ECS 171: Machine Learning

Summer 2023
Edwin Solares
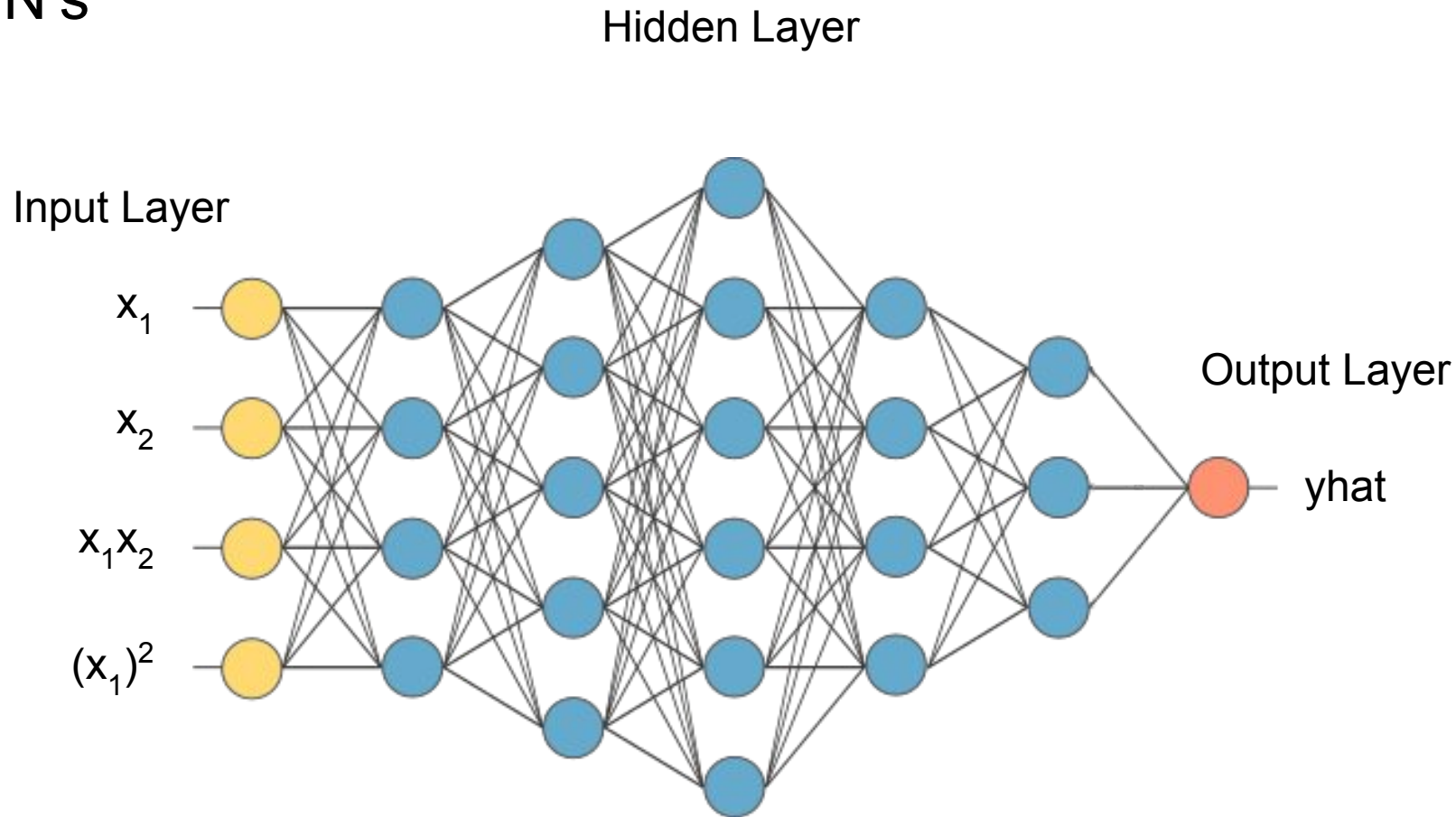easolares@ucdavis.edu
Convolutions

Convolution Neural Networks

CNN's

A special build of a Neural Network that is optimized for pattern recognition

- Can detect geometric shapes
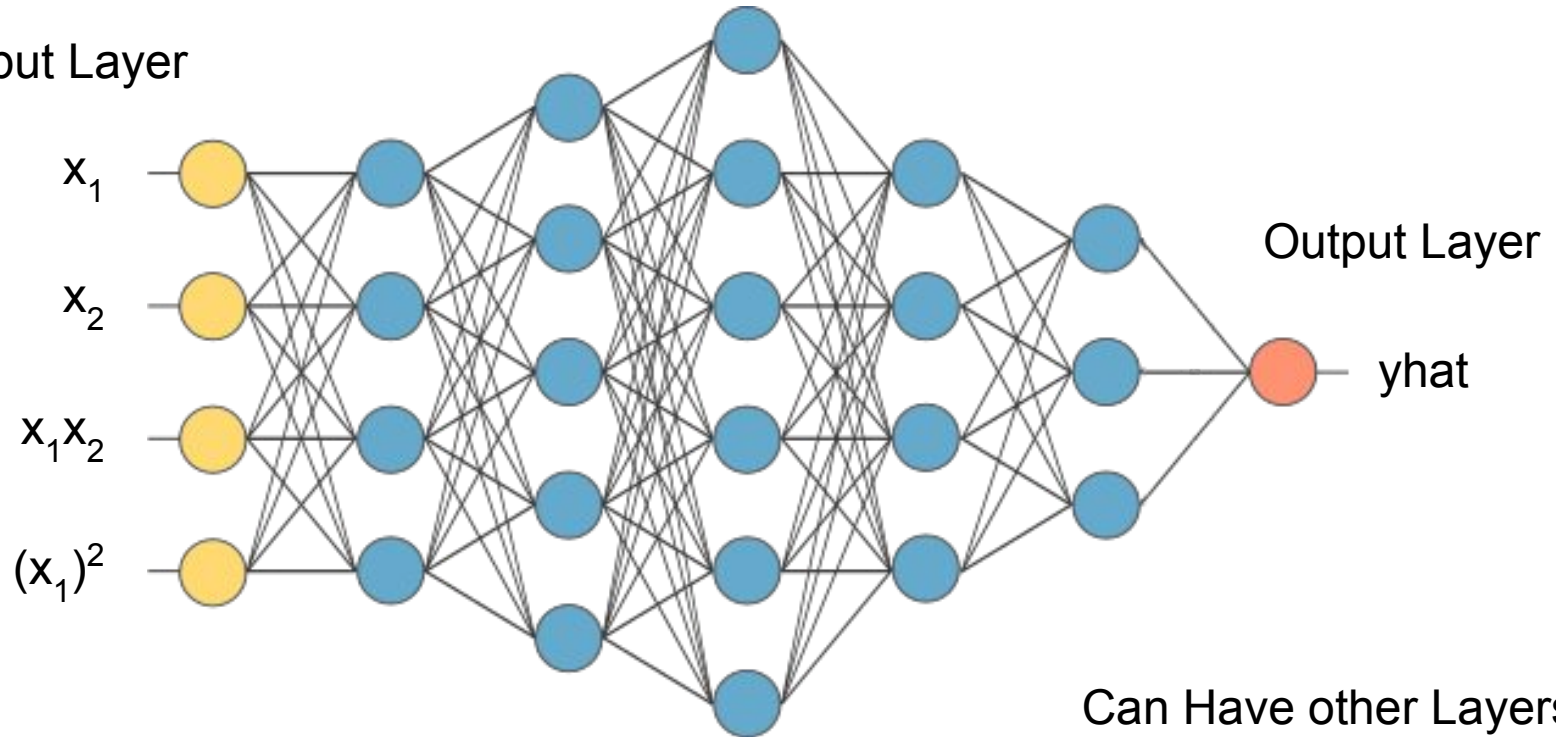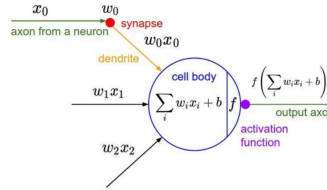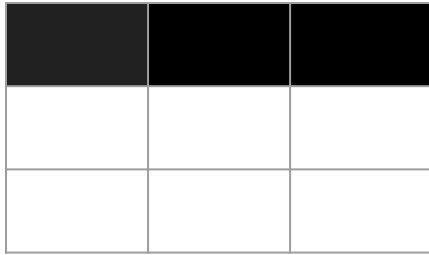- With deeper layers → more complex geometric pattern detection

DNN's

Hidden Layer

Input Layer

x_1

x_2

x_1x_2

$(x_1)^2$

Output Layer

yhat

CNN's

Convolutional Layer

Input Layer

x_1

x_2

x_1x_2

$(x_1)^2$

Output Layer

yhat

Can Have other Layers

Filters

Top Edge Filter

1

Left Edge Filter

1

AND → Corner
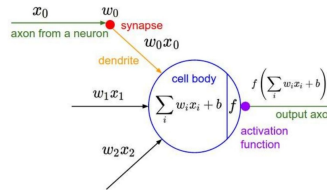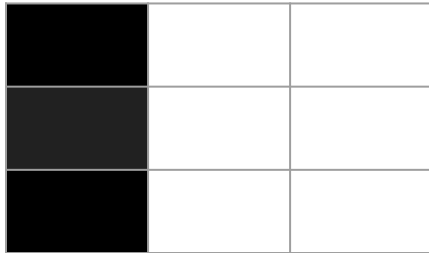
Filters: Matrix Convolution

Top Edge Filter

1	1	1
0	0	0
-1	-1	-1

Left Edge Filter

1	0	-1
1	0	-1
1	0	-1

Filters: Matrix Convolution

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

1	0	-1
1	0	-1
1	0	-1

3 x 3

6 x 6

Filters: Matrix Convolution

0 value when pixel is uniform
Large value when pixel is not uniform
Max value when pixel fits pattern

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

6 x 6

*

1	0	-1
1	0	-1
1	0	-1

3 x 3

=
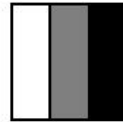
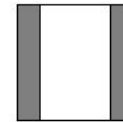| -0	30	30	0
0	30	30	0
0	30	30	0
0	30	30	0

4 x 4

Filters: Matrix Convolution

0 value when pixel is uniform
Large value when pixel is not uniform
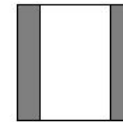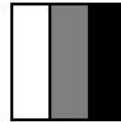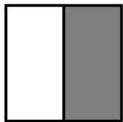Max value when pixel fits pattern

$$\begin{bmatrix} 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix} \rightarrow \begin{bmatrix} 1*10 & 0*10 & -1*10 \\ 1*10 & 0*10 & -1*10 \\ 1*10 & 0*10 & -1*10 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 30 & 30 & 0 \\ ? & ? & ? & ? \\ ? & ? & ? & ? \\ ? & ? & ? & ? \end{bmatrix}$$

Filters: Matrix Convolution

0 value when pixel is uniform
Large value when pixel is not uniform
Max value when pixel fits pattern

$$
\begin{bmatrix}
10 & 10 & 10 & 0 & 0 & 0 \\
10 & 10 & 10 & 0 & 0 & 0 \\
10 & 10 & 10 & 0 & 0 & 0 \\
10 & 10 & 10 & 0 & 0 & 0 \\
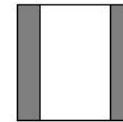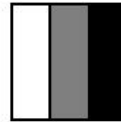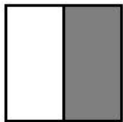10 & 10 & 10 & 0 & 0 & 0 \\
10 & 10 & 10 & 0 & 0 & 0
\end{bmatrix}
\quad
\begin{bmatrix}
1 & 0 & -1 \\
1 & 0 & -1 \\
1 & 0 & -1
\end{bmatrix}
\rightarrow
\begin{bmatrix}
1*10 & 0*10 & -1*0 \\
1*10 & 0*10 & -1*0 \\
1*10 & 0*10 & -1*0
\end{bmatrix}
\quad
\begin{bmatrix}
0 & 30 & 30 & 0 \\
? & ? & ? & ? \\
? & ? & ? & ? \\
? & ? & ? & ?
\end{bmatrix}
$$

Filters: Matrix Convolution

0 value when pixel is uniform
Large value when pixel is not uniform
Max value when pixel fits pattern

$$\begin{bmatrix} 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \end{bmatrix}$$
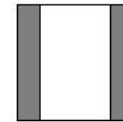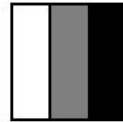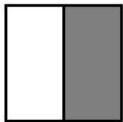
$$\begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix} \rightarrow \begin{bmatrix} 1*10 & 0*0 & -1*0 \\ 1*10 & 0*0 & -1*0 \\ 1*10 & 0*0 & -1*0 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 30 & 30 & 0 \\ ? & ? & ? & ? \\ ? & ? & ? & ? \\ ? & ? & ? & ? \end{bmatrix}$$
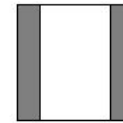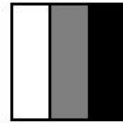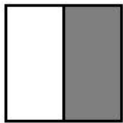
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$$\begin{bmatrix} 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix}$$

$$\begin{bmatrix} 1*0 & 0*0 & -1*0 \\ 1*0 & 0*0 & -1*0 \\ 1*0 & 0*0 & -1*0 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 30 & 30 & 0 \\ ? & ? & ? & ? \\ ? & ? & ? & ? \\ ? & ? & ? & ? \end{bmatrix}$$
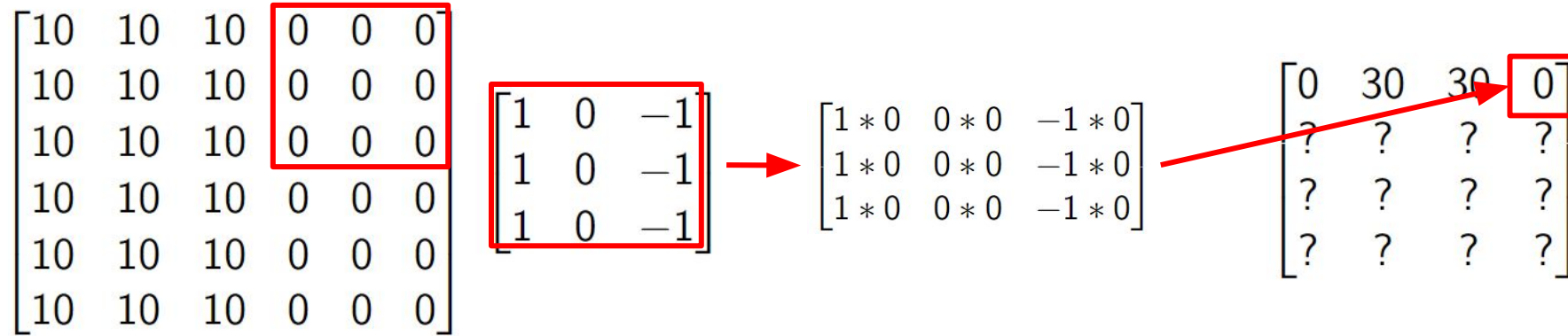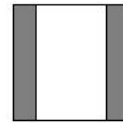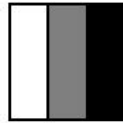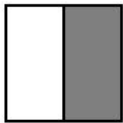
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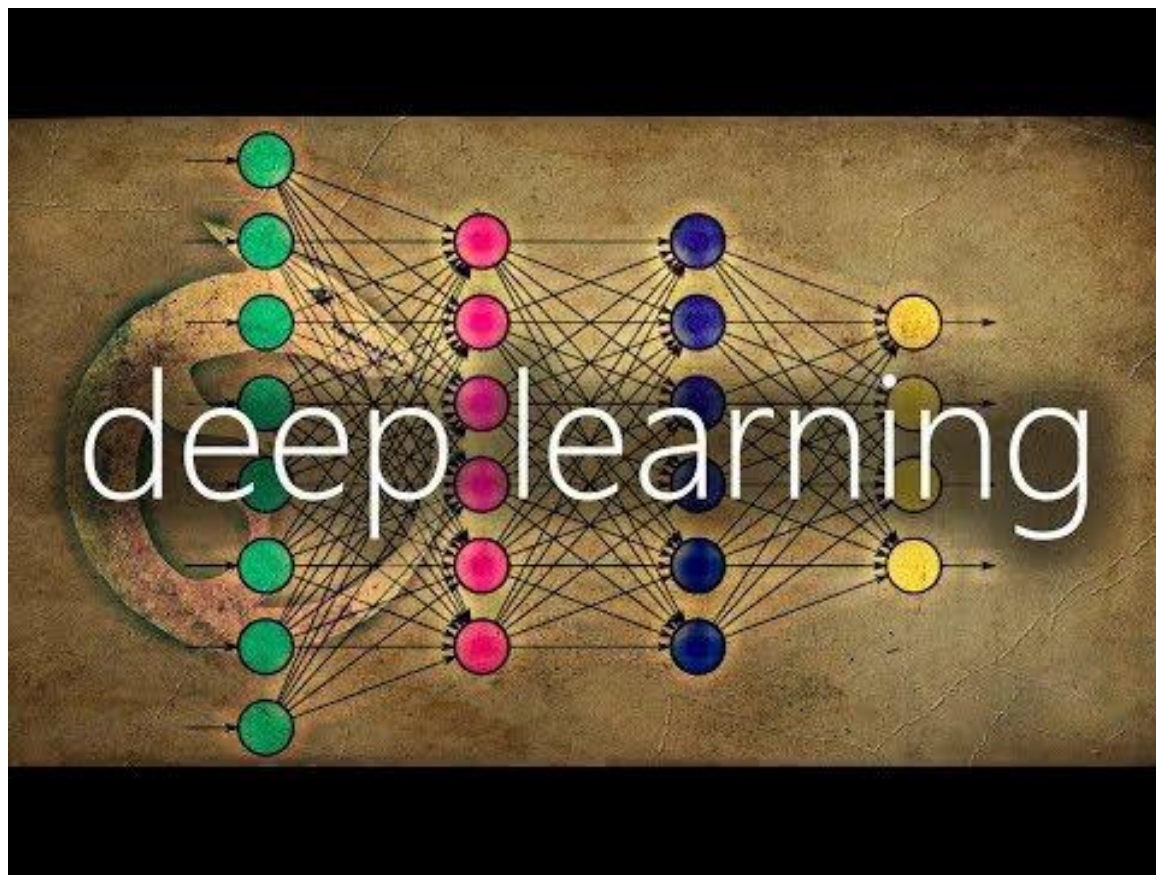Max value when pixel fits pattern

$$\begin{bmatrix} 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \\ 10 & 10 & 10 & 0 & 0 & 0 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix} \longrightarrow \begin{bmatrix} 0 & 30 & 30 & 0 \\ 0 & 30 & 30 & 0 \\ 0 & 30 & 30 & 0 \\ 0 & 30 & 30 & 0 \end{bmatrix}$$

Filters Time!

https://deeplizard.com/resource/pavq7noze2

Filters

Jupyter Notebooks Time!

https://colab.research.google.com