**SYDE 556/750**

# Simulating Neurobiological Systems
# Lecture 7: Analysing Representations

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Octber 25, 2021

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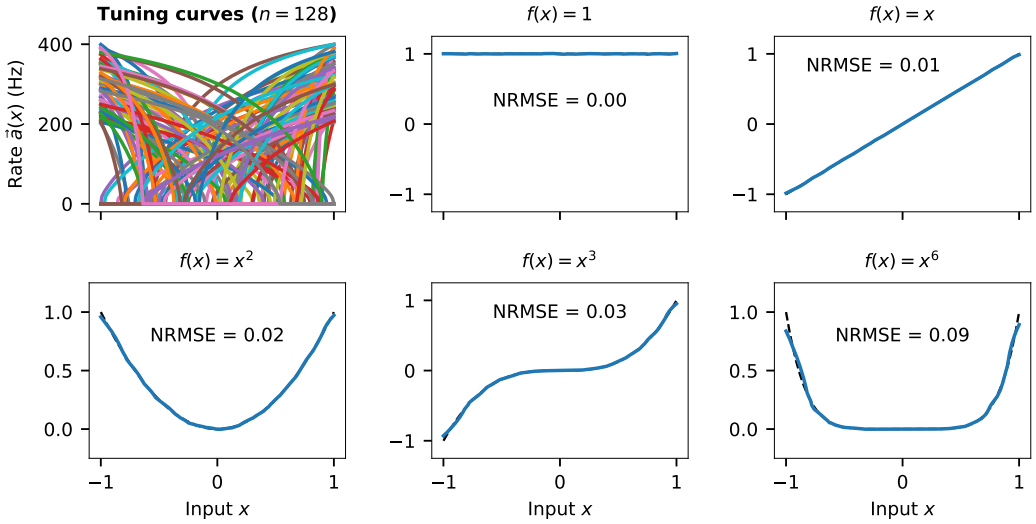
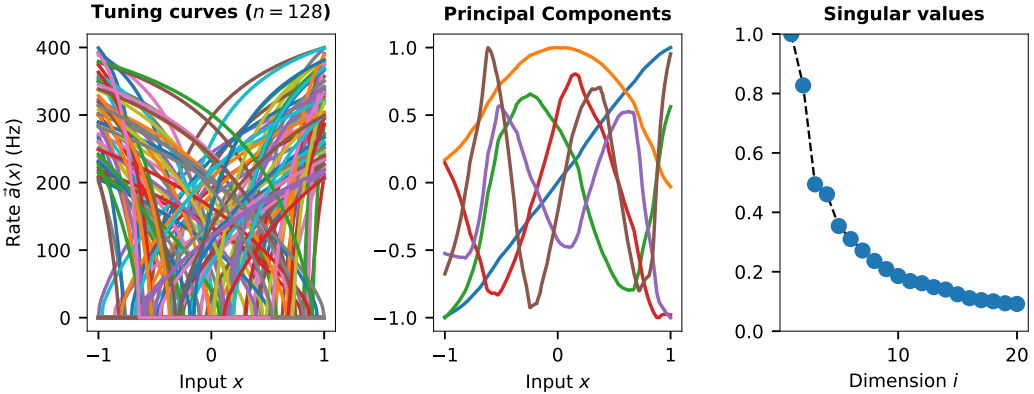
- Content: Terry Stewart, Andreas Stöckel, Chris Eliasmith

UNIVERSITY OF WATERLOO | FACULTY OF ENGINEERING

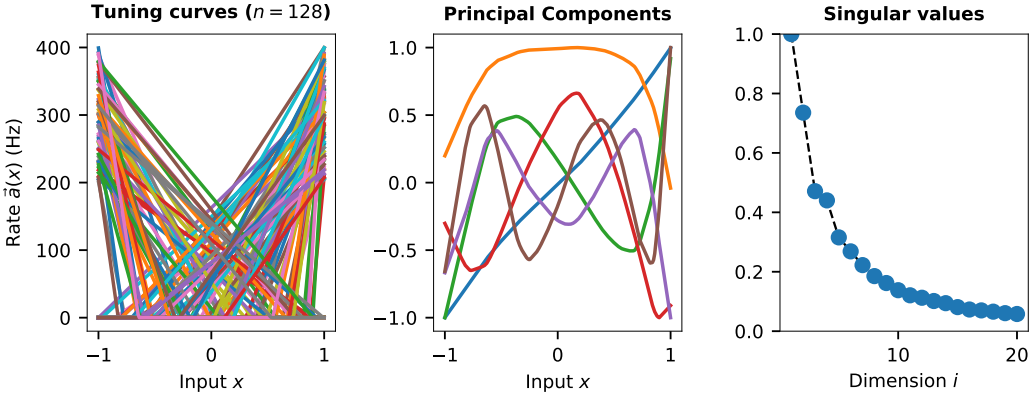
# Decoding Polynomials



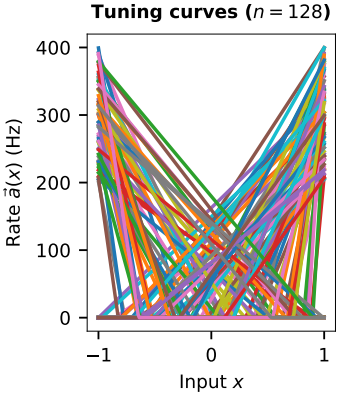
# LIF Tuning Curve Principal Components

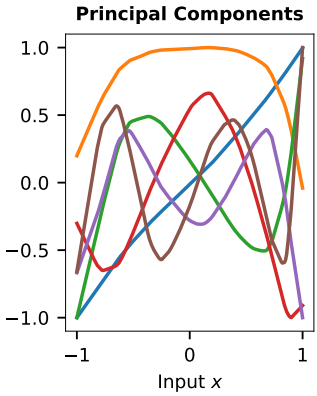


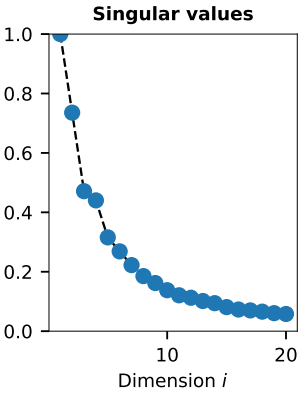
# ReLU Tuning Curve Principal Components



# ReLU Tuning Curve Principal Components

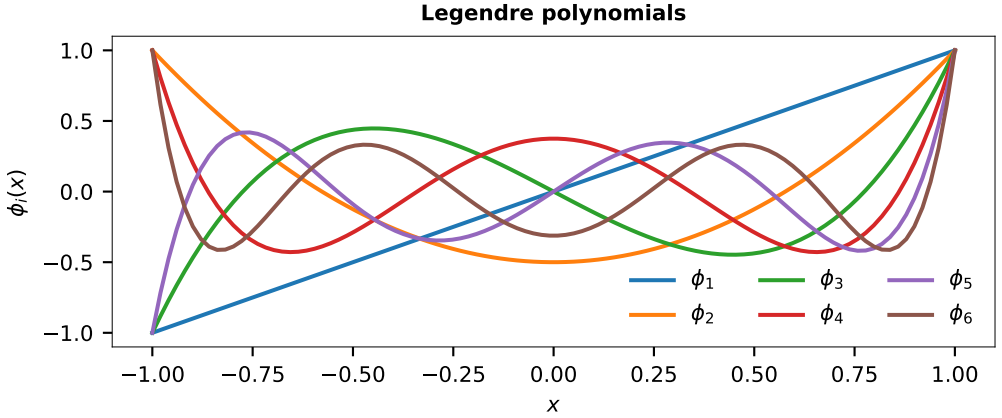


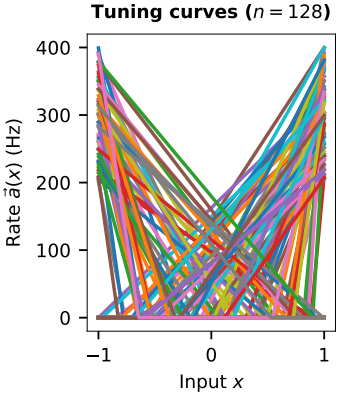

**≈ Legendre Basis**

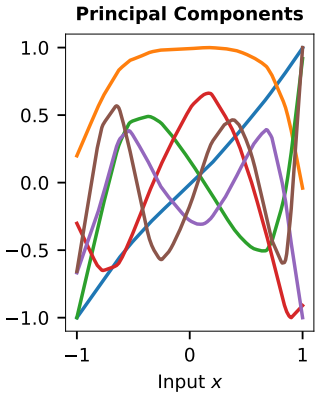
# Reminder: Legendre Polynomials

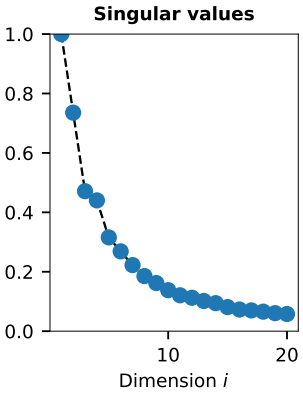



$$\varphi_i(x) = \frac{1}{2^i} \sum_{k=0}^{n} \binom{i}{k}^2 (x-1)^{i-k}(x+1)^k$$

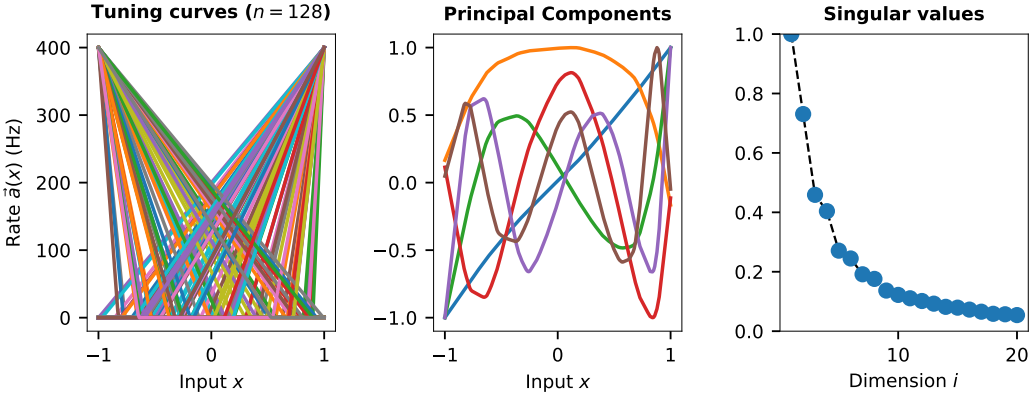
# Modifying the Basis – Same Maximum Rate (I)



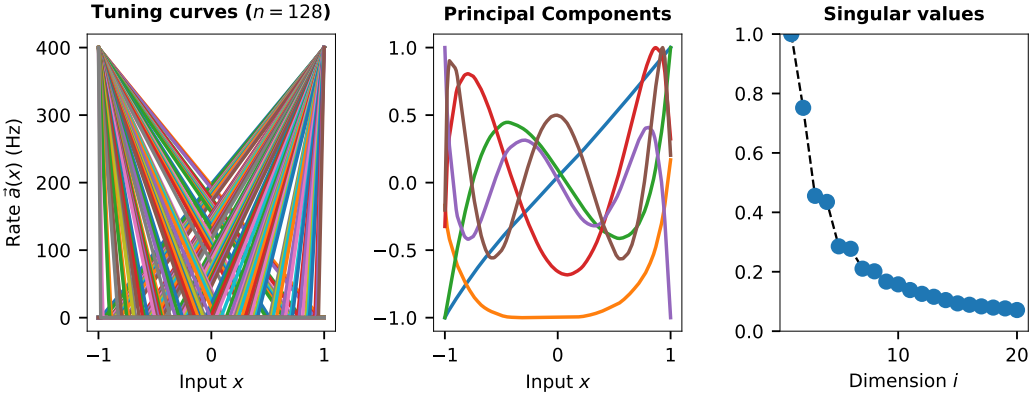



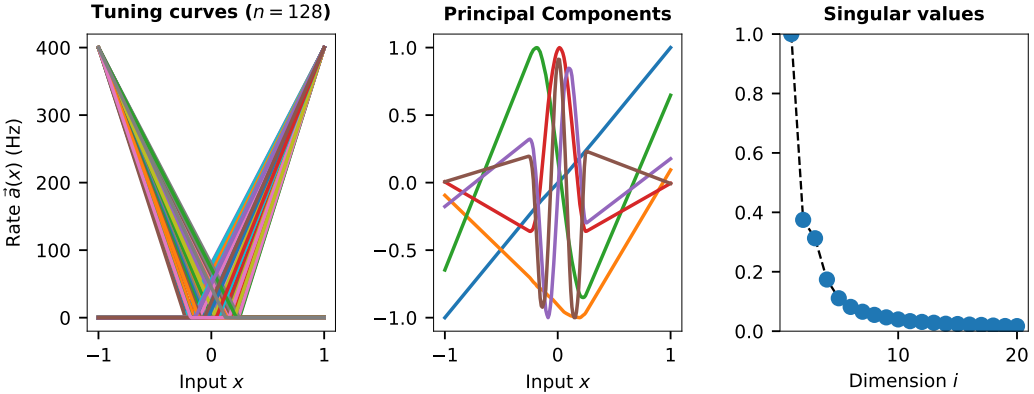
# Modifying the Basis – Same Maximum Rate (I)



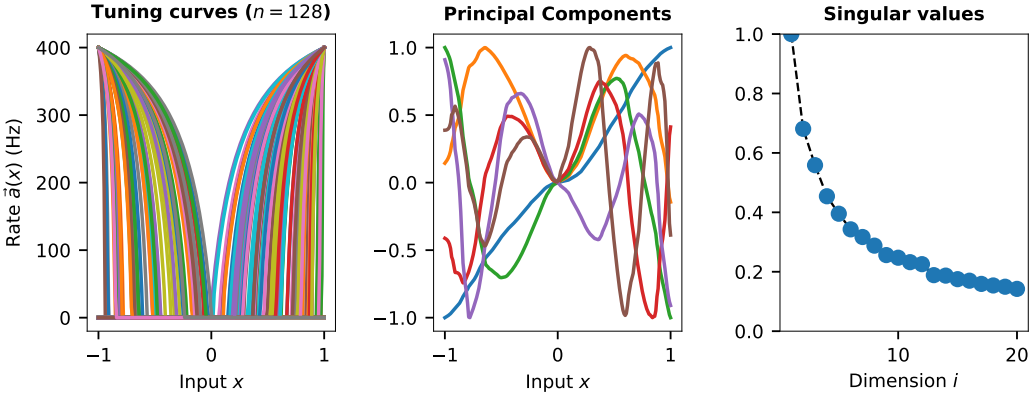
# Modifying the Basis – Equidistant $x$-Intercepts (II)



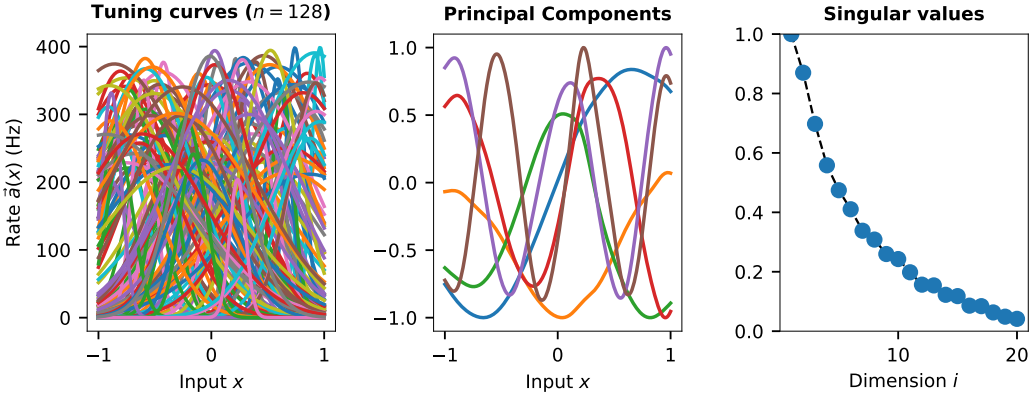
# Modifying the Basis – Limited $x$-Intercepts (III)



# Modifying the Basis – Symmetric Tuning Curves (IV)



# Gaussian Tuning Curve Principal Components



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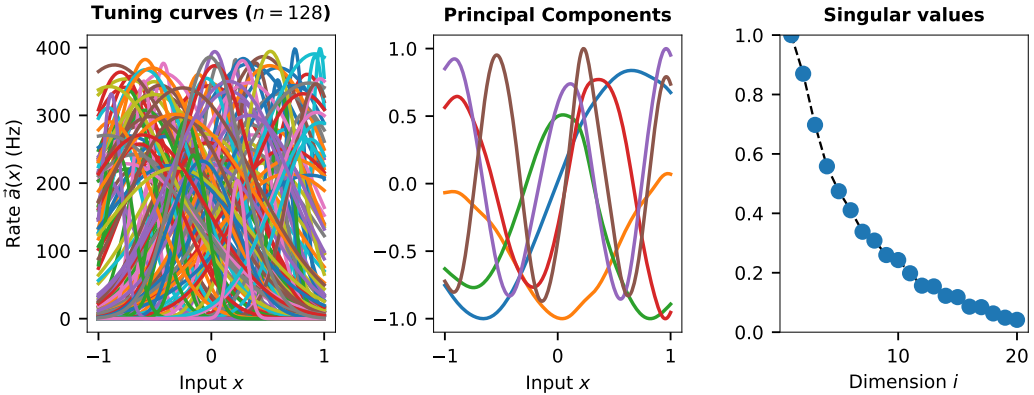
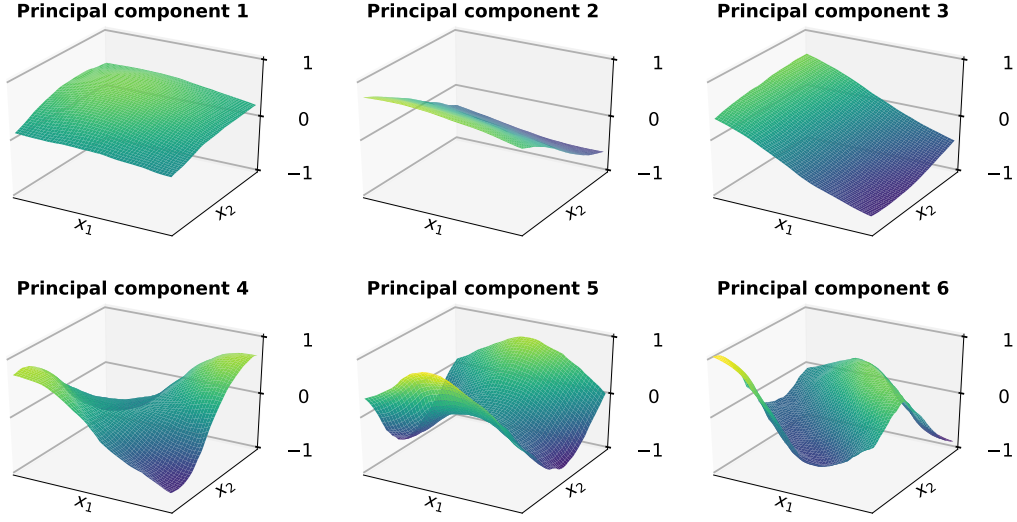
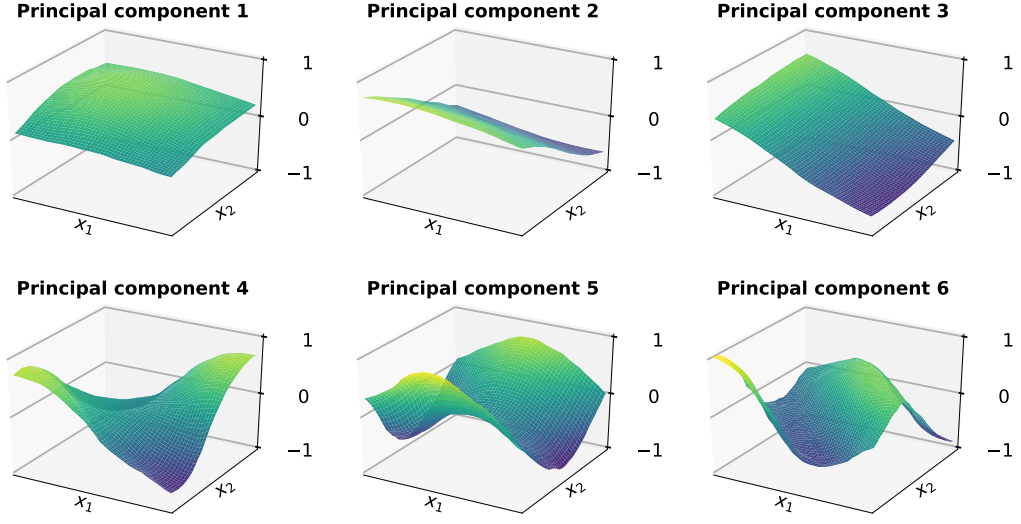



**≈ Fourier Basis**

# 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 computing particular functions
  $\Rightarrow$ Full network optimization (must use gradient descent)

# Image sources

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