

Accurate real time localization tracking
in clinical environment using Bluetooth
Low Energy and deep learning

Abstract

The study focuses on investigating the feasibility of tracking patients and clinical staff wearing Bluetooth Low Energy tag in radiation oncology clinic using (ANN) and (CNN)

- . ANN + CNN > CNN
- . ANN + CNN > thresholding
- . ANN + CNN > triangulation

Data Collection

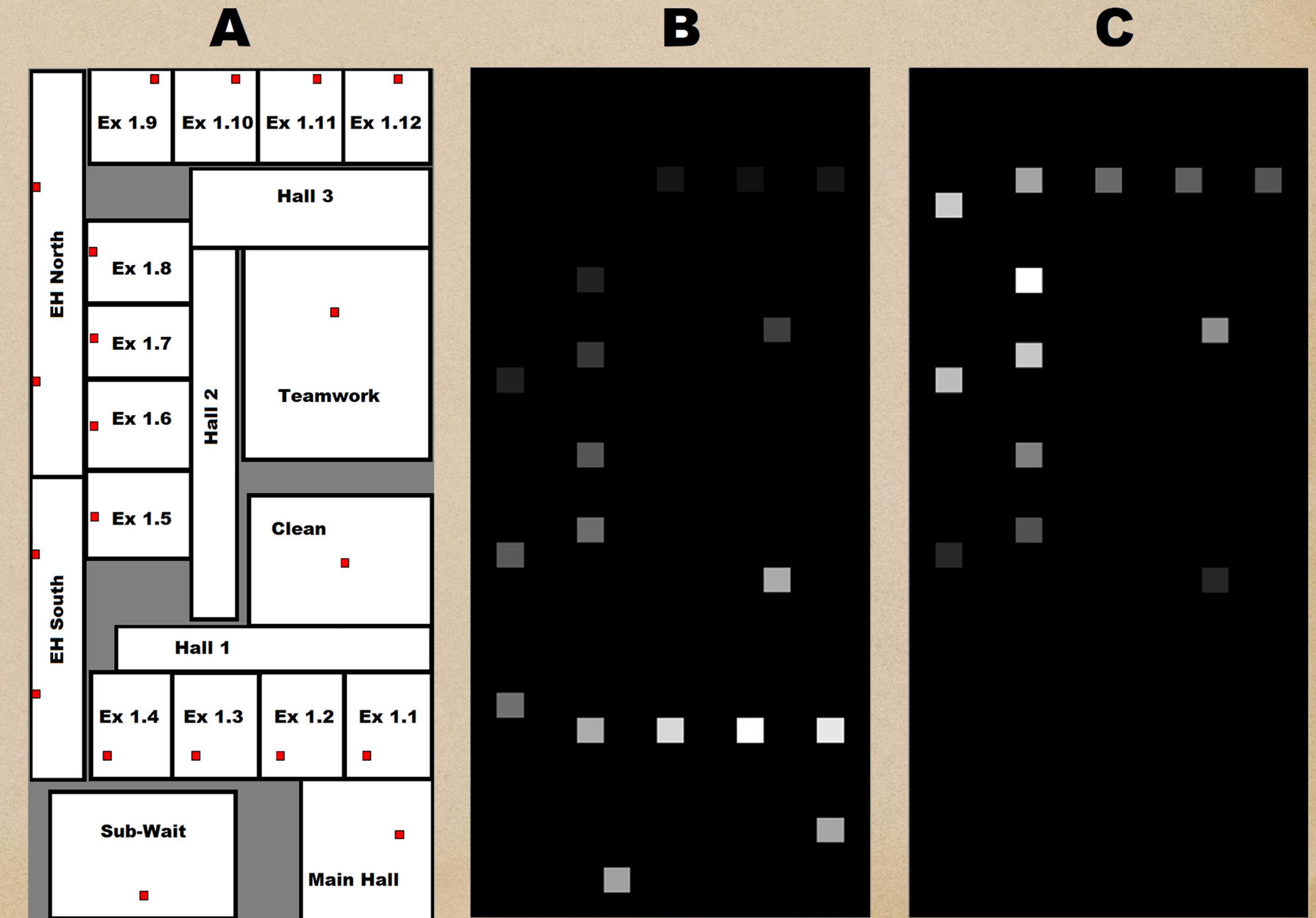
Receiver : 21 個

Sample : 10 次

RSSI : -150 ~ -60

Time : Receiver \times 4 分鐘

Frequency : 10Hz



Data Processing

- Step 1 數據進行平均，採集率 $10 \text{ Hz} \rightarrow 1 \text{ Hz}$
- Step 2 將任何低於- 100 的 RSSI 改成 0
- Step 3 將其餘元素進行normalized
- Step 4 將normalized的結果放入 34×15 的圖相對應位置中
 - * 每秒代表一張圖
 - * 每個區域各自產生240 張圖 $\rightarrow 21 \times 240$

Normalized

E_{sig} = 本次的**RSSI** 值

E_{min} = 向量中最小的**RSSI**值

E_{max} = 向量中最大的**RSSI**值

E_{norm} = 最大值為 1 , 最小值為0

$$E_{norm} = \frac{E_{sig} - E_{min}}{E_{max} - E_{min}}$$

Neural network architecture and training

Step 1 Original image $\rightarrow 34 \times 15$

Step 2 Convolution layer $\rightarrow 7 \times 7 \times 32$

Step 3 MaxPooling $\rightarrow 2 \times 2$

Step 4 Convolution layer $\rightarrow 3 \times 3 \times 32$

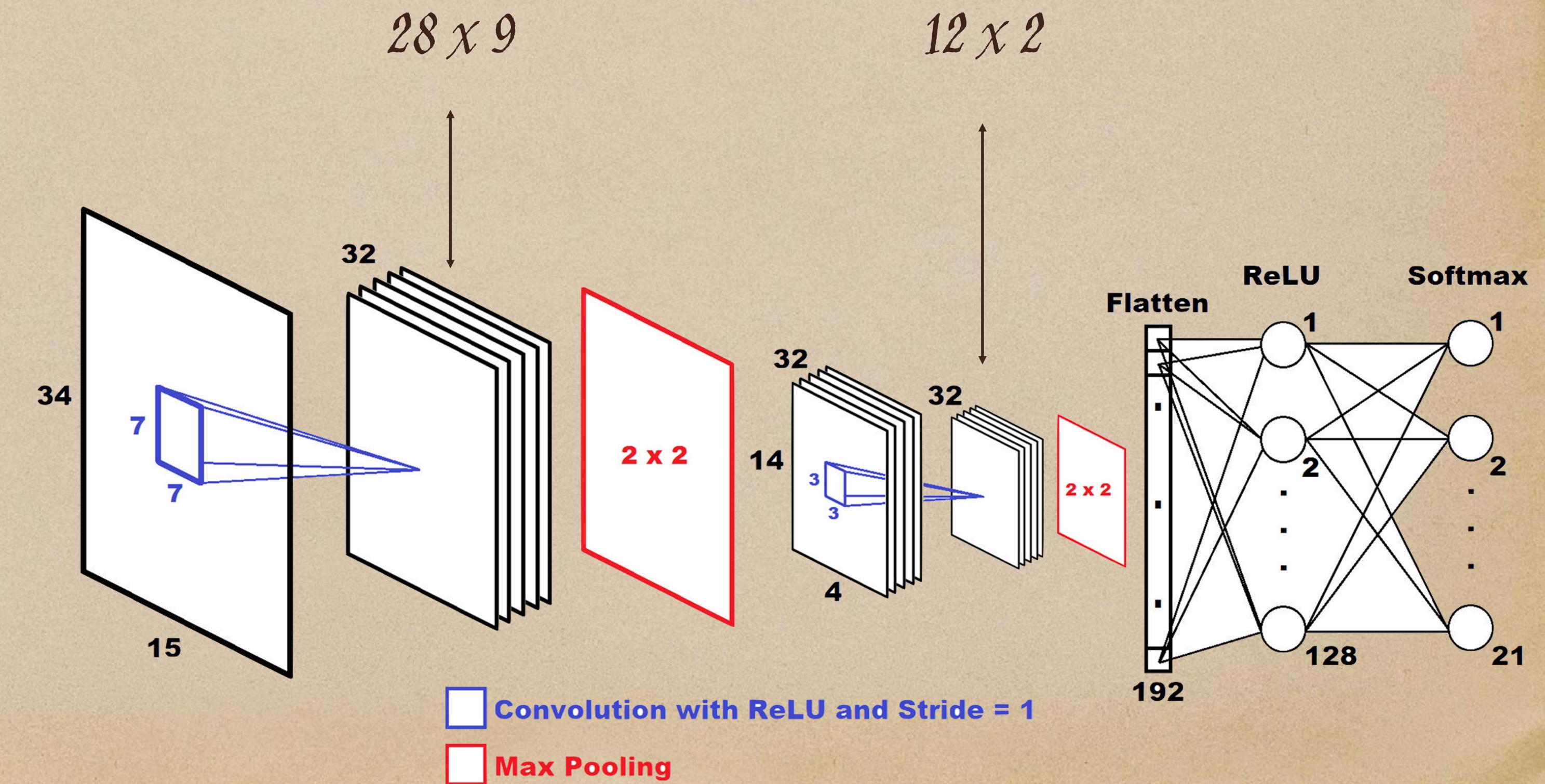
Step 5 MaxPooling $\rightarrow 2 \times 2$

Step 6 Flatten $\rightarrow 192$

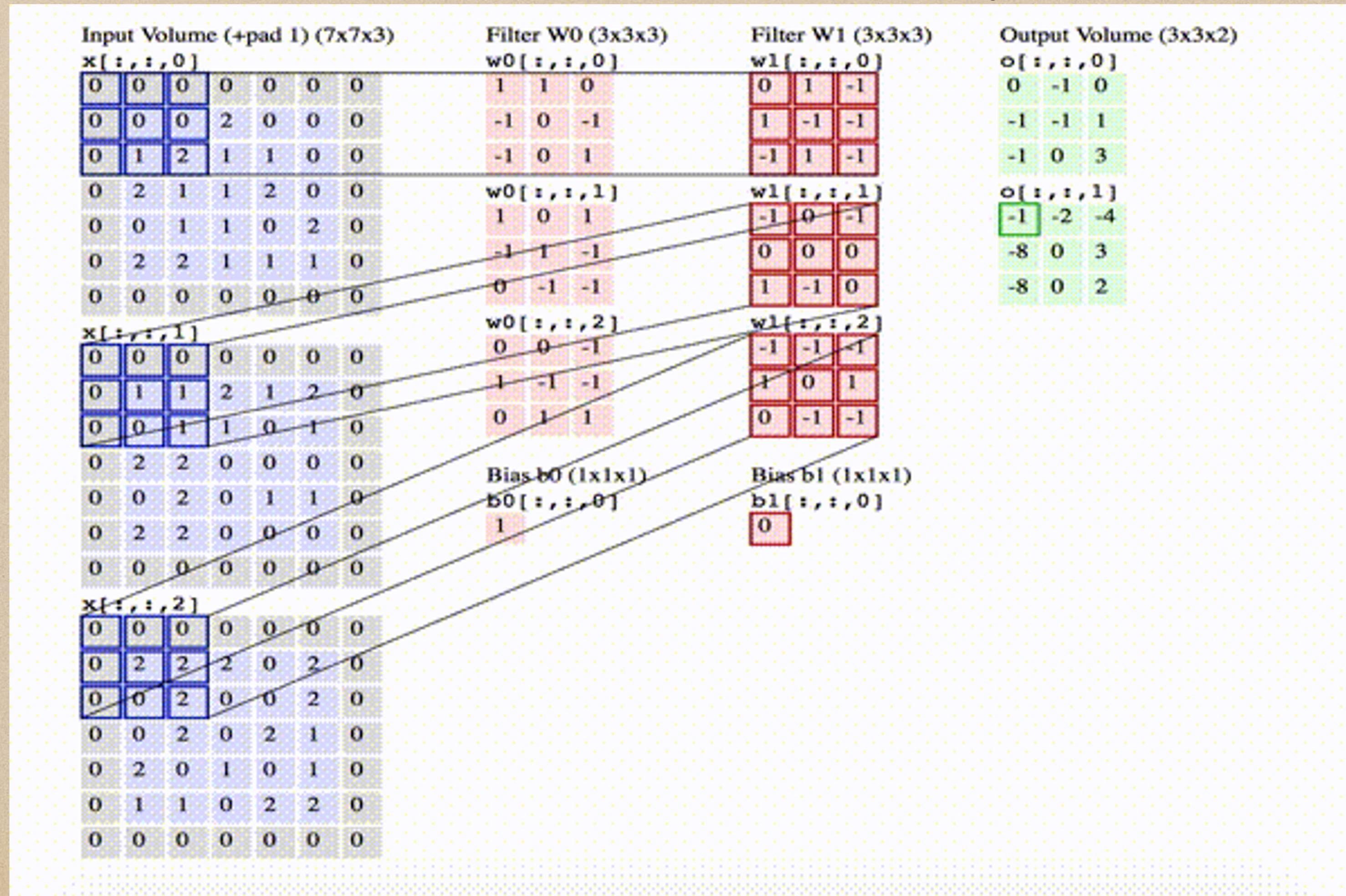
Step 7 Fully Connect $\rightarrow 128$

Step 8 ReLU $\rightarrow 128$

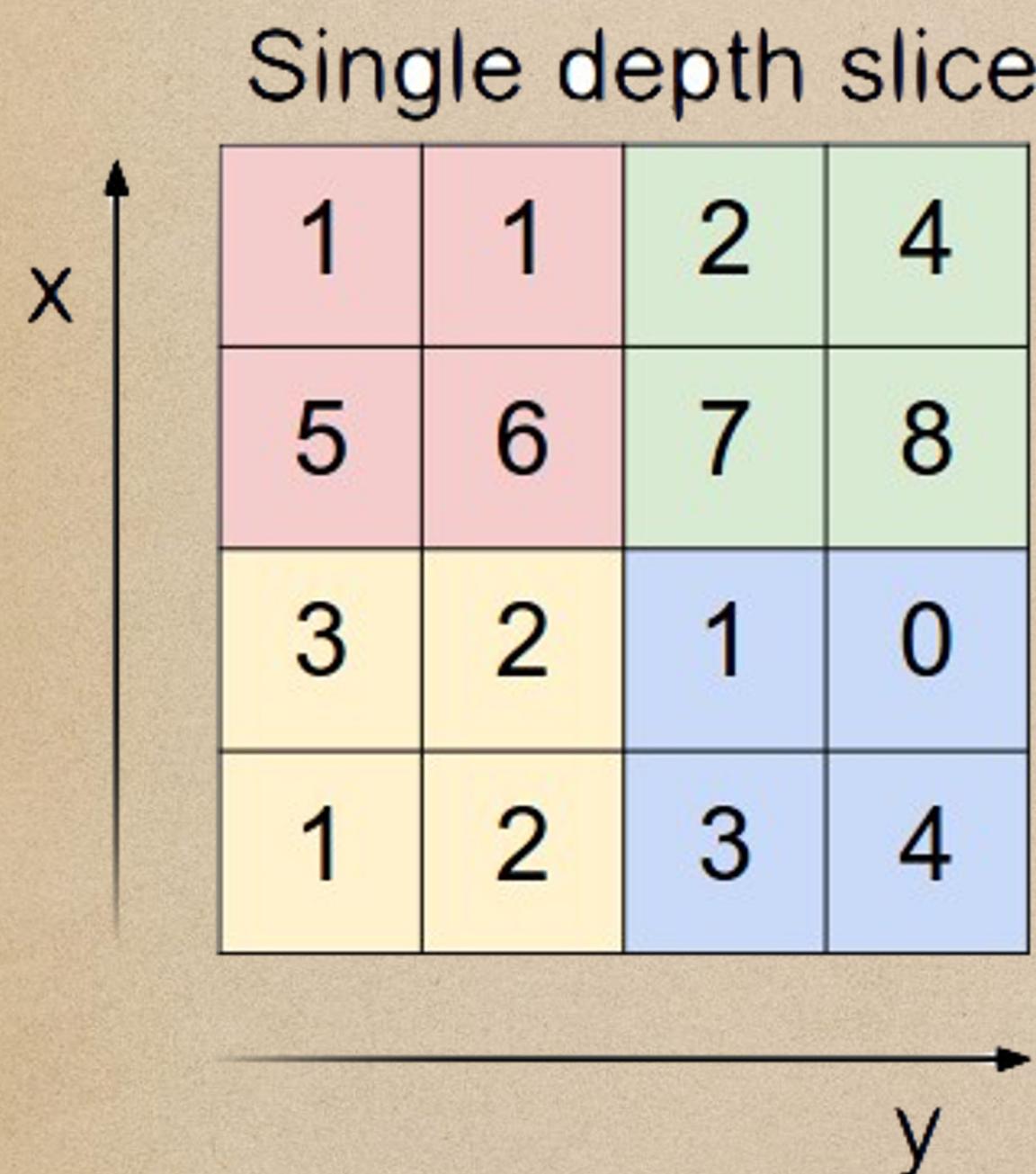
Step 9 Softmax $\rightarrow 21$



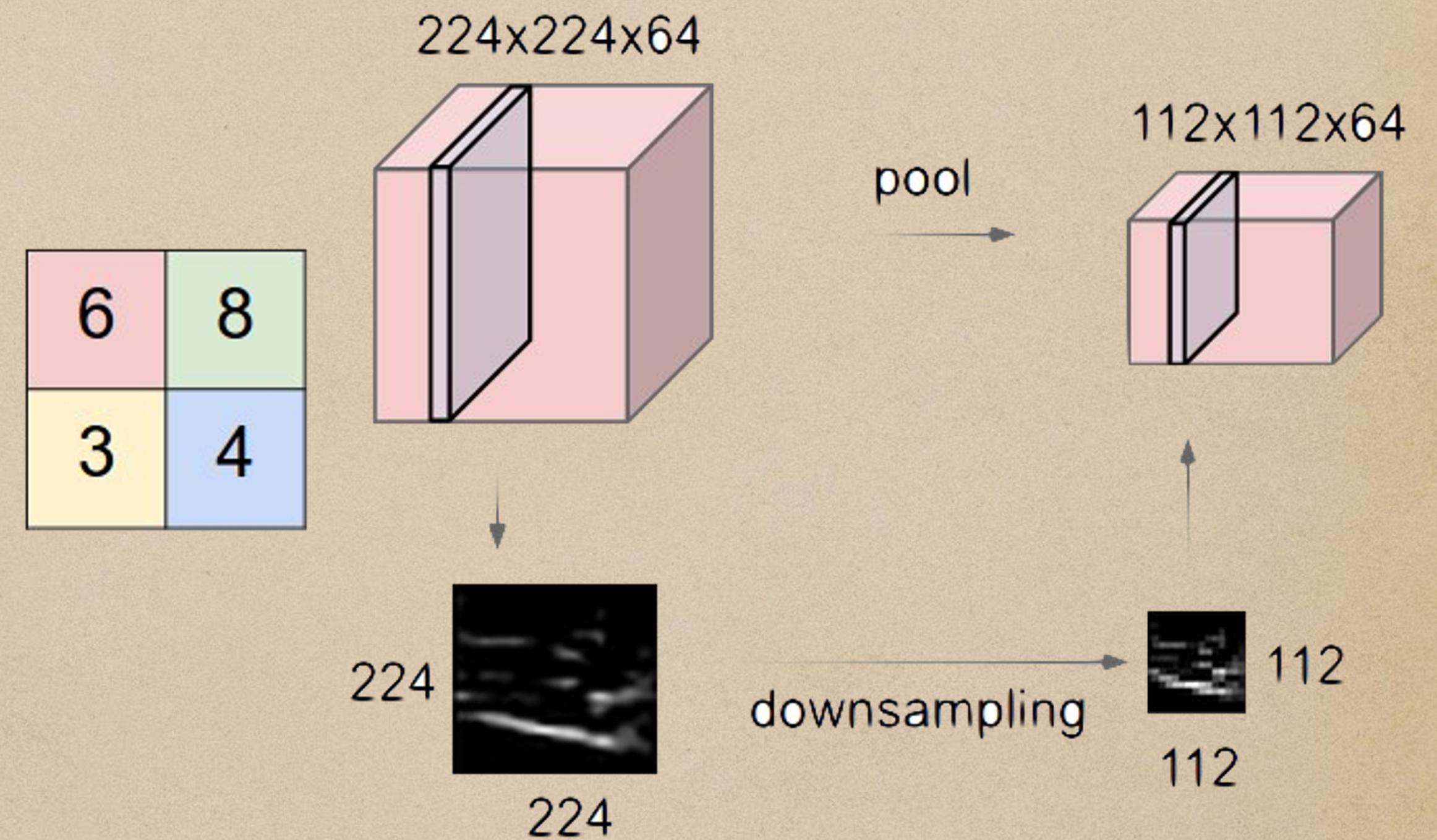
Convolution layer



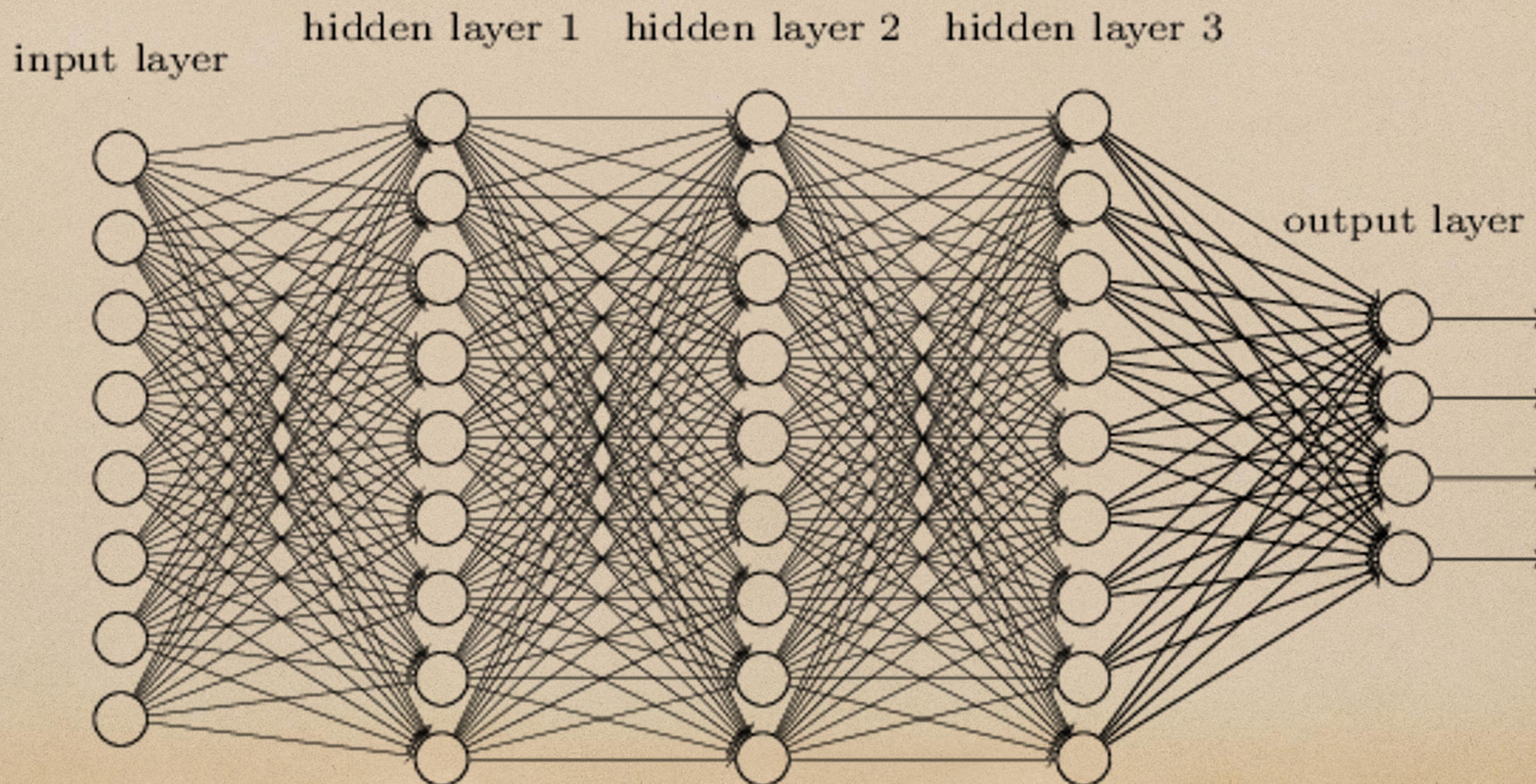
MaxPooling



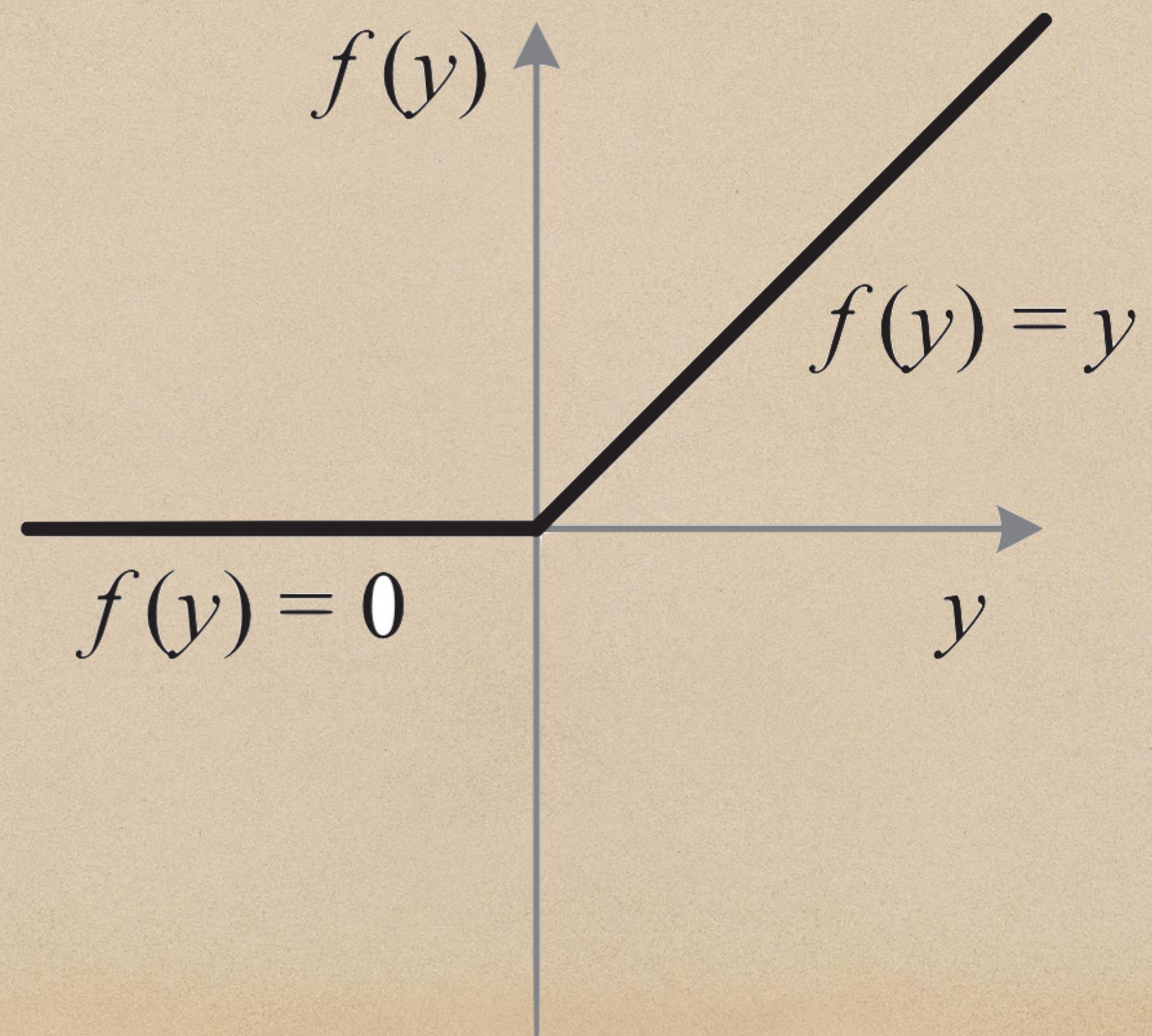
max pool with 2x2 filters
and stride 2

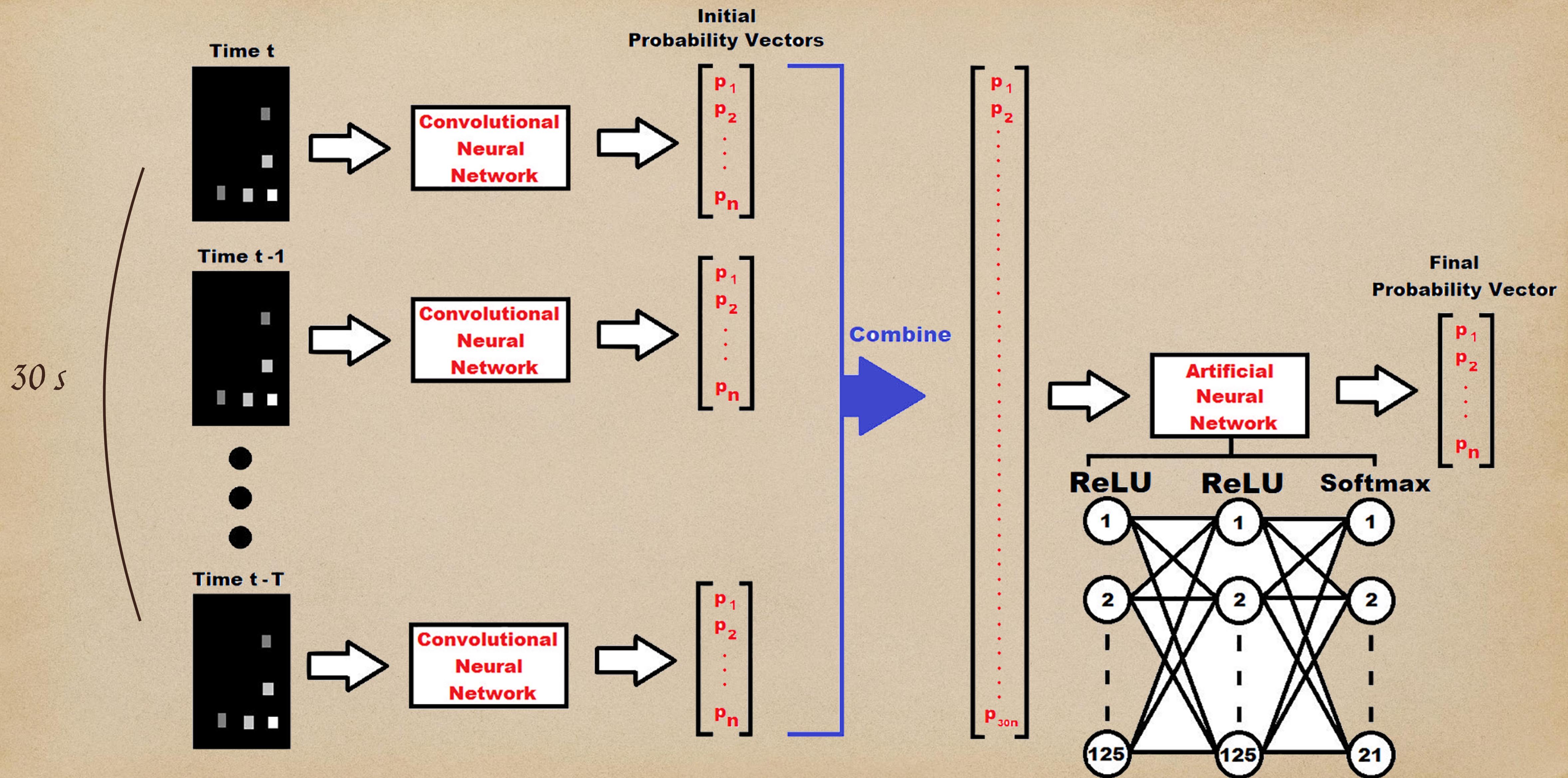


Fully Connect



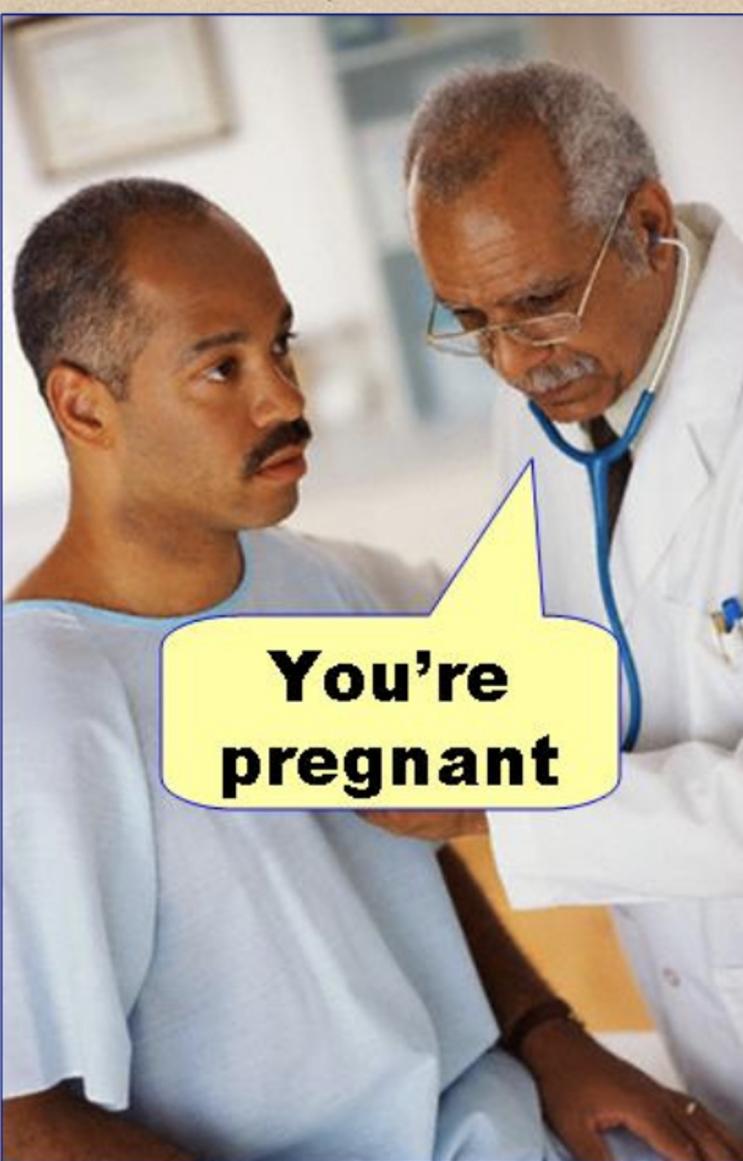
ReLU





Neural Network Evaluation

Type I error
(false positive)



Type II error
(false negative)



Predicted class

	<i>P</i>	<i>N</i>
<i>P</i>	True Positives (TP)	False Negatives (FN)
<i>N</i>	False Positives (FP)	True Negatives (TN)

Evaluation Metrics

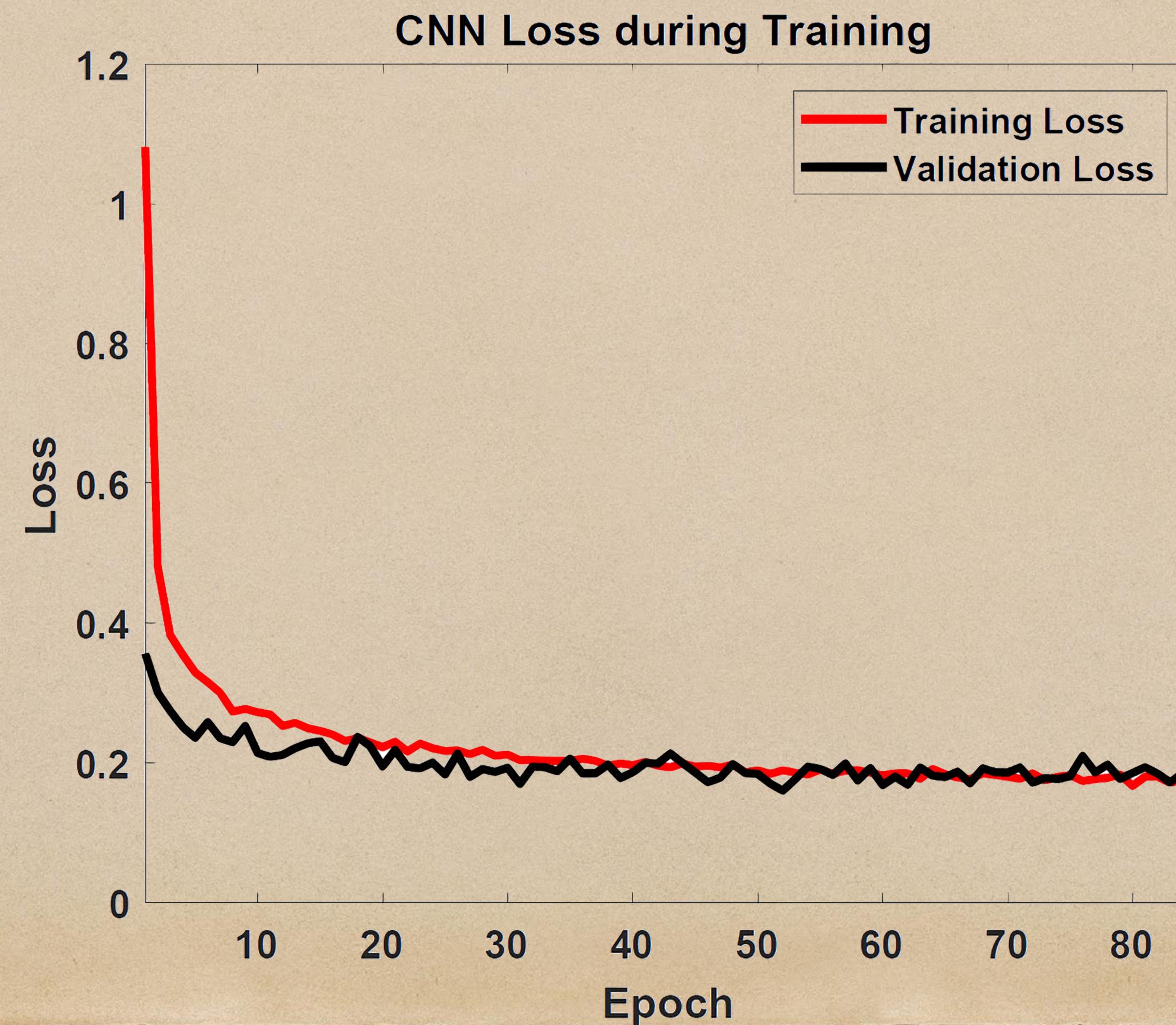
$$\text{precision} = \frac{\text{TP}}{\text{Tp} + \text{FP}}$$

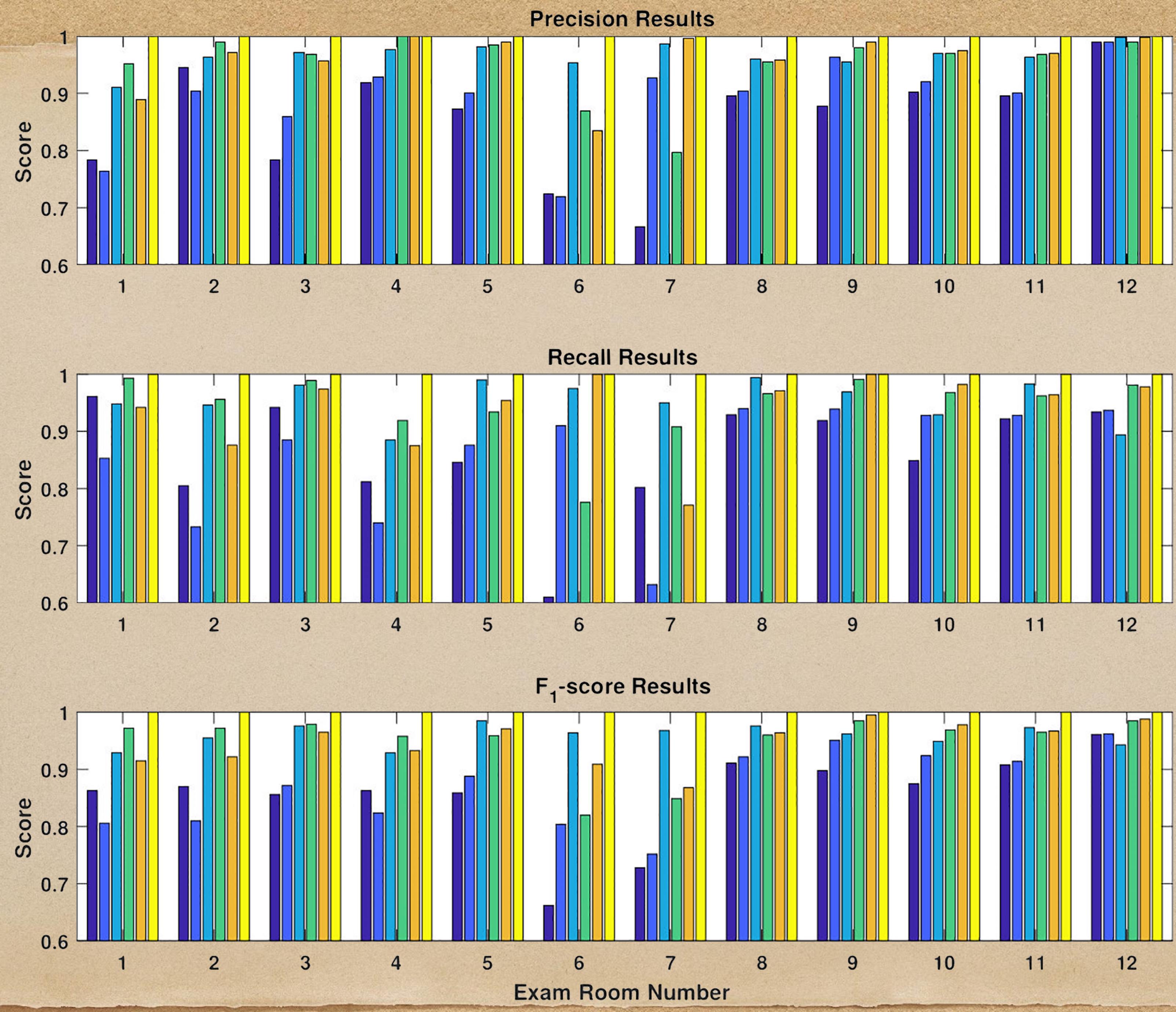
$$\text{Fscore} = \frac{2\text{TP}}{2\text{TP} + \text{FP} + \text{FN}}$$

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}}$$

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}$$

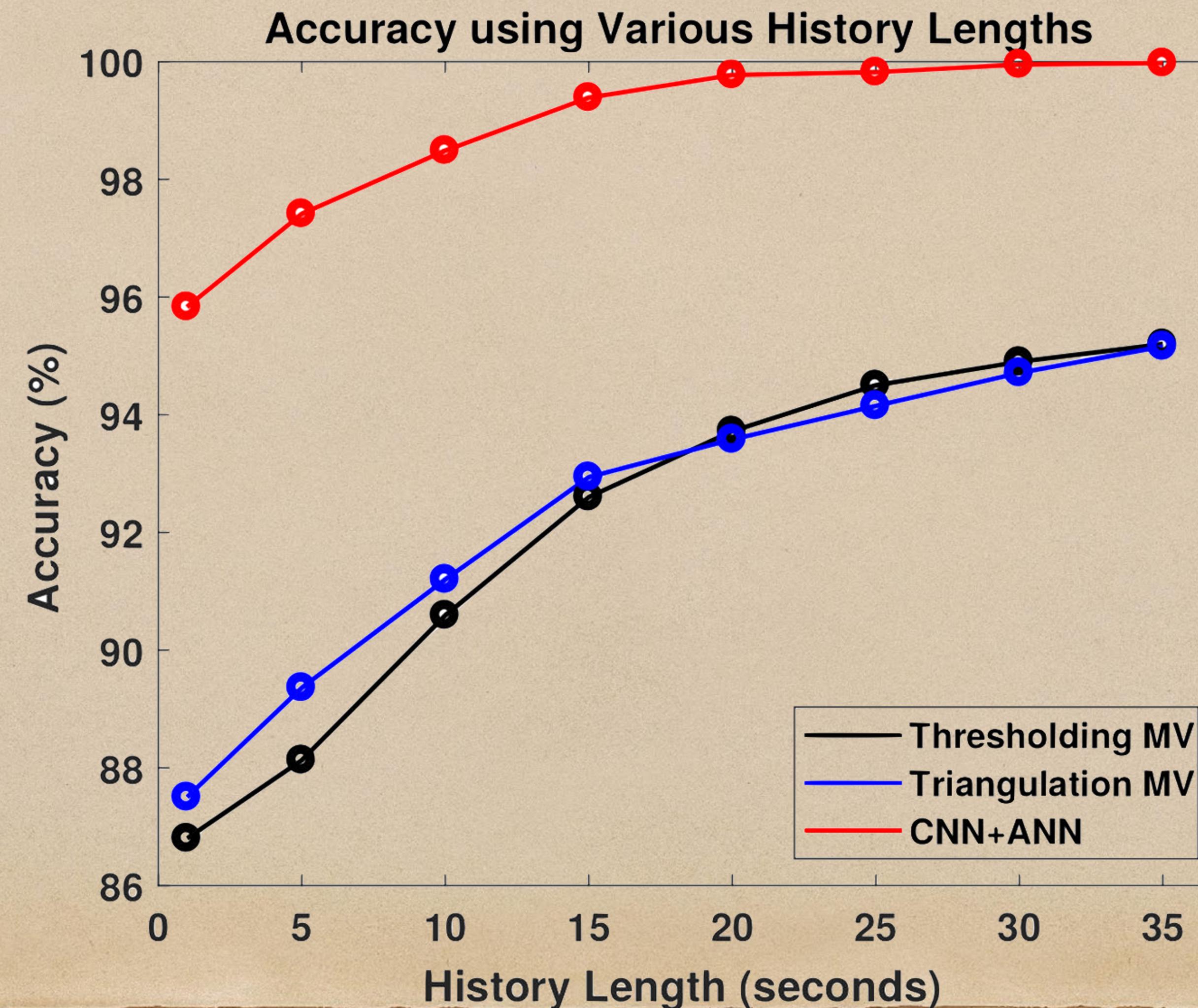
Train Result





Thresholding Triangulation CNN Thresholding MV Triangulation MV CNN+ANN

Result



Conclusion

- $ANN + CNN > CNN$
- $ANN + CNN > thresholding$
- $ANN + CNN > triangulation$