E9 205 Machine Learning for Signal Processing

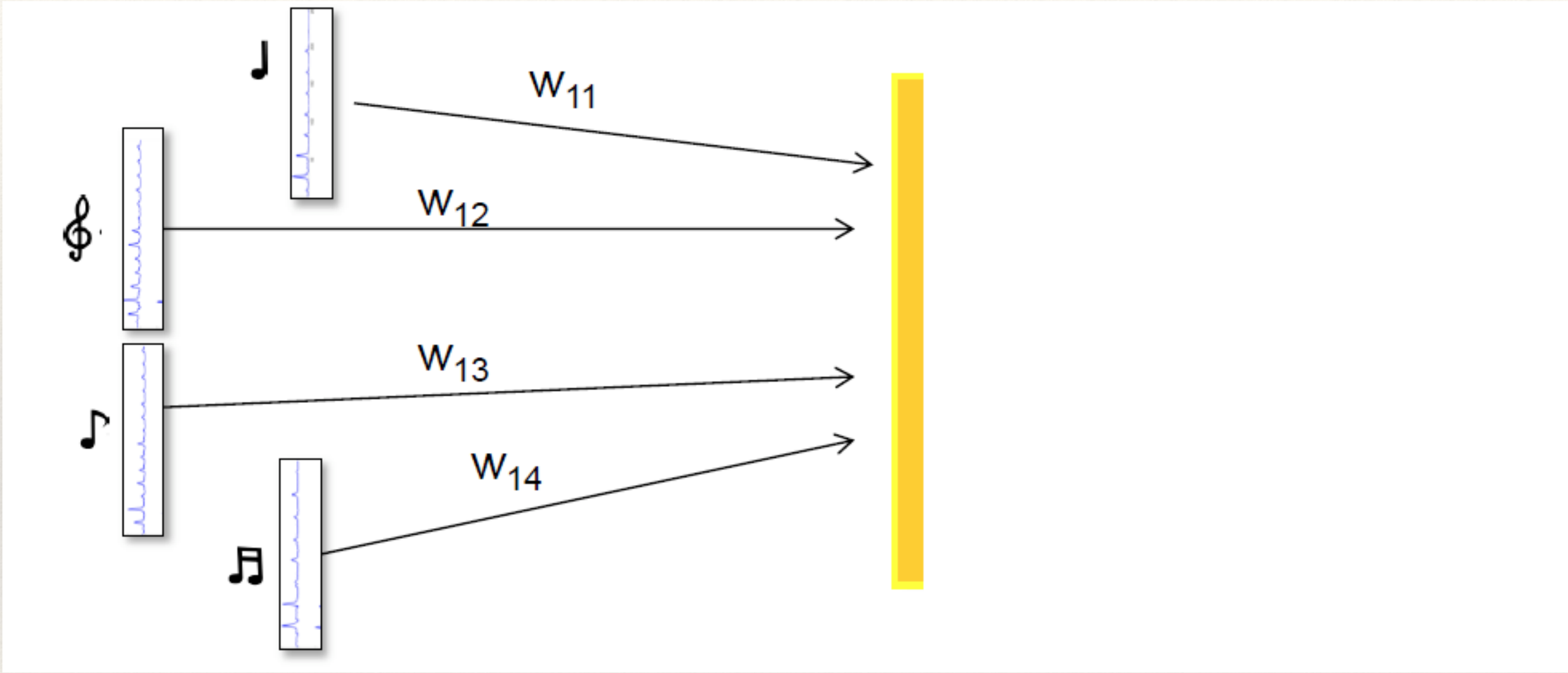
Non-negative Matrix Factorization

16-09-2019

Established 1911

INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान

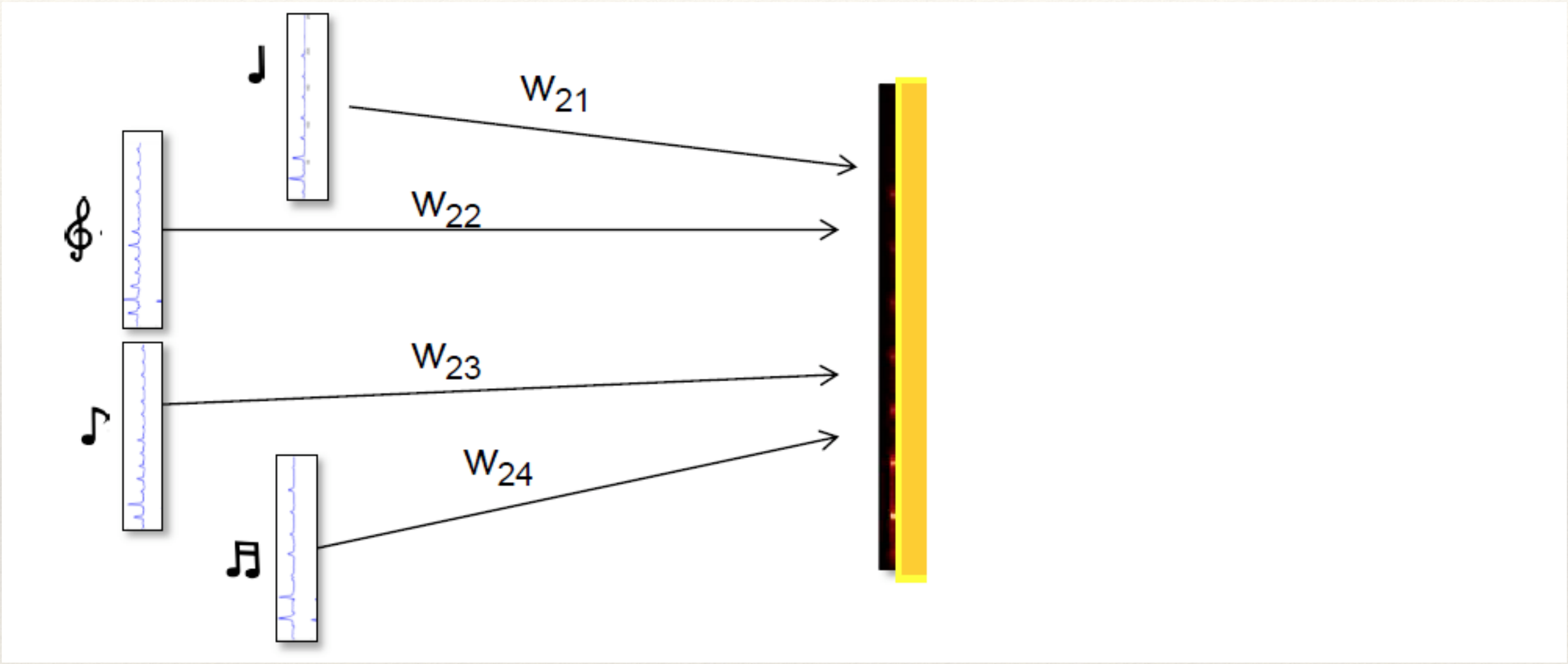
Audio Composition



- 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



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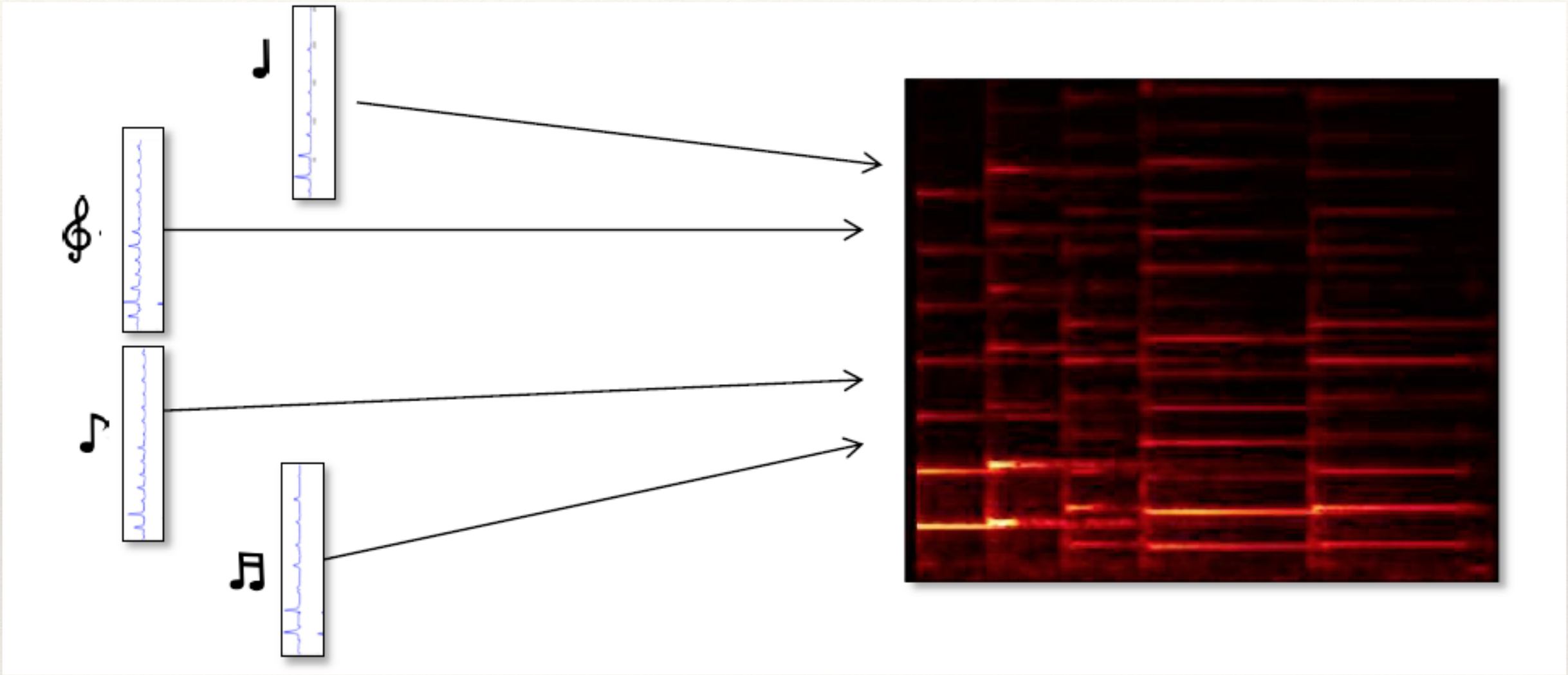
Audio Composition



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

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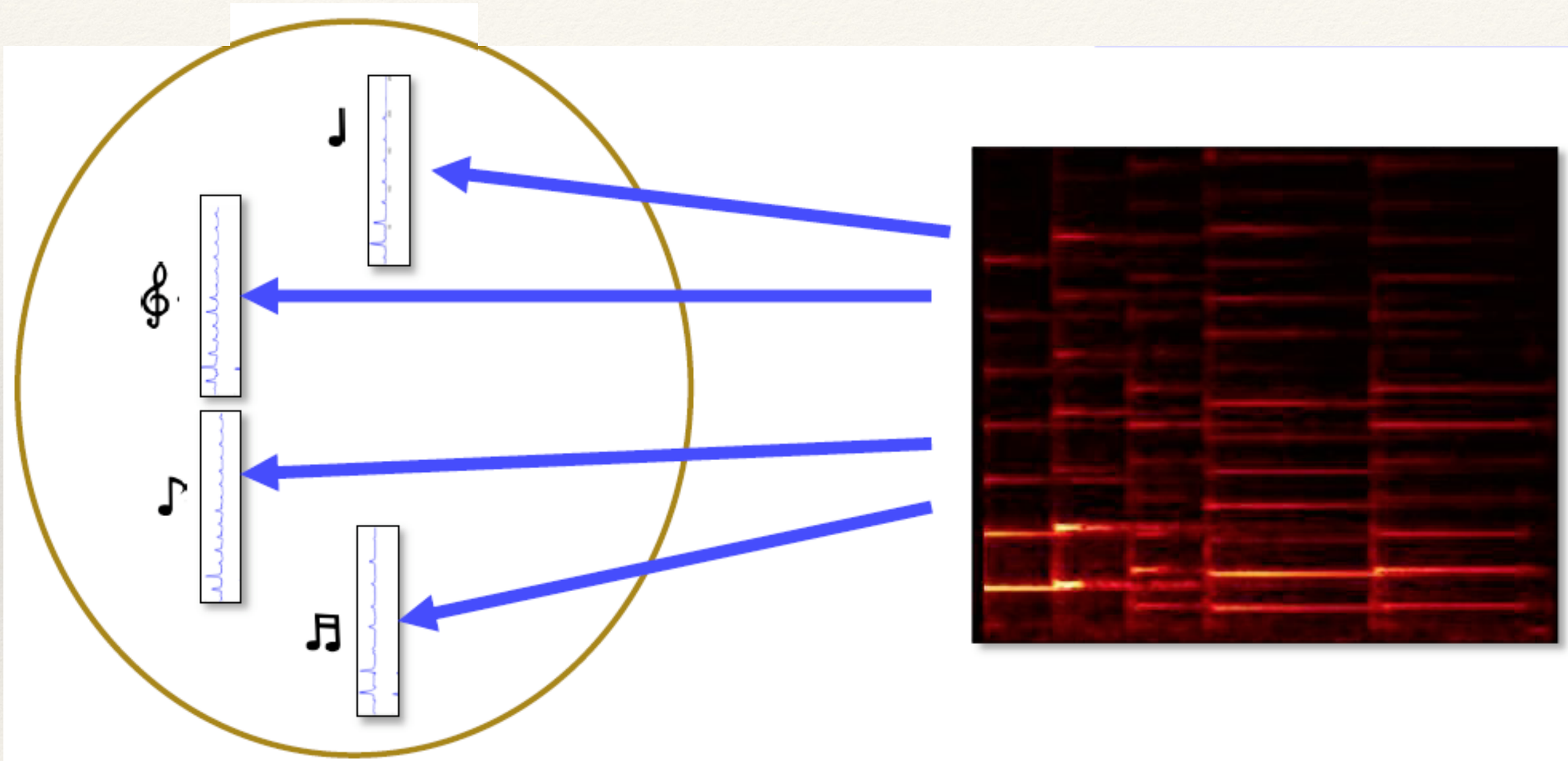
Audio Decomposition



- 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 $\mathbf{b}^j_{k\times 1}$
- At each frame - non-negative combination of components are allowed - +ve weights $\mathbf{w}_{j\times 1}$

$$\mathbf{V} = \mathbf{BW}$$

- Applying NMF to decompose the components

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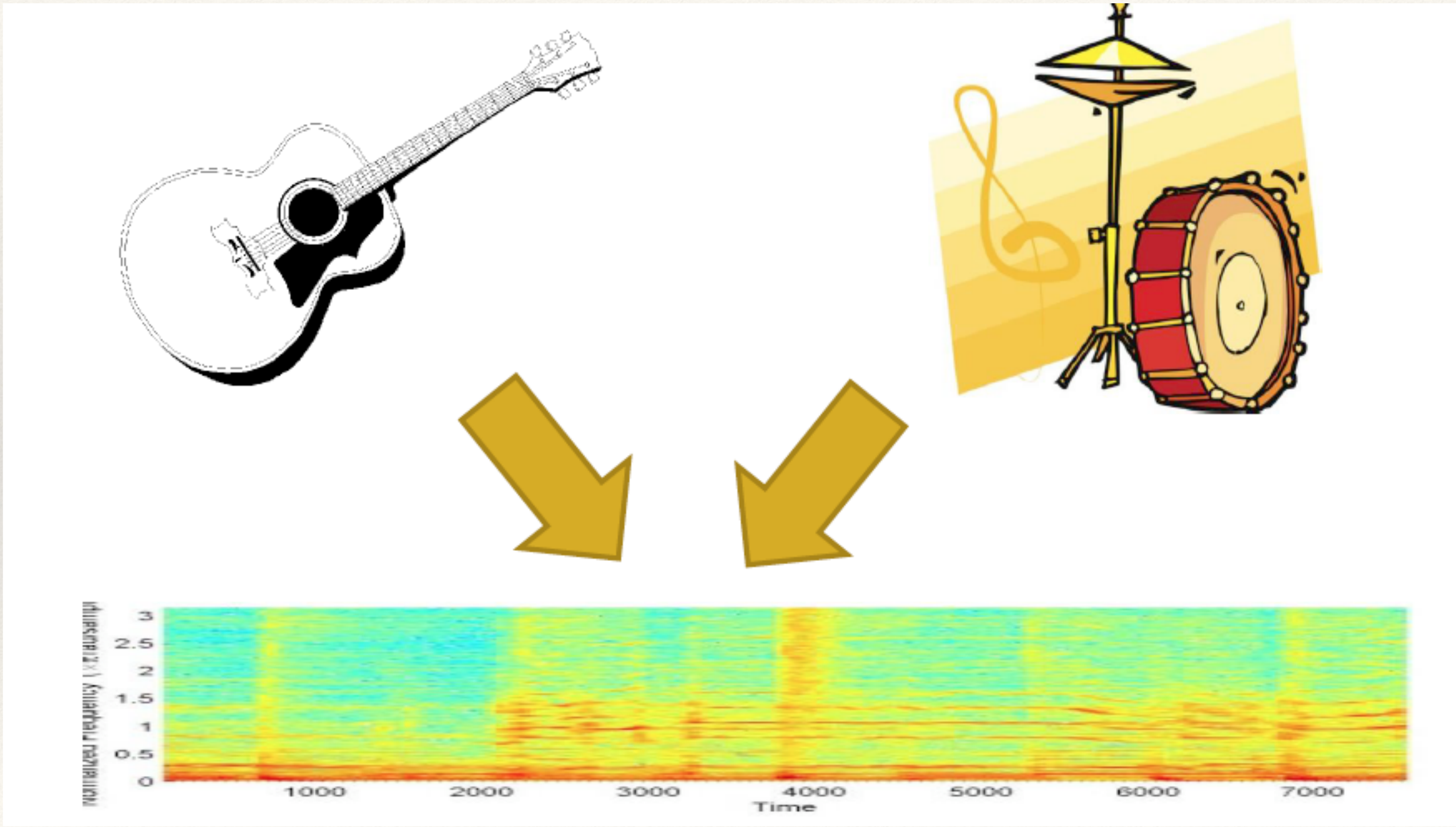
NMF Audio Example

Audio from two sources



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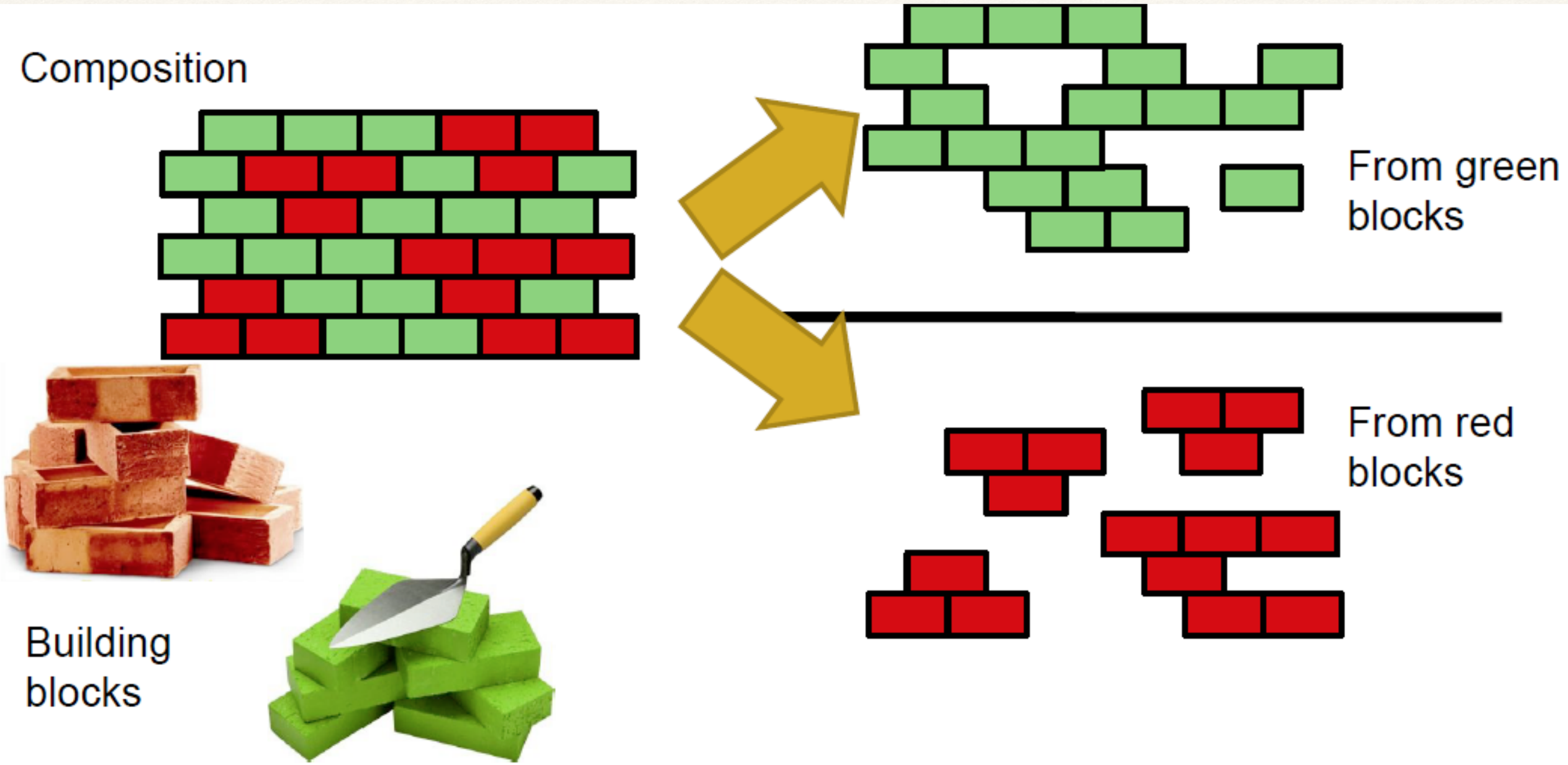
Audio from two sources



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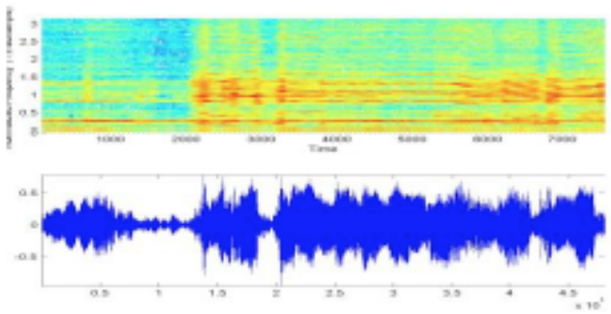
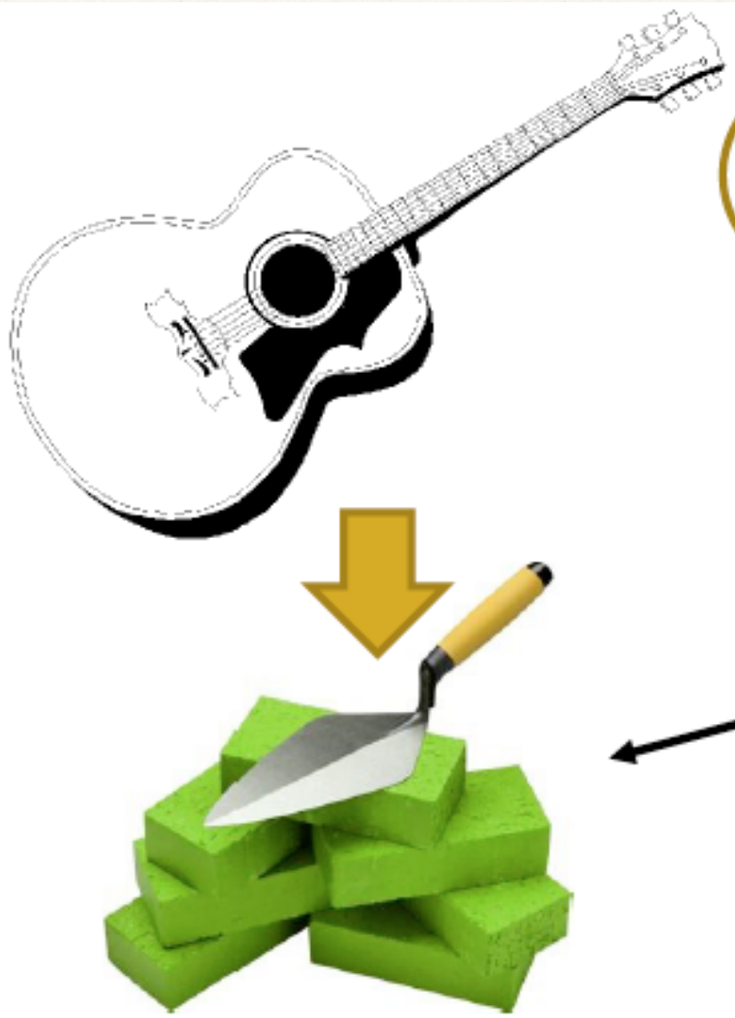
Basis Estimation from Source I





$$V_1 = B_1 W_1$$

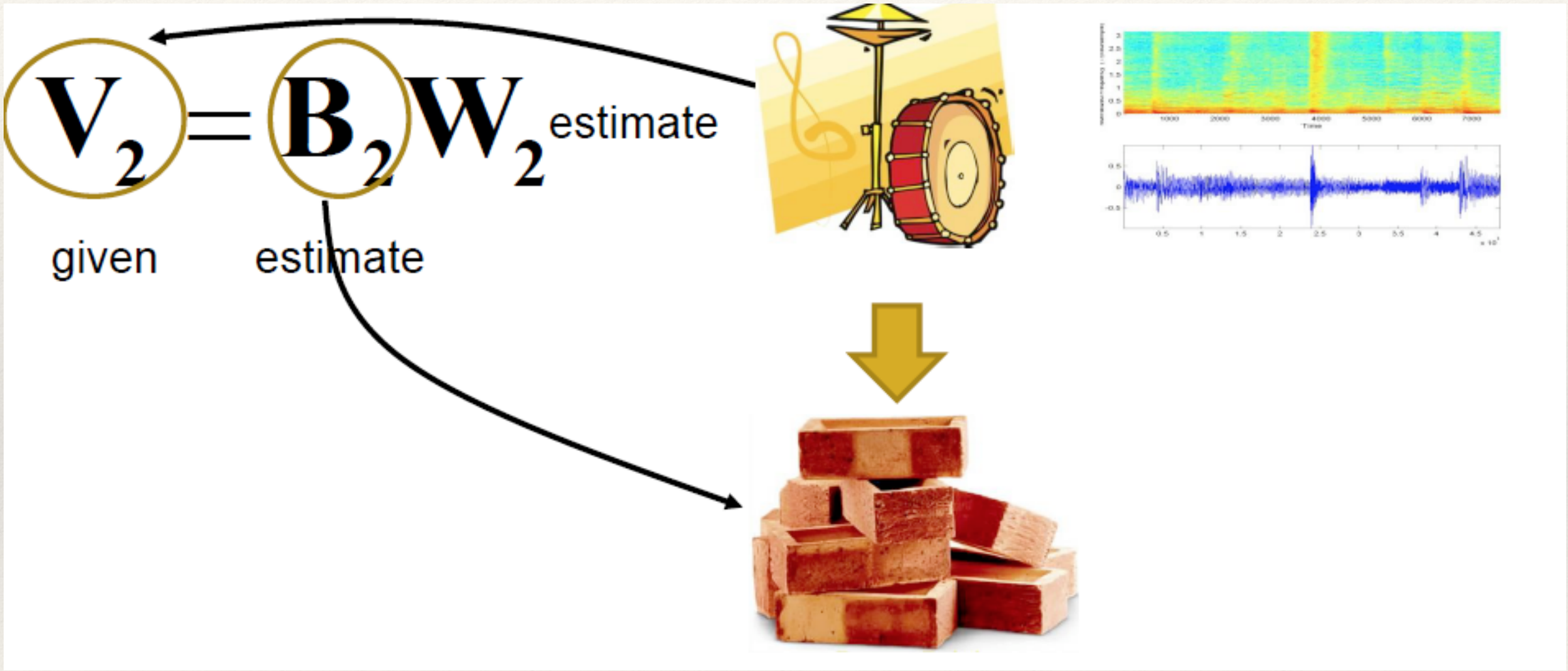
estimate

given

estimate

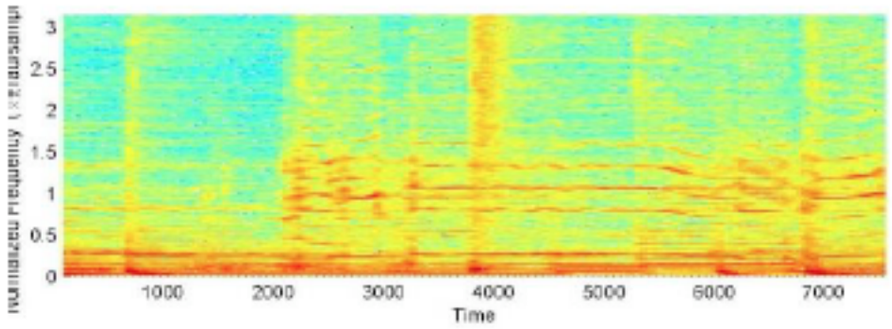
http://mlsp.cs.cmu.edu/courses/fall2014/lectures/slides/class10.nmf.pdf

Basis Estimation from Source II



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

Finding the Mixing Weights



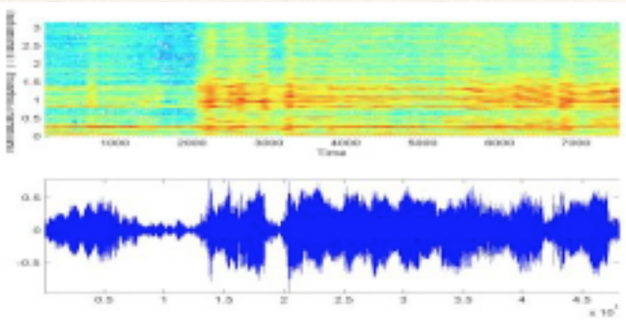
$$\mathbf{V} = \mathbf{B}\mathbf{W}$$

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

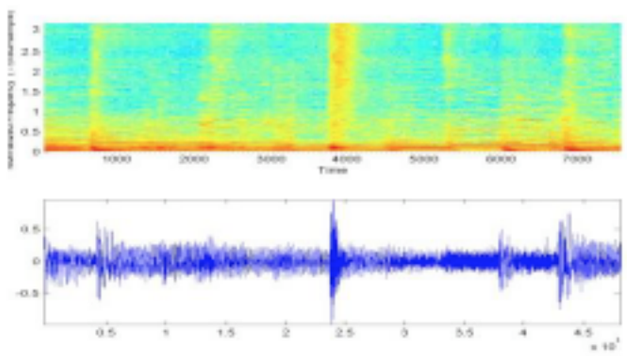
given estimate

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

Finding the Mixing Weights - Known Sources



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



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

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

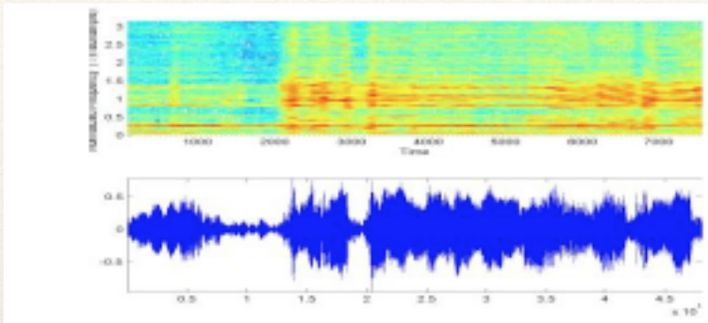
$$\begin{bmatrix} \mathbf{B}_1 & \mathbf{B}_2 \end{bmatrix} \quad \begin{bmatrix} \mathbf{W}_1 \\ \mathbf{W}_2 \end{bmatrix}$$

given

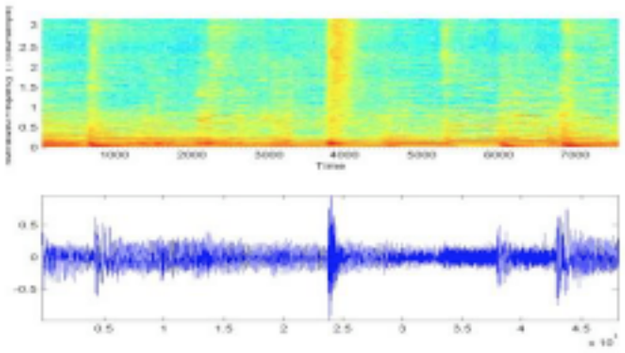
estimate

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

Finding the Mixing Weights - Unknown Source-II



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



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

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

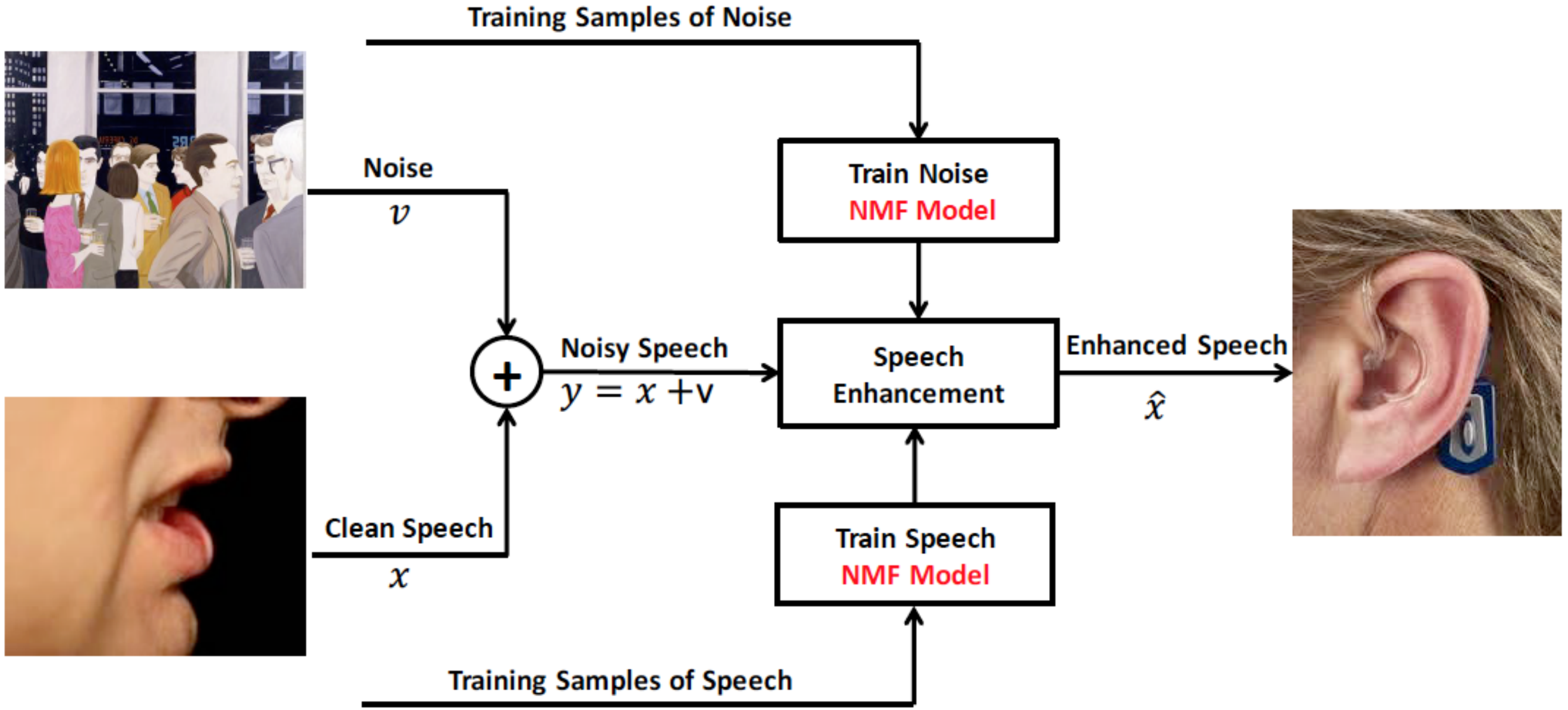
$$\begin{bmatrix}\mathbf{B}_1 & \mathbf{B}_2\end{bmatrix} \quad \begin{bmatrix}\mathbf{W}_1 \\ \mathbf{W}_2\end{bmatrix}$$

given — estimate — estimate

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

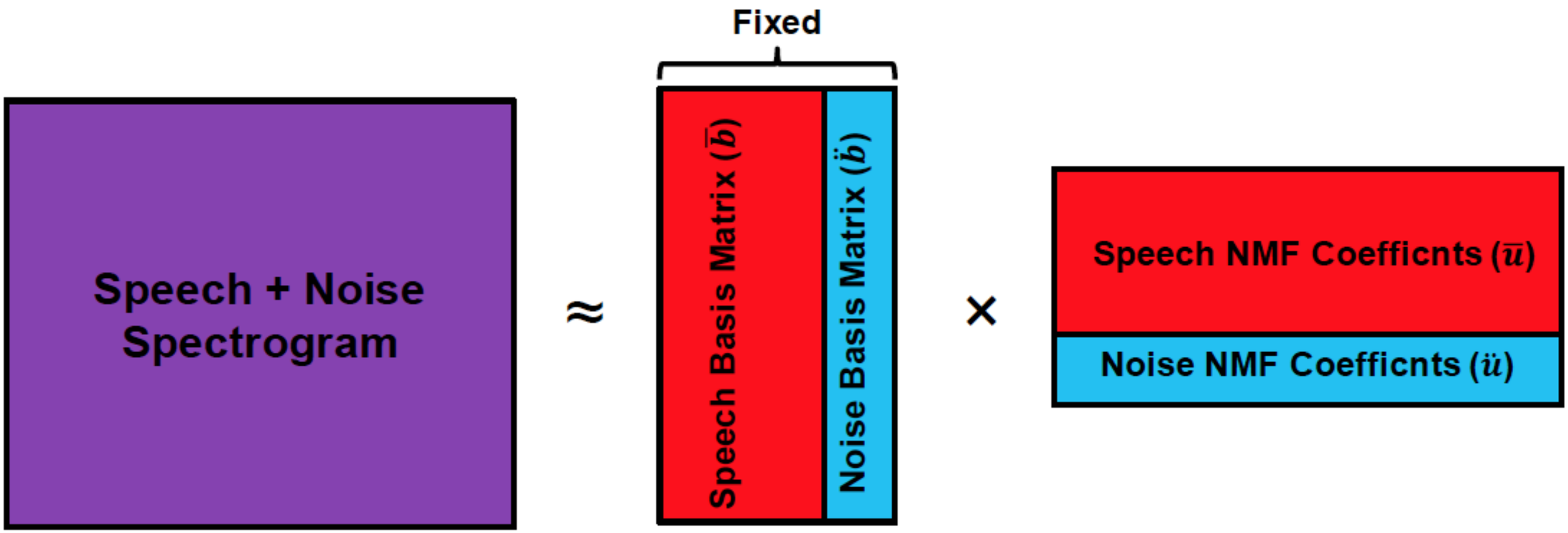
NMF Speech Denoting

Denoising using NMF



https://www.kth.se/social/upload/52388cfcf276544049fe1499/NR_using_NMF.pdf

Denoising using NMF



https://www.kth.se/social/upload/52388cfcf276544049fe1499/NR_using_NMF.pdf

Denoising using NMF