ABAid: Navigation Aid for Blind People Using Acoustic Signal

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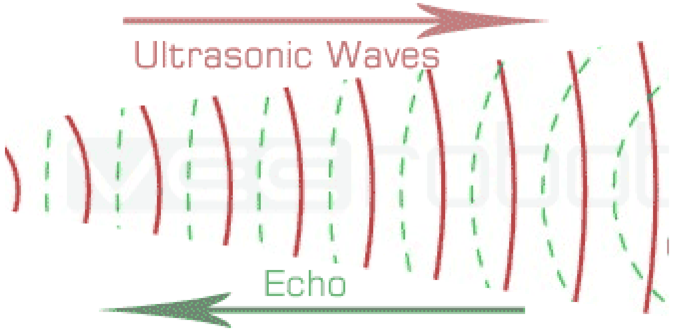
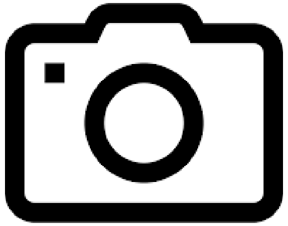
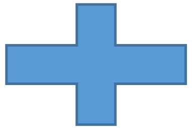
Normal Case for Visually Impaired People

What Others Are Doing to Help Them

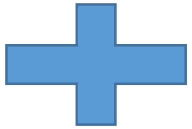


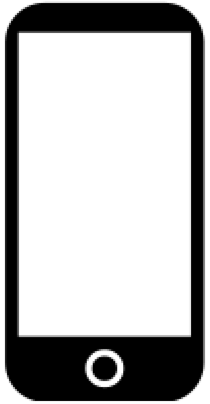


What Have Been Added in Common



What If….





What Has a Smart Phone Intergrated

- Camera
- Speaker
- Microphone
- Inertial Measurement Unit (**IMU**)

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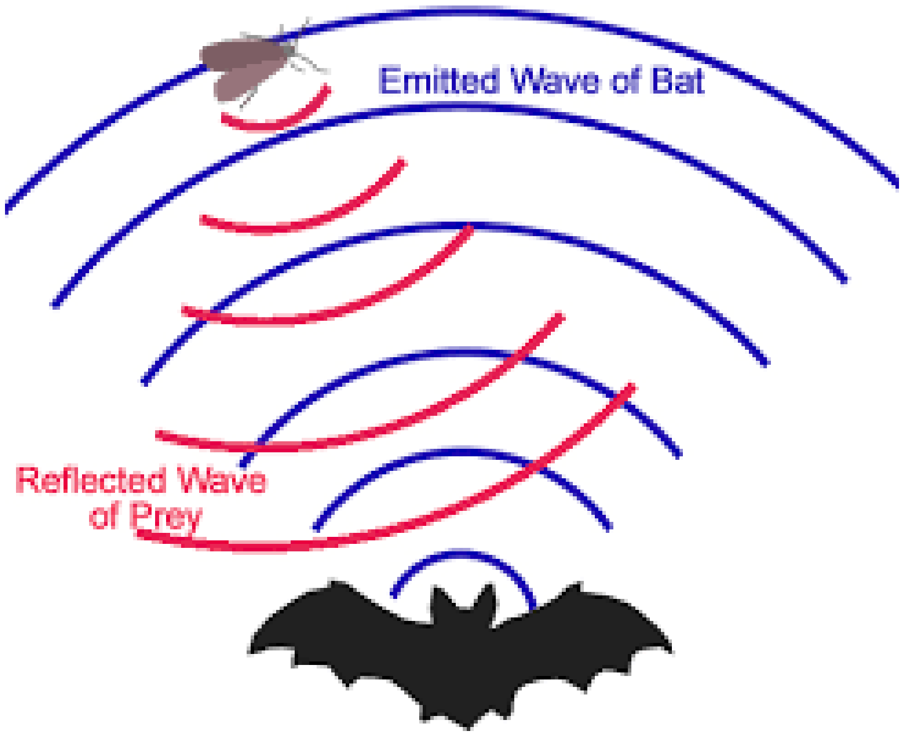
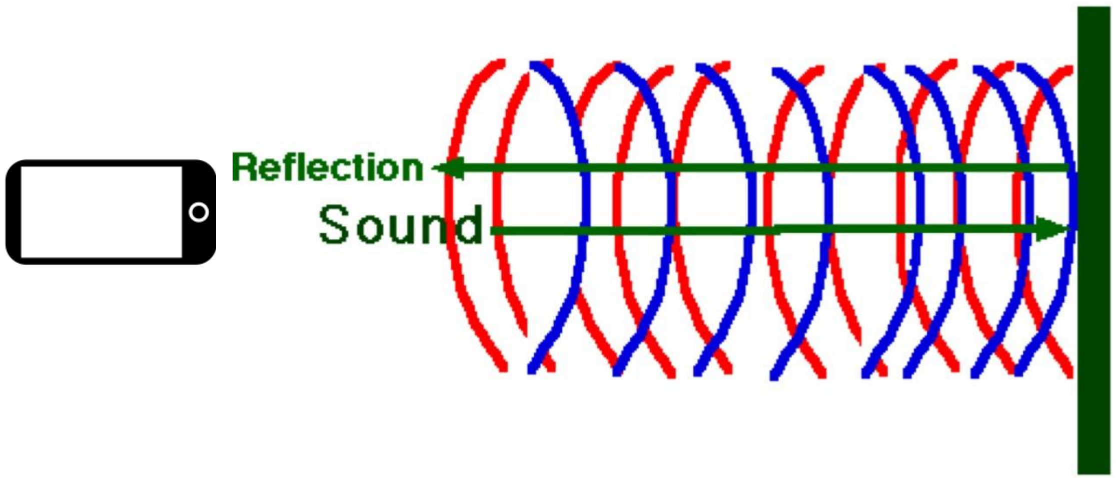
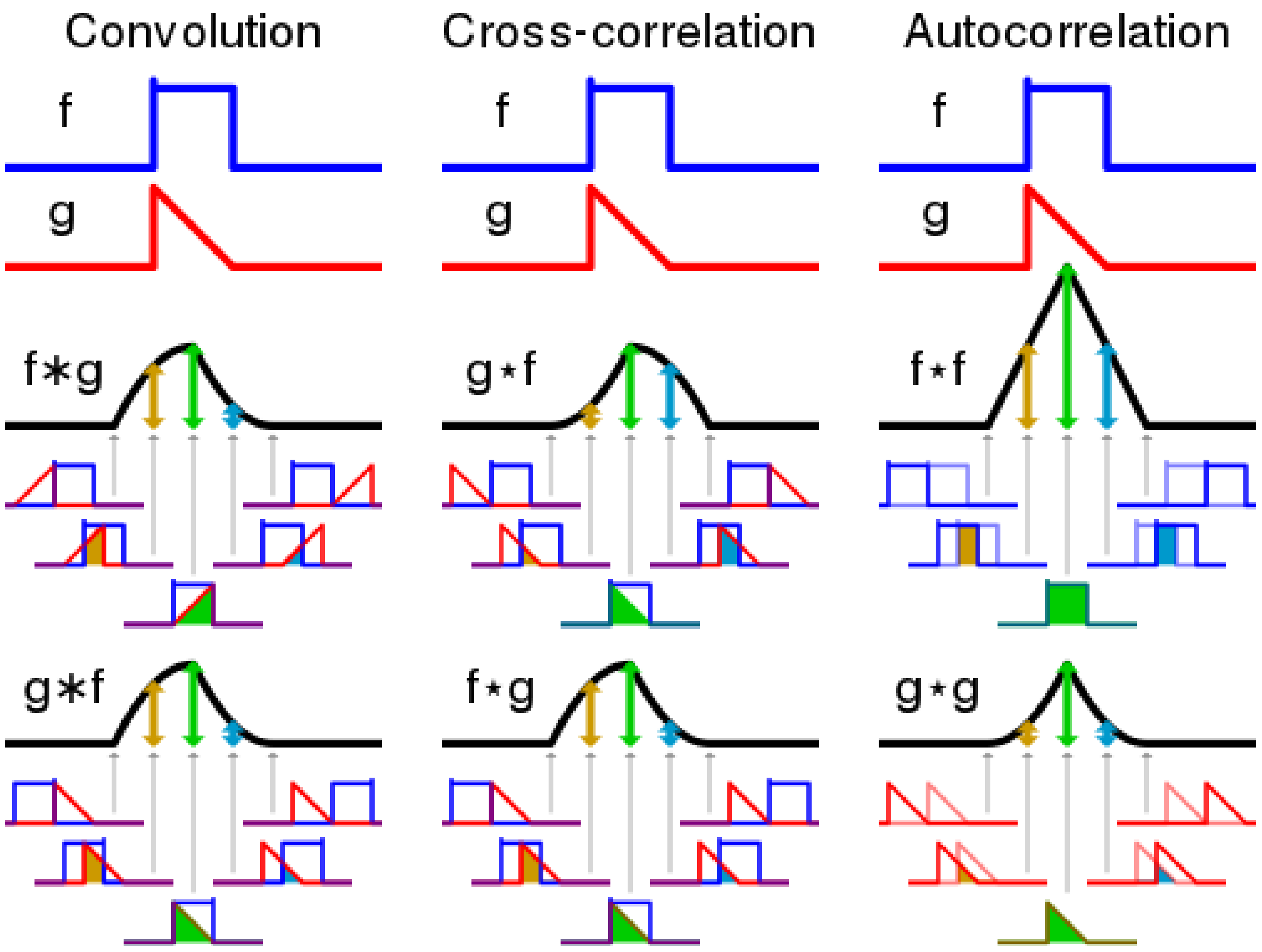
Acoustic Distance Measurement





Cross-correlation



$$\mathrm{Xcorr}(f,g)[n] \stackrel{def}{=\!=} \sum_{m=0}^{N-1} f[m]g[m+n].$$

Measure propogation delay by :

Xcorr(Recorded Signal, ModulatedEmittedSignal)

How to Design Emitted Signal?

- Avoid daily noise, which is mostly lower frequency

  => high frequency

- Avoid disturbing user while emitting sound

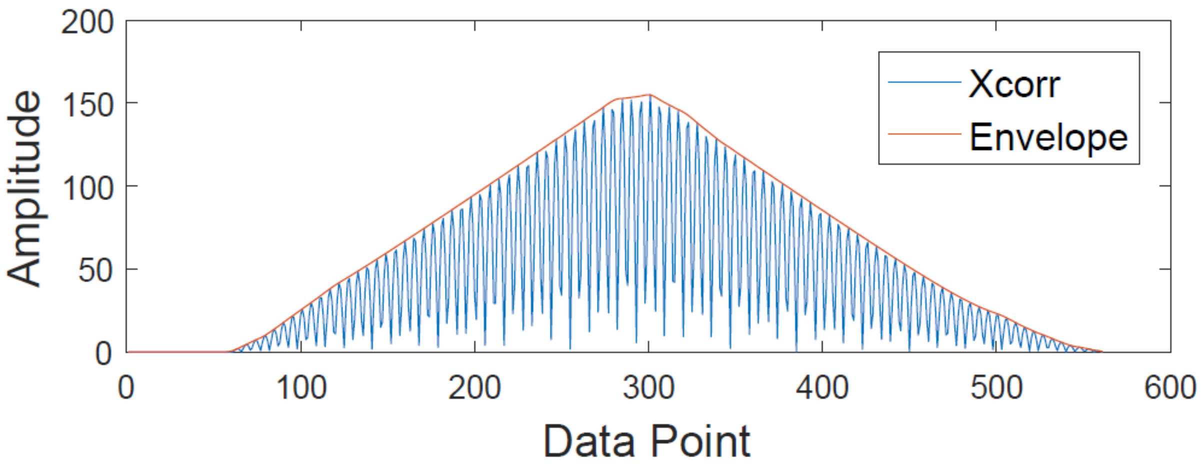
  => frequency should be greater than 18kHz

- Supported by phone (sample rate up to 44.1kHz)

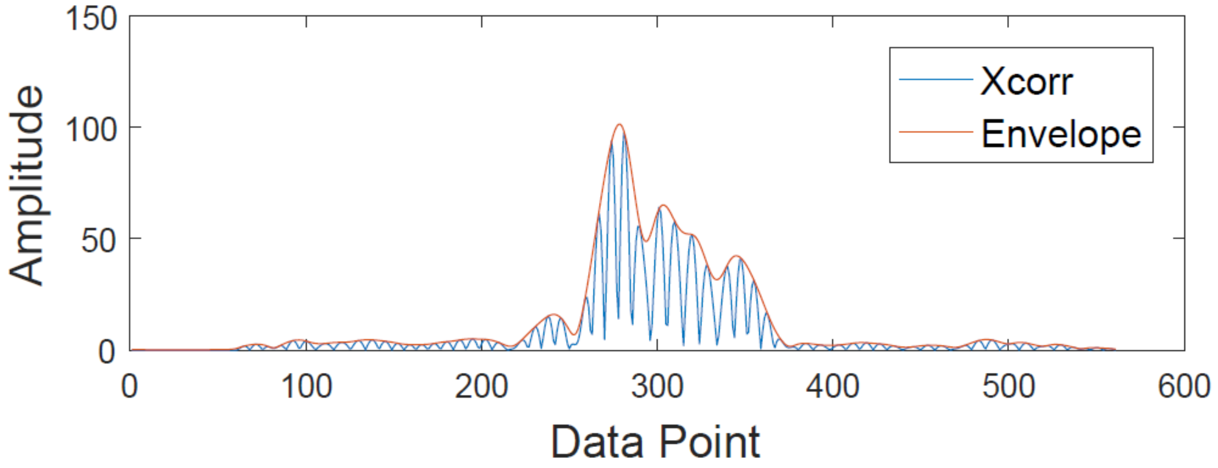
  => frequency should be less than 22kHz

Emitted Signal Frequency should be in [18kHz, 22kHz]

Simulation for Detecting Delays

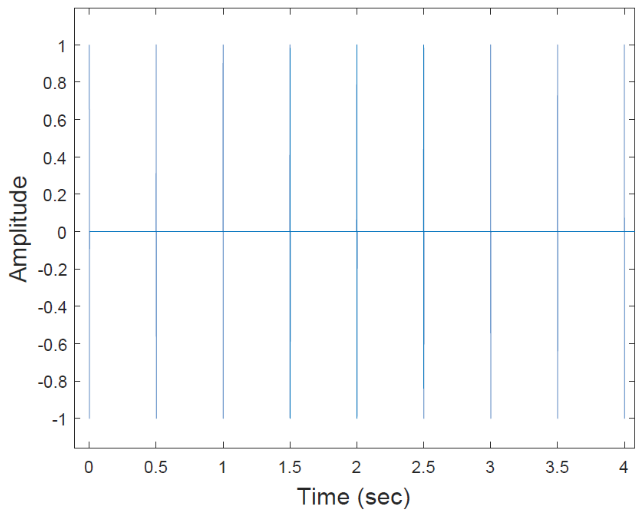


Xcorr(RecordedSignal, SingleFrequencyEmittedSignal)

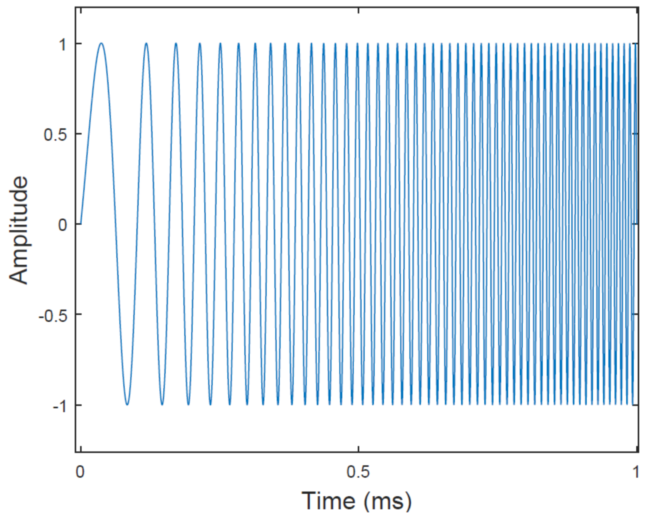


Xcorr(RecordedSignal, VariousFrequencyEmittedSignal)

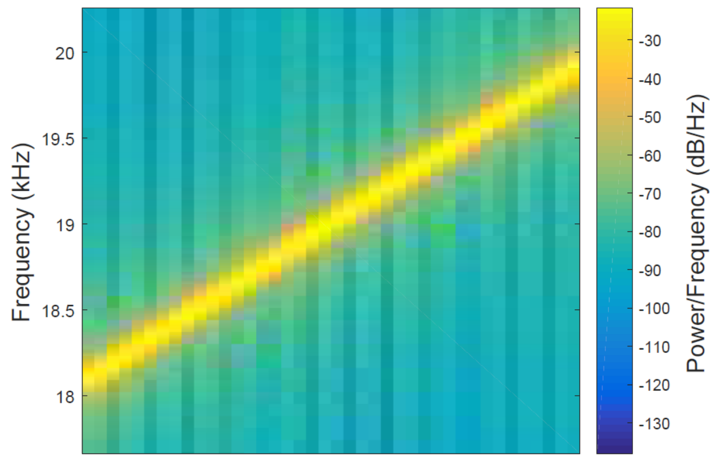
Final Version of Emitted Signal



(a) Emitted Chirps



(b) Signal Form of Each Chirp



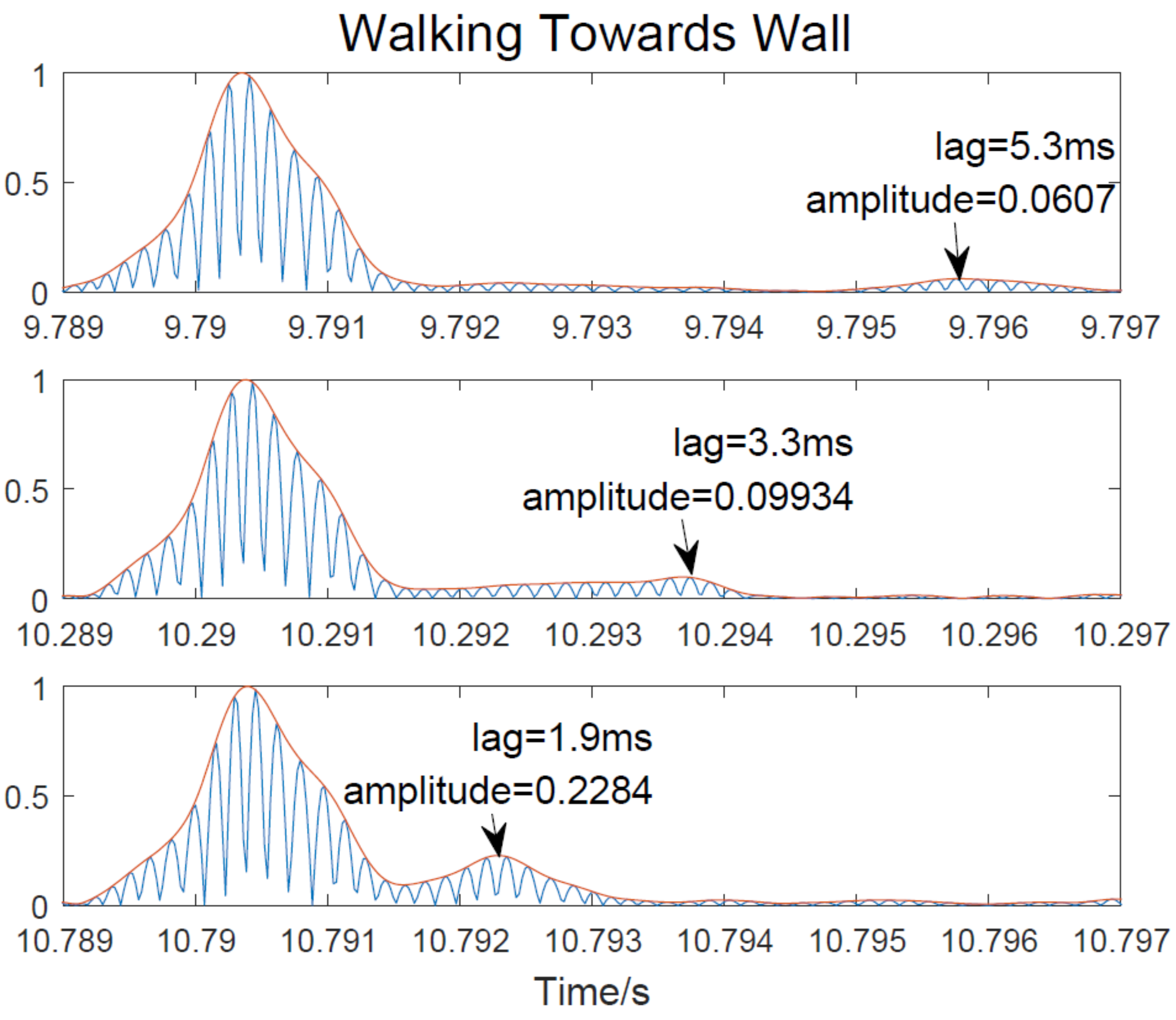
(c) Spectrogram of Each Chirp

Frequency: 18kHz – 20kHz

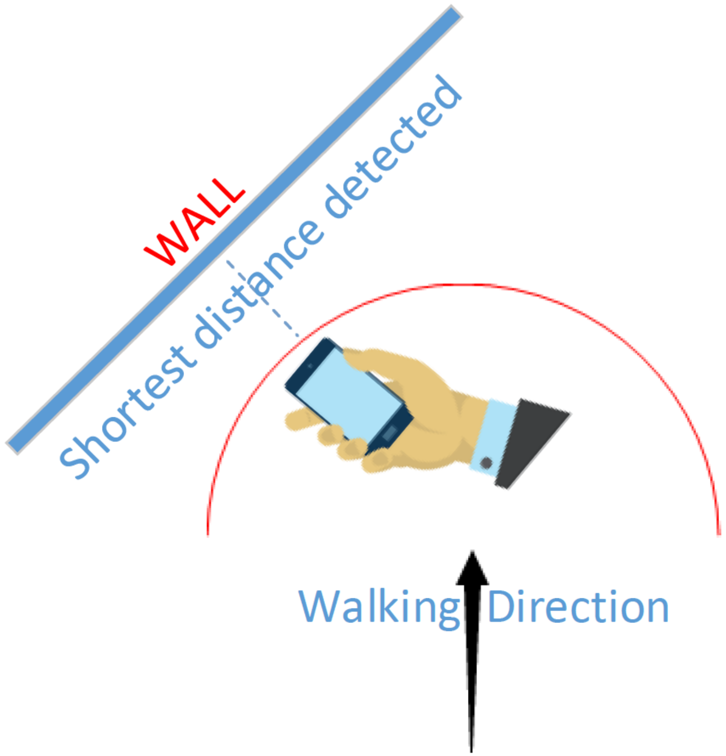
Wavelength: 17cm – 19cm

Period: 0.5s (1ms chirp with 499ms silence)

Measuring Distance



After Distance Measured



Use IMU (Gyroscope) to calculate the angle between **the starting point** and the **shortest-distance-location**

Evaluation

- 6 participants
- Android phone, with speaker, microphone and gyroscope (100Hz)
- Scenarios: outdoor glass-wall, indoor TV and indoor stone-wall

(a) Measuring the distance (Left) and orientation (Right) relative to a glass wall in outdoor environment.

(b) Measuring the distance (Left) and orientation (Right) relative to a hanging TV in indoor environment.

(c) Measuring the distance (Left) and orientation (Right) relative to a stone wall in indoor environment.

Evaluation

Average error rate in distance measuring:

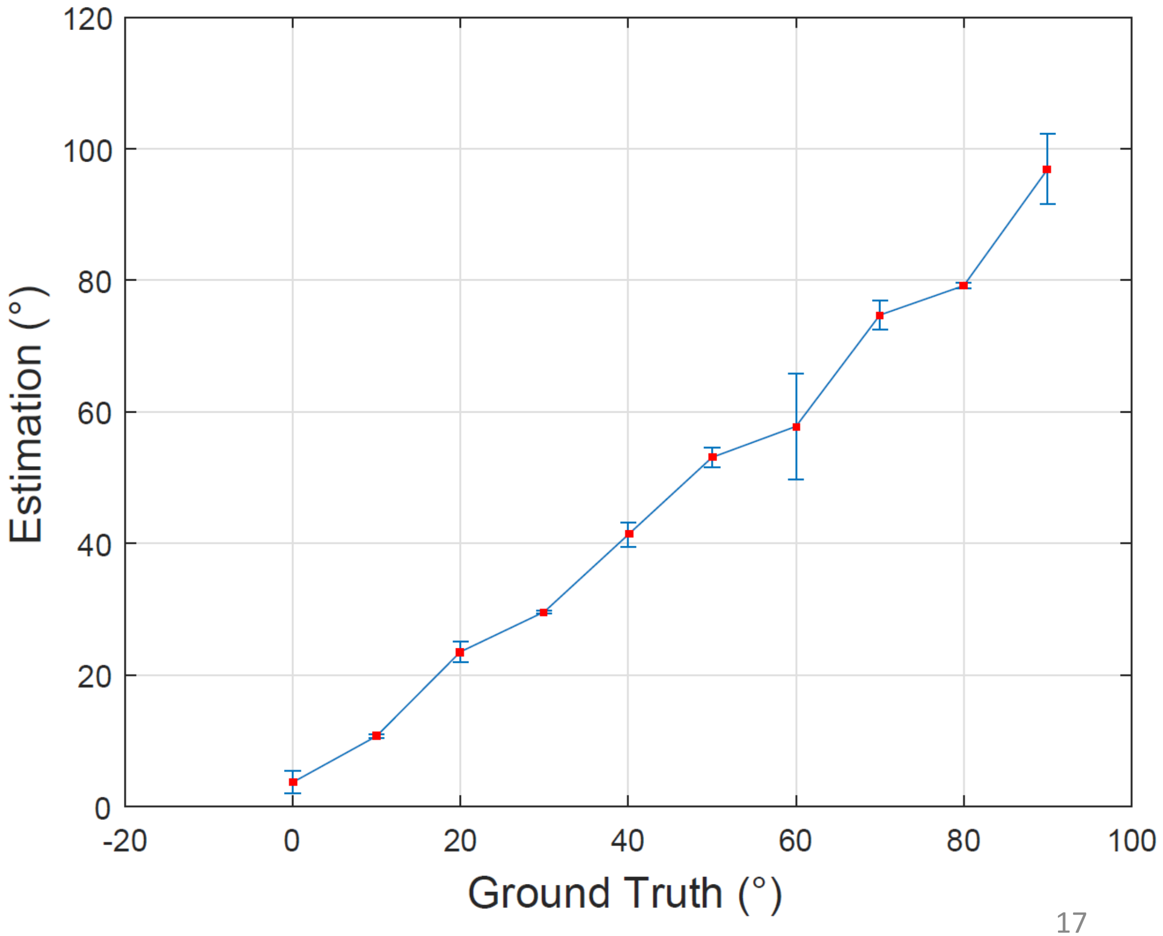
3.24%

Outdoor		Scenarios		Overall
User 1	3.46%	Outdoor-glass	3.35%	
User 2	2.90%	Indoor-glass	1.99%	
User 3	2.94%	Indoor-stone	2.27%	3.24%
User 4	3.15%	With noise	4.78%	
User 5	4.94%	Without noise	3.05%	
User 6	2.72%			

Evaluation

Average error in angle measuring:

2.73 degree



Further Application Scenario

SHENZHEN
UNIVERSITY

THANK YOU !