Using FMCW to Measure Distance

Yumeng Yuan; Renyou Yan; Tianyang Liu
Shanghaitech University

ABSTRACT

We use FMCW (frequency modulated continous wave) to measure the distance of objects within 35cm. We record the emitted wave and the accepted wave. Then count the difference between them and calculate the distance using the following formulas.(v = 340m/s)

INTRODUCTION

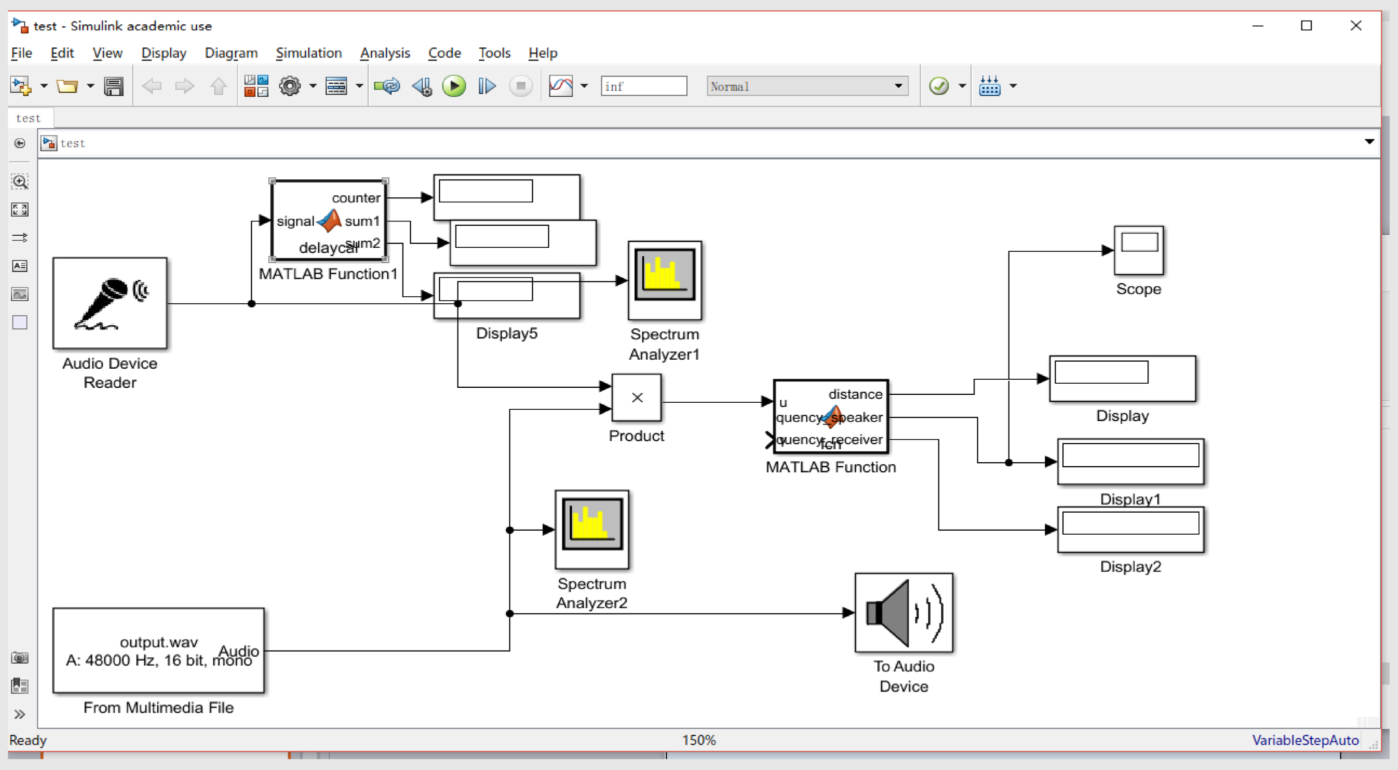
We use FMCW to measure distance mainly according to: $\text{distant} = \Delta t * v, \Delta t = \frac{\Delta f}{slop}$, $\text{slop} = \frac{f_1 - f_0}{T_{sweep}}$.
To compute $f_1 - f_0$, we multiply received signal by the transmitted signal, then we can recognize $f_1 - f_0$ with Fourier transform.

PROBLEMS AND IDEAS

In this method, we need to know the difference between the emitted wave and the accepted wave. To get this, we uses some trigonometric functions and Fourier transform.

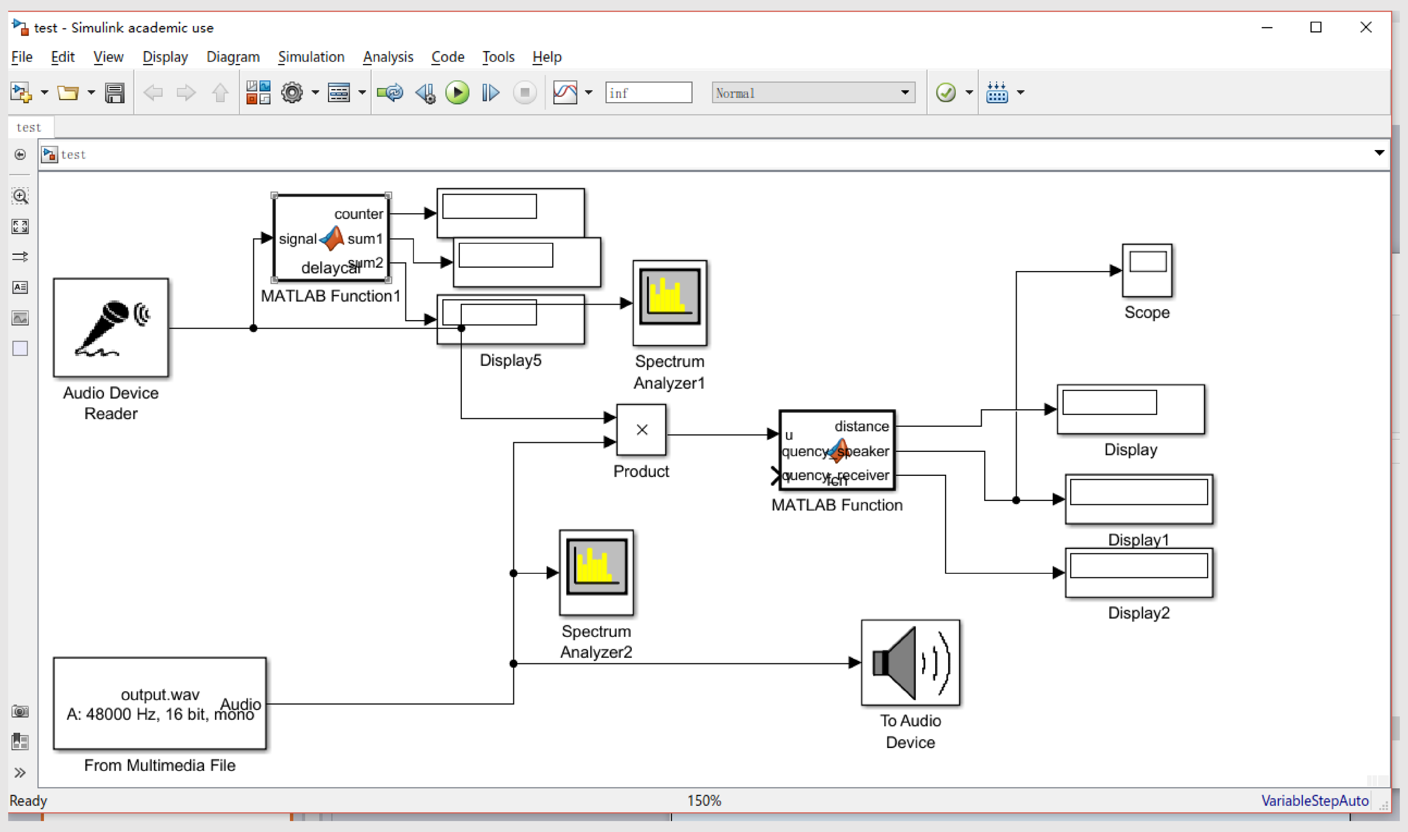
The ability of device to generate a proper FMCW is a big challenge. As we know, wider range and shorter T_{sweep} of FMCW will lead to a better resolution. We control the FMCW range between 8k~16kHz, T_{sweep}=0.1s, considering that the microphone can receive at most 16kHz signal. In this case, a 48kHz sampling rate translates to a resolution of 0.71 cm/sample, a 0.1s T_{sweep} corresponds to 480 samples. With 8–16 kHz FMCW range, each sample corresponds to a 1.67 Hz frequency shift. Further, we choose each Fourier bin corresponds to 10Hz frequency. Consequentially, a 2.5cm displacement creates 11.73 Hz frequency shift, which can be detected by Fourier transform.

DESIGN



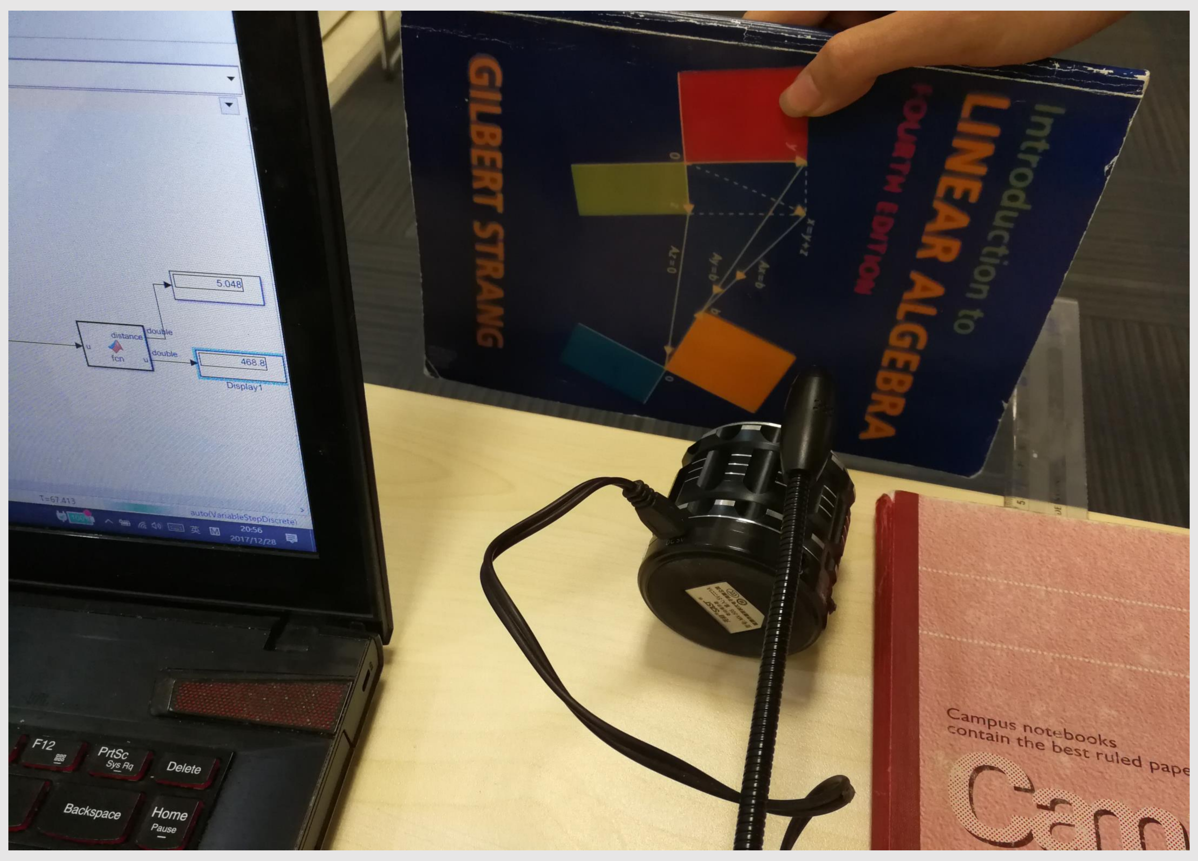
- MATLAB Function1 is to eliminate the delay of this system, but it seems not useful.
- We multiply the origin signal and the accepted signal together and pass it into next Function to find the difference between them and calculate the distance.

$$NewSignal = \cos(tf_1(t)) \times (\cos(tf_1(t+\Delta)) + \cos(tf_2(t+\Delta))$$

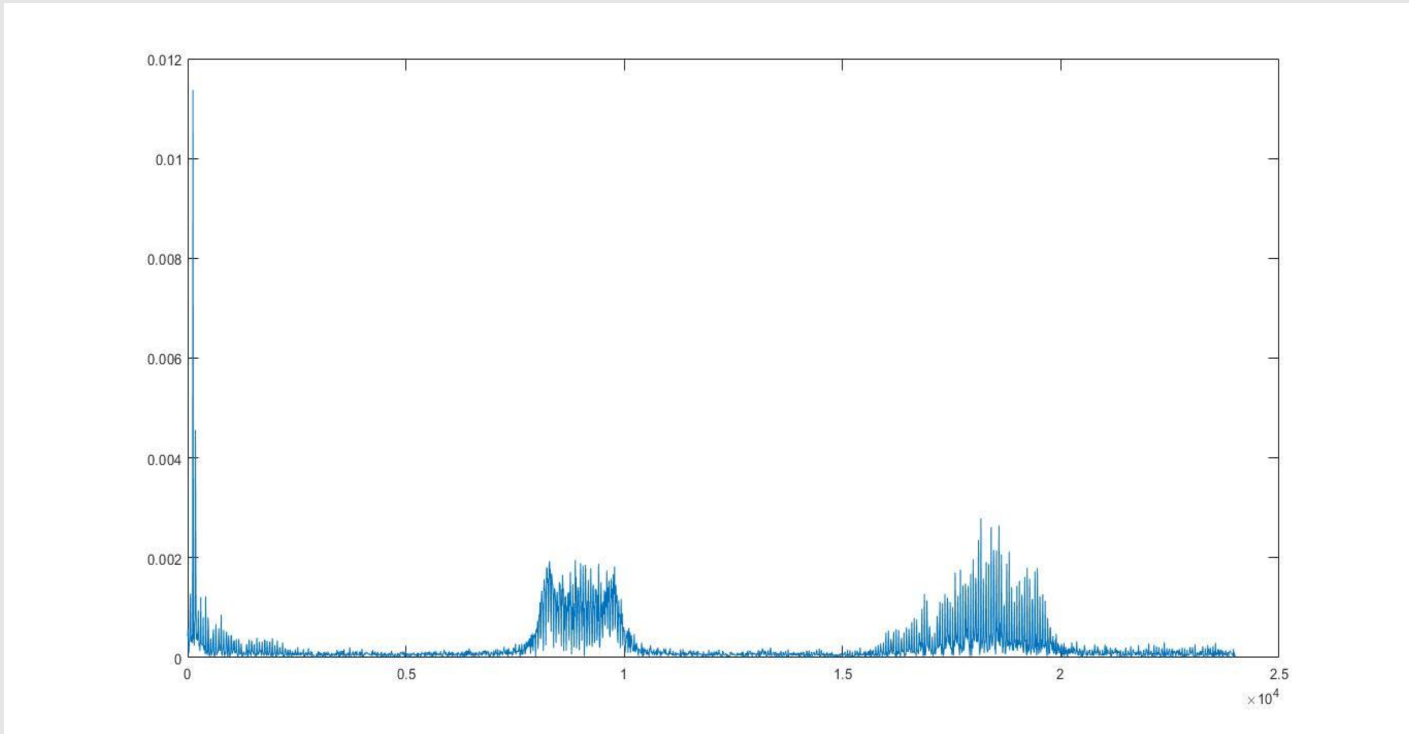


- We give up to estimate the delay. Instead, we estimate the offset at last in the begin few seconds.
- We put the product operation into Function

IMPLEMENTATION



RESULTS



The precision is 2.5cm.
The measurement range is 35cm.

REFERENCES

1. Nandakumar R, Gollakota S, Watson N F, et al. Contactless Sleep Apnea Detection on Smartphones[C]. international conference on mobile systems, applications, and services, 2015: 45-57.

CONTACT

Yumeng Yuan
Email: yuanym@shanghaitech.edu.cn
Renyou Yan
Email: yanry@shanghaitech.edu.cn
Tianyang Liu
Email: liutianyang@sari.ac.cn