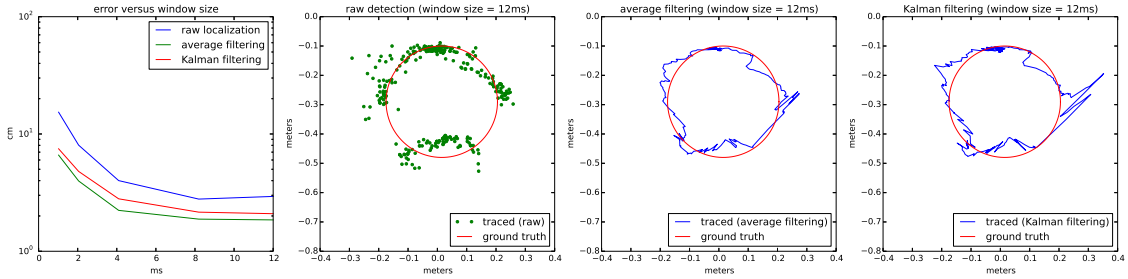
Fig. 8: Localization of circle movement with different sound sources. Sound source is moving at 10 cm per second



(a) white noise



(b) music A



(c) music B

Fig. 9: Localization of circle movement with different sound sources. Sound source is moving at 20 cm per second