Hearing the Truth about **Binaural Acoustic Localization**

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Where did that come from?

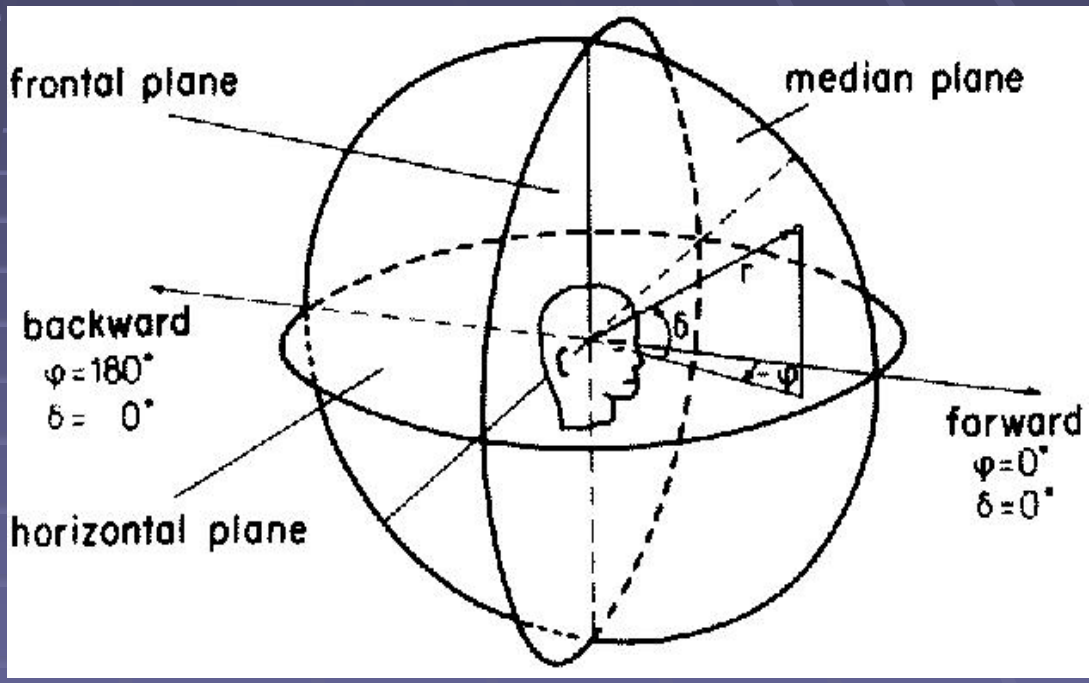
- Localization is used every day
- Done subconsciously to avoid dangers
- Numerous applications
  - tracking speakers
  - monitoring equipment

- How do we process sounds?

Head-Related Transfer Functions

Horizontal Plane

- Sound arrives at one ear first



Vertical Plane

- Difficulty:
  no time delay
- Using your (ears,)

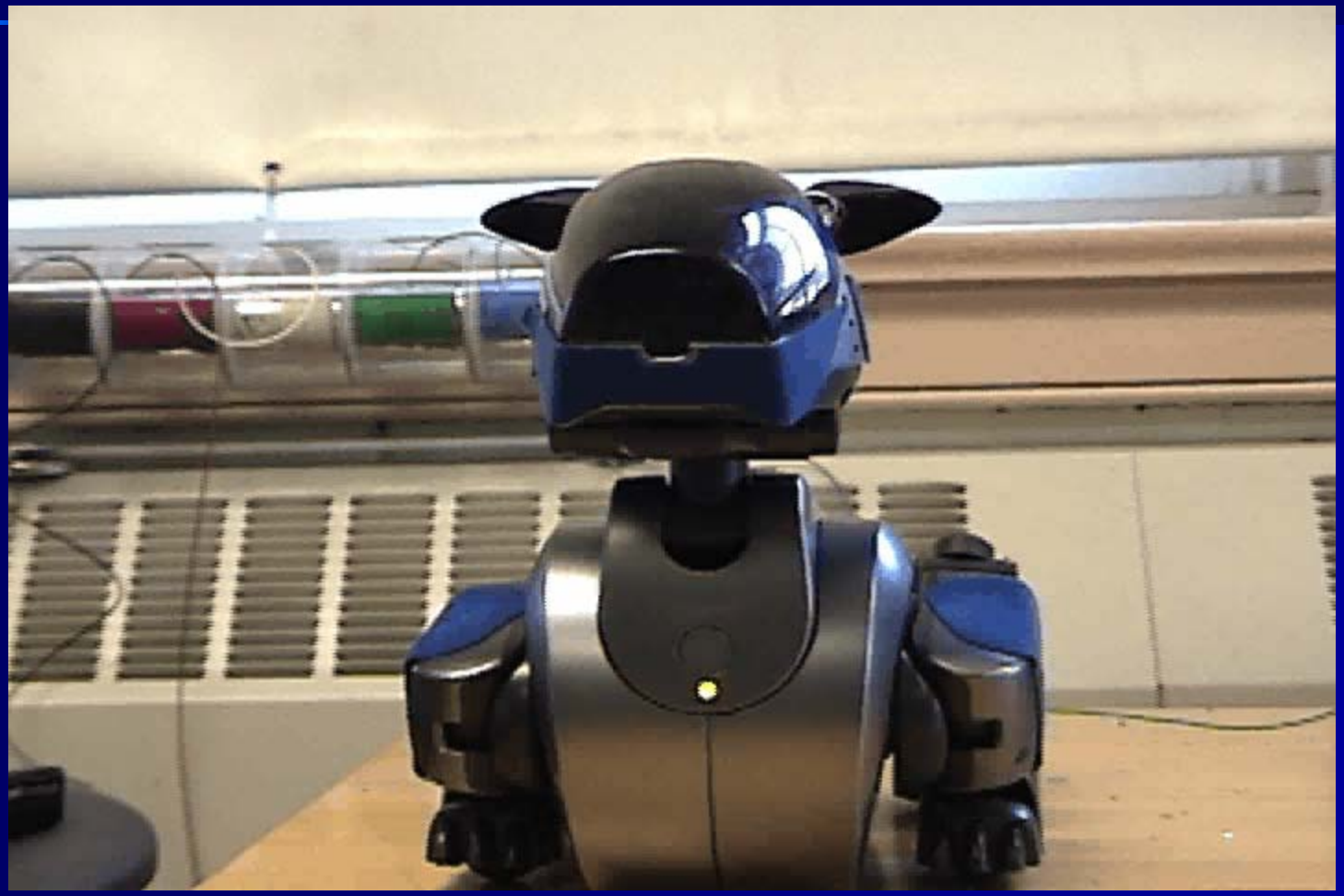
Head and Shoulders

the Setup

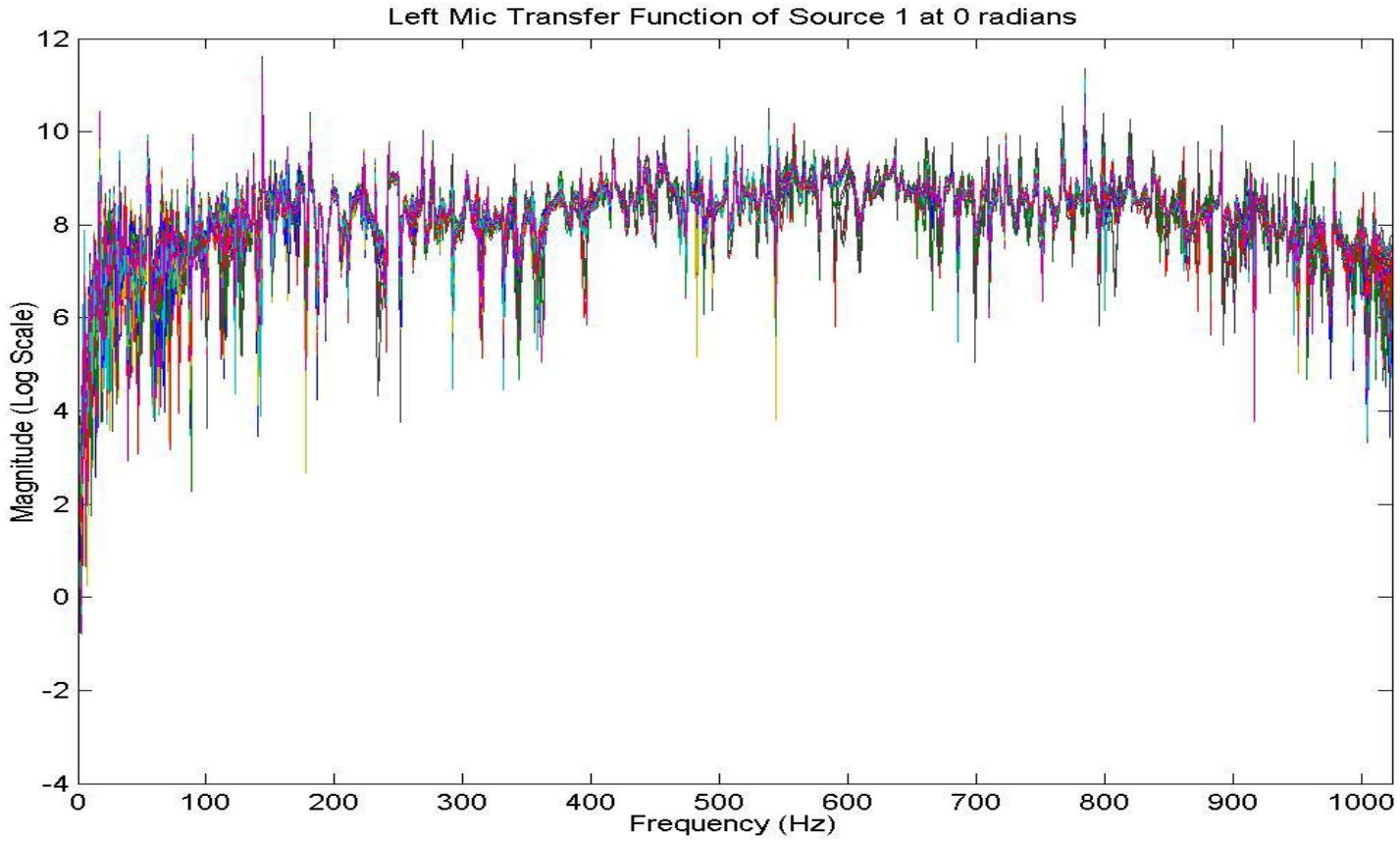
- Good ole Matlab!
- The front hemisphere <nod>
- Fourier Analysis to obtain HRTF(δ,*f*)

Inside the head

Modifications



Methods 1: Transfer Functions



- $H_L(f) = X_L(f)/S(f)$

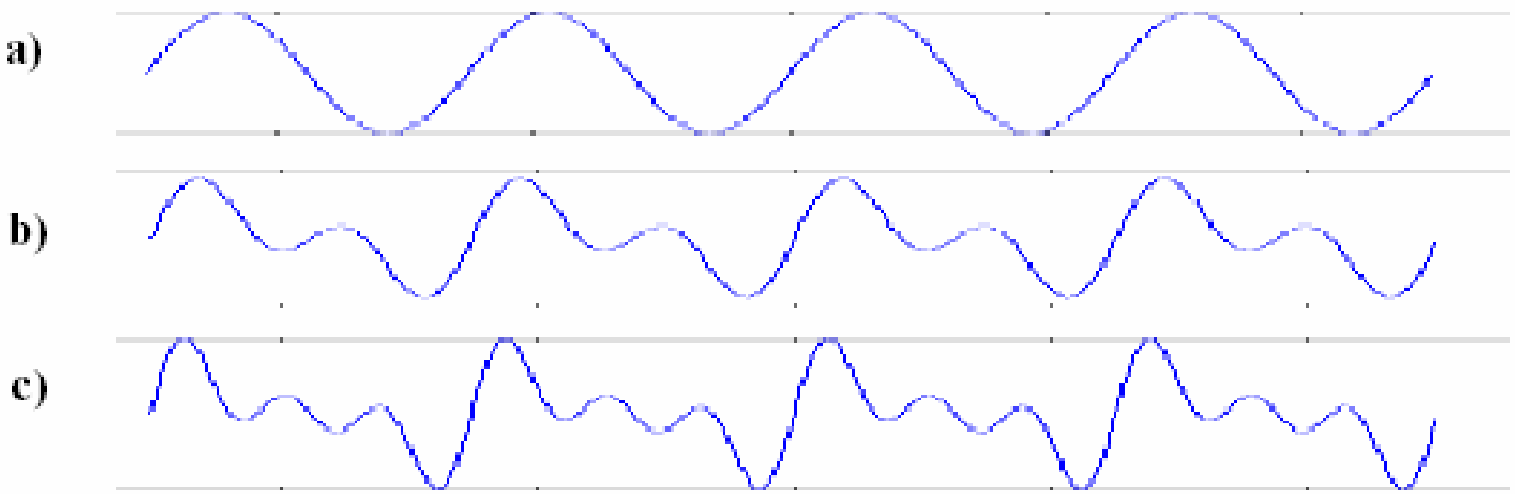
Fourier Review

- Discrete Fourier Transform:

$$M(p) = \sum_{n=0}^{N-1} m(n) \bullet e^{-j\omega np}$$

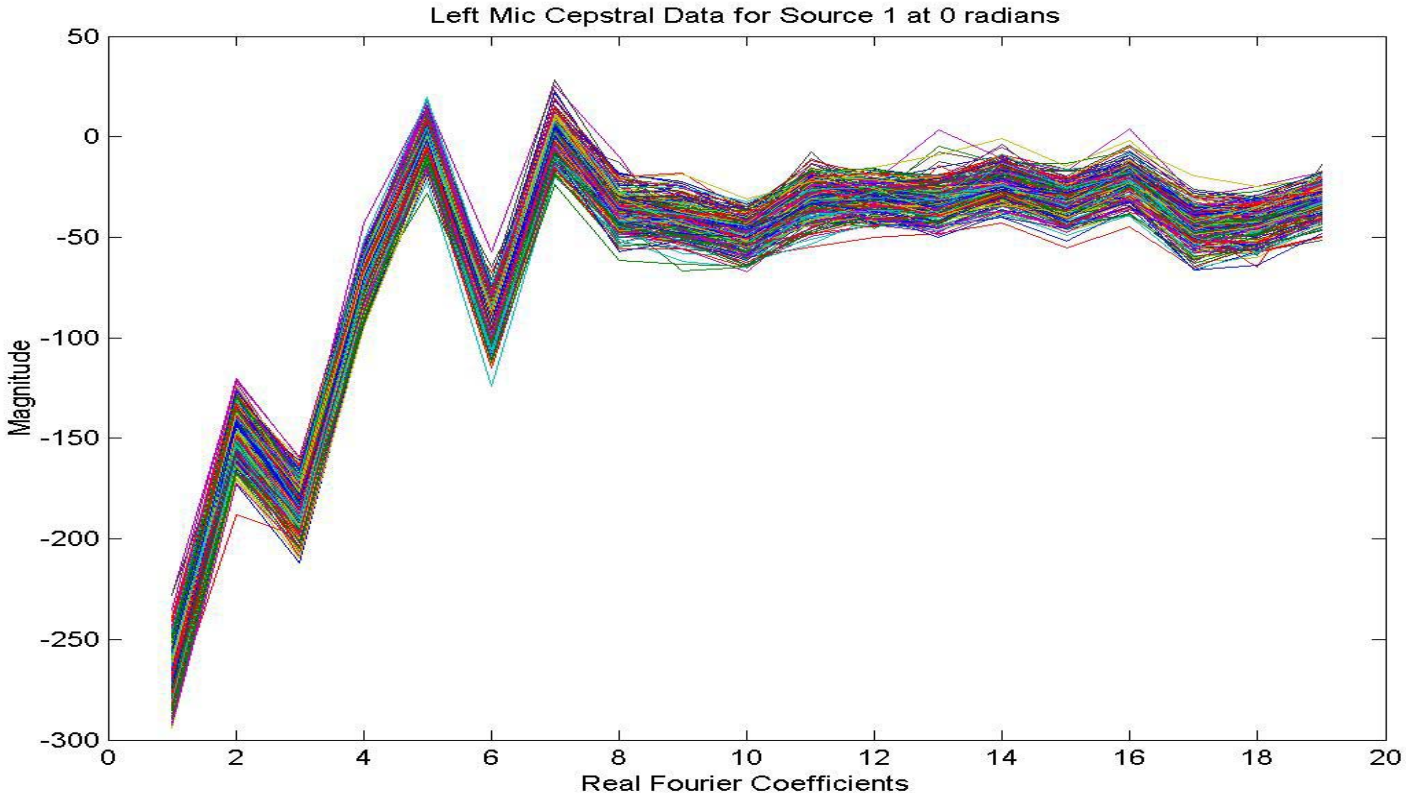
- Output is quantized in Frequency Domain

Coefficient Representation



a) sin(x), **b)** sin(x) + sin(2x), **c)** sin(x) + sin(2x) + (4+ sin(3x))

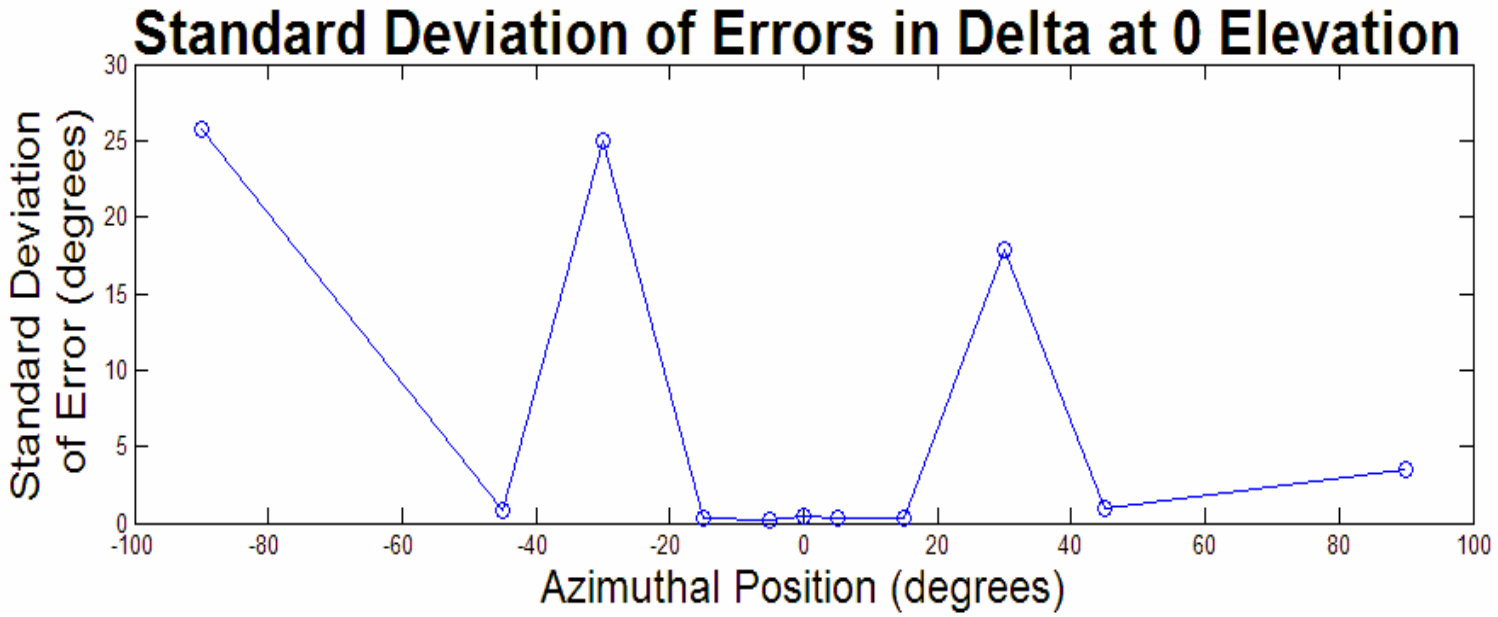
Methods 2: Cepstral Analysis

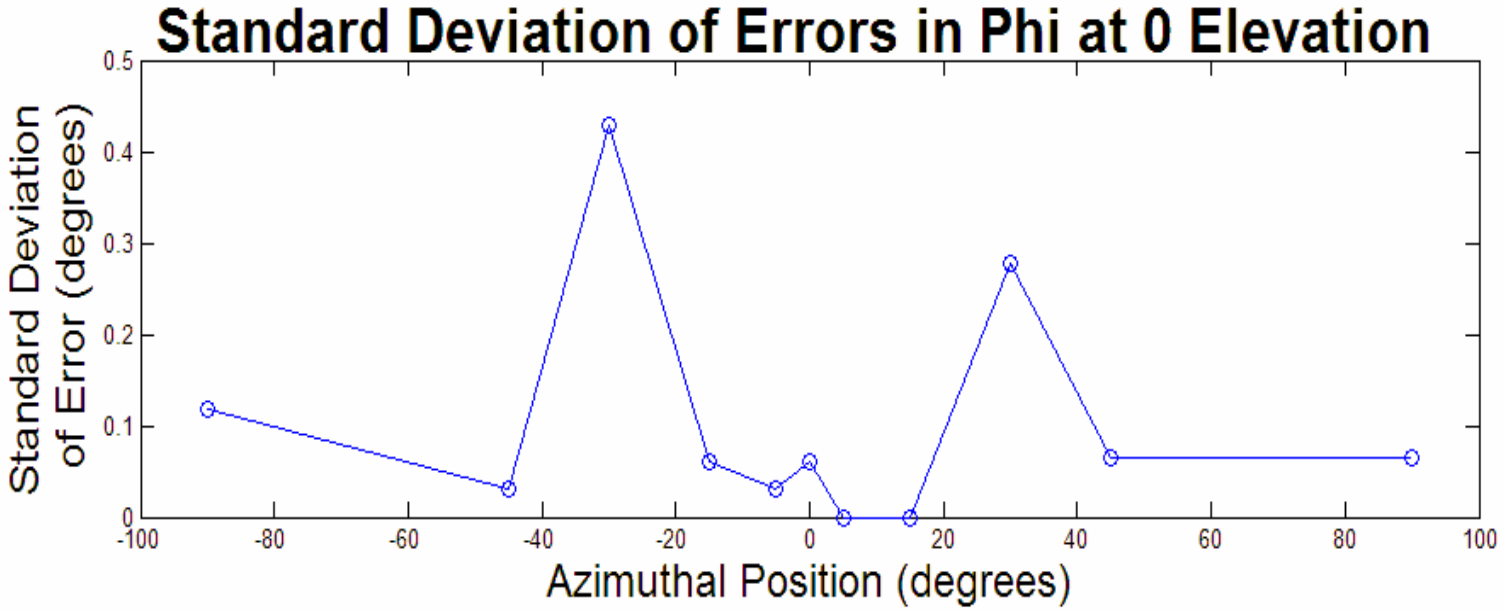


- $C_L(f) = \text{fft}(\log(\text{abs}(H(f))))$

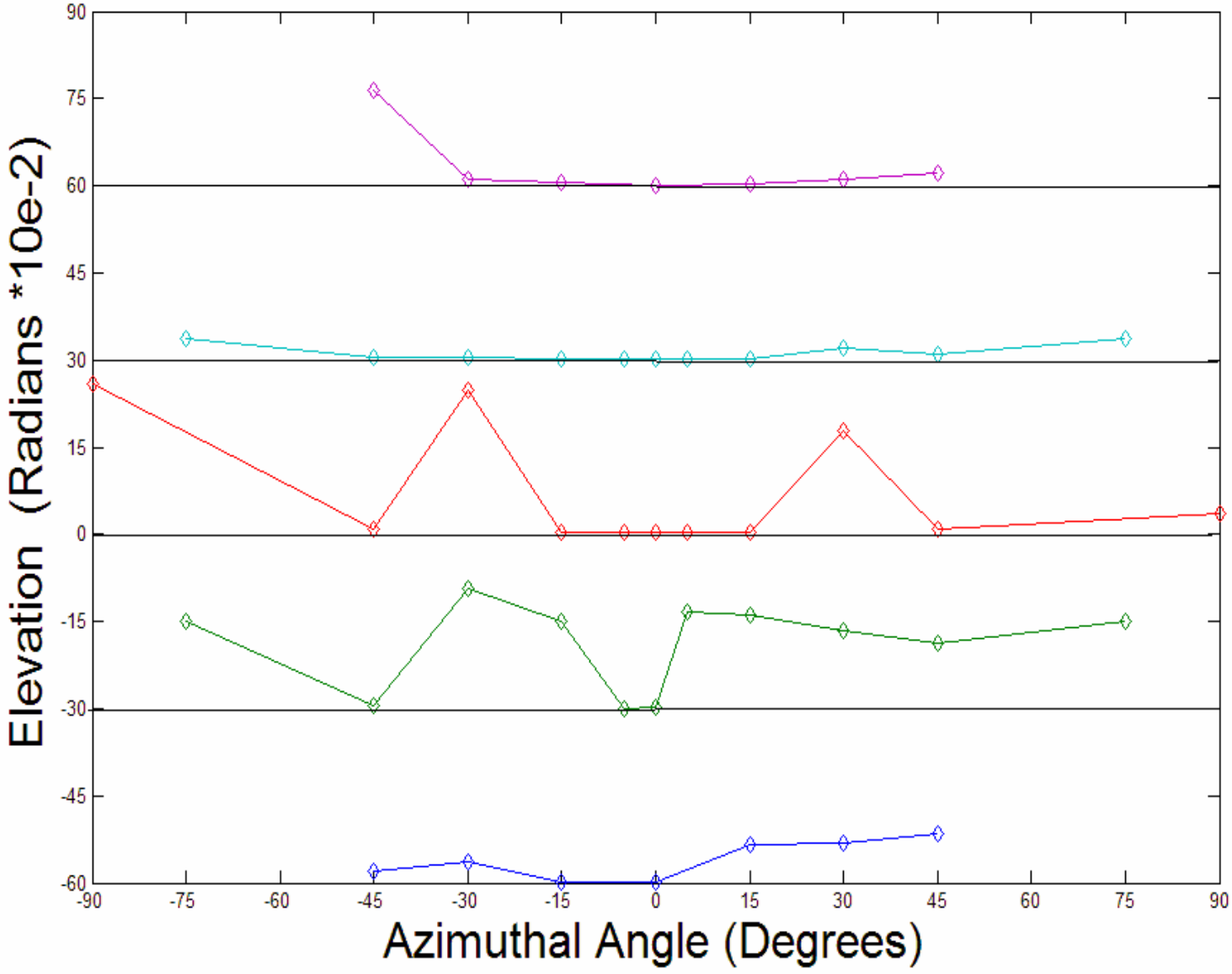
Results

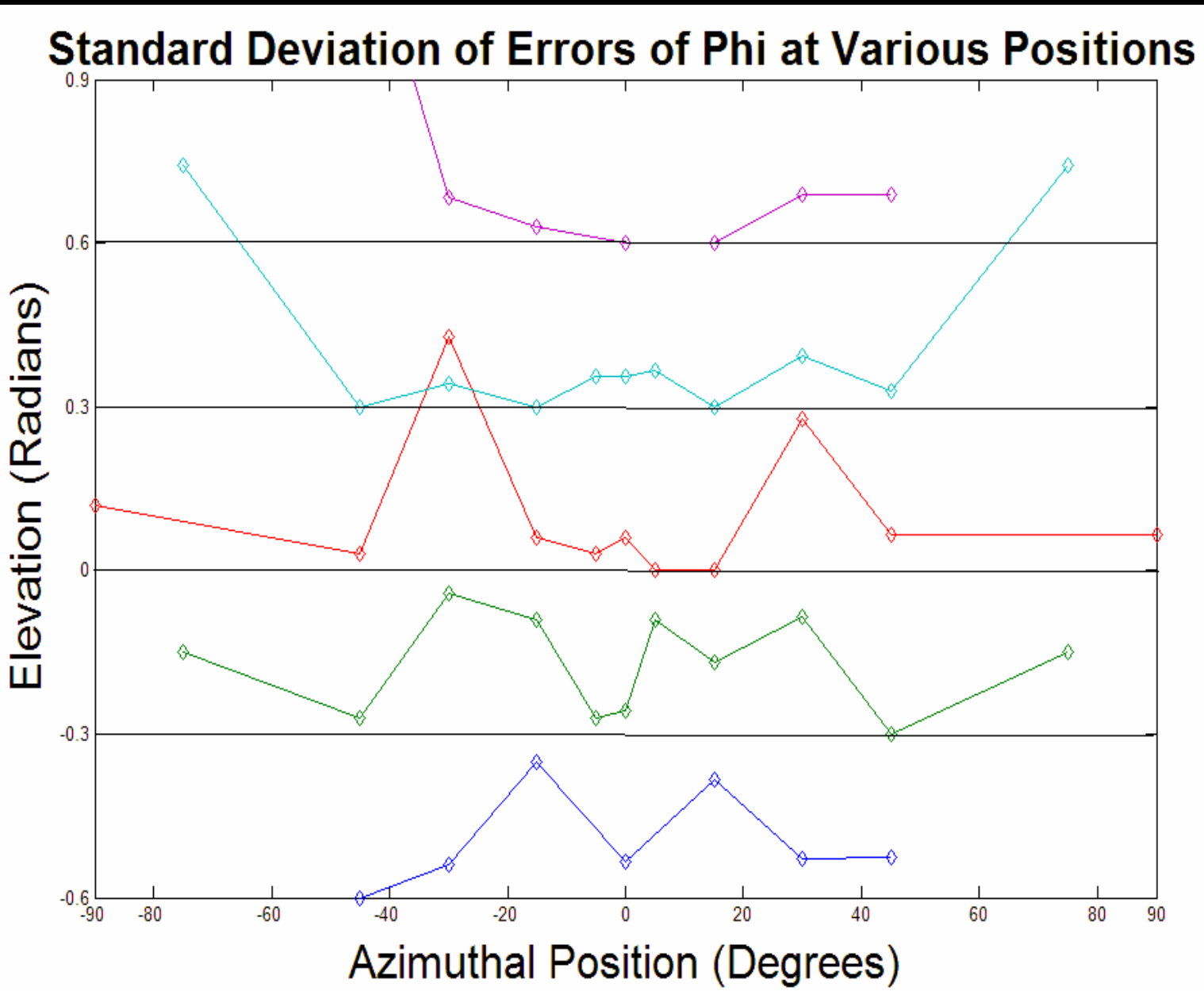
- Matching “template” Cepstral Data with instantaneous data has a high degree of success to find elevation
- Calculations for time shift are precise, but delta (azimuthal angle) is dependent on angle of elevation due to spherical coordinates

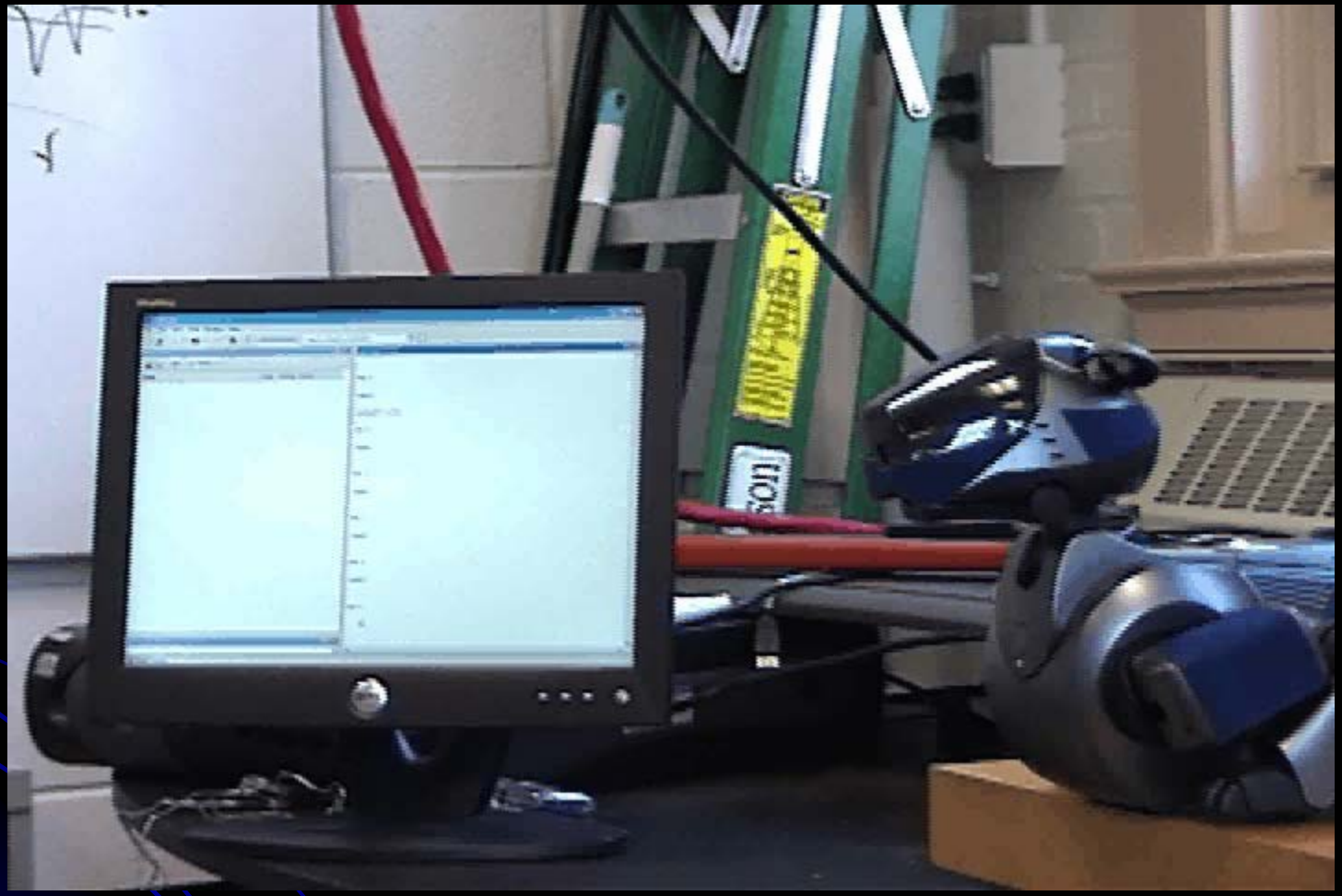

Standard Deviation of Errors in Delta at 0 Elevation
Standard Deviation of Error (degrees)
Azimuthal Position (degrees)
30
25
20
15
10
5
0
-100
-80
-60
-40
-20
0
20
40
60
80
100


Standard Deviation of Errors in Phi at 0 Elevation
Standard Deviation of Error (degrees)
Azimuthal Position (degrees)
0.5
0.4
0.3
0.2
0.1
0
-100
-80
-60
-40
-20
0
20
40
60
80
100

Standard Deviation of Errors of Delta




Standard Deviation of Errors of Phi at Various Positions
Elevation (Radians)
0.9
0.6
0.3
0
-0.3
-0.6
-90
-80
-60
-40
-20
0
20
40
60
80
90
Azimuthal Position (Degrees)



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