SYDE 556/750

Simulating Neurobiological Systems
Lecture 9: Analysing Representations

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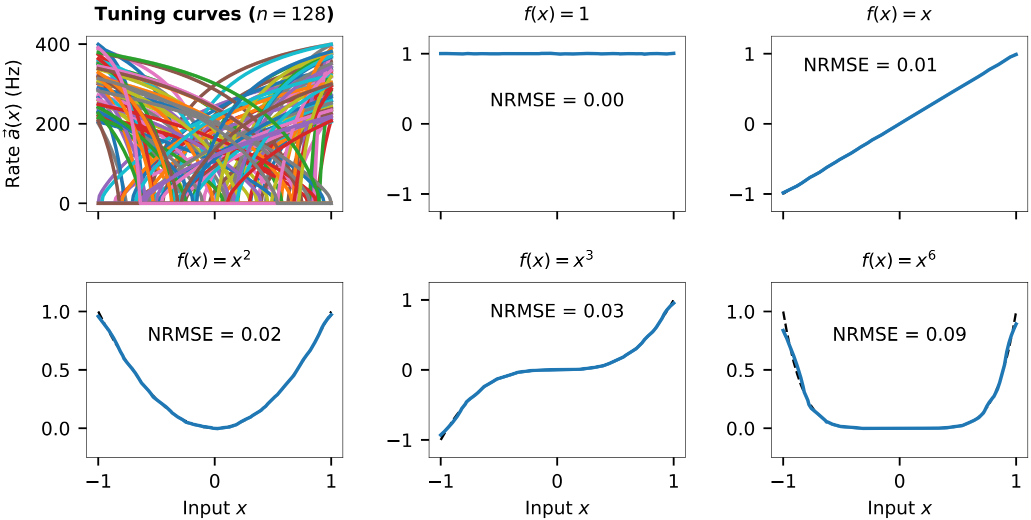
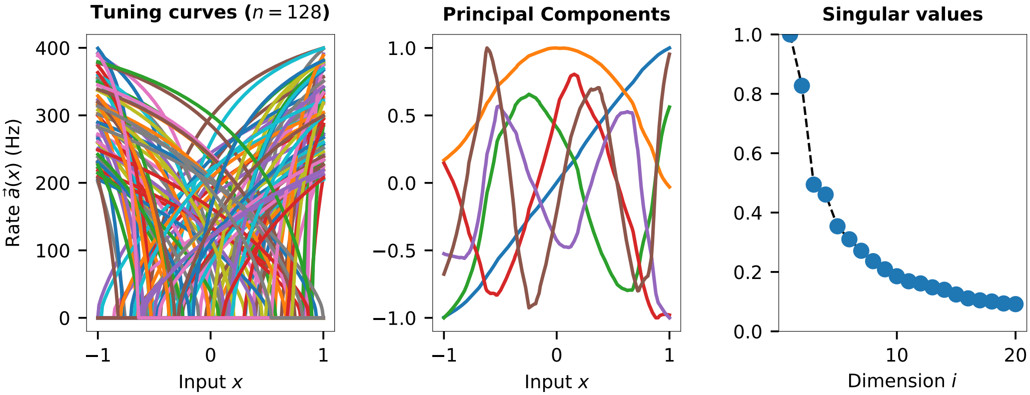
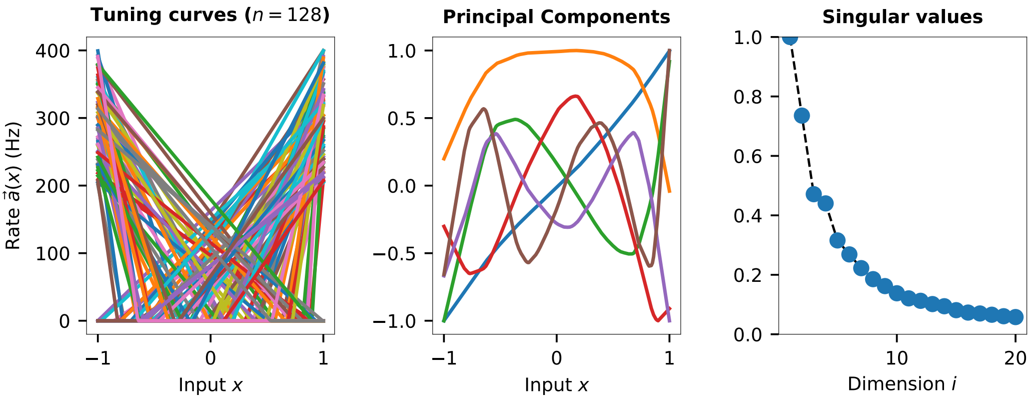
Decoding Polynomials



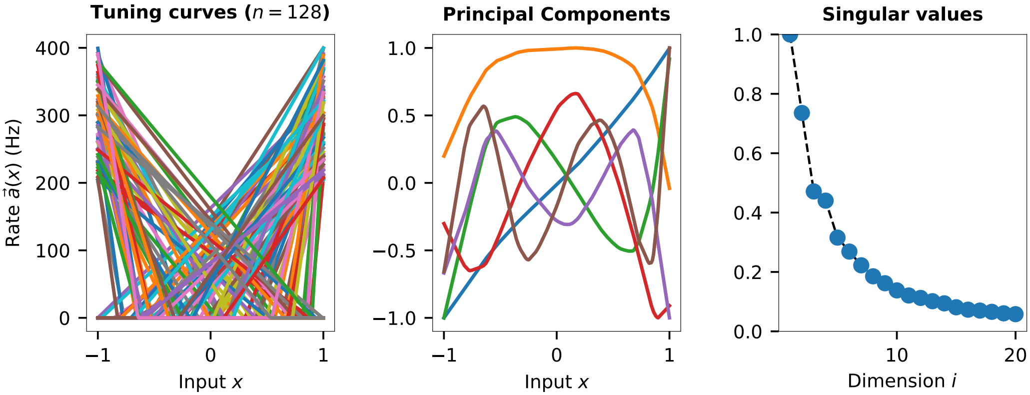
LIF Tuning Curve Principal Components



ReLU Tuning Curve Principal Components

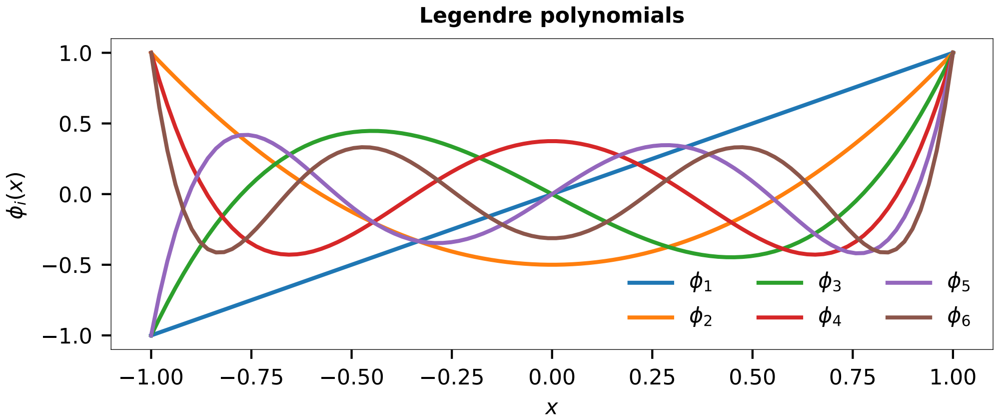


ReLU Tuning Curve Principal Components



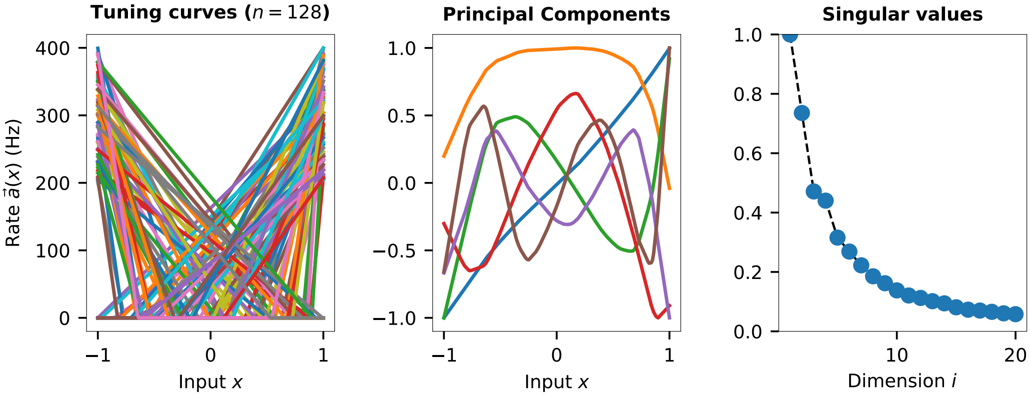
≈ Legendre Basis

Reminder: Legendre Polynomials

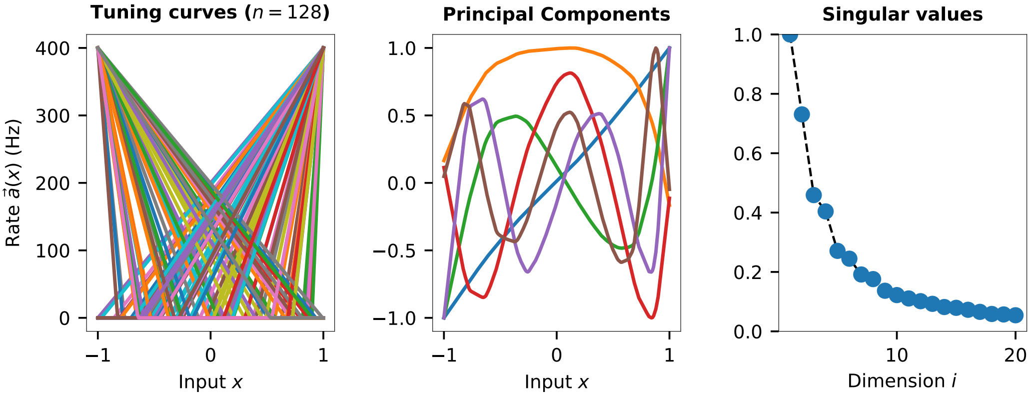


$$\varphi_i(x) = \frac{1}{2^i} \sum_{k=0}^{n} \binom{i}{k}^2 (x-1)^{i-k} (x+1)^k$$

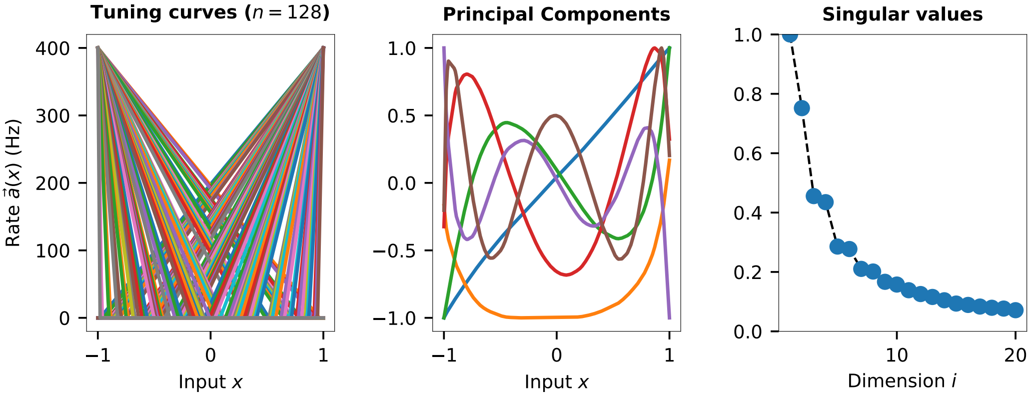
Modifying the Basis – Same Maximum Rate (I)



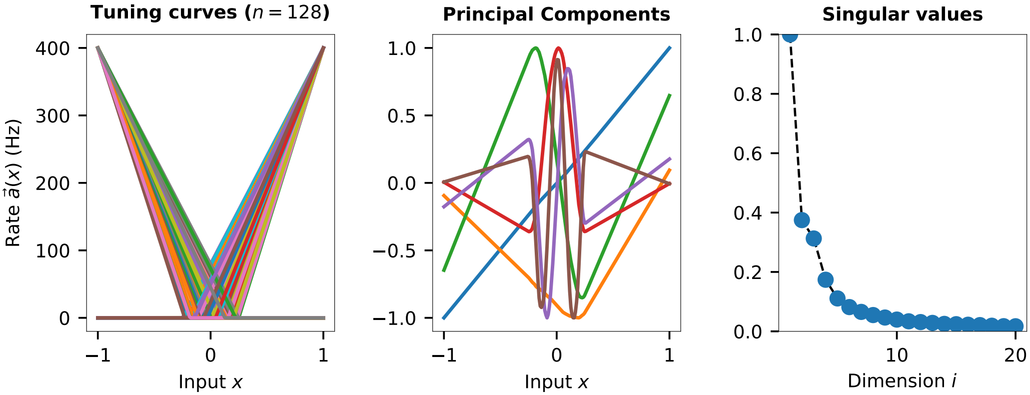
Modifying the Basis – Same Maximum Rate (I)



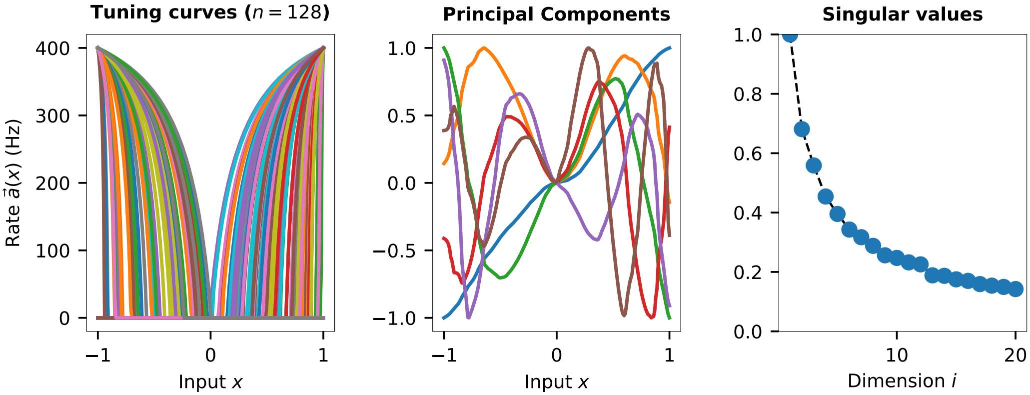
Modifying the Basis – Equidistant x-Intercepts (II)



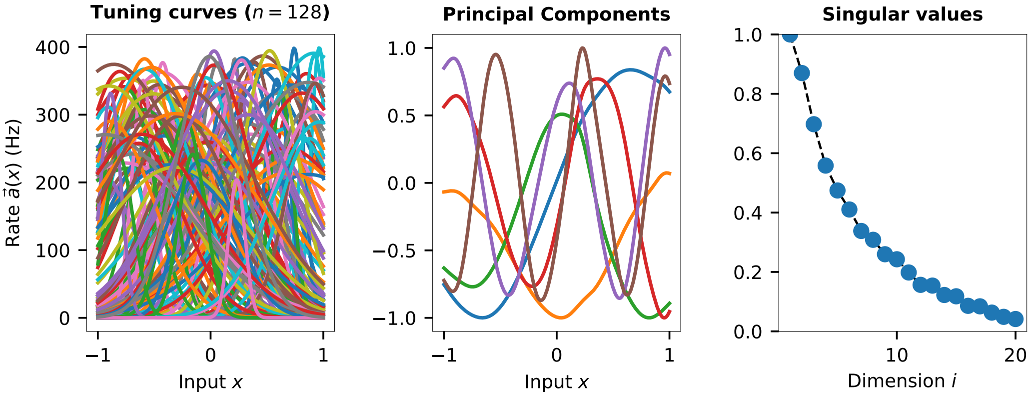
Modifying the Basis – Limited x-Intercepts (III)



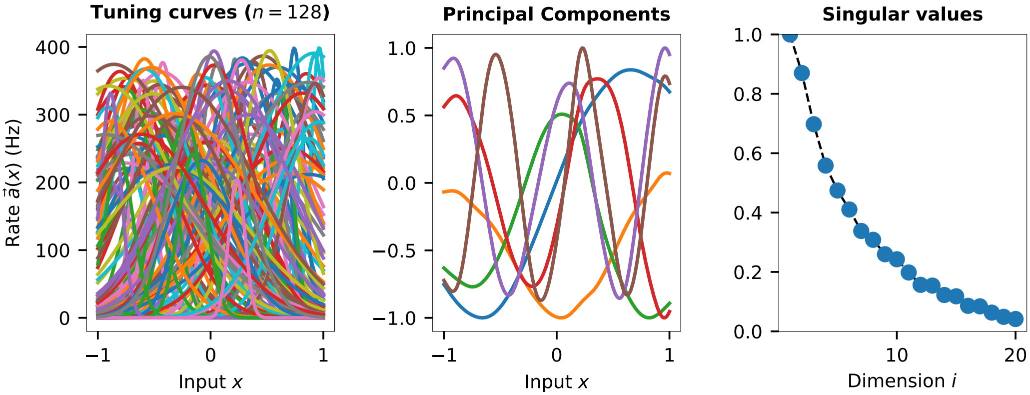
Modifying the Basis – Symmetric Tuning Curves (IV)



Gaussian Tuning Curve Principal Components

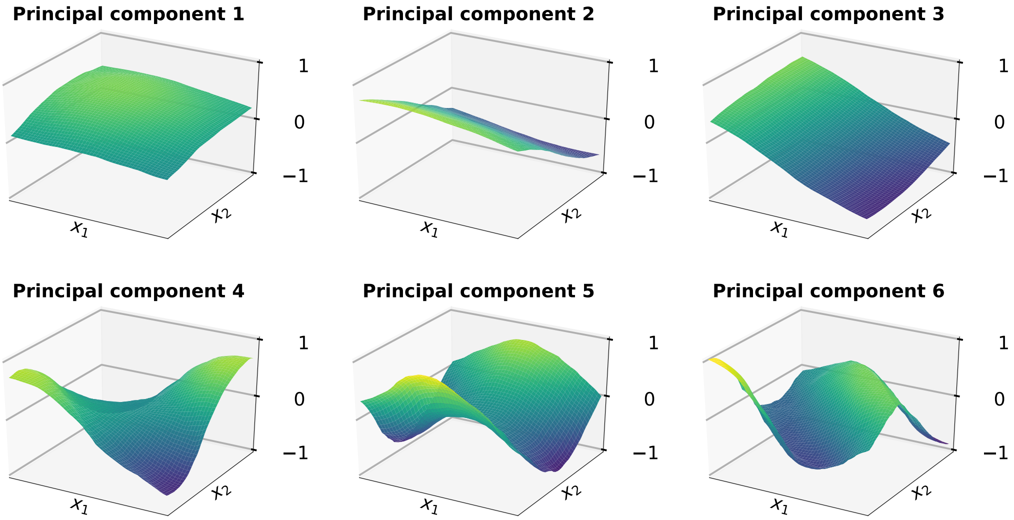


Gaussian Tuning Curve Principal Components

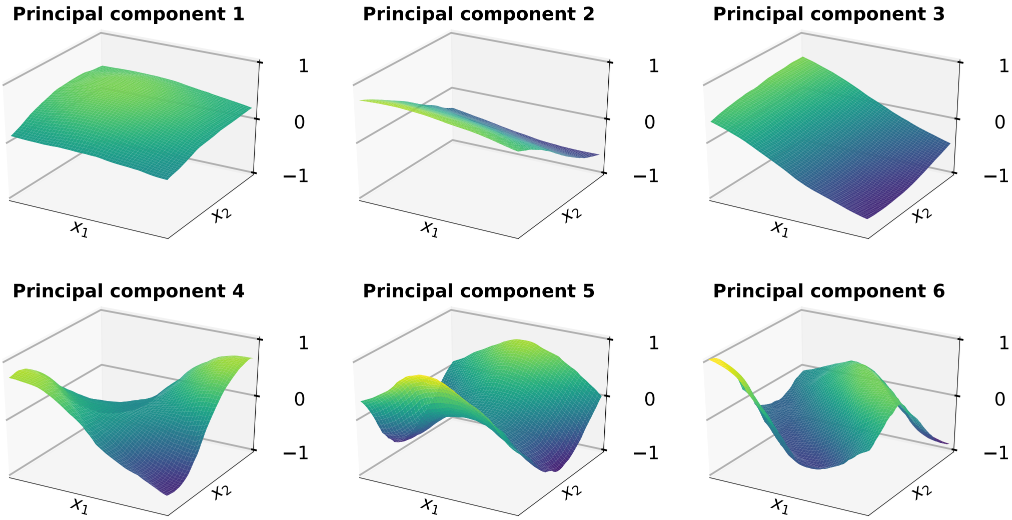


$\approx$ Fourier Basis

PCA of 2D Tuning Curves



PCA of 2D Tuning Curves



Combination of 2D Polynomials

Conclusions

- Can use **PCA** to find the basis functions underlying neural representations
- **Singular values** inversely proportional to noise
- **Basis function shape** depends on
  - x-intercept distributions
  - Neuron response curve $G[J]$
- Finding optimal tuning curves for representations
  $\Rightarrow$ Full network optimization (must use gradient descent)

Image sources

Title slide
Maurice Denis: Homage to Cézanne, 1900
From Wikimedia.