SOURCE AND DIRECTION OF ARRIVAL ESTIMATION BASED ON MAXIMUM LIKELIHOOD COMBINED WITH GMM AND EIGENANALYSIS

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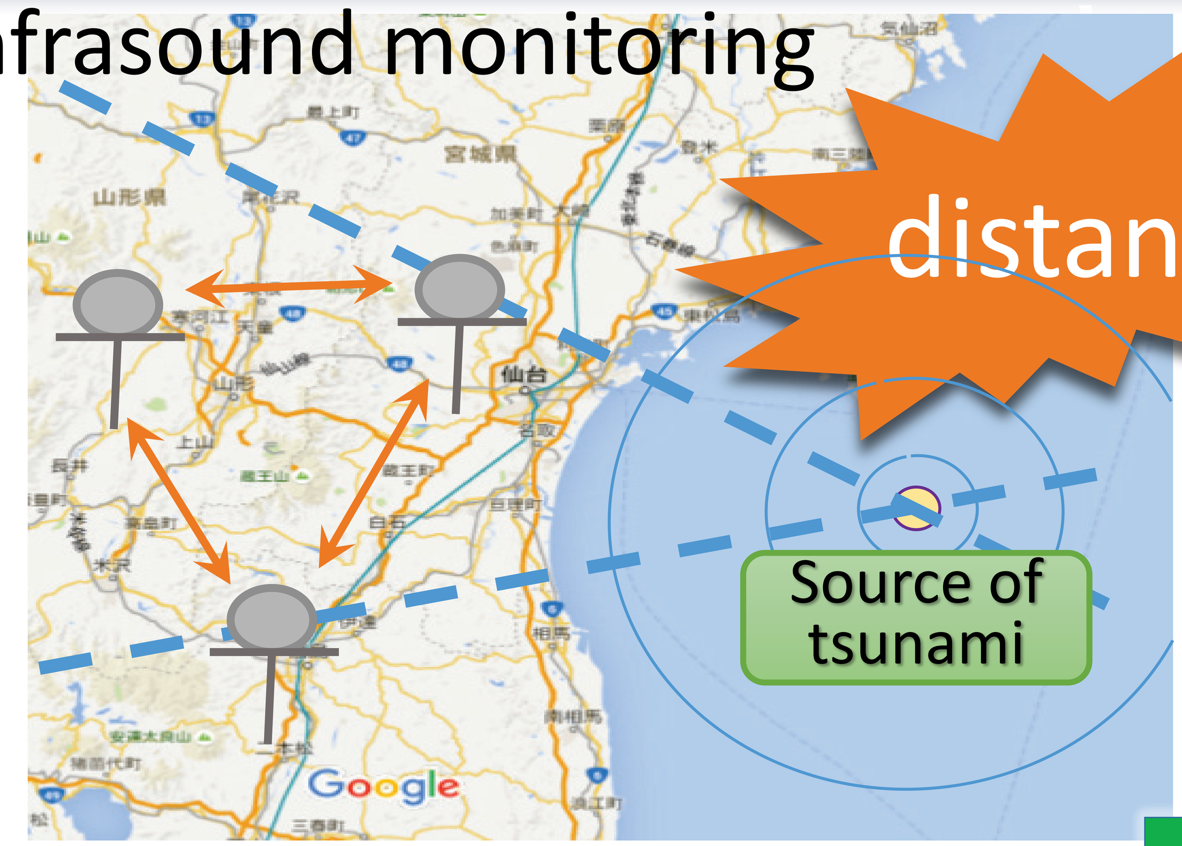
Purpose / Motivation

Infrasound monitoring

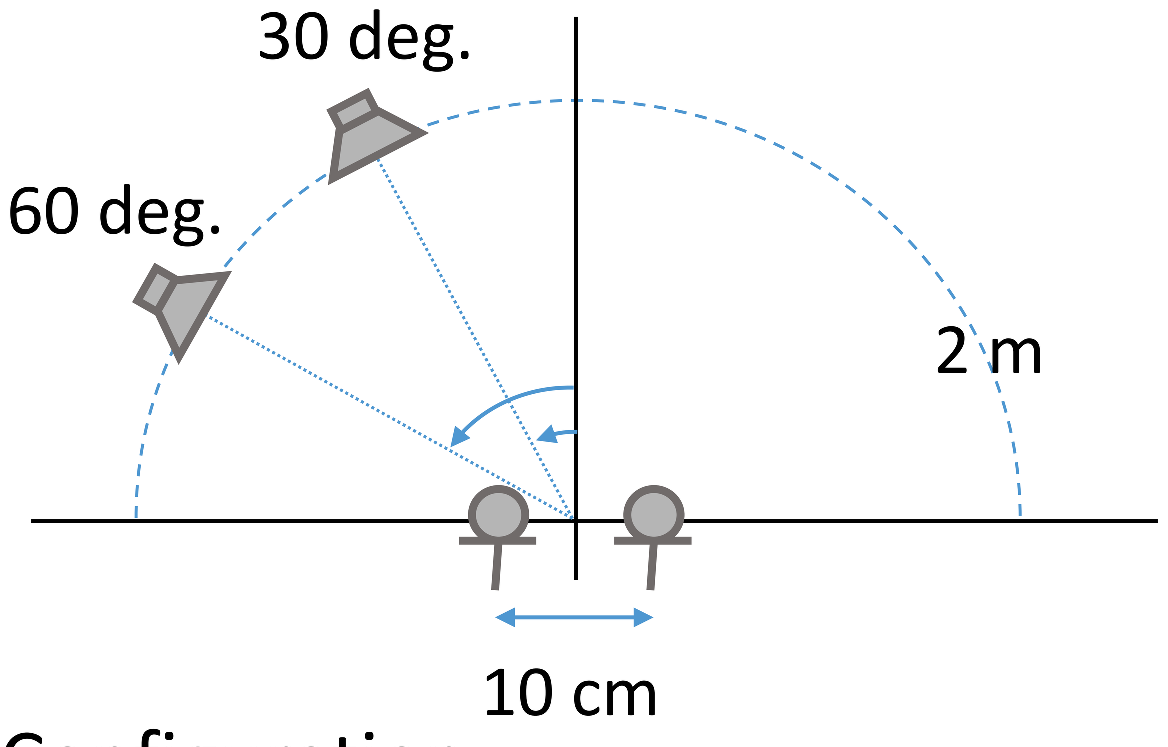


Phase and Amplitude are different.

What we want

- Waveform of source signal
- Direction of arrival (DOA)

Numerical simulation

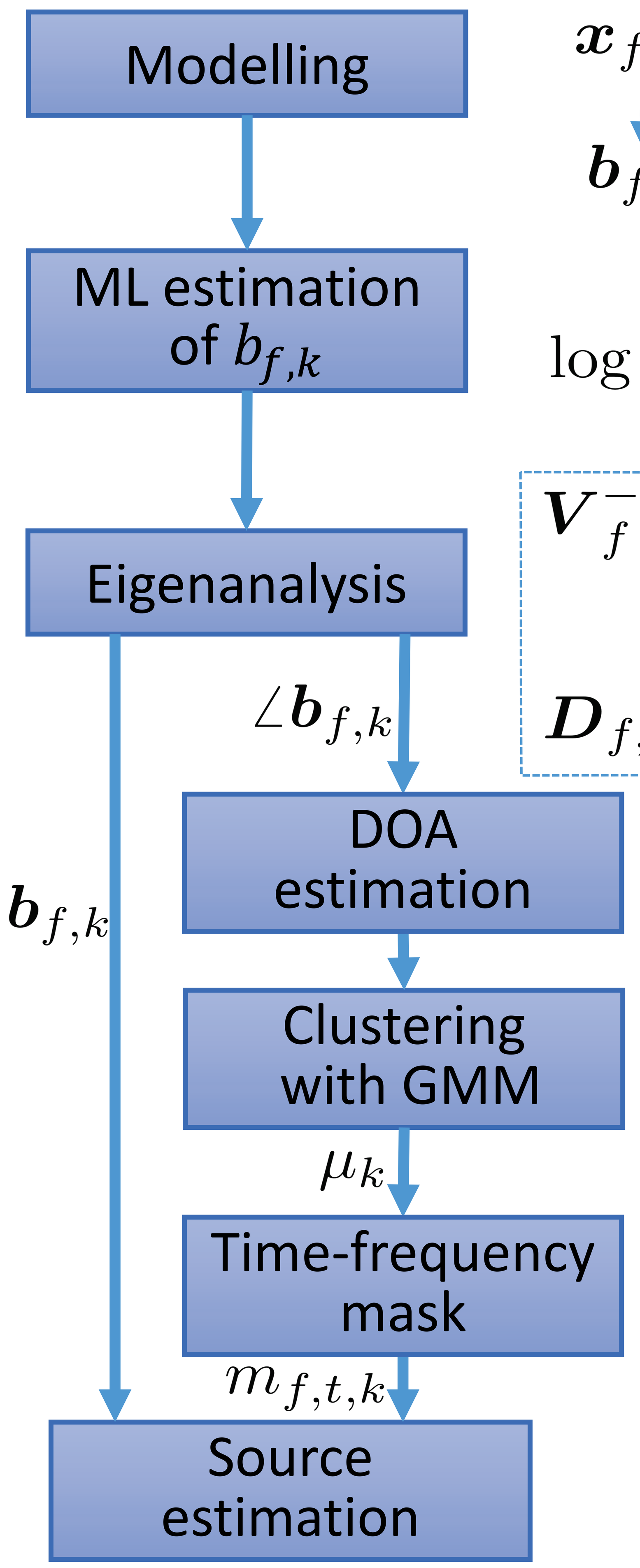


Configuration

Speech signals:
Five female and five male speakers, 5.2 s duration on average

Parameters	Values
Direction (deg.)	30, 60
SNR (dB)	10, 20
Level difference $(1-\beta)$	0.0 to 0.4 with 0.1 step

Formulation



$$\boldsymbol{x}_{f,t} = \boldsymbol{b}_{f,k}\boldsymbol{S}_{f,t,k} + \boldsymbol{N}_{f,t}$$

Unknown

$$\boldsymbol{b}_{f,k} = [a_{1,f,k}\exp(j2\pi f\delta_{1,f,k}) \quad a_{2,f,k}\exp(j2\pi f\delta_{2,f,k}) \quad \cdots]$$

$$\log p(\boldsymbol{x}_{f,t}|\delta_{\cdot,f,k}) = C - \boldsymbol{x}_{f,t}^H\boldsymbol{V}_f^{-1}\boldsymbol{x}_{f,t} + \frac{|\boldsymbol{b}_{f,k}^H\boldsymbol{V}_f^{-1}\boldsymbol{x}_{f,t}|^2}{\boldsymbol{b}_{f,k}^H\boldsymbol{V}_f^{-1}\boldsymbol{b}_{f,k}}$$

$$\boldsymbol{V}_f^{-1} = \boldsymbol{U}_f\Lambda_f\boldsymbol{U}_f \equiv \boldsymbol{W}_f^H\boldsymbol{W}_f$$

$$\boldsymbol{D}_{f,t} \equiv \boldsymbol{W}_f\boldsymbol{x}_{f,t}\boldsymbol{x}_{f,t}^H\boldsymbol{W}_f^H$$

$$\frac{|\boldsymbol{b}_{f,k}^H\boldsymbol{W}_f^H\boldsymbol{W}_f\boldsymbol{x}_{f,t}|^2}{\boldsymbol{b}_{f,k}^H\boldsymbol{W}_f^H\boldsymbol{W}_f\boldsymbol{b}_{f,k}} = \frac{\boldsymbol{c}_{f,k}^H\boldsymbol{D}_{f,t}\boldsymbol{c}_{f,k}}{\boldsymbol{c}_{f,k}^H\boldsymbol{c}_{f,k}}$$

Point 2

Rayleigh quotient

$$\boldsymbol{b}_{f,k} = \boldsymbol{V}_f\boldsymbol{W}_f^H\tilde{\boldsymbol{c}}_{f,t}$$

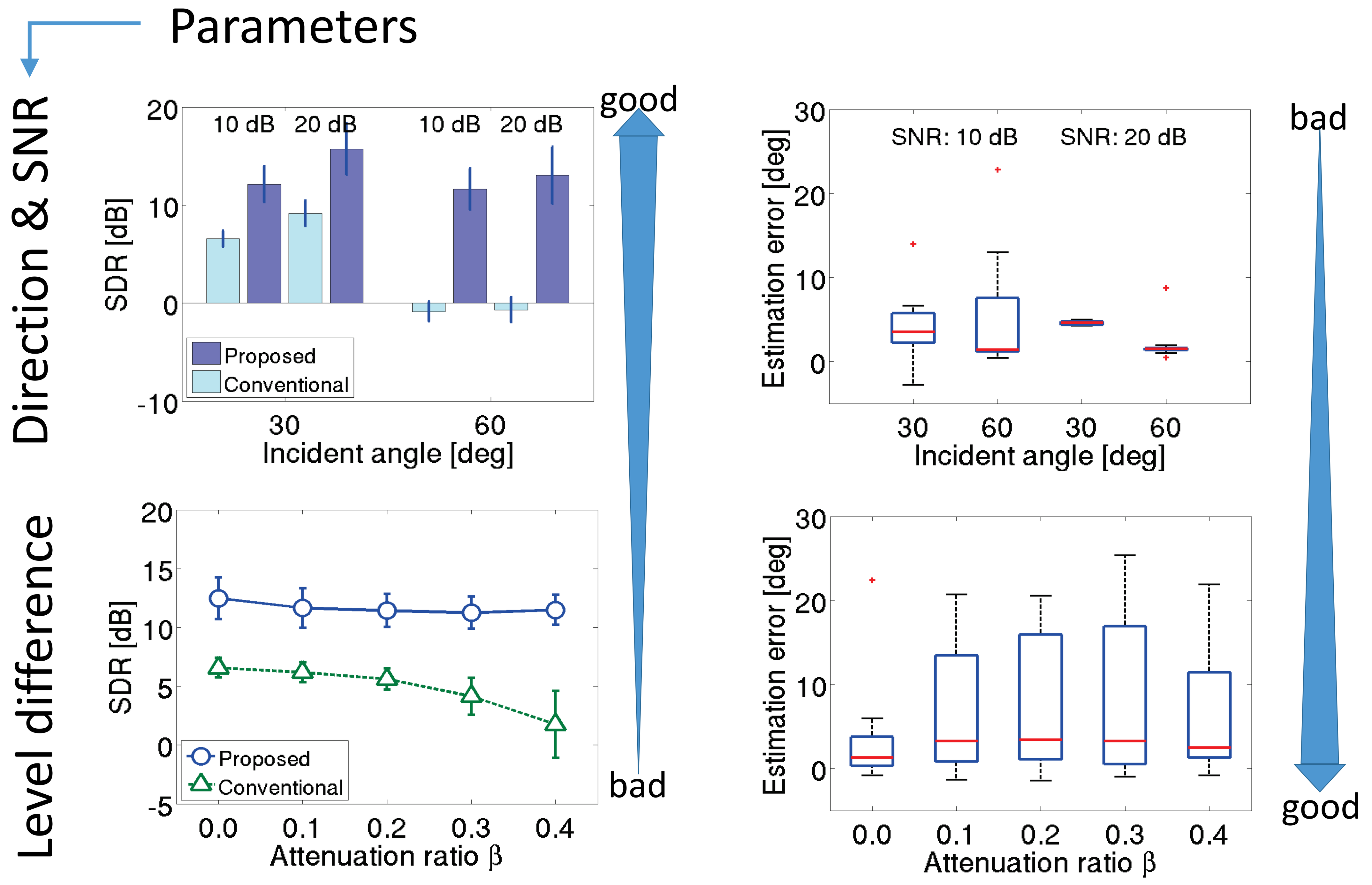
Eigenvector corresponding to the largest eigenvalue

$$\angle\boldsymbol{b}_{f,k} = 2\pi f(\delta_{l,f,k} - \delta_{1,f,k}) \equiv 2\pi f\varphi_{f,k}$$

$$m_{f,t,k} = \frac{1}{\sqrt{2\pi}\sigma_k}\exp\left\{\frac{(\varphi_{f,t,k}-\mu_k)^2}{2\sigma_k^2}\right\} / \max_{f,t,k}[m_{f,t,k}]$$

$$\boldsymbol{S}_{f,t,k} = m_{f,t,k}\frac{\boldsymbol{b}_{f,k}^H\boldsymbol{V}_f^{-1}\boldsymbol{x}_{f,t}}{\boldsymbol{b}_{f,k}^H\boldsymbol{V}_f^{-1}\boldsymbol{b}_{f,k}}$$

Results



Waveform estimation

Direction of arrival

Summary

It is shown that the method successfully keeps its performance even when signal levels are different among microphones.