Group 3: Project 1

1) Implement the radial basis function (RBF) network described in Poggio & Edelman (1990) for 2D images. Use the equations in Poggio & Girosi (1990; see Note 21). In particular, the weights c_m for point m can be estimated by:

$$c_m = (G^T G + \lambda I)^{-1} G^T y_m$$

where

G is a K x K matrix constructed by evaluating each view-tuned RBF unit at each of the K stored views, λ is a "regularization" parameter that biases the weights to be close to 0 (set λ to be around 0.001 as a start), and y_m is the "standard" view for point m. The superscript T denotes matrix transpose, and the superscript -1 denotes matrix inverse. Use a Gaussian RBF:

$$G(i,j) = \exp\left(-\left\|x_i - x_j\right\|^2/\sigma\right)$$

where $\left\|x_i - x_j\right\|$ is the Euclidean distance between the 2D views and σ is the width of the RBF.

2) Simulate how the network learns to recognize a simple object (e.g., a square) at different orientations.

3) How does performance change as you alter the number of stored views, the RBF width and the regularization parameter?

4) How does performance change as you rotate the test view away from the training views? How does performance differ between interpolation and extrapolation (see Bulthoff & Edelman, 1992)?

5) Explain the relationship between narrow tuning (small σ), look-up tables (grandmother cells), and poor generalization (over-fitting). Explain why tuning that is too broad (large σ) can also lead to poor generalization (under-fitting).

References:

Poggio, T. & Girosi, F. (1990). Regularization algorithms that are equivalent to multilayer networks. *Science, 247,* 978-982.

Poggio, T. & Edelman, S. (1990). A network that learns to recognize three-dimensional objects. *Science, 343,* 263-266.

Bulthoff, H.H. & Edelman, S. (1992). Psychophysical support for a two-dimensional view interpolation theory of object recognition. *Proceedings of the National Academy of Sciences, 89,* 60-64.