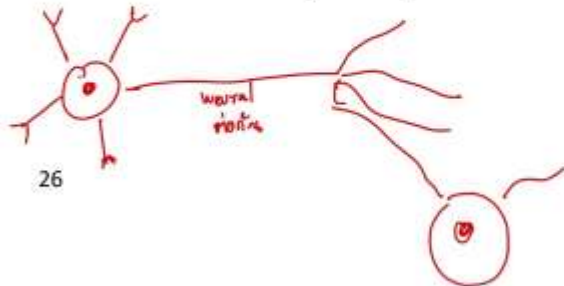
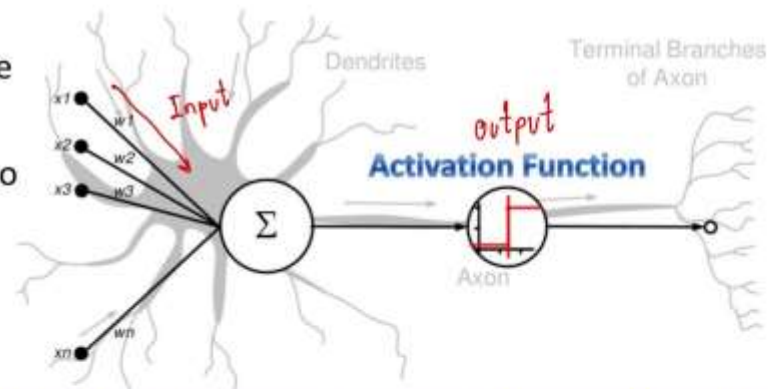


Artificial

Neural Network for Classification

မိန့်ပုံအရ လူ့ဗေဒဆိုင်ရာ/သိပ္ပံပညာရှင်များက

- Started by psychologists and neurobiologists to develop and test computational analogues of neurons
- A neural network: A set of connected input/output units where each connection has a **weight** associated with it
- During the learning phase, the **network learns by adjusting the weights** so as to be able to predict the correct class label of the input tuples



Artificial Neural Networks as an analogy of Biological Neural Networks

Classifier Evaluation Metrics: Confusion Matrix

□ Confusion Matrix:

Actual class\Predicted class	C_1	$\neg C_1$
C_1	True Positives (TP)	False Negatives (FN)
$\neg C_1$	False Positives (FP)	True Negatives (TN)

- In a confusion matrix w. m classes, $CM_{i,j}$ indicates # of tuples in class i that were labeled by the classifier as class j

- May have extra rows/columns to provide totals

□ Example of Confusion Matrix:

Actual class\Predicted class	buy_computer = yes	buy_computer = no	Total
buy_computer = yes	6954	46	7000
buy_computer = no	412	2588	3000
Total	7366	2634	10000

Classifier Evaluation Metrics: Accuracy, Error Rate, Sensitivity and Specificity

A\P	C	¬C	
C	TP	FN	P
¬C	FP	TN	N
	P'	N'	All

- **Classifier accuracy**, or recognition rate

- Percentage of test set tuples that are correctly classified

$$\text{Accuracy} = (TP + TN) / \text{All}$$

- **Error rate**: $1 - \text{accuracy}$, or
 $\text{Error rate} = (FP + FN) / \text{All}$

- **Class imbalance problem**

- One class may be *rare*
 - E.g., fraud, or HIV-positive
- Significant *majority of the negative class* and minority of the positive class
- Measures handle the class imbalance problem
 - **Sensitivity** (recall): True positive recognition rate
 - **Sensitivity** = TP / P
 - **Specificity**: True negative recognition rate
 - **Specificity** = TN / N

Classifier Evaluation Metrics: Precision and Recall, and F-measures

- **Precision:** Exactness: what % of tuples that the classifier labeled as positive are actually positive?

$$P = \text{Precision} = \frac{TP}{TP + FP}$$

TP: True Positive (ที่ model ระบุว่า positive)
FP: False Positive (ที่ model ระบุว่า positive แต่จริงๆ ไม่ใช่)

- **Recall:** Completeness: what % of positive tuples did the classifier label as positive?

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

TP: True Positive (ที่ model ระบุว่า positive)
FN: False Negative (ที่ model ระบุว่า negative แต่จริงๆ เป็น positive)

- Range: [0, 1]
- The “inverse” relationship between precision & recall
- **F measure (or F-score):** harmonic mean of precision and recall
 - In general, it is the weighted measure of precision & recall

$$F_\beta = \frac{1}{\alpha \cdot \frac{1}{P} + (1 - \alpha) \cdot \frac{1}{R}} = \frac{(\beta^2 + 1)PR}{\beta^2 P + R}$$

Assigning β times as much weight to recall as to precision)

- **F1-measure (balanced F-measure)**

- That is, when $\beta = 1$,

$$F_1 = \frac{2PR}{P + R}$$

PR: Precision (↑)
R: Recall (→)

F1-score