Gunfire Locator for Ukrainian Army

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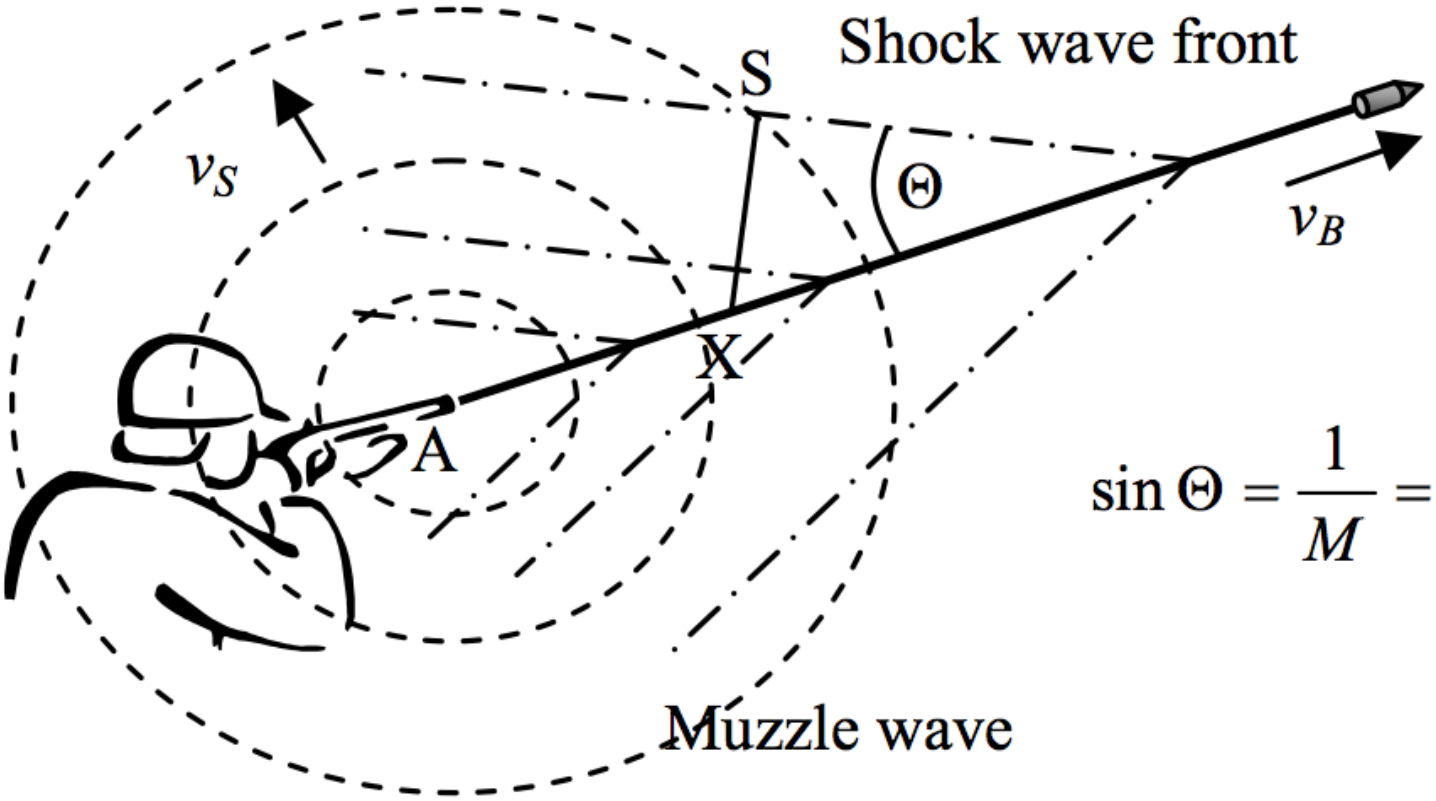
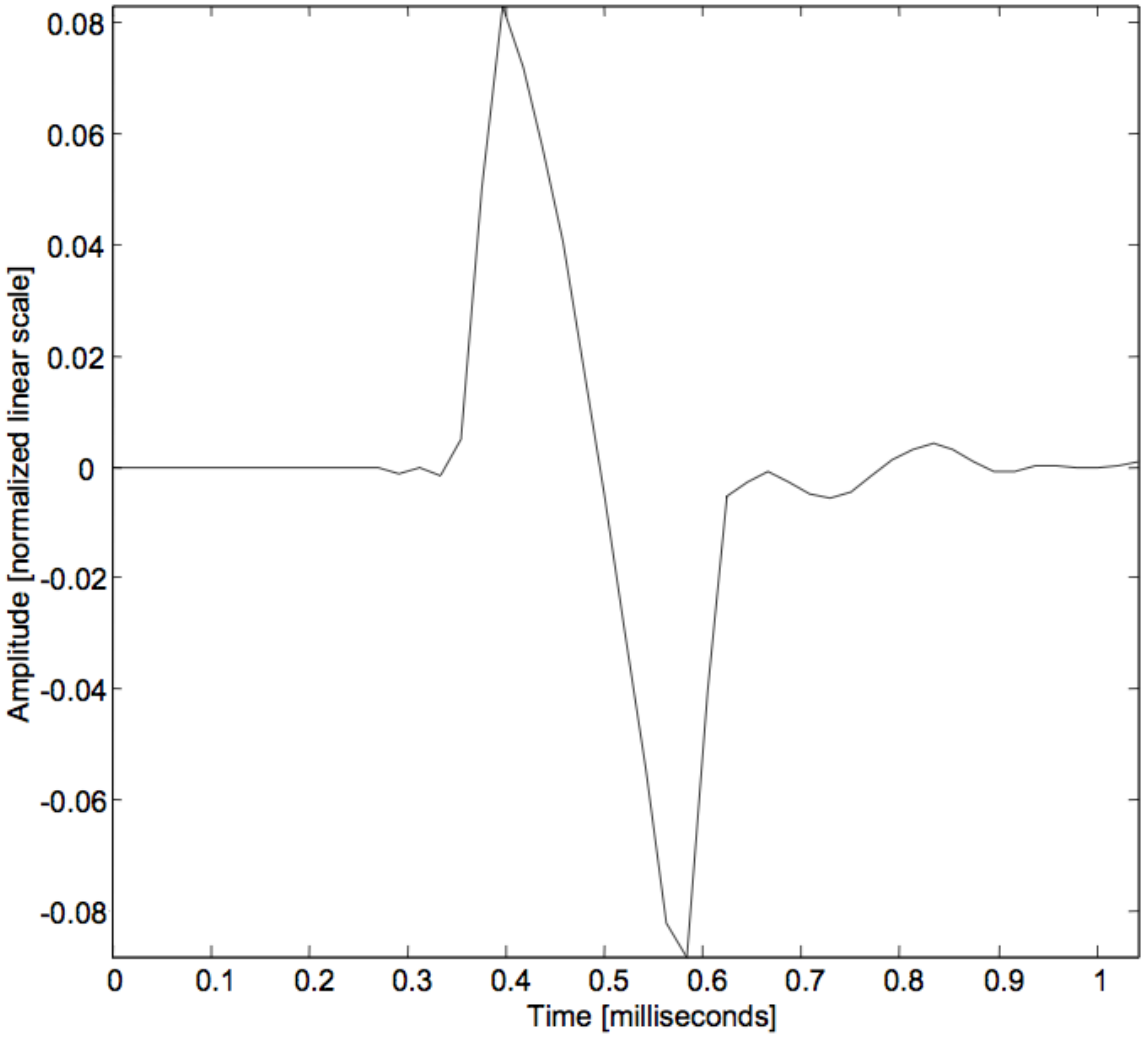
Acoustic events generated by shot



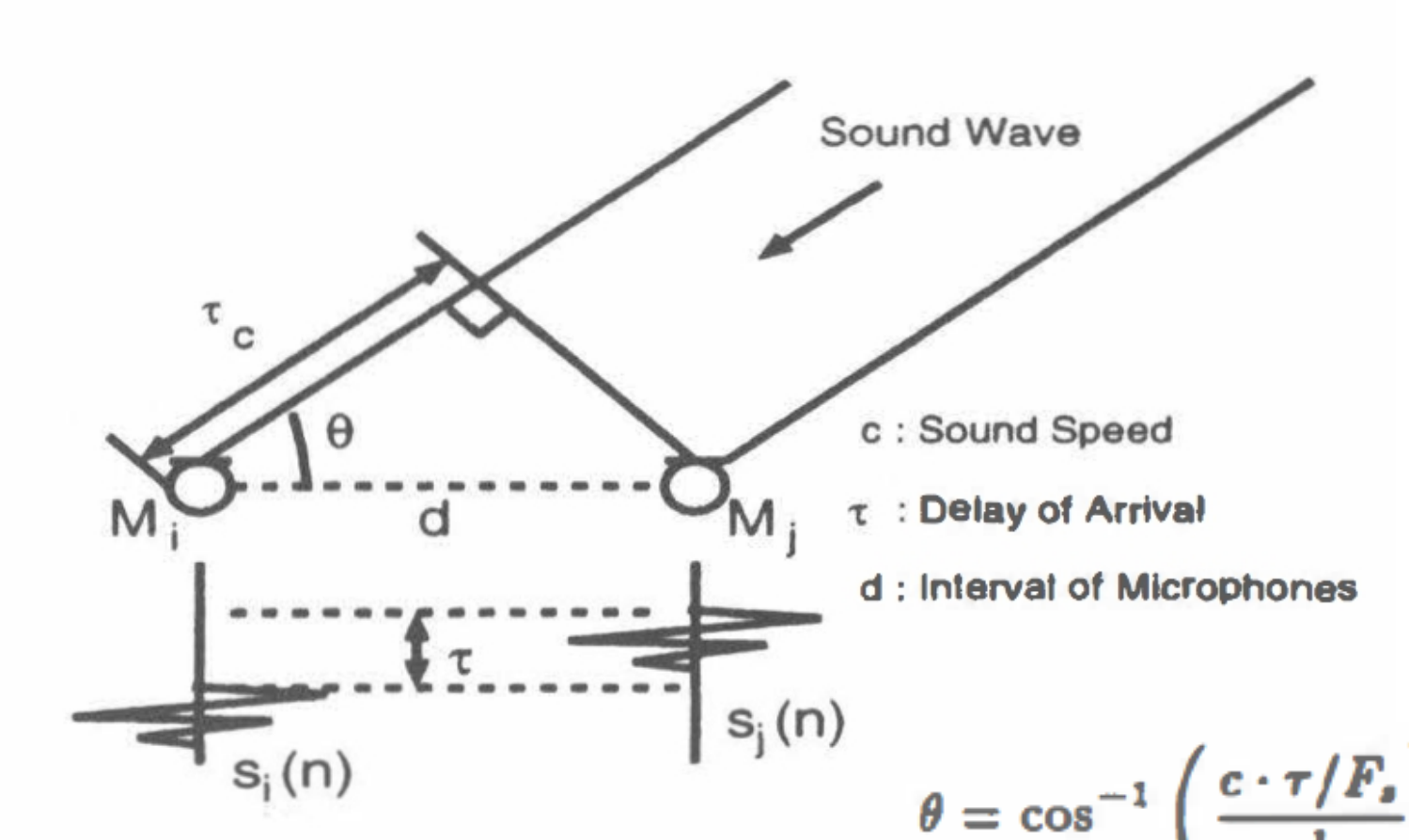
$$\sin\Theta = \frac{1}{M} = \frac{v_S}{v_B}$$

Shock Wave

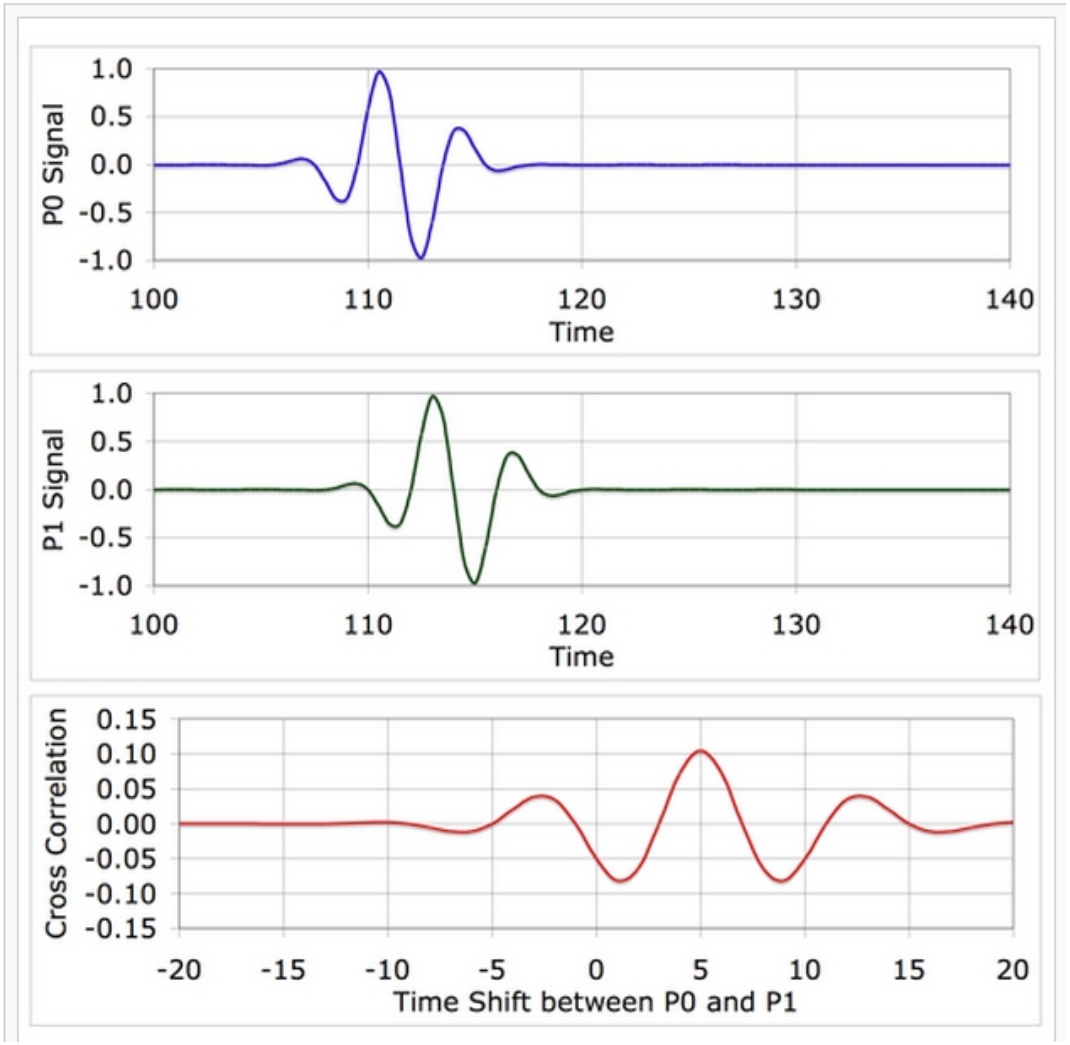


$$T \approx 1.82\left(\frac{d}{c}\right)\left(\frac{Mx}{l}\right)^{\frac{1}{4}}$$

Sound source localization



Time Delay of Arrival with GCC



$$csp_{ij}(k) = \mathrm{DFT}^{-1}\left[\frac{\mathrm{DFT}\left[s_i(n)\right]\mathrm{DFT}\left[s_j(n)\right]^*}{\left|\mathrm{DFT}\left[s_i(n)\right]\right|\left|\mathrm{DFT}\left[s_j(n)\right]\right|}\right]$$

$$\tau = \underset{k}{\mathrm{argmax}}(\mathrm{CSP}_{ij}(k)).$$

In Theory

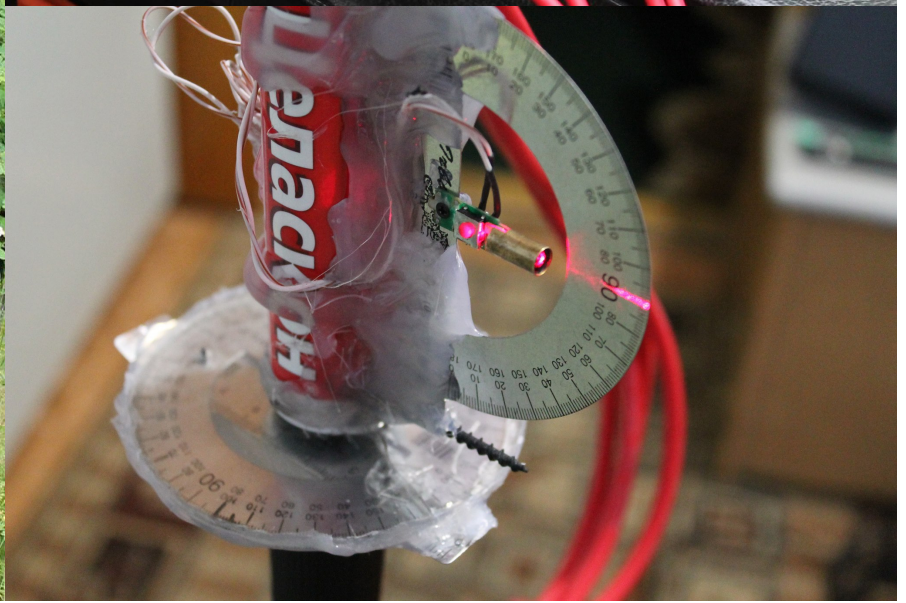
1) Record audio sample
2) Detect gunfire by shock wave
3) Calculate TDOA
4) Indicate Azimuth
5) …
6) PROFIT!

In Reality


start finishing!
QUIET
BROGRAMMER
AT WORK
www.scrumguides.com

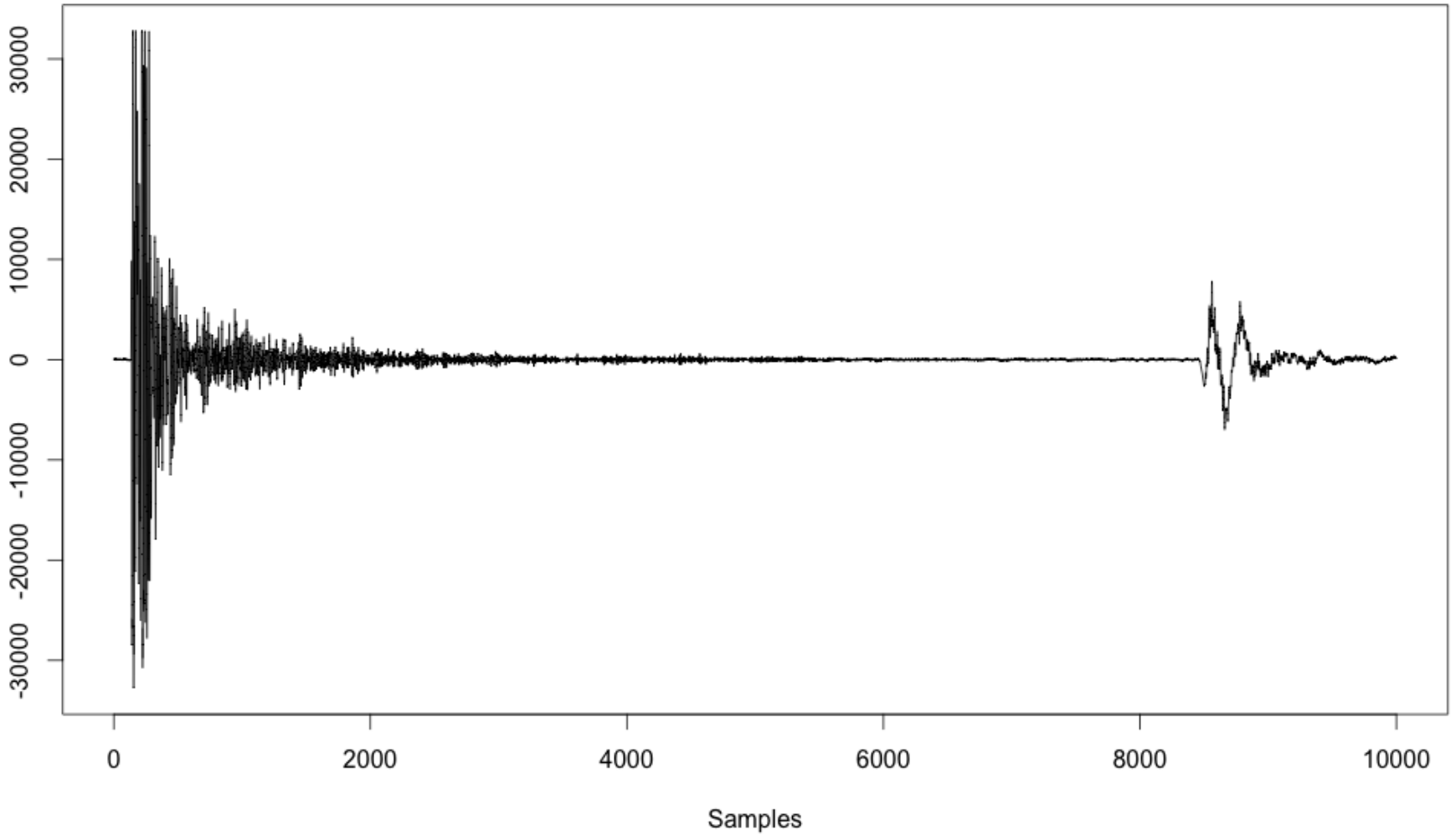
Hardware

PreSonus AudioBox 44 VSL, 4 x NUMARK WM200, 44100 Hz, 16 bit, 4 x mono, PC/Mac

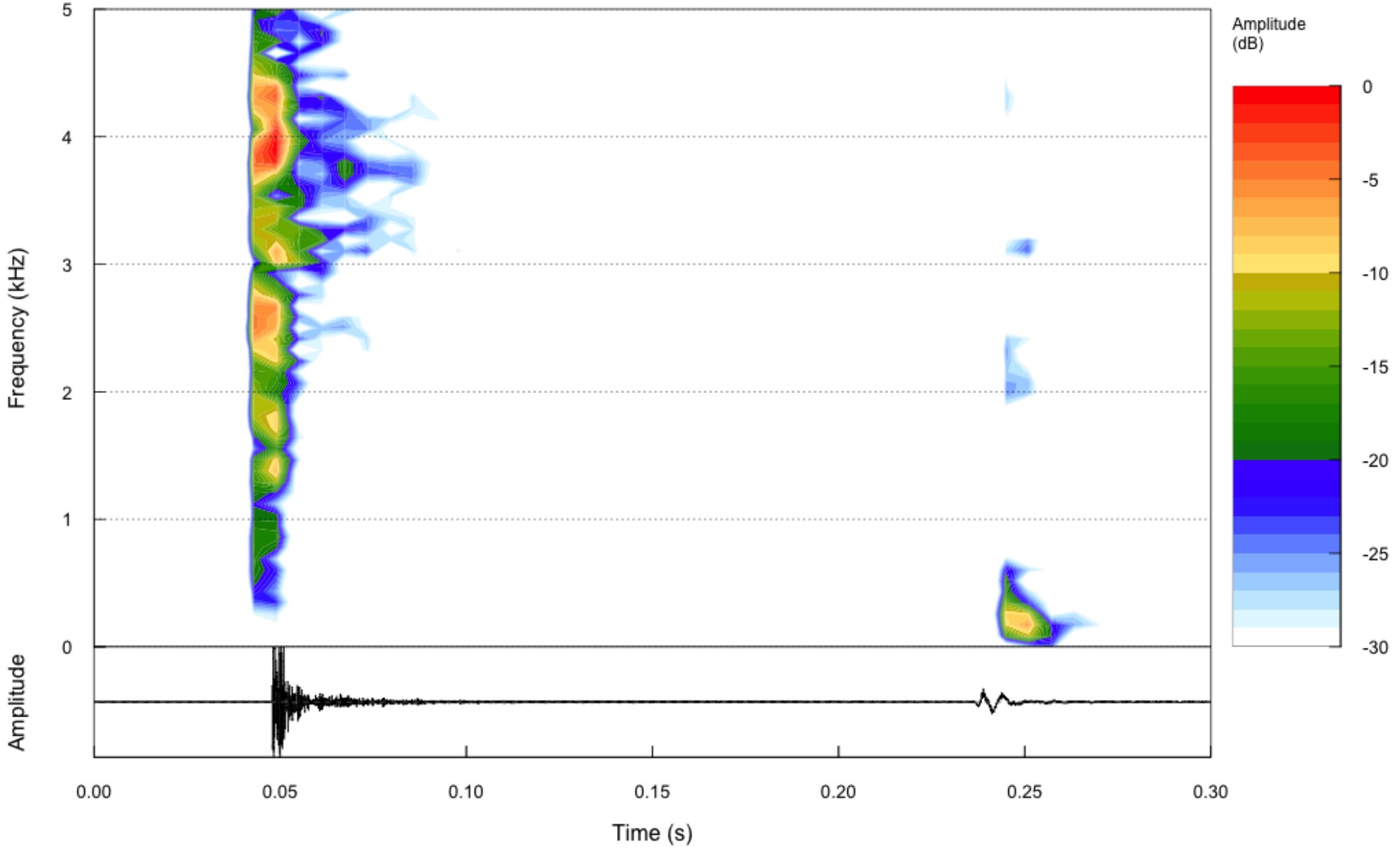


Recorded Audio – 3.8Gb

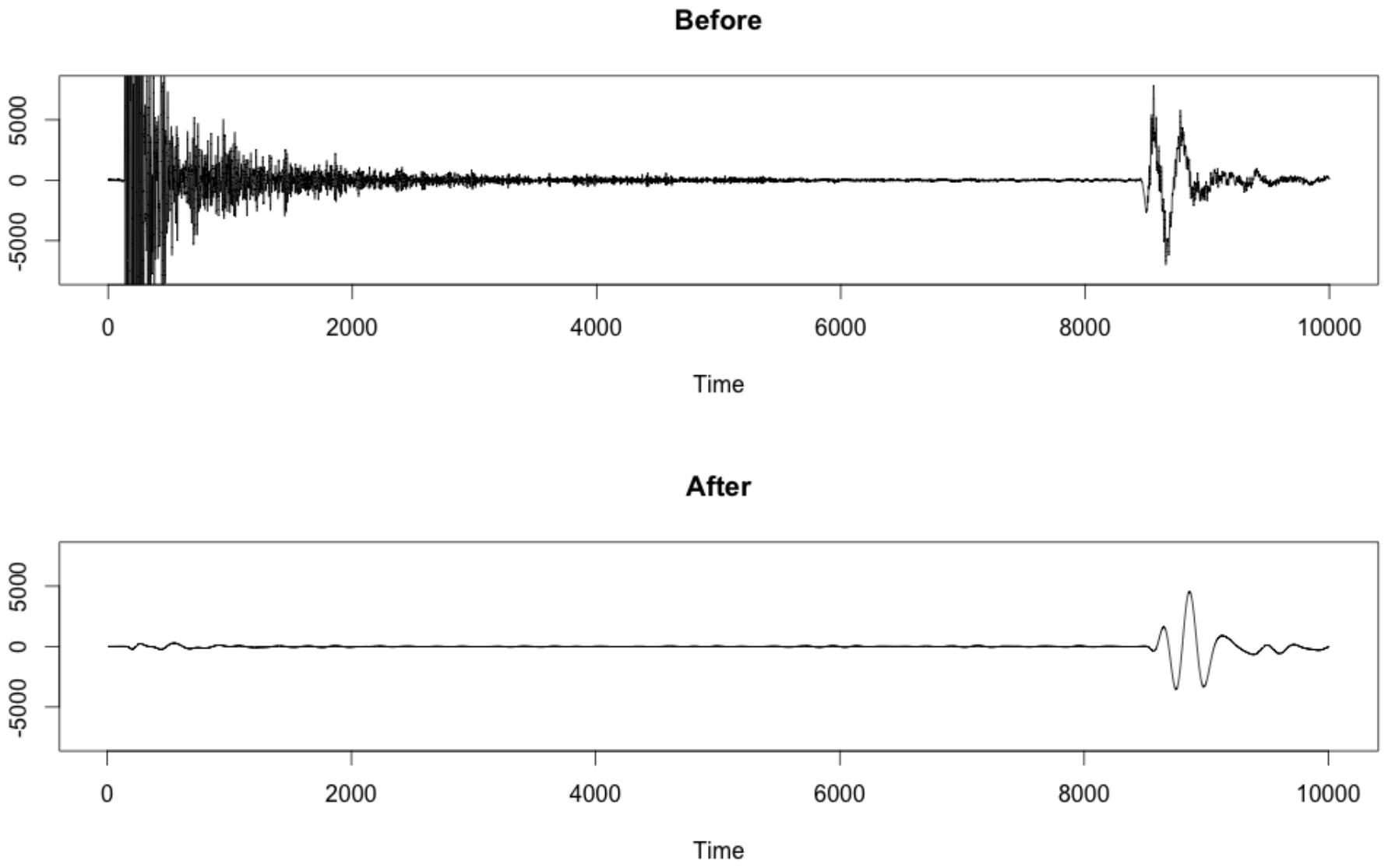
Issues


30000
20000
10000
0
-10000
-20000
-30000
0
2000
4000
6000
8000
10000
Samples

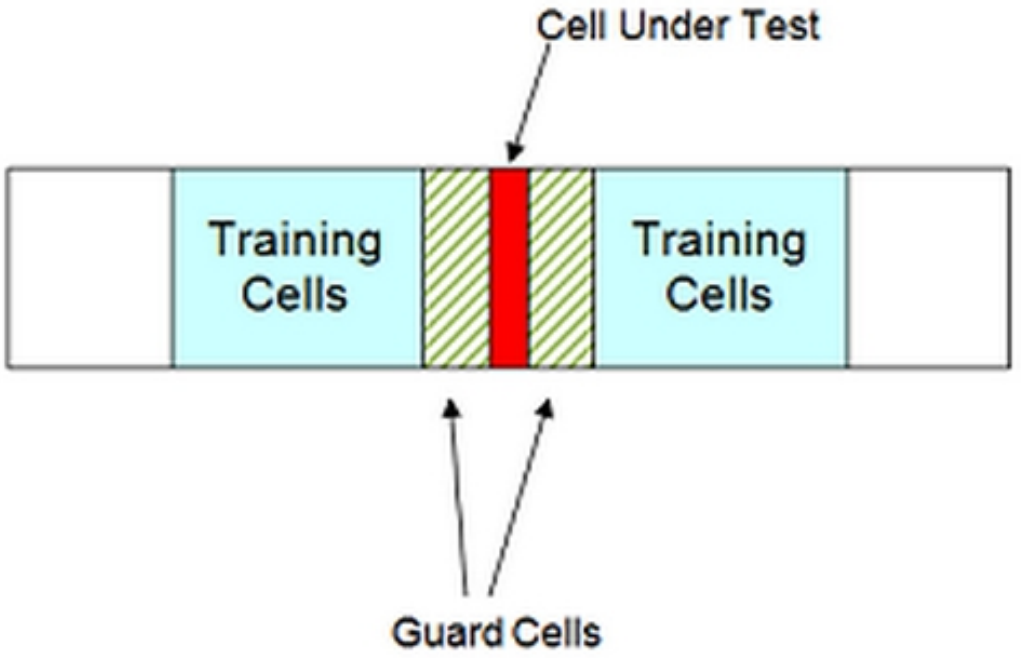
Spectrogram



Band-Pass Filter – 100Hz - 500Hz



CFAR detector



$$T = \alpha P_n$$

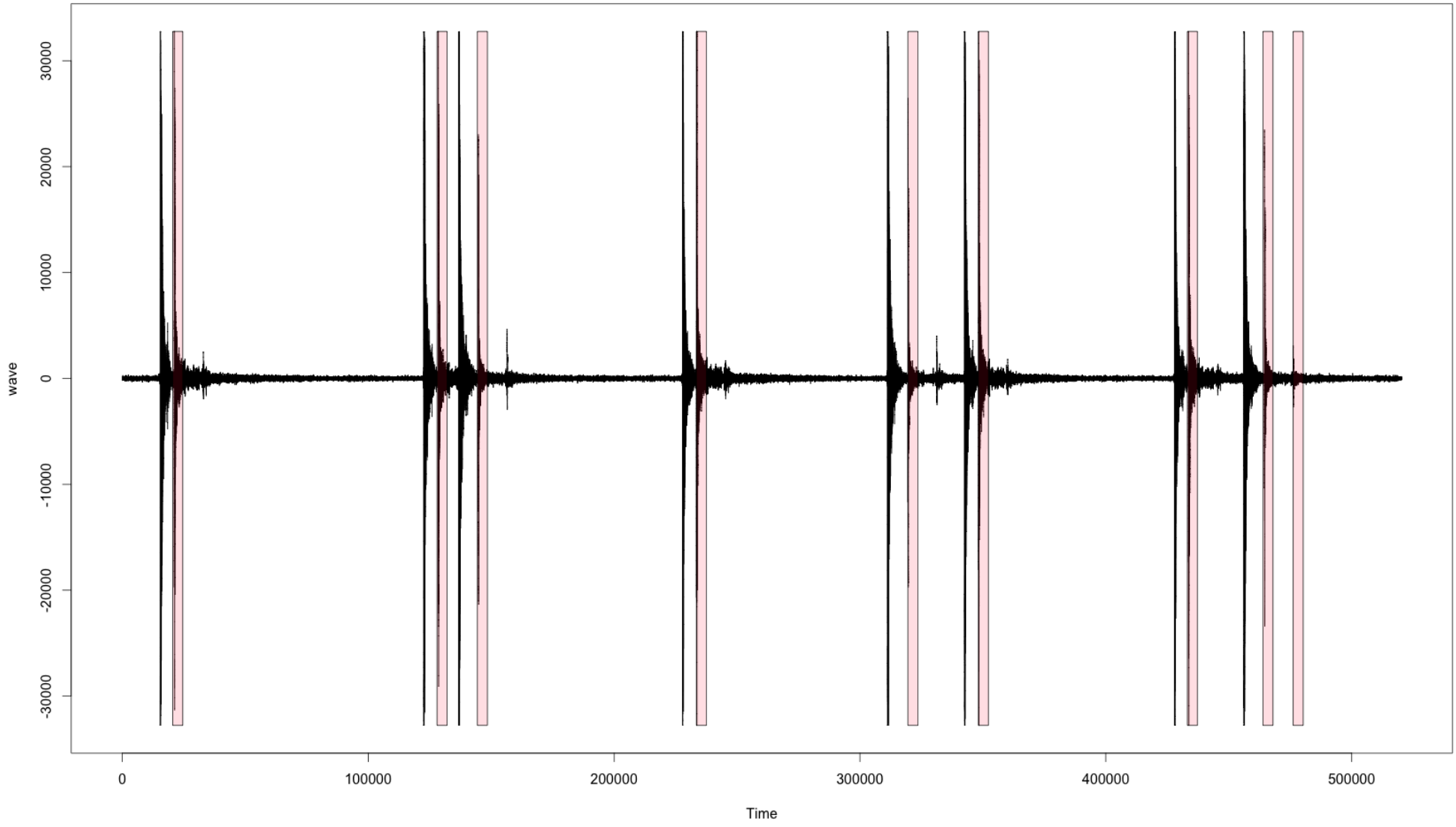
$$P_n = \frac{1}{N} \sum_{m=1}^{N} x_m$$

$$\alpha = N(P_{fa}^{-1/N} - 1)$$

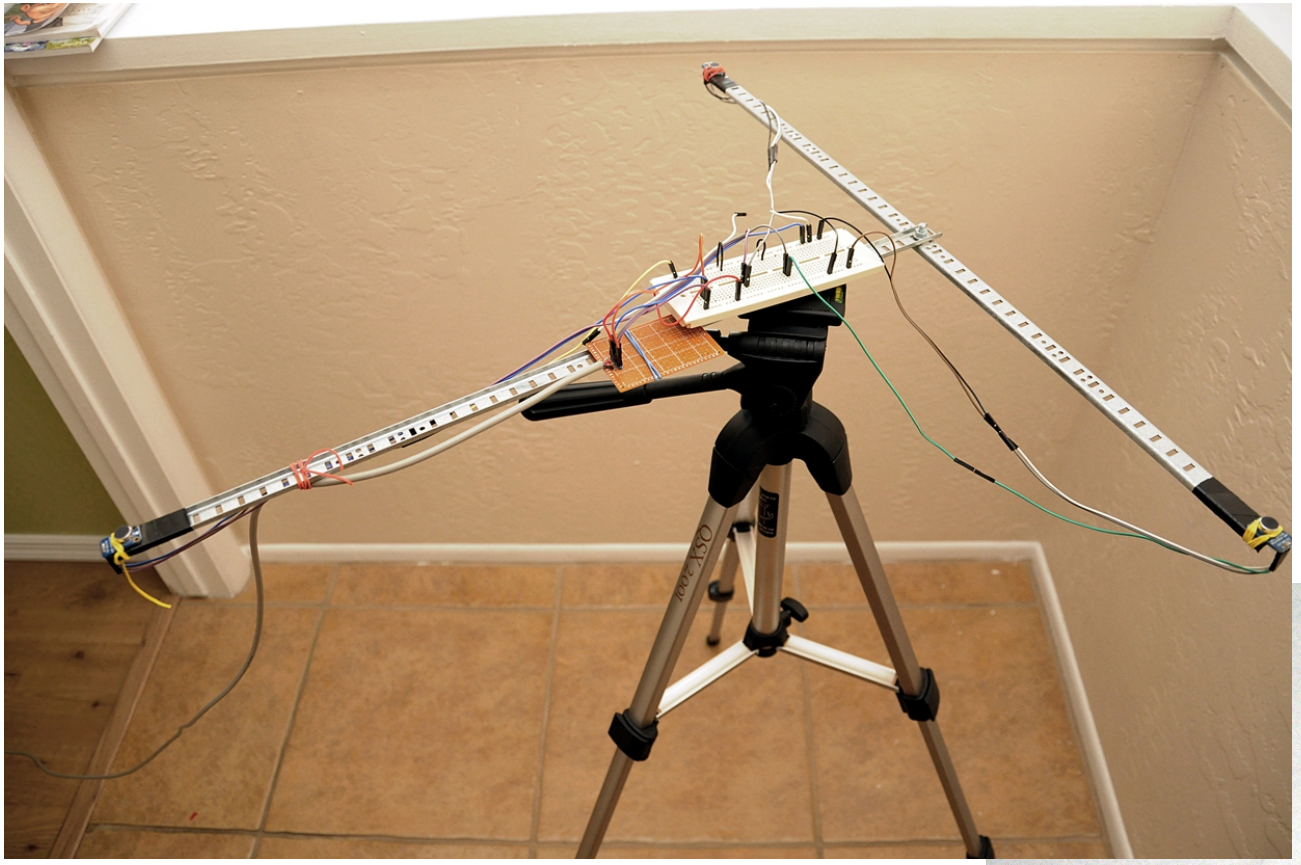
Algorithm

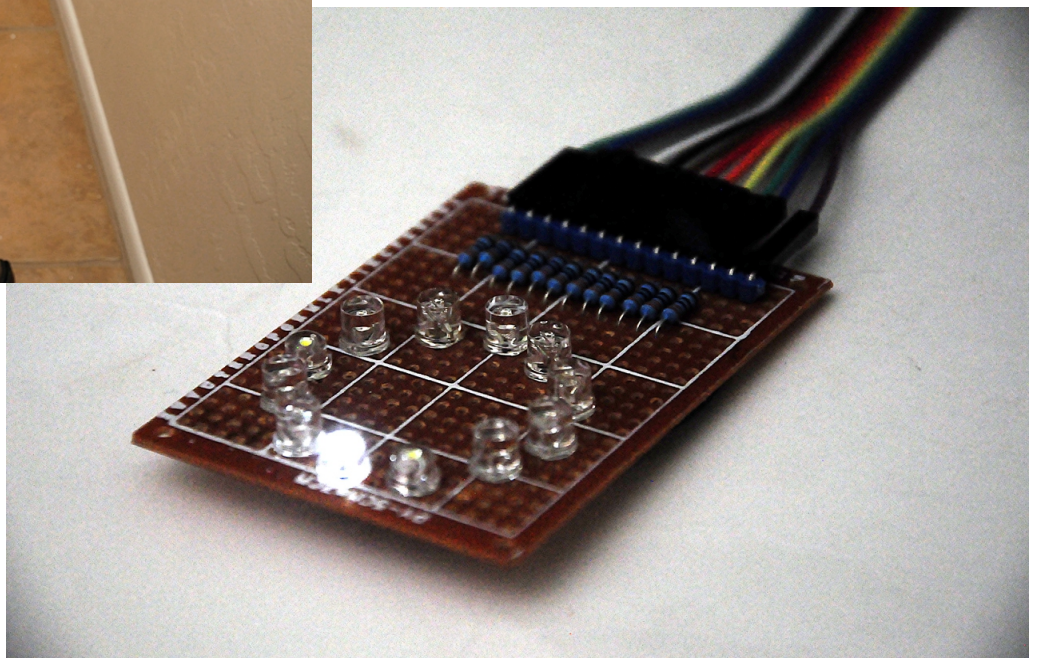
1) Sliding Window: 5120 samples, 1024 step
2) Apply Band-Pass filter
3) Detect Impulse by CFAR
4) Calculate TDOA
5) Indicate Azimuth
6) …
7) PROFIT!

Accuracy - 0.88, SNR - 50dB



Platform – Work in Progress





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References

[1] Robert C. Maher. Modeling and signal processing of acoustic gunshot recordings. Proc. IEEE Signal Processing Society 12th DSP Workshop, Jackson Lake, WY, September, 2006, pp. 257-261.

[2] Gyula Simon, Miklós Maróti, Ákos Lédeczi. Sensor Network-Based Countersniper System. Institute for Software Integrated Systems Vanderbilt University. 2004.

[3] Τακανobu Nishiur, Τακeshi Υαmαdα, Sατoshi Νακαmura, Kiyohiro Shikαno. Localization of multiple sound sources based on a CSP analysis with a microphone array. 2002.

Thank You!

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