Probabilistic Neural Network (PNN)

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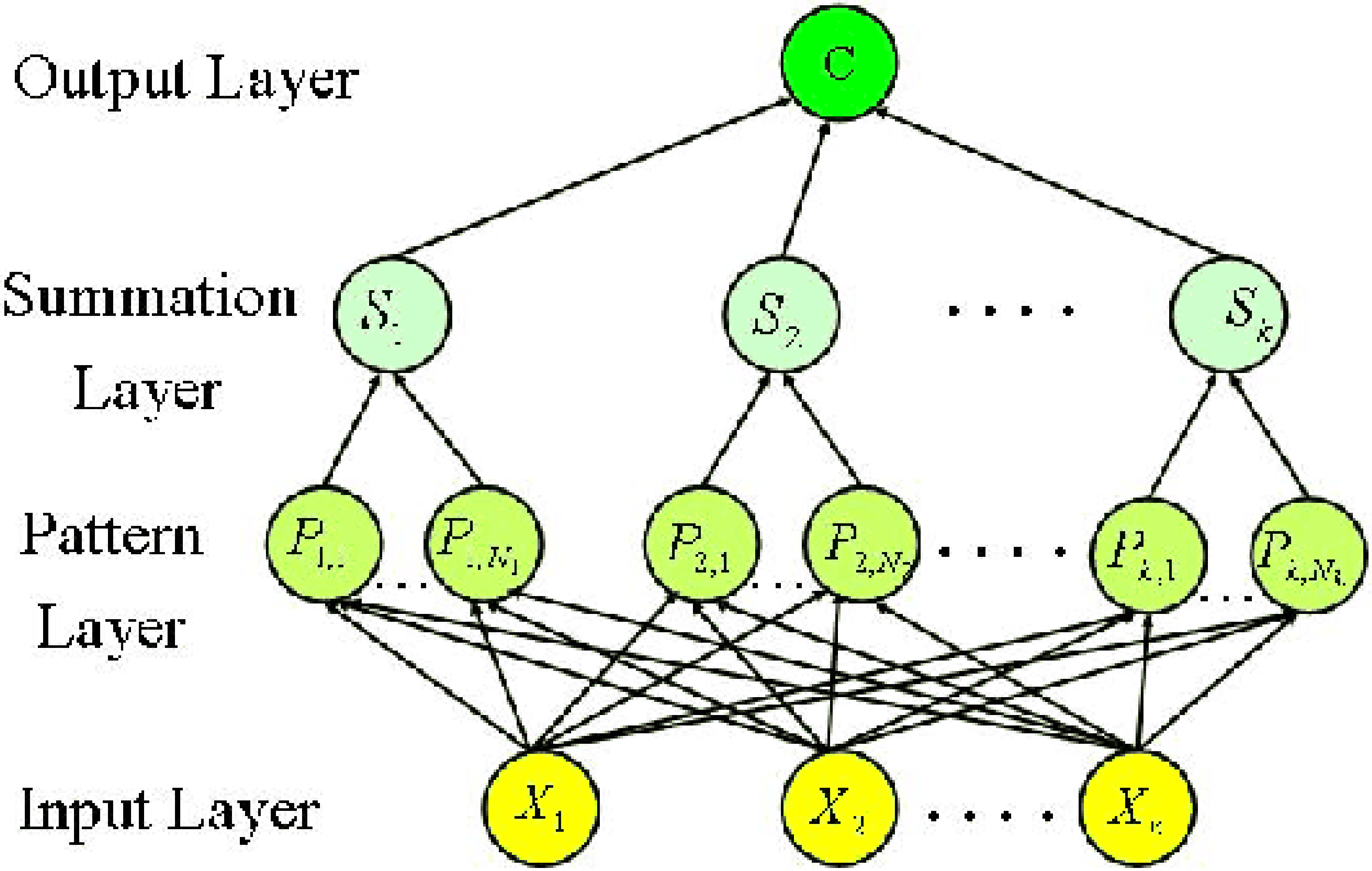
Introduction

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{ $-((||\mathrm{x} - x_j||)^2 \ / \ 2\sigma^2)$}

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

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

σ 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≠j***

Then x ∈ i (eth number of class)

Else

x ∈ 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 (σ)

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

Φ, and Ψ

Samples belongs to class Φ

(1,5), (3,2)

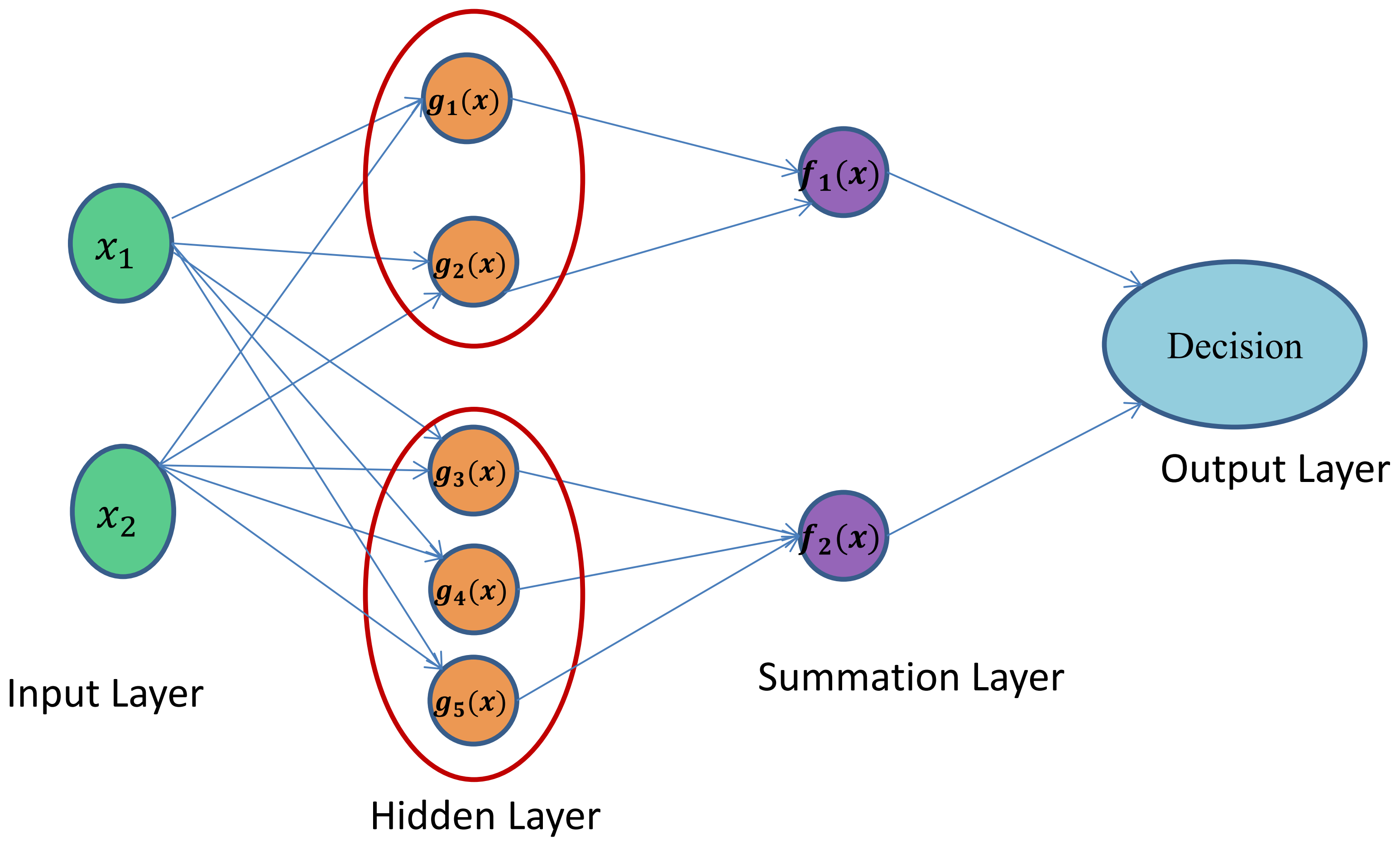
Samples belongs to class Ψ

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

and let the smoothing parameter σ=.5

Hands On PNN

Network Details:



Hands On PNN

Calculation at Hidden Layer:

if the σ 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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