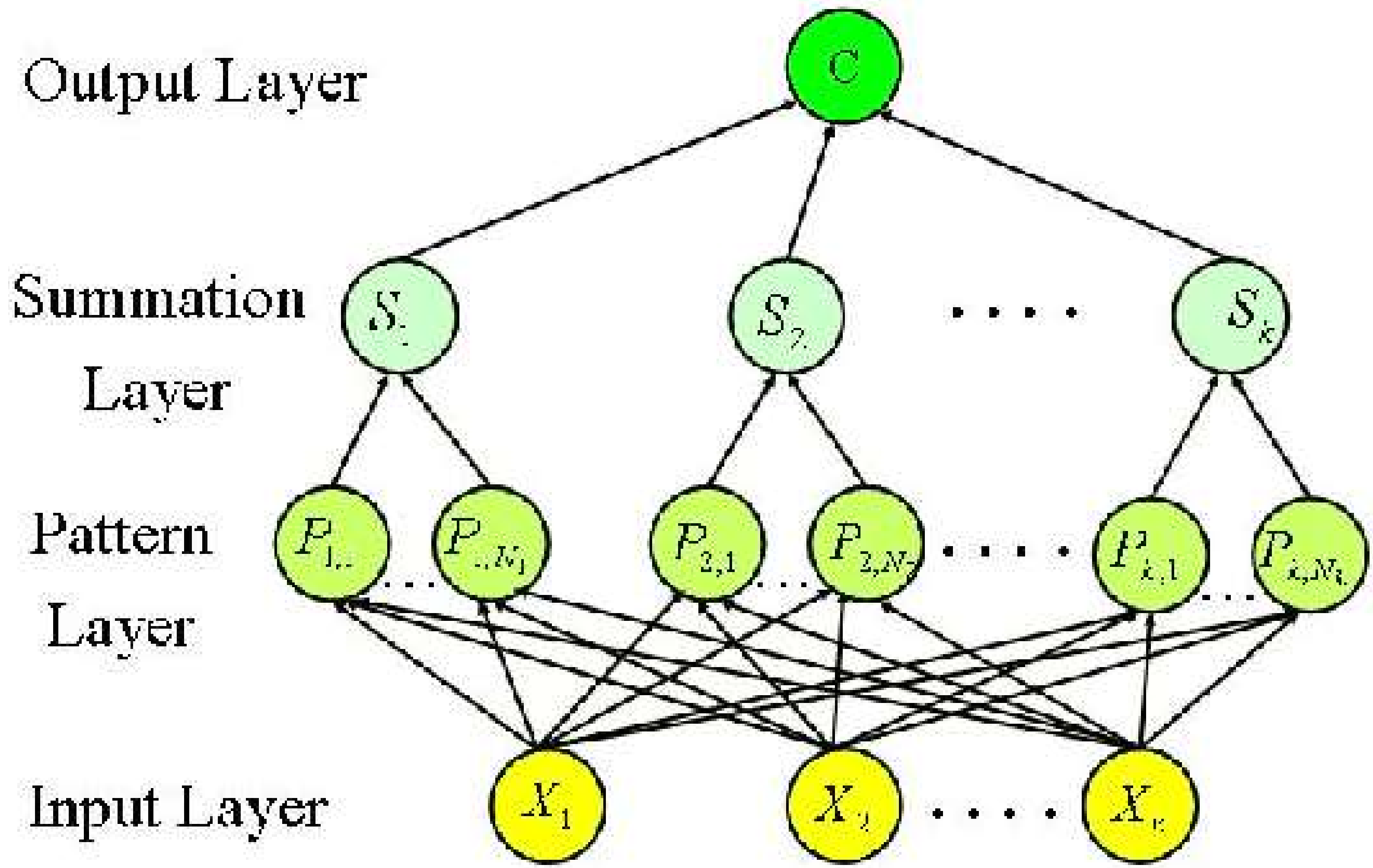
# Introduction

Probabilistic Neural Network was introduced by D.F. Specht in the early 1990s. PNN is a feed forward Neural Network greatly inspired by Bayesian Network.

It's a Four Layer Architecture consists of

1. Input Layer
2. Hidden Layer
3. Pattern Layer/Summation Layer
4. Output Layer

# PNN Architecture



# PNN Architecture Details

**Input Layer:**

It supplies input to the hidden layer. (Extracted Features from the dataset are supplied here).

**Hidden Layer:**

- There are total n Neurons in Hidden Layer.
- They are grouped based on their corresponding class.
- If there are C Classes and n Neurons then in each group there will be n/C neurons.
- Output X at each neuron will be computed by a probability density function ( generally used Gaussian distribution).
- Hence $g_i(x) = \frac{1}{\sqrt{2\prod\sigma^2}} \exp\{-((||x - x_j||)^2 / 2\sigma^2)\}$

Where i=1 …….. n (Neurons in Hidden Layer)

j=1 ………. k (Number of Inputs in Input Layer)

$\sigma$ is the smoothing parameter ( values depends on the data set or estimated heuristically)

# PNN Architecture Details

**Pattern Layer/Summation Layer:**

All the neurons which belongs to that class will be summationed here.

$$f_i(x) = \sum_{j=1}^{l} g_l(x)$$

where i=1 ……… C (Classes)

l is the number of neurons which belongs to that class.

**Output Layer:**

It decides in which class test sample belongs by comparing the f's values of the pattern layer.

***If*** $f_i(x) \geq f_j(x)$ ***// Given*** $i \neq j$

***Then*** $x \in i$ ***(eth number of class)***

***Else***

$x \in j$ ***(eth number of class)***

***End***

# Advantages of using PNN

**Advantages:**

- ✓ Fast Training Process.
- ✓ An inherently parallel structure.
- ✓ Guaranteed to converge to an optimal classifier as the size of the representative training set increases.
- ✓ Training samples can be added or removed without extensive retraining.

**Disadvantages:**

- ✓ Large memory requirements.
- ✓ It is vital to find an accurate smoothing parameter ($\sigma$)

# Applications of PNN

- Probabilistic neural networks in modeling structural deterioration of storm water pipes.
- Probabilistic Neural Networks in Solving Different Pattern Classification Problems.
- Application of probabilistic neural networks to population pharmacokineties.
- Probabilistic Neural Networks to the Class Prediction of Leukemia and Embryonal Tumor of Central Nervous System.
- Ship Identification Using Probabilistic Neural. Networks
- Probabilistic Neural Network-Based sensor configuration management in a wireless AD-HOC network.
- Probabilistic Neural Network in character recognizing.

# Hands On PNN

Let we have 2D dataset, consist of 2 different class represented by different patterns

$\Phi$, and $\Psi$

Samples belongs to class $\Phi$

(1,5), (3,2)

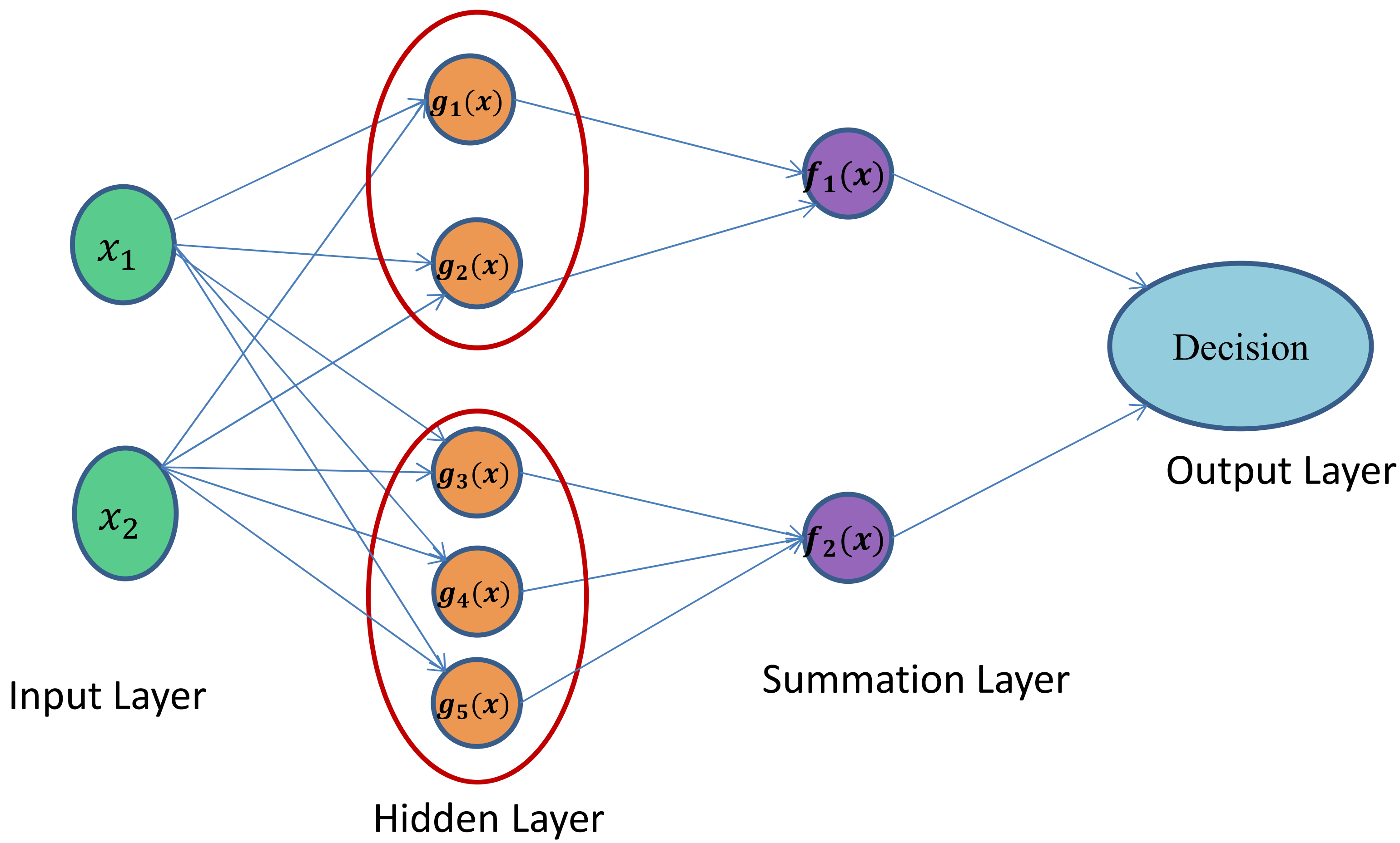
Samples belongs to class $\Psi$

(7,9),(8,6),(9,5)

and let the smoothing parameter $\sigma$=.5

# Hands On PNN

## Network Details:



# Hands On PNN

**Calculation at Hidden Layer:**

if the $\sigma$ is fixed we will have only

$$g_i(x) = \exp\{ -((||x - x_j||)^2 / 2\sigma^2)\}$$

$$g1(x)=\exp\{-\frac{(x_1-1)^2 + (x_2-5)^2}{(.5)^2}\}$$

$$g2(x)=\exp\{-\frac{(x_1-3)^2 + (x_2-2)^2}{(.5)^2}\}$$

$$g3(x)=\exp\{-\frac{(x_1-7)^2 + (x_2-9)^2}{(.5)^2}\}$$

$$g4(x)=\exp\{-\frac{(x_1-8)^2 + (x_2-6)^2}{(.5)^2}\}$$

$$g5(x)=\exp\{-\frac{(x_1-9)^2 + (x_2-5)^2}{(.5)^2}\}$$

# Hands On PNN

**Calculation at Pattern/Summation Layer:**

$$f_1(x) = g_1(x) + g_2(x)$$

$$f_2(x) = g_3(x) + g_4(x) + g_5(x)$$

**Calculation at Output Layer:**

*If* $(f_1(x) >= f_2(x))$

*X will belong to* $f_1$ *class*

*Else*

*X will belong to* $f_2$ *class*

# Hands On PNN

**Testing:**

***Let we have a testing vector***

***(3,5)***

***Then***

***At output layer we have***

$$f_1(x) = \exp\{-\frac{(3-1)^2 + (5-5)^2}{(.5)^2}\} + \exp\{-\frac{(3-3)^2 + (5-2)^2}{(.5)^2}\} = 3.3546e\text{-}004$$

$$f_2(x) = \exp\{-\frac{(3-7)^2 + (5-9)^2}{(.5)^2}\} + \exp\{-\frac{(3-8)^2 + (5-6)^2}{(.5)^2}\} + \exp\{-\frac{(3-9)^2 + (5-5)^2}{(.5)^2}\} = 6.8136e\text{-}046$$

# Hands On PNN

**Testing:**

**Here** $f_2(x) > f_1(x)$

**Therefore testing samples x will belong to**

$f_{2\ (second\ class)}$

# Thanks

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