

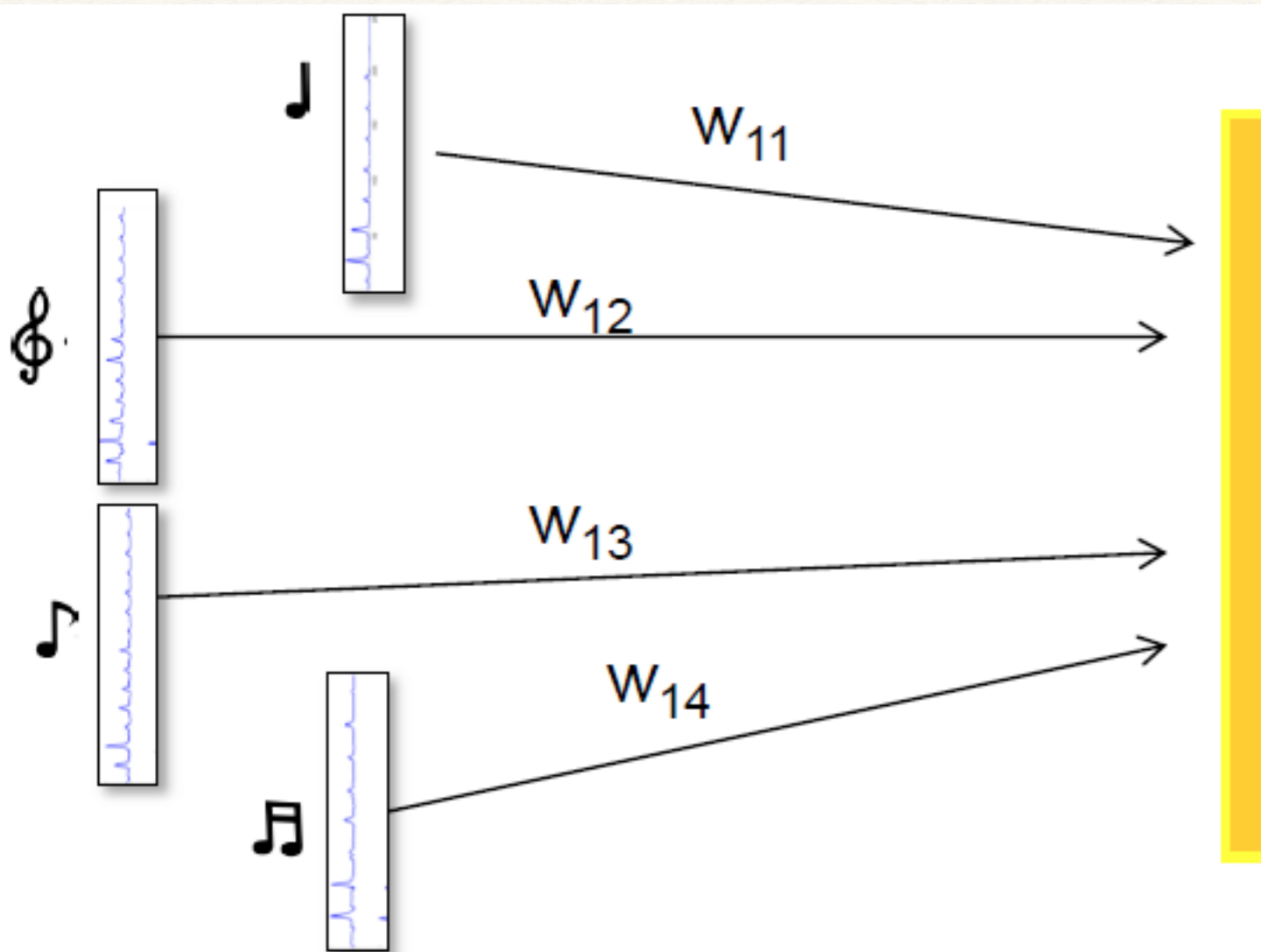
E9 205 Machine Learning for Signal Processing

Non-negative Matrix Factorization

10-08-2016

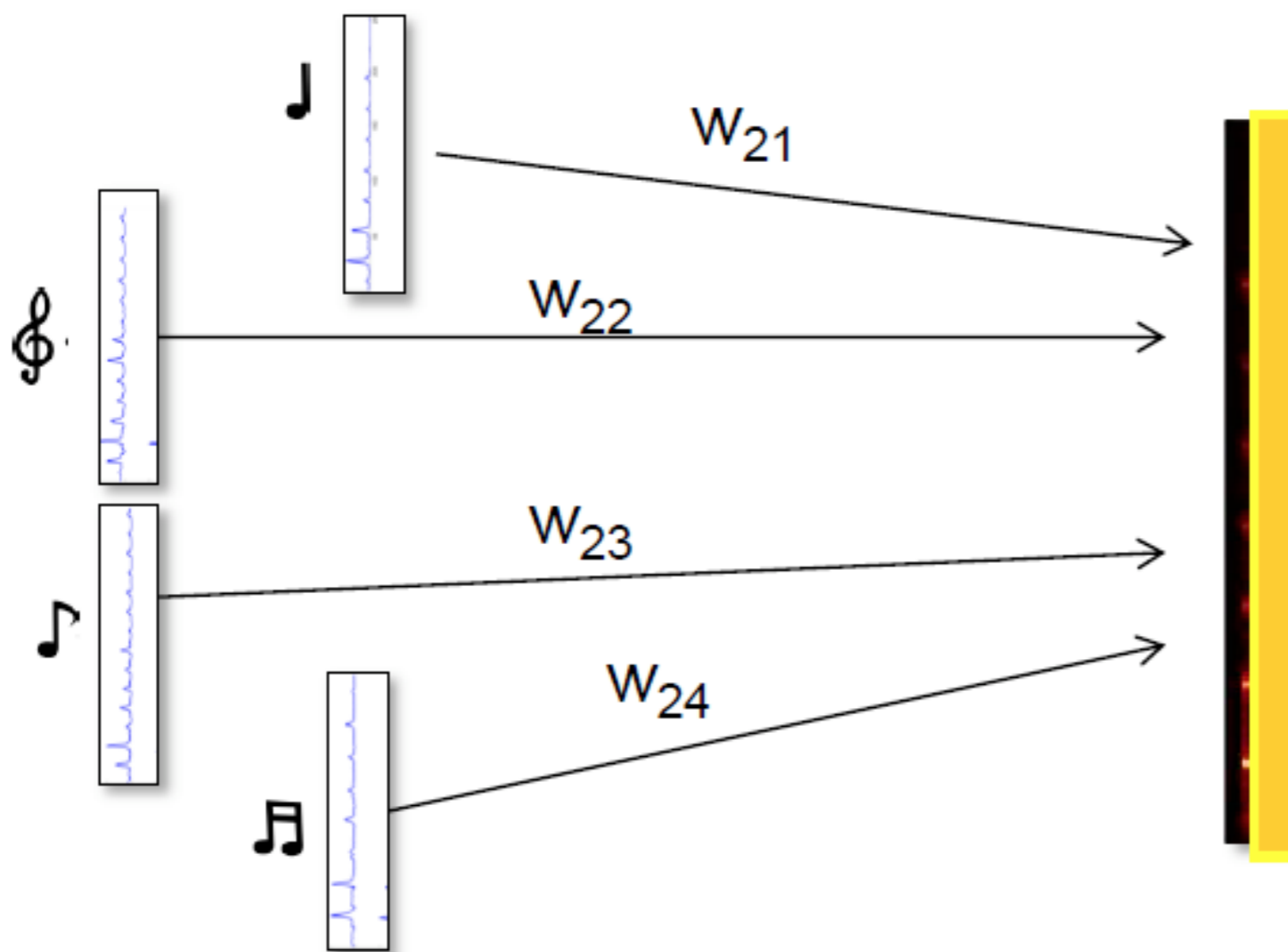


Audio Composition



- ❖ Audio signal generated by a number of individual components (example - different instruments).

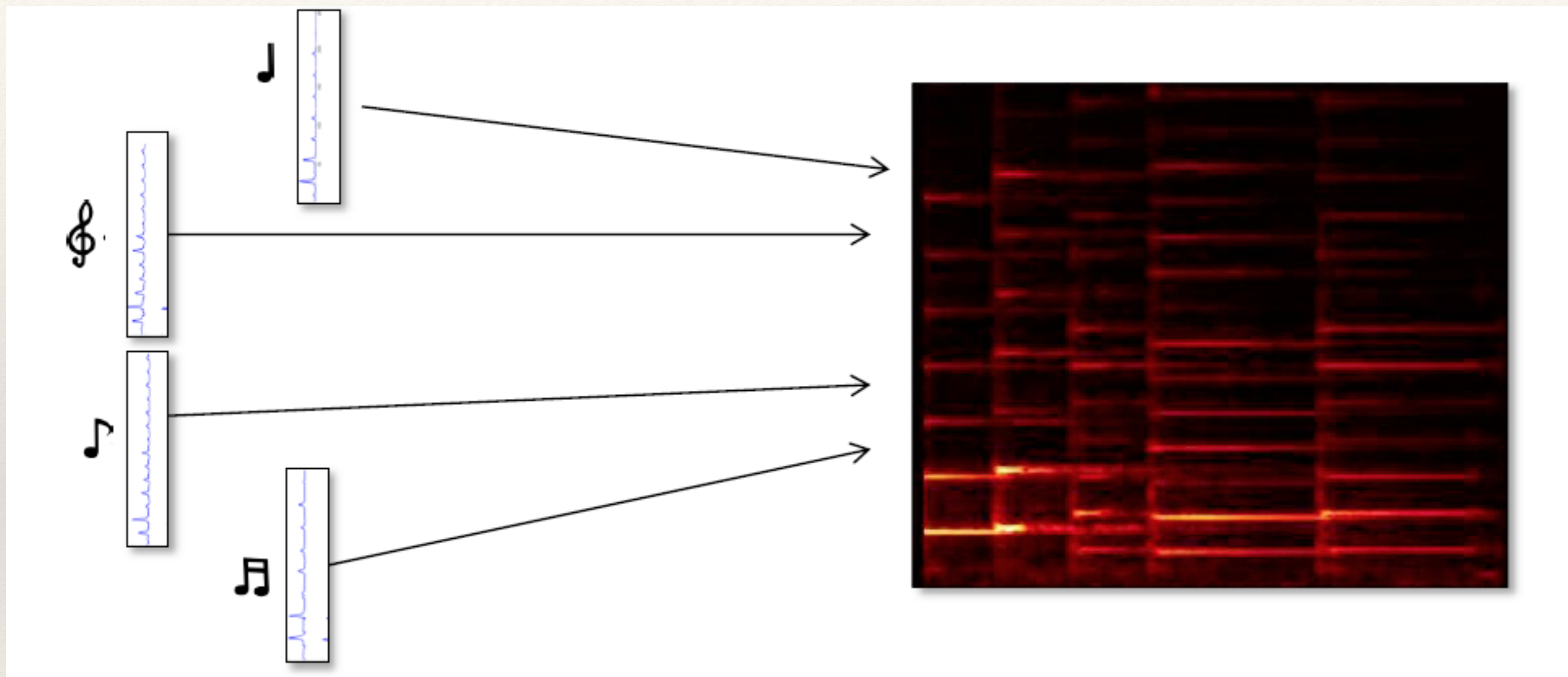
Audio Composition



- ❖ Audio signal generated by a number of individual components (example - different instruments).

<http://mlsp.cs.cmu.edu/courses/fall2014/lectures/slides/class10.nmf.pdf>

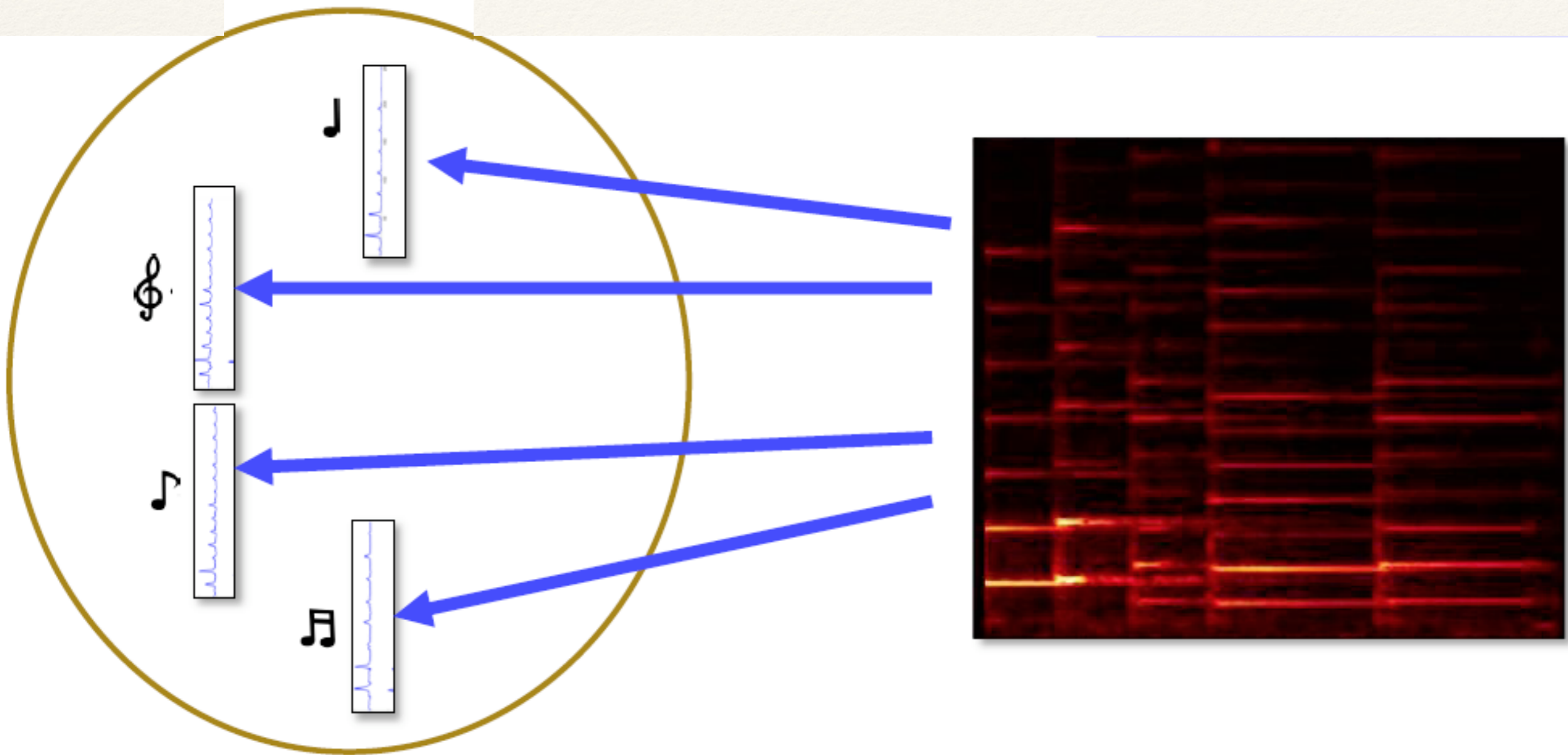
Audio Composition



- ❖ Audio signal generated by a number of individual components (example - different instruments).

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Audio Decomposition



- ❖ Decomposing an audio signal back to its fundamental components.

Required Properties for Decomposition

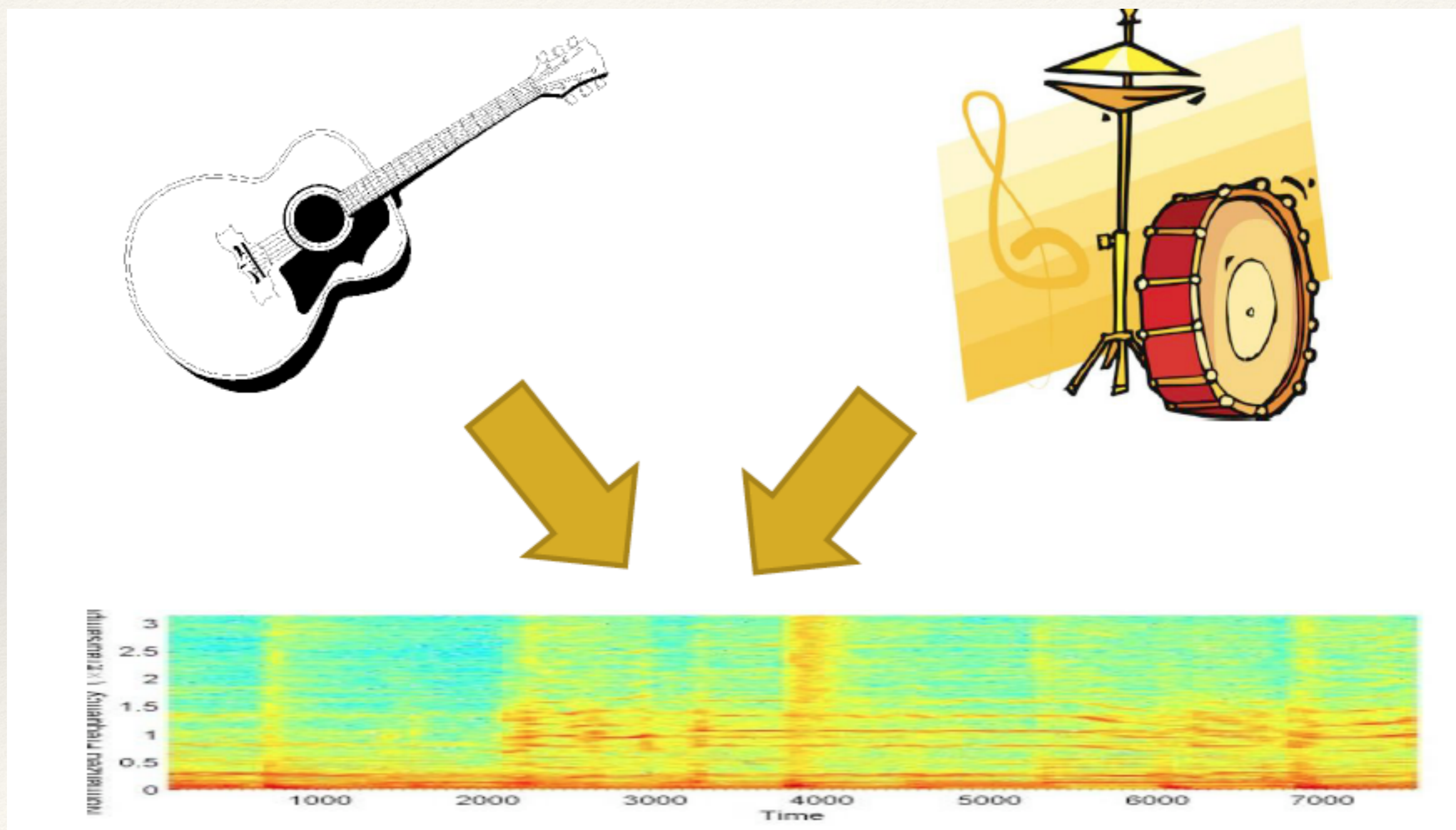
- ❖ Given input is sequence of power spectral vectors (positive) - power spectrogram $\mathbf{V}_{k \times n}$
- ❖ Decomposition into a sequence of component power spectral vectors (positive) - basis $\mathbf{b}_{k \times 1}^j$
- ❖ At each frame - non-negative combination of components are allowed - +ve weights $\mathbf{w}_{j \times 1}$

$$\mathbf{V} = \mathbf{B}\mathbf{W}$$

- ❖ Applying NMF to decompose the components

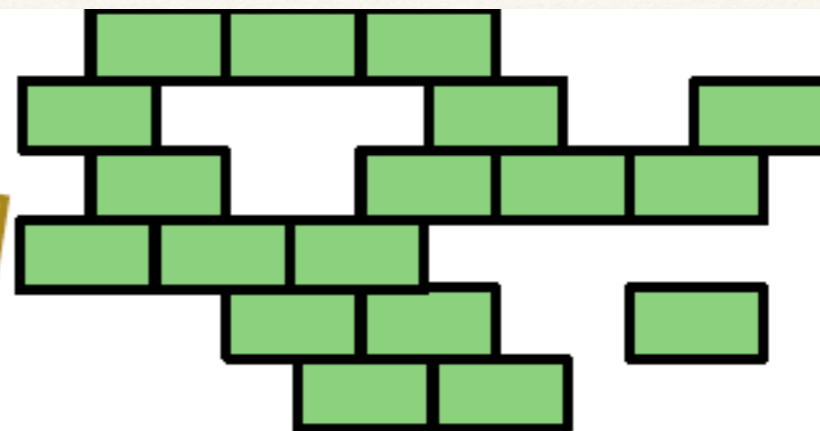
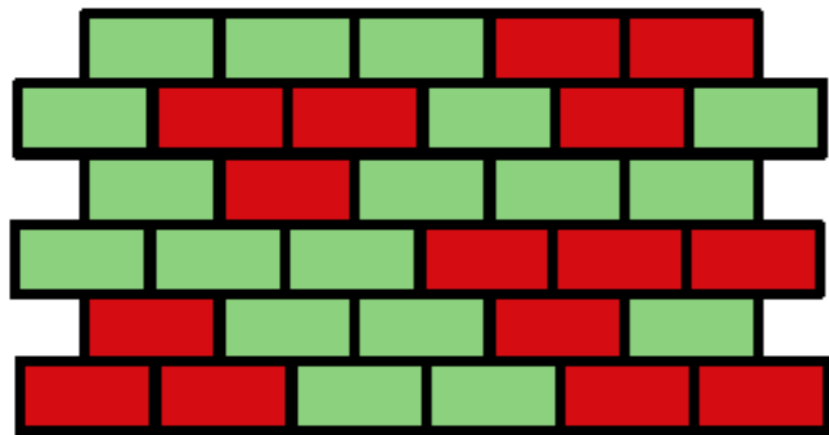
NMF Audio Example

Audio from two sources

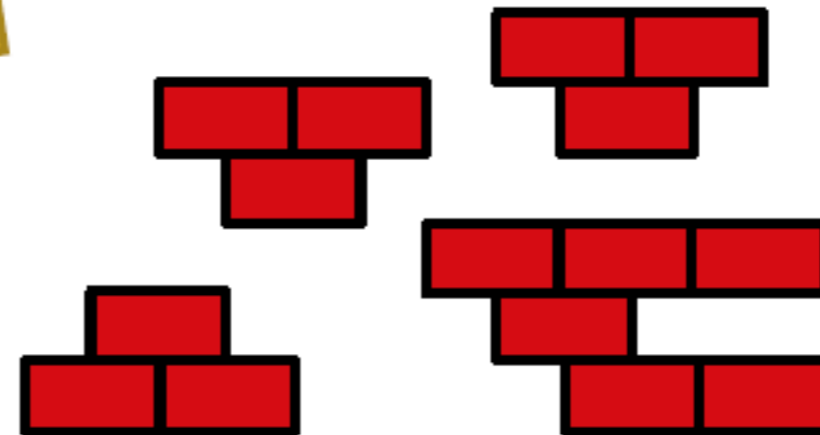


Audio from two sources

Composition



From green blocks

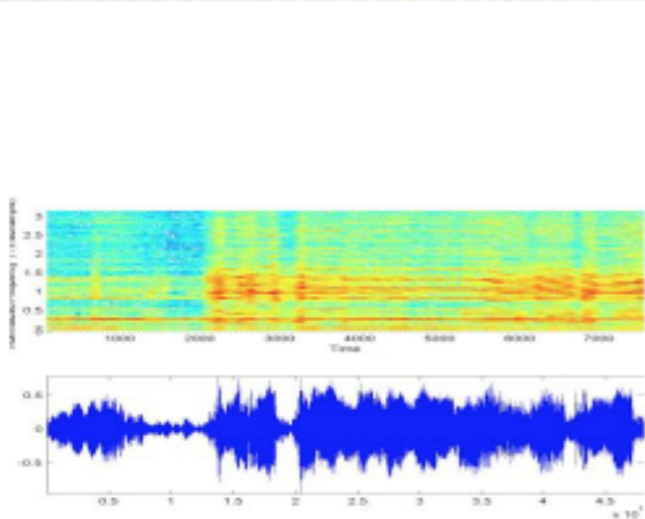


From red blocks



Building blocks

Basis Estimation from Source I

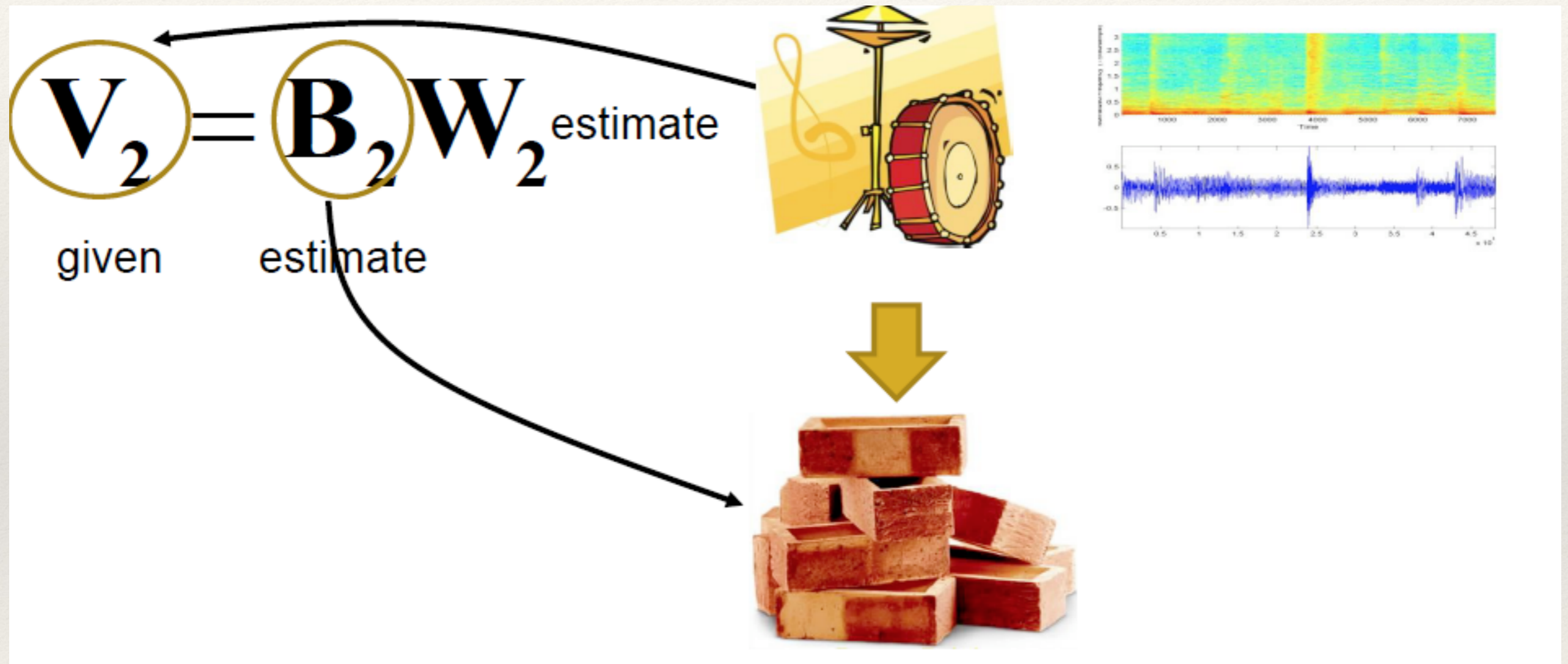


$$\mathbf{V}_1 = \mathbf{B}_1 \mathbf{W}_1 \text{ estimate}$$

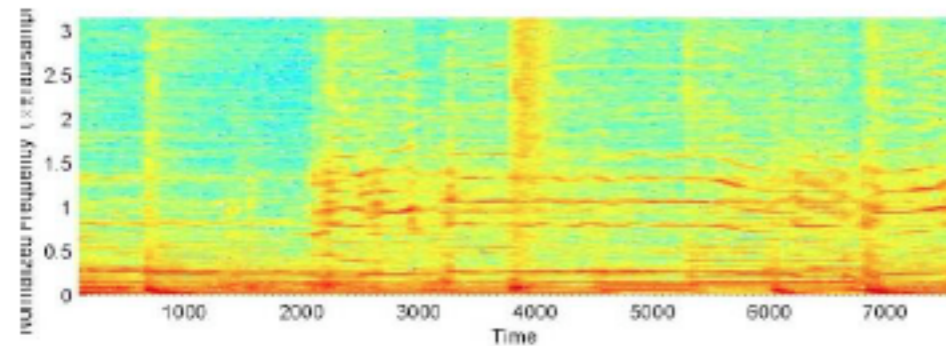
given estimate



Basis Estimation from Source II



Finding the Mixing Weights



given



$$\mathbf{V} = \mathbf{B}\mathbf{W}$$

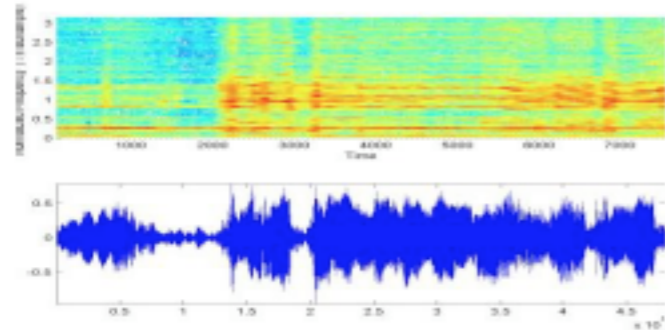
$$\begin{bmatrix} \mathbf{B}_1 & \mathbf{B}_2 \end{bmatrix} \begin{bmatrix} \mathbf{w}_1 \\ \mathbf{w}_2 \end{bmatrix}$$

given

estimate

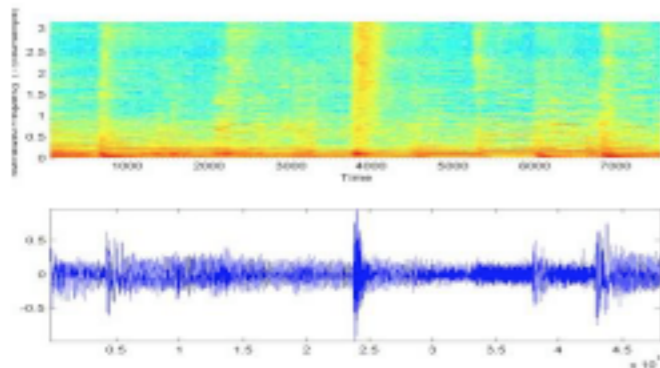


Finding the Mixing Weights - Known Sources



estimate

$$\mathbf{B}_1 \mathbf{W}_1$$



estimate

$$\mathbf{B}_2 \mathbf{W}_2$$

$$\mathbf{V} = \mathbf{B} \mathbf{W}$$

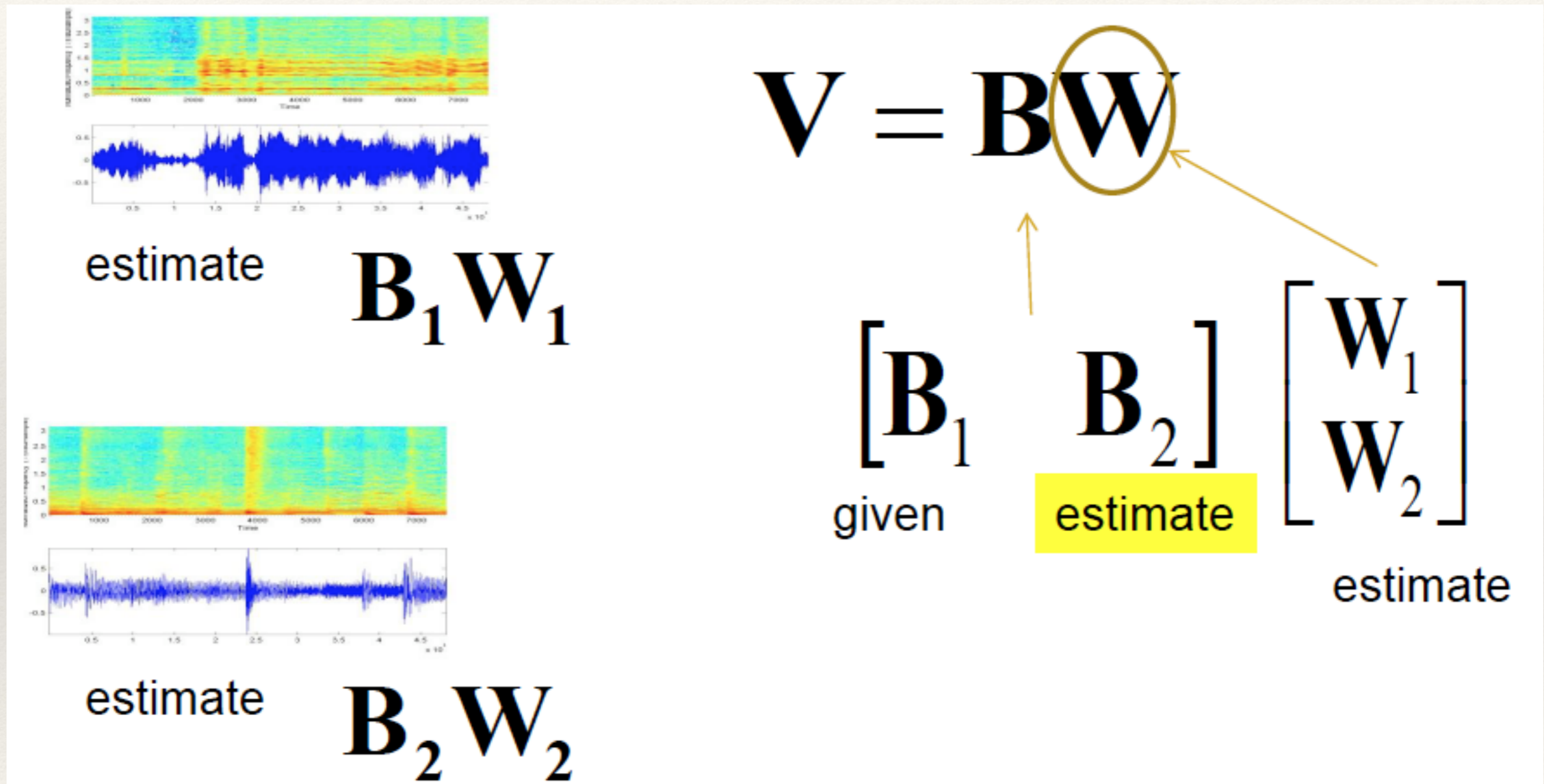
$$\begin{bmatrix} \mathbf{B}_1 & \mathbf{B}_2 \end{bmatrix}$$

given

$$\begin{bmatrix} \mathbf{W}_1 \\ \mathbf{W}_2 \end{bmatrix}$$

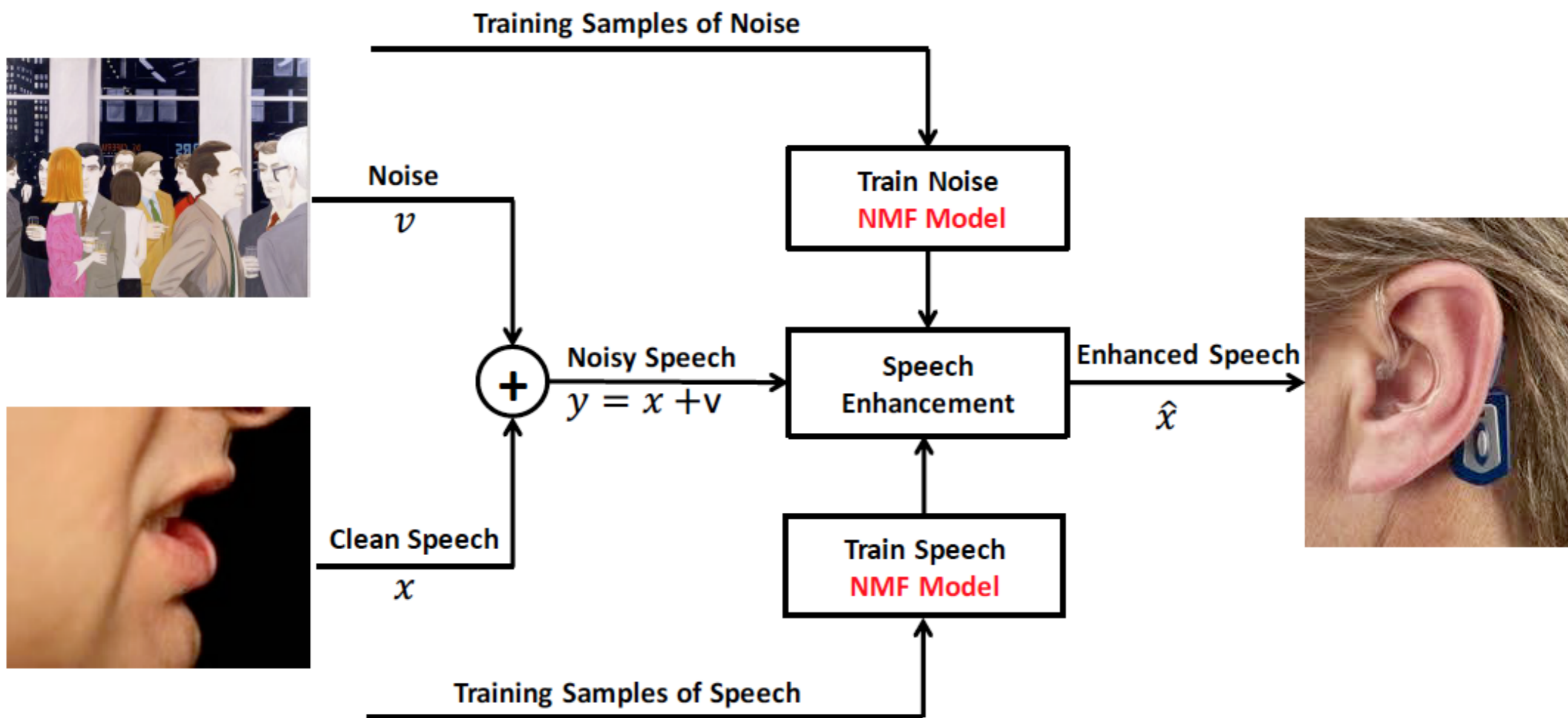
estimate

Finding the Mixing Weights - Unknown Source-II

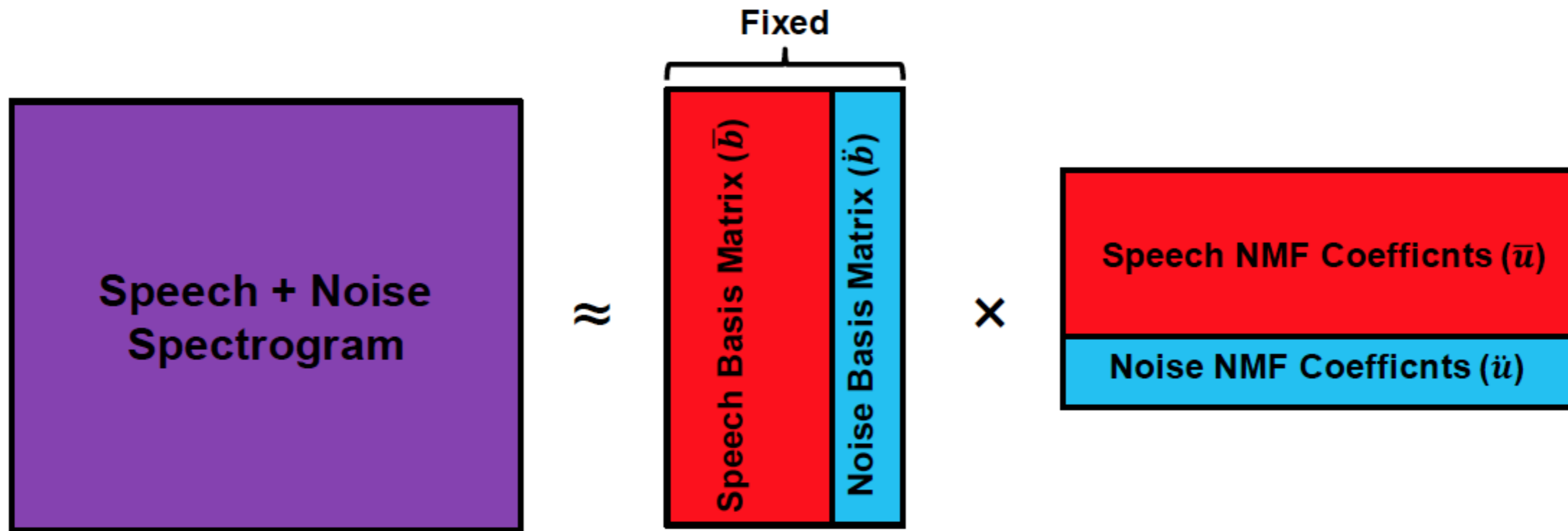


NMF Speech Denoting

Denoising using NMF

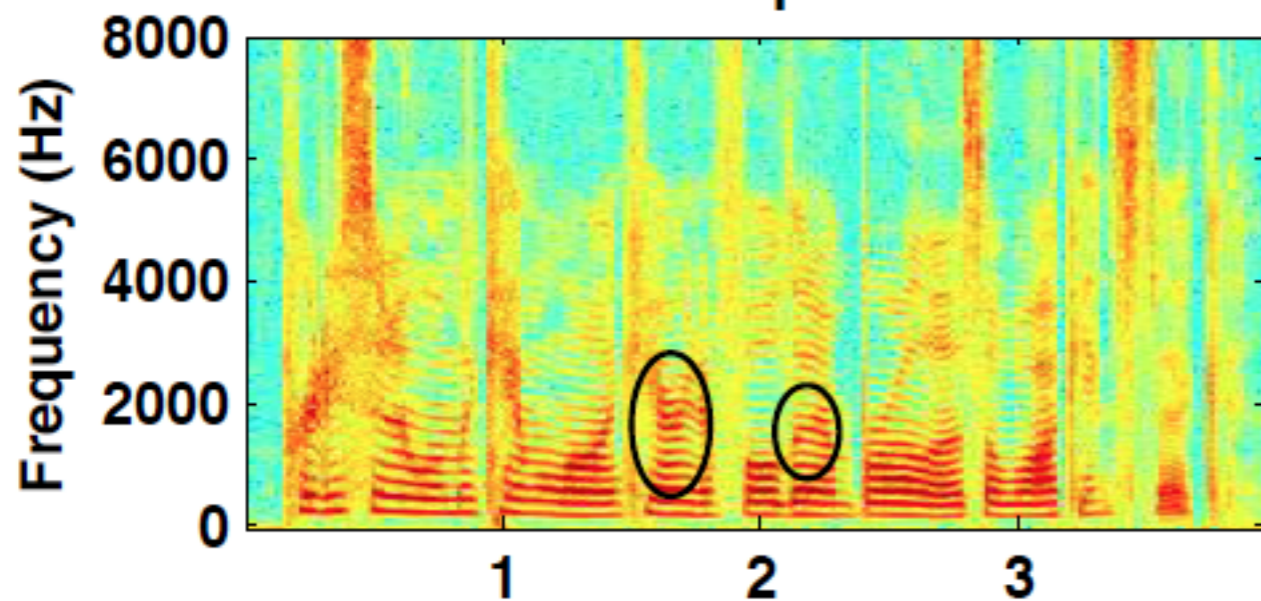


Denoising using NMF

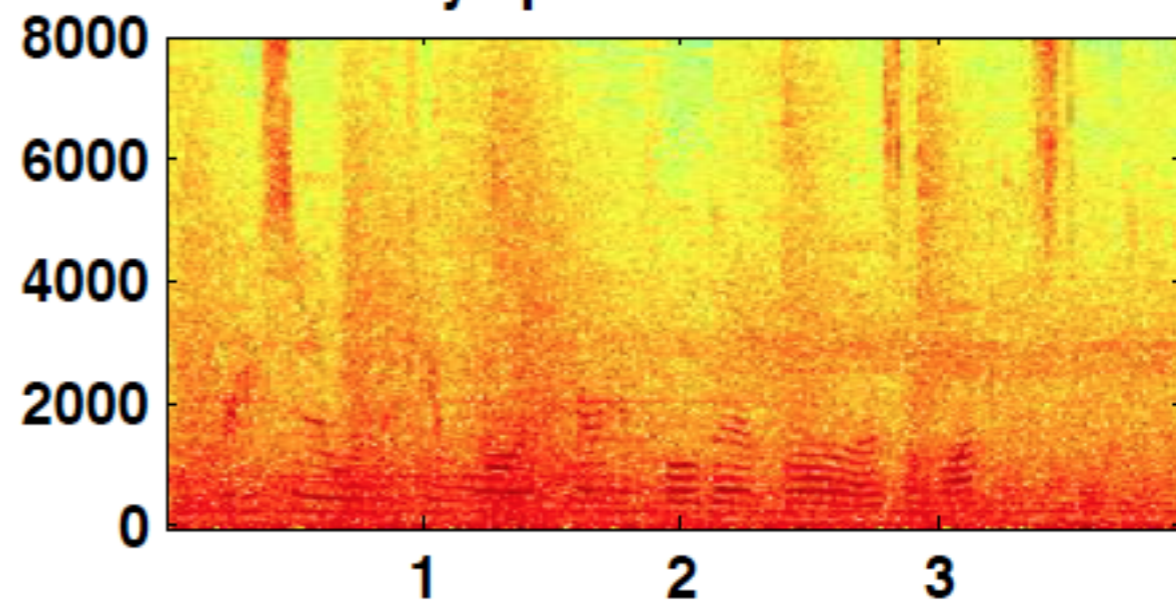


Denoising using NMF

Clean speech



Noisy speech at 0 dB SNR



Enhanced speech,

