# A CSC 103: How Computers Work
# Intro to Deep Learning

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# Deep Learning Overview

# How to learn a recipe?



$X_1$ $X_2$ $X_3$ $X_4$ $X_5$ $X_6$

input data

?

$Y_1$ $Y_2$ $Y_3$



parameters

# Deep learning for images

$X_1$

$X_2$

$X_3$

$X_4$

$X_5$

$X_6$

input data

?

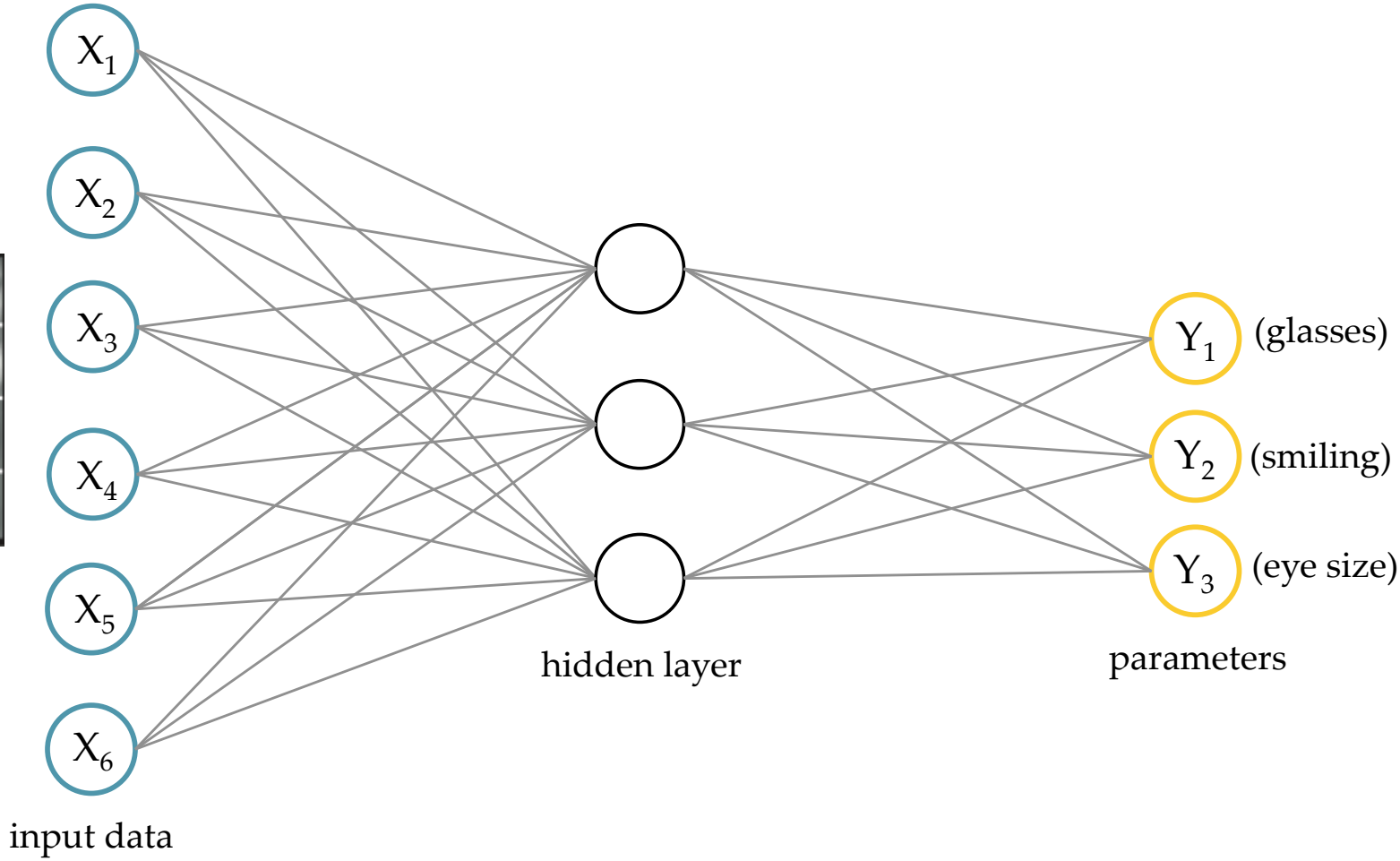
$Y_1$ (glasses)

$Y_2$ (smiling)

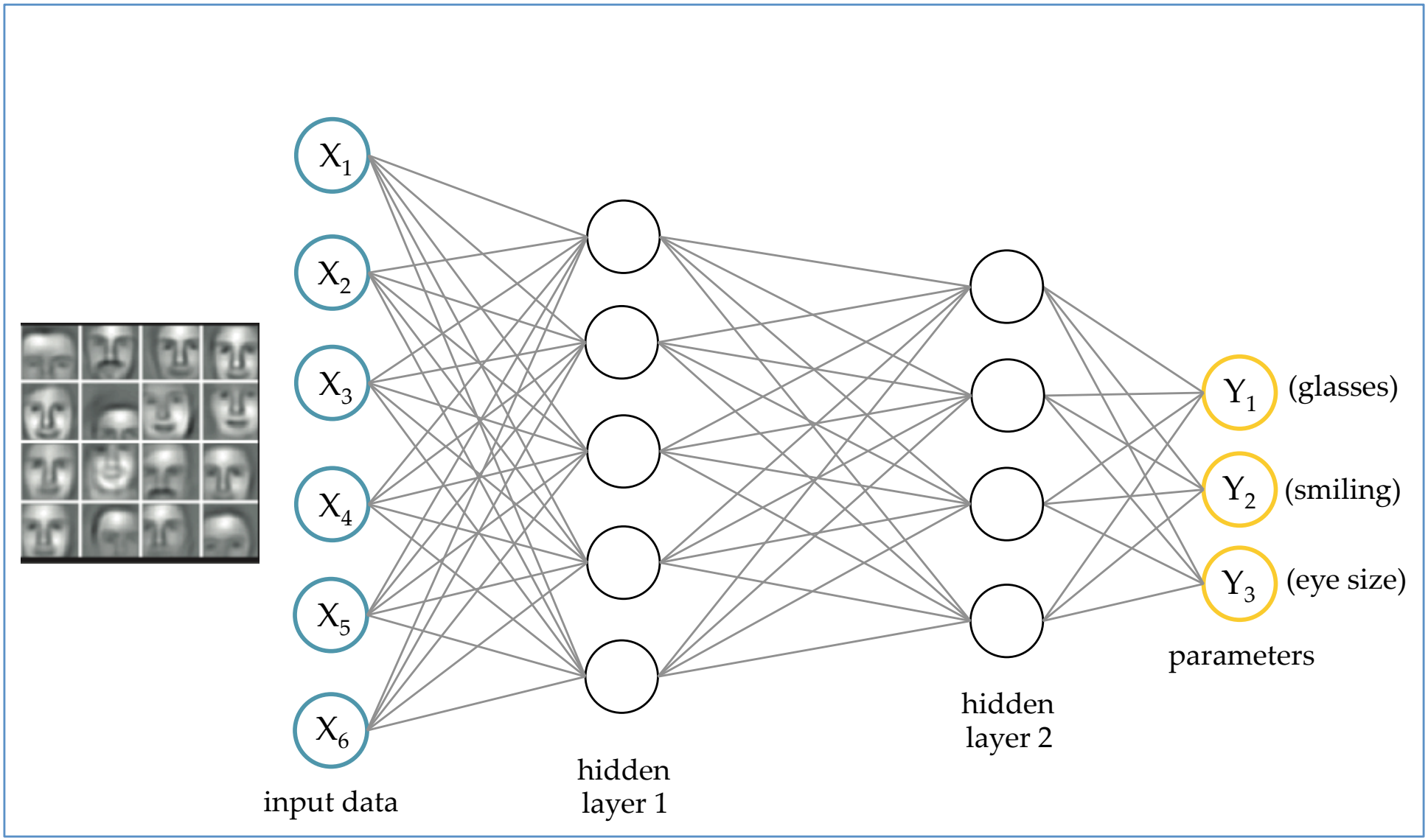
$Y_3$ (eye size)

parameters

# Classical neural network

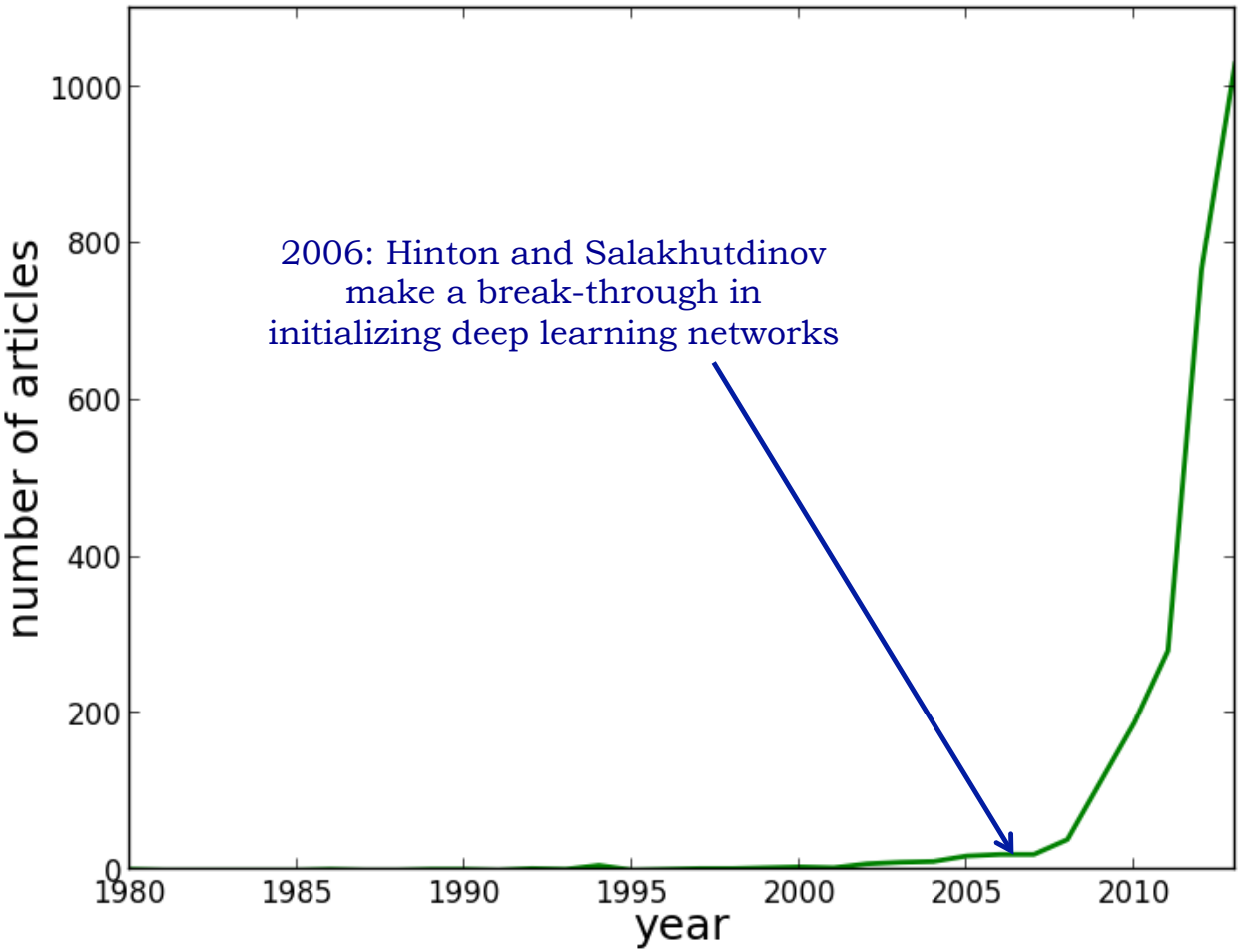


# Deep network



# Rise of deep learning

**Number of papers that mention deep learning per year**



# Break-through: unsupervised learning, autoencoder

**Goal:** initialize the deep learning weights







input

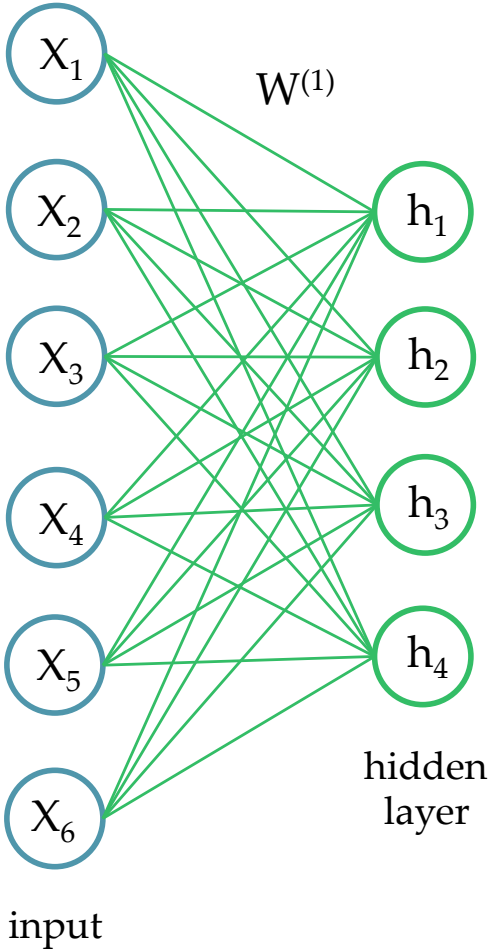
# Break-through: unsupervised learning, autoencoder

**Goal:** initialize the deep learning weights

1. Project data into a lower dimension:

$$h_j = \sigma\left(W_j^{(1)} \cdot x\right)$$

$$\sigma(z) = \frac{1}{1 + e^{-z}}$$



# Break-through: unsupervised learning, autoencoder

**Goal:** initialize the deep learning weights

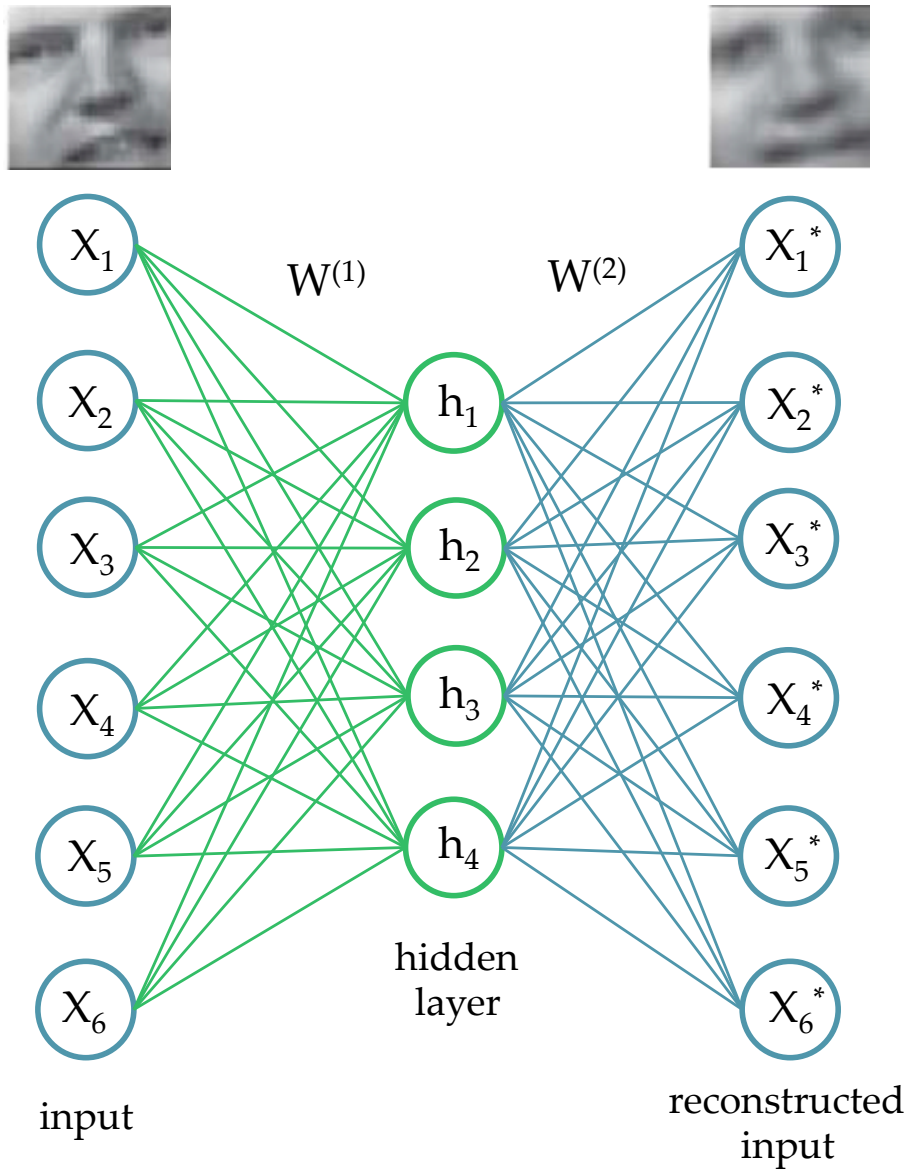
1. Project data into a lower dimension:

$$h_j = \sigma\left(W_j^{(1)} \cdot x\right)$$

$$\sigma(z) = \frac{1}{1 + e^{-z}}$$

2. Minimize objective function:

$$J_x(W) = \frac{1}{2}\left|\left|x - x^*\right|\right|^2$$



# Break-through: unsupervised learning, autoencoder

original image

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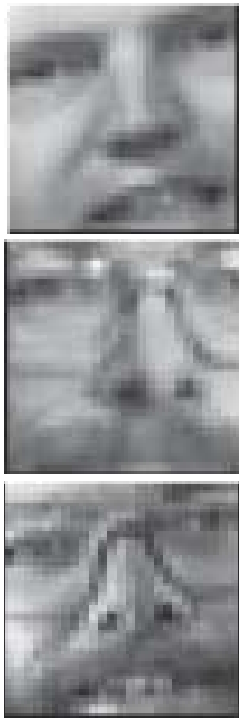
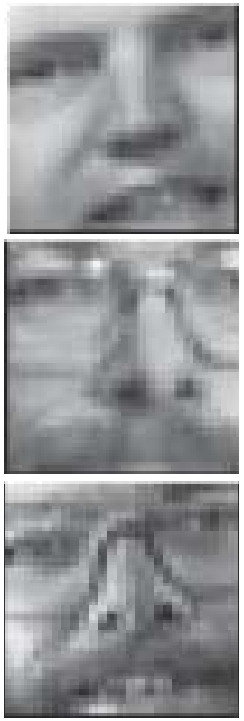
original image



compression and feature reduction

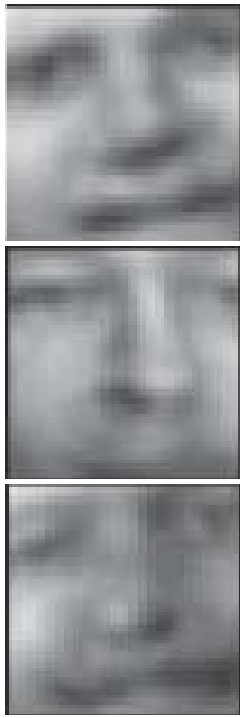
# Break-through: unsupervised learning, autoencoder

original image



compression and feature reduction

reconstructed image



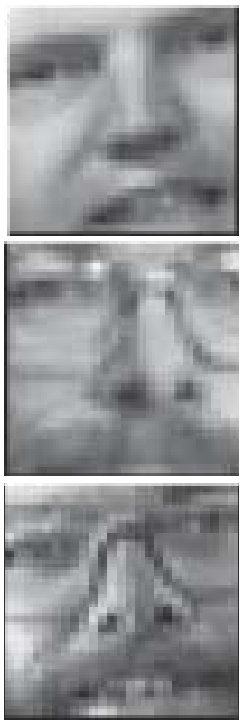
# Break-through: unsupervised learning, autoencoder

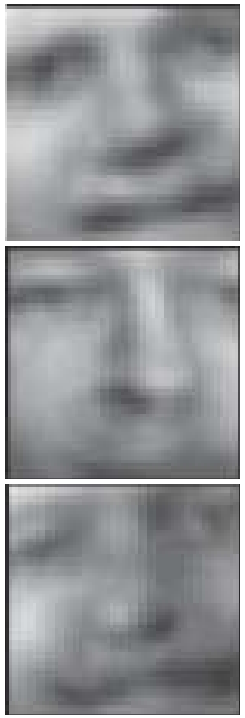
original image

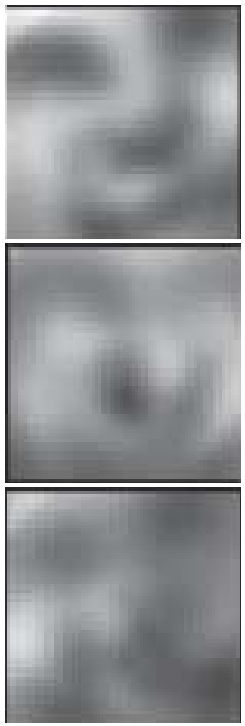
compression and feature reduction

reconstructed image

PCA

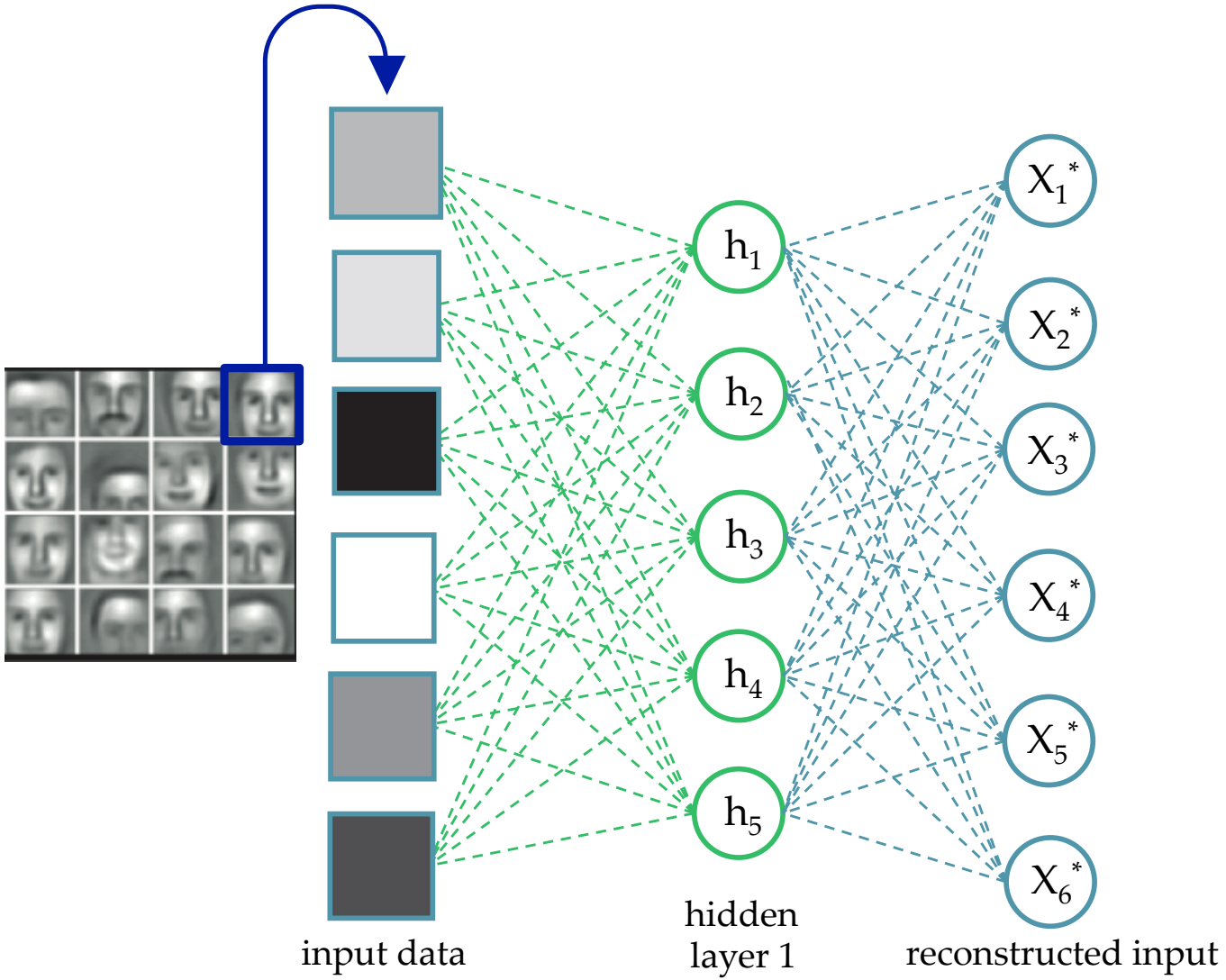




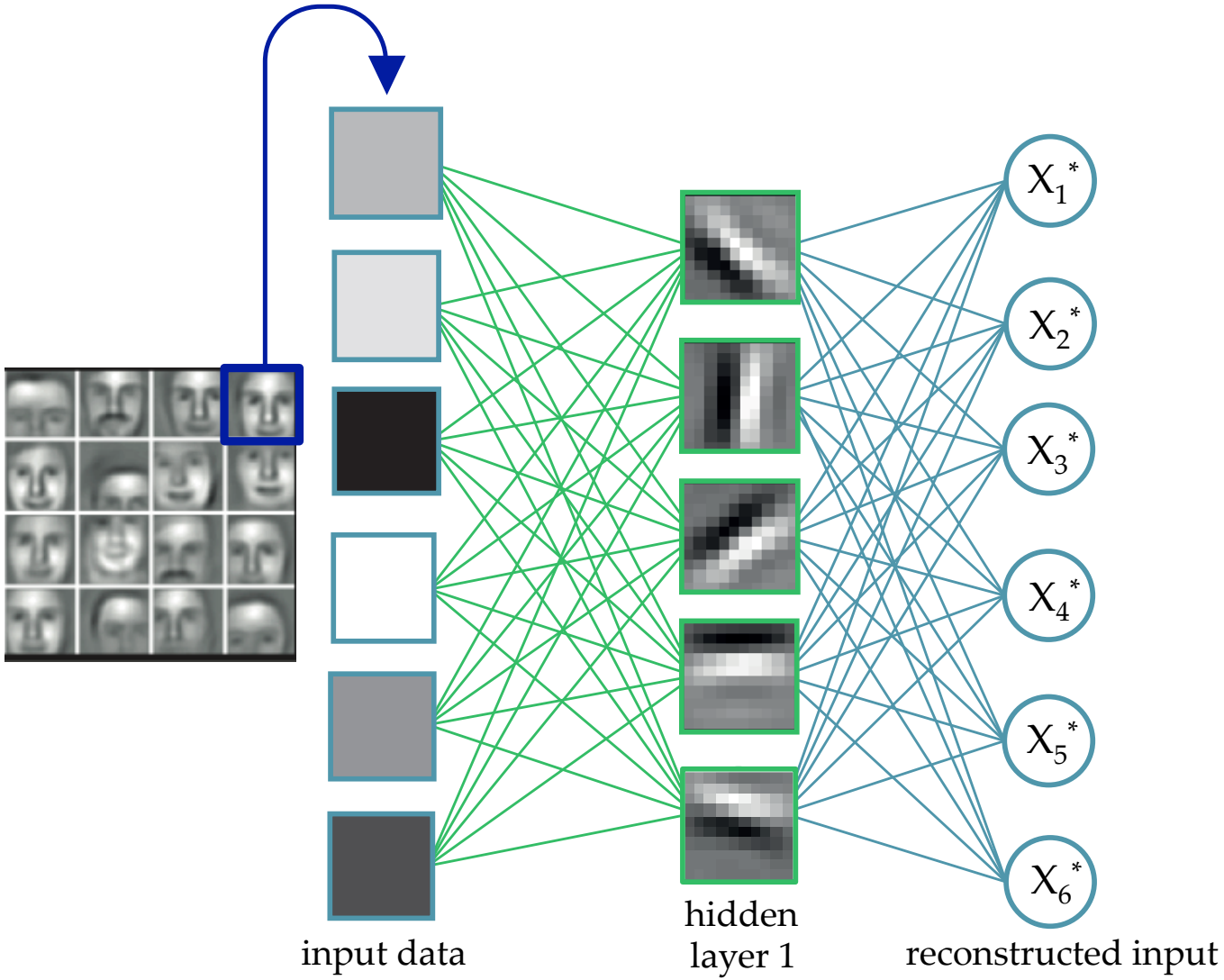


# Transform the input data

# Feature learning for hidden layer 1



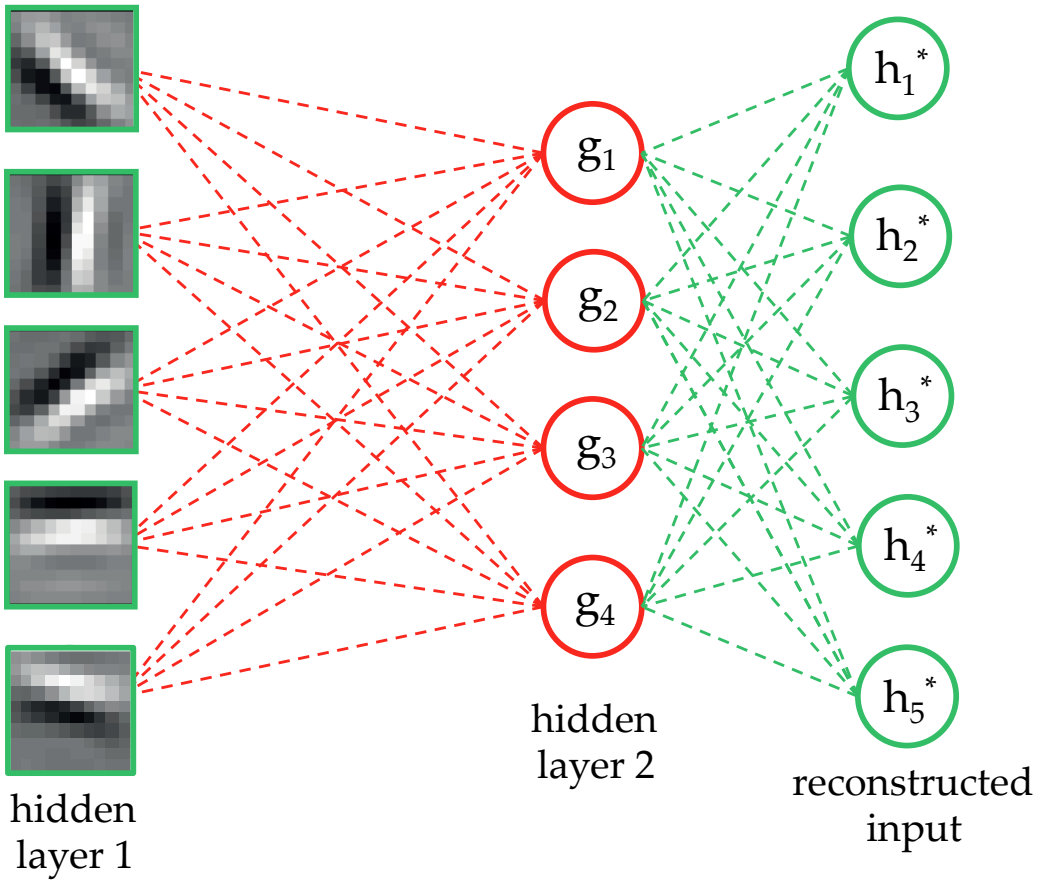
# Feature learning for hidden layer 1



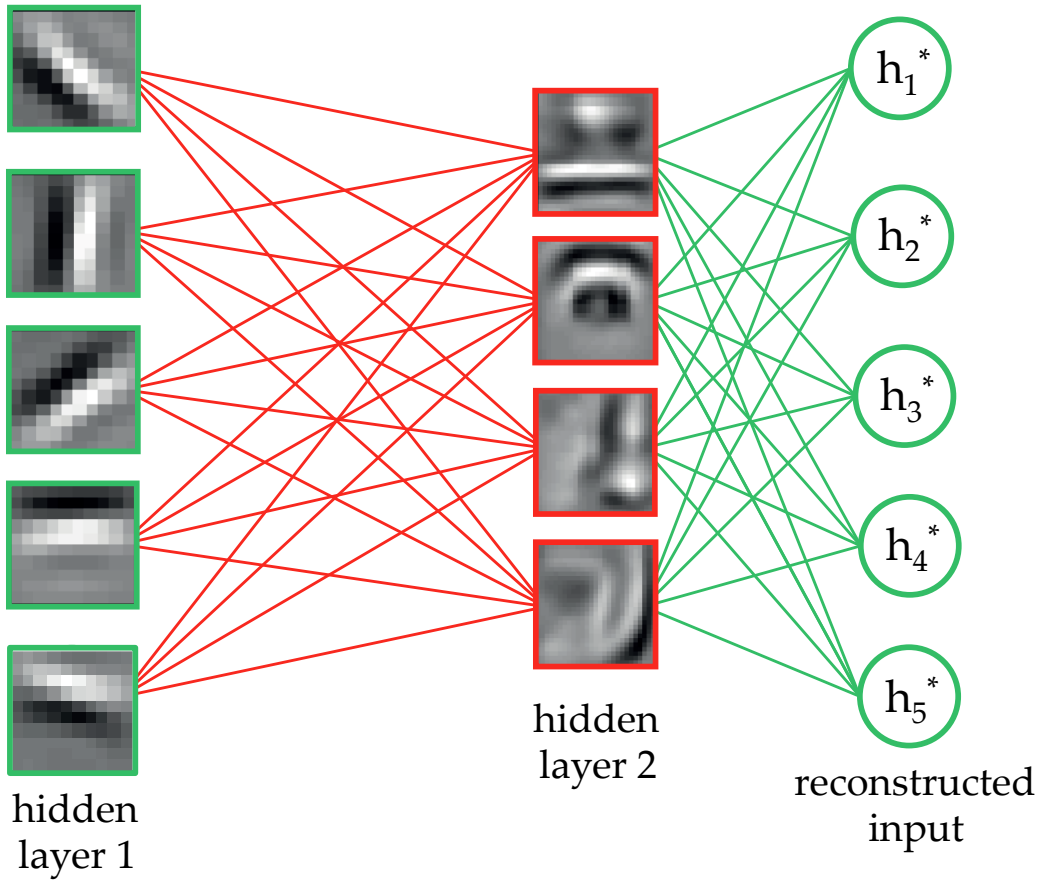
# Low-level features become the new data

hidden
layer 1

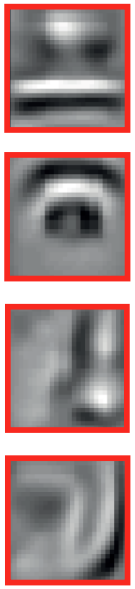
# Feature learning for hidden layer 2



# Feature learning for hidden layer 2

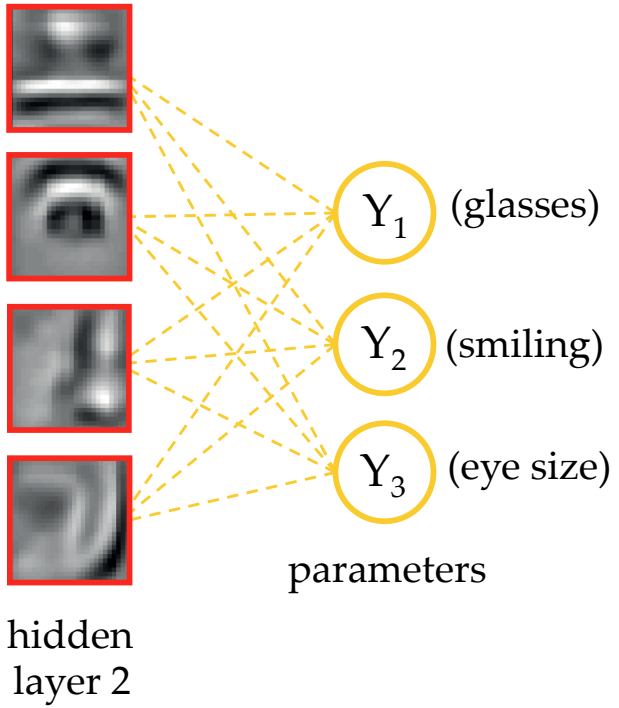


# High-level features become the new data

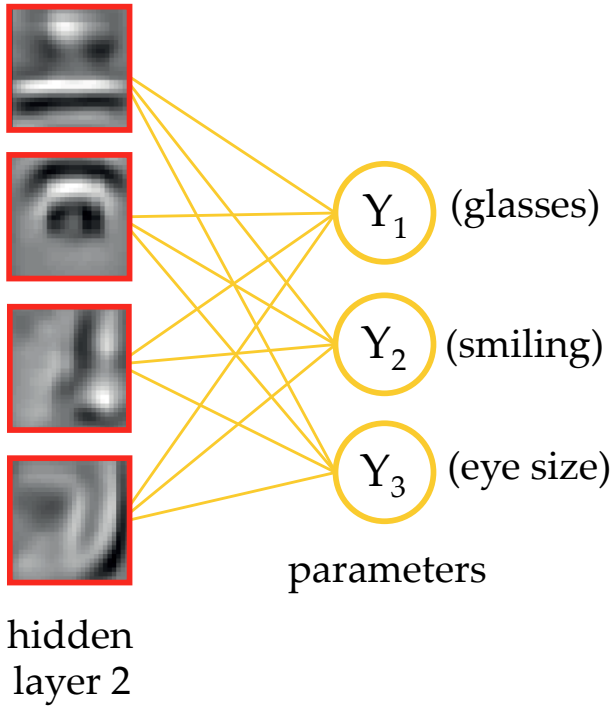


hidden
layer 2

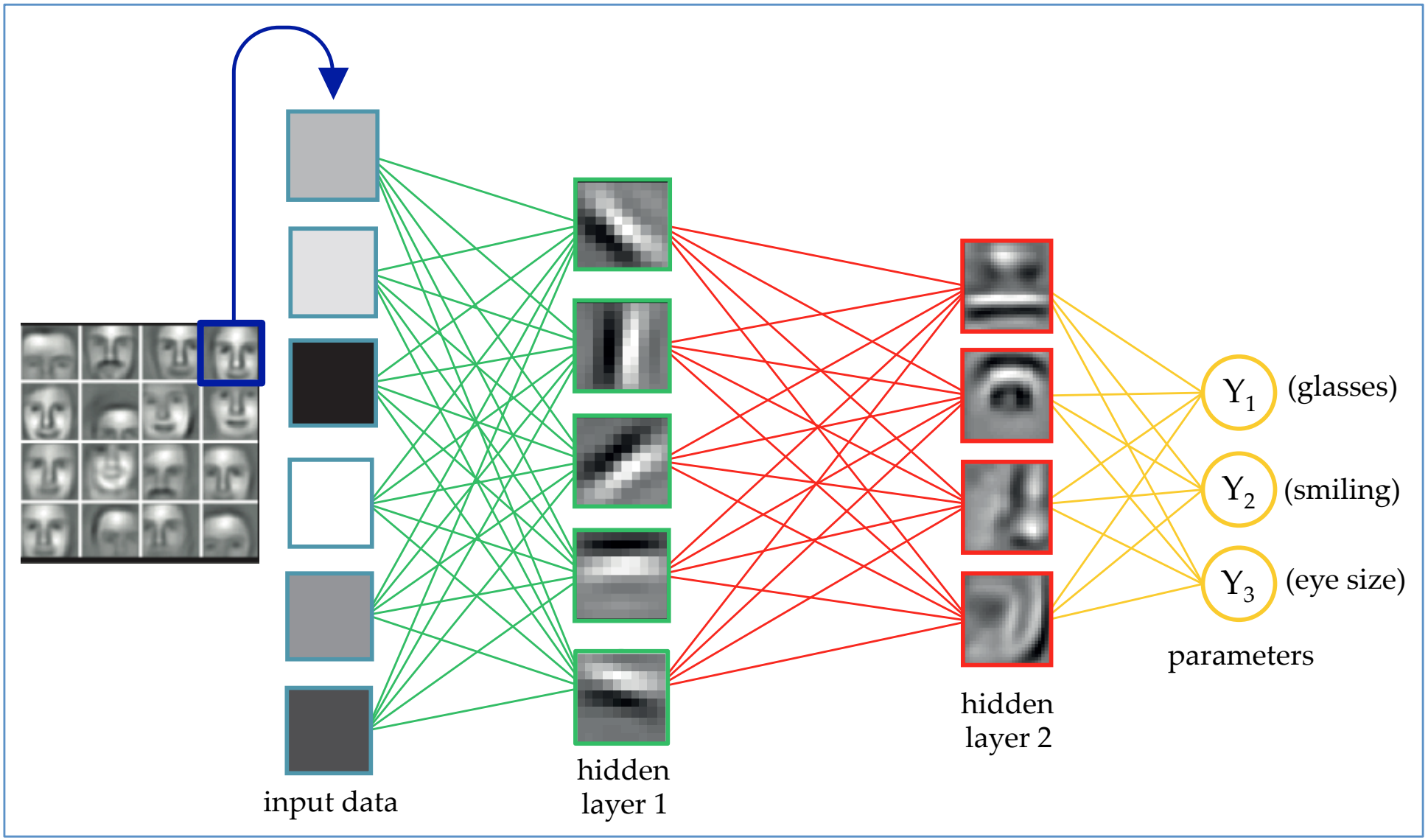
# Last layer: use the parameters



# Last layer: use the parameters

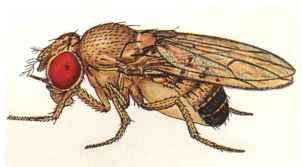


# "Fine-tune" the entire deep network



# Deep Learning for Biology

# A deep learning method for population genetics



GACTGGCTA
AGCTAGCTT
TAATCCGCA