

Digital Neural Network Hardware For Classification

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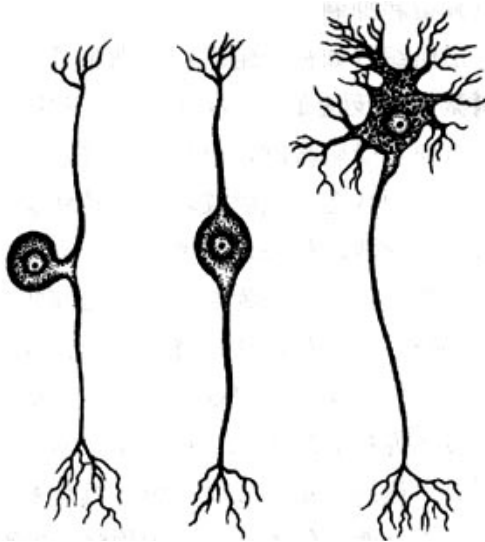


Overview

1. Introduction
 - *Motivation*
2. Parts of the Project
 - *Board*
 - *ZISC*
 - *Application*
 - *ZISC and QuickCog*
3. Conclusion

Motivation

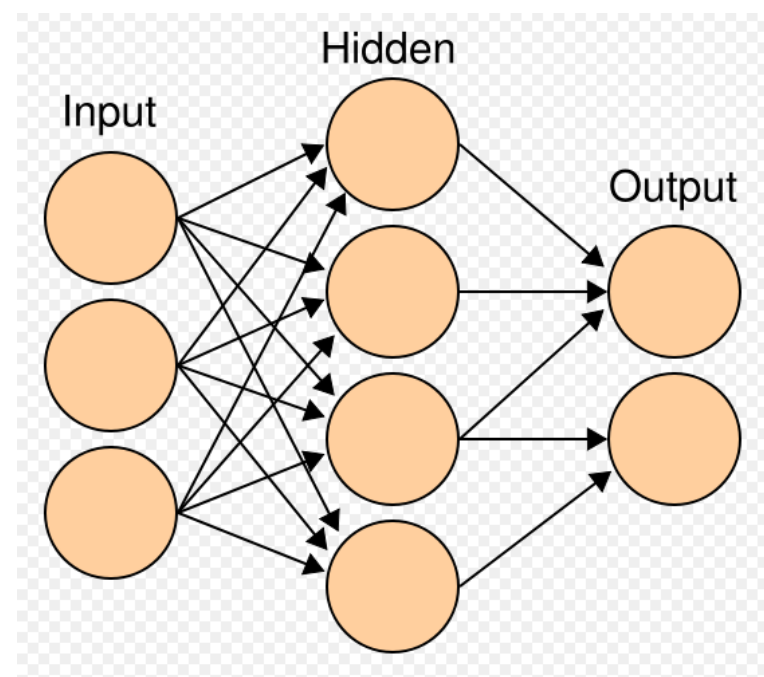
- Neural Network



Neuron

- Other advantages include:

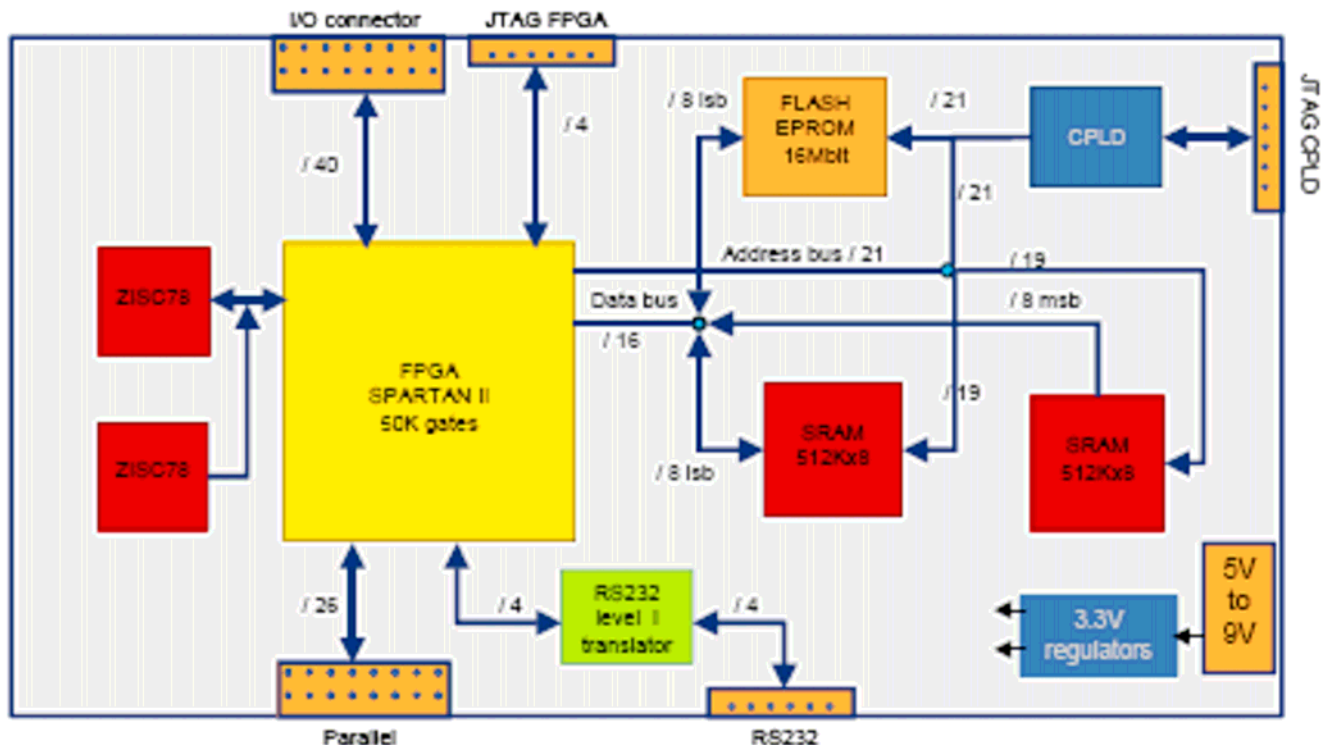
- Adaptive learning
- Self-Organisation
- Real Time Operation
- Fault Tolerance via Redundant Information Coding



Neural Network

Board

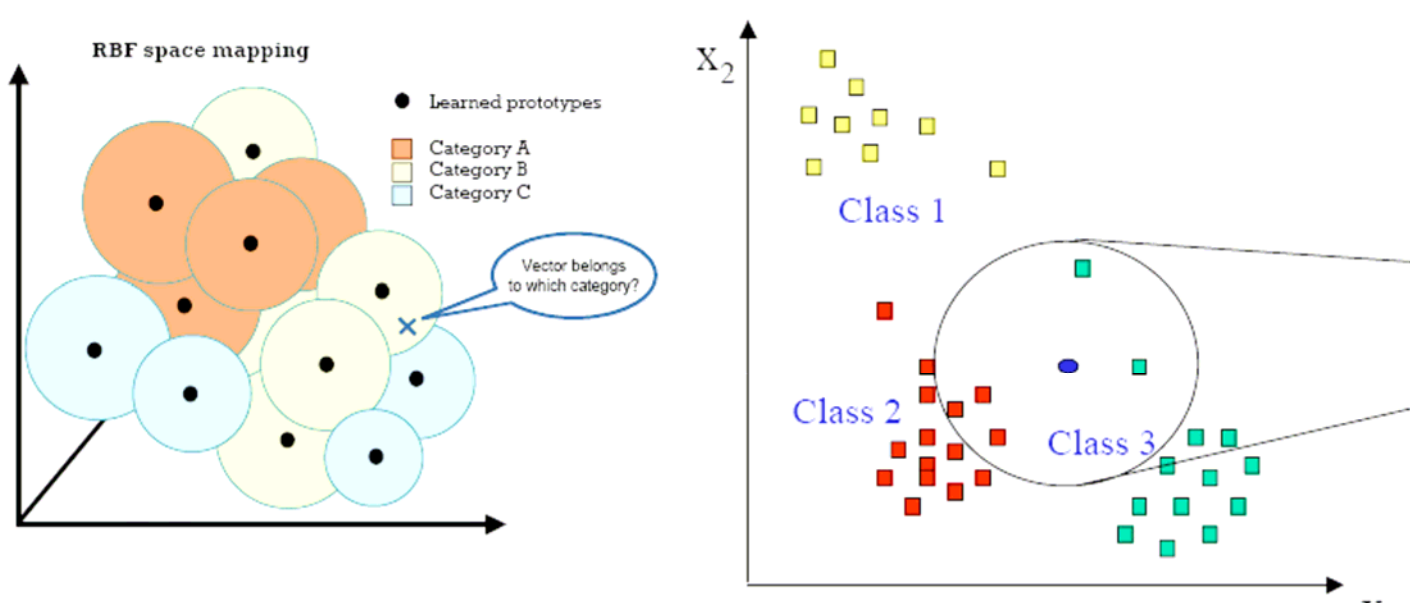
- **MUREN:**High-Speed Pattern Recognition Embedded Board Using a ZISC Neural Network



ZISC—Neural Model

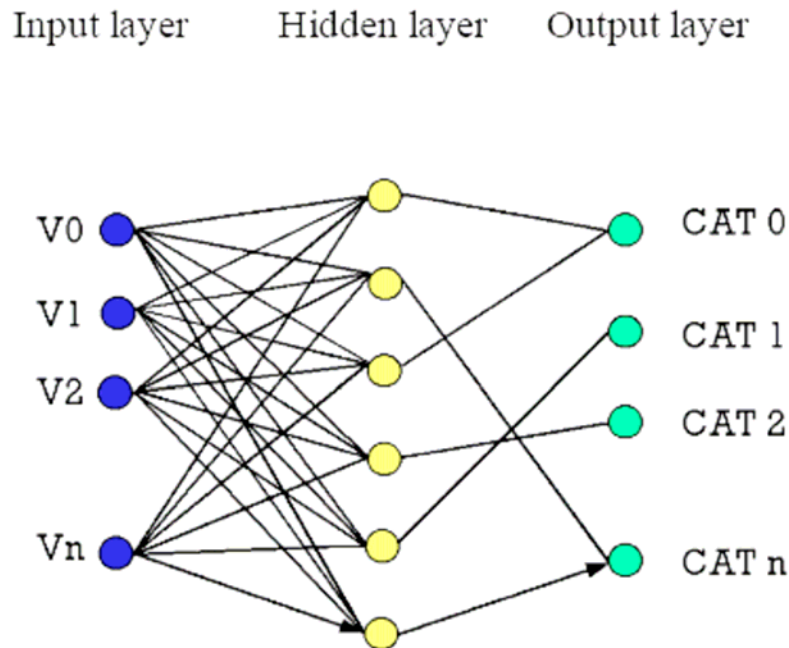
- ZISC: Zero Instruction Set Computing

The neural network model can be a Radial Basis Function or K-Nearest Neighbor model. No need programming!



ZISC—Network

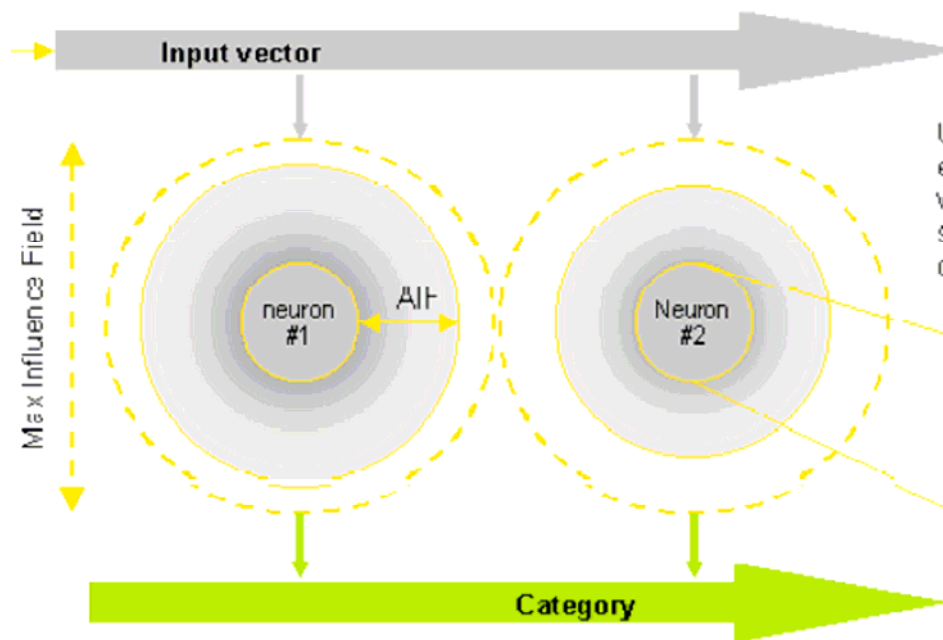
- RBF neural network model**



RBF-like Network Topology

ZISC—Field

- Actual Influence Field (AIF)
- Maximum Influence Field (MAF)
- Minimum Influence Field (MIF)

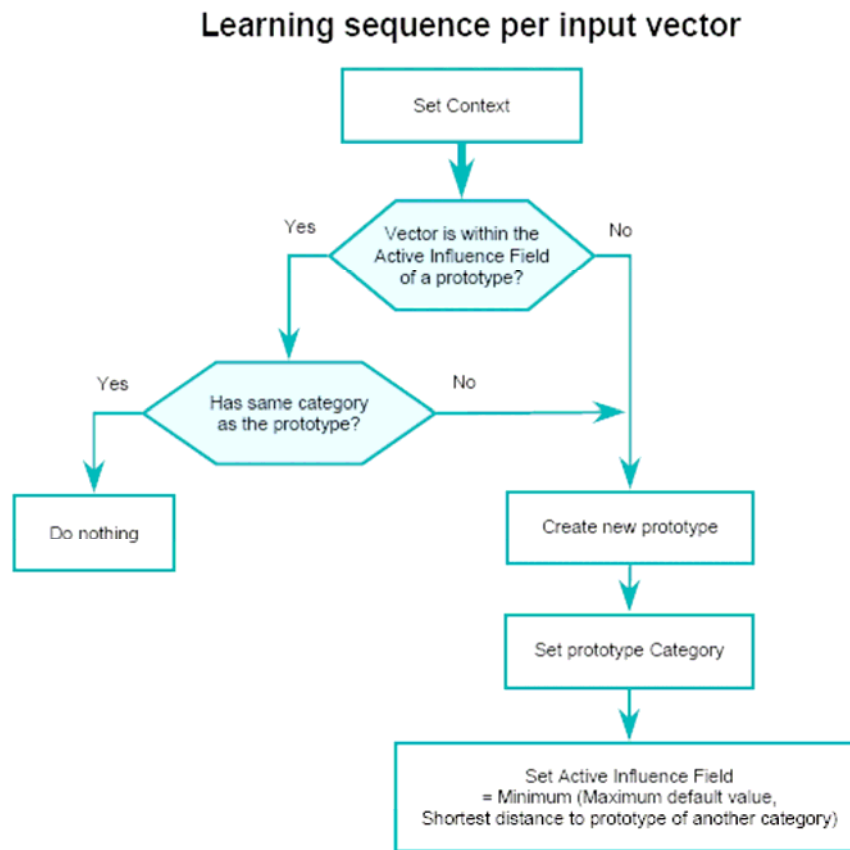


ZISC—Field

- **The Active Influence Field (AIF)**
Defines the space around a given prototype where generalization can occur.
- **The Maximum Influence Field (Maxif)**
Defines the largest influence field value that can be assigned to a neuron newly committed following the learning of a new prototype.
- **The Minimum Influence Field (Minif)**
Defines the value below which an influence field shrinks.

ZISC—Training

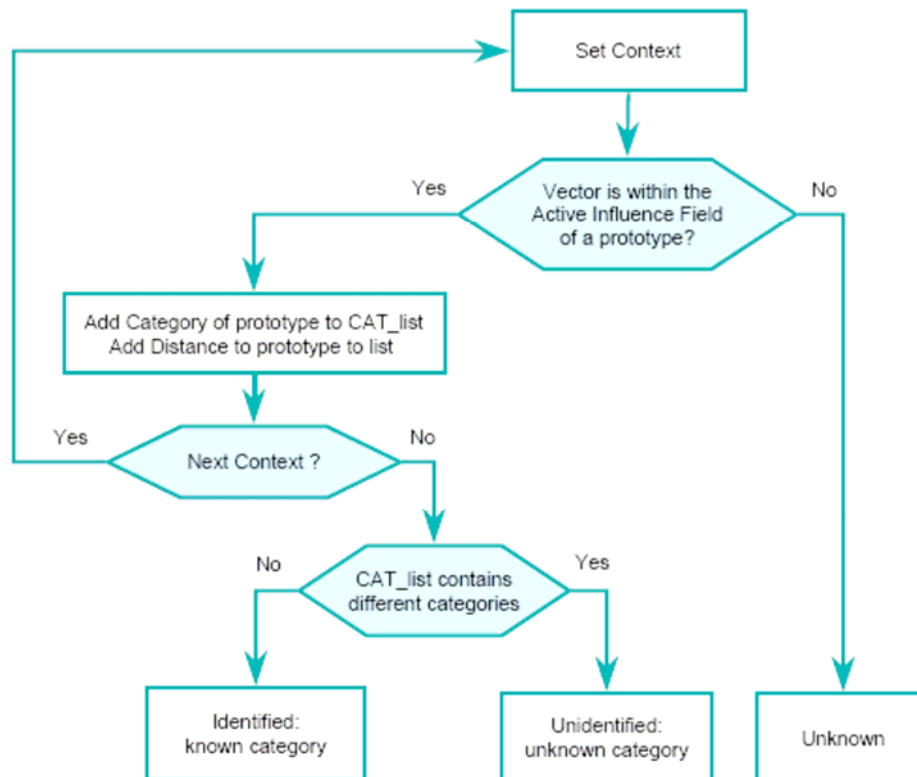
- Three Steps: Learning, Testing, Recognition/Classification



ZISC—Recognition

- Recognition/Classification

Recognition sequence per input vector



ZISC—Problem

- Where Unidentified classification comes from?

Several prototypes with different categories but overlapping Active Influence

Field due to a reduction limited to the Minimum Influence.

Different identification of a vector under different context (i.e. sub-networks).

- How can we solve?

Use KNN!

C_WIZARD

- Classification Software C_WIZARD
- C_WIZARD is designed to build, evaluate and fine-tune a ZISC-based recognition engine.
- Four Mode : Learn, Test, Recognition, View
- Data Files

Comma separated value (CSV) format:

Context value	Category value	Vector components
(1-byte)	(2-byte)*	(64-byte)

Application — Create Input Files

- We used the Breast cancer data.
- classes: 2; samples: 683; features: 10
- Jung-Ying Wang from the National Taiwan University has used the BP neural network to classify the Breast cancer data with 10-fold cross-validation.
- Data Mining Analysis (breast-cancer data)
<http://www.csie.ntu.edu.tw/~p88012/AI-final.pdf>
- The correctly classified is 95.1684%.
- The incorrectly classified is 4.8316%.

Application — Create Input Files

- First, change the data into the ASCII form in Matlab
- Normalization: 0-255
- Create Context, Category and Vector
- Learn samples : 199, Test samples:199, Recognition: 171

	A	B	C	D	E	F	G	H	I	J
1	17.99	20.57	19.69	11.42	20.29	12.45	18.25	13.71	13	12.46
2	10.38	17.77	21.25	20.38	14.34	15.7	19.98	20.83	21.82	24.04
3	122.8	132.9	130	77.58	135.1	82.57	119.6	90.2	87.5	83.97

	A	B	C	D	E	F	G	H	I	J	K
1	0	1	29.979	97.447	28.758	13.618	119.18	45.639	12.977	19.062	84.614
2	0	1	96.417	86.667	91.121	59.134	72.699	26.703	11.633	24.575	58.598
3	0	1	59.245	98.827	57.446	31.4	103.82	48.353	15.265	27.617	123.51
4	0	1	73.607	51.742	73.728	40.724	126.31	84.176	27.292	39.416	116.81
5	0	1	59.728	101.93	57.693	31.92	103.71	46.234	19.884	25.449	80.879
6	0	1	93.038	36.823	95.914	55.446	116.19	128.45	86.633	79.846	132.14

Application—Learn

C_Wizard 3.0.0
File View Help

Learn | View | Test | Recognition

Controls

Learn Abort

First Sample: 1
Last Sample: 199
Iterations: 5
Time (sec.): 105,70

Neuron Growth

Committed Neurons Per Category

Category: 1
Neurons: 13

Data File Information

Data File Path: C:\Programme\Silicon Recognition\C_Wizard\D
Number of Samples: 199
Input Format: Binary ASCII

Zisc Information

Neurons Committed: 28
Clear Zisc

Minimum Influence Field: 2
Maximum Influence Field: 4096
Mode: RBF KNN

Application—Test

C_Wizard 3.0.0
File View Help

View Learn Test Recognition

Controls

Test Abort

First Sample: 1
Last Sample: 199
Iterations: 0
Time (sec.): 11,203

Identified
Correct: 174 (87,43 %) Incorrect: 3 (1,507 %)
Uncertain
Correct: 1 (0,502 %) Incorrect: 3 (1,507 %)
Unidentified: 18 (9,045 %)
Summary
Correct Id. 87 % Error(s) 2 % Unknown 9,045 %

Data File Information
Data File Path: C:\Programme\Silicon Recognition\C_Wizard\D
Number of Samples: 199
Input Format: Binary ASCII

Zisc Information
Neurons Committed: 28
Clear Zisc

Minimum Influence Field: 2
Maximum Influence Field: 4096
Mode: RBF KNN

Total Hits Per Category

Category	Hits
1	219
2	120

Category: 1
Hits: 219

Application—Recognition/Classification

The screenshot displays the C_Wizard 3.0.0 software interface, which is used for neural network training and recognition. The interface is divided into several sections:

- View, Learn, Test, Recognition:** A horizontal menu at the top of the main workspace.
- Controls:** A section on the left containing a progress bar, a "Classify" button, an "Abort" button, and input fields for "First Sample" (1), "Last Sample" (171), "Iterations" (0), and "Time (sec.)" (9.8437).
- Classification Results:** A central area showing the following data:

Identified	150	Percentage	87.71929 %
Uncertain	10	Percentage	5.847953 %
Unidentified	11	Percentage	6.432748 %
Recognition	17,37142	Patterns Per Second	
- Data File Information:** A section on the right showing the "Data File Path" as "C:\Programme\Silicon Recognition\C_Wizard\D" and the "Number of Samples" as 171.
- Input Format:** Radio buttons for "Binary" and "ASCII", with "ASCII" selected.
- Zisc Information:** A section showing "Neurons Committed" as 28 and a "Clear Zisc" button.
- Minimum Influence Field:** A green bar indicating a value of 2.
- Maximum Influence Field:** A green bar indicating a value of 4096.
- Mode:** Radio buttons for "RBF" (selected) and "KNN".
- Total Hits Per Category Per Vector:** A bar chart at the bottom left showing hits for two categories (1 and 2) across two vectors. Category 1 has 3 hits for vector 1 and 1 hit for vector 2. Category 2 has 1 hit for vector 1 and 3 hits for vector 2.
- Category:** A dropdown menu set to 1.
- Hits:** An input field set to 3.
- Vector:** An input field set to 1.

Letter Recognition

- I used the Letter Image Data which I have classify in the sensor signal processing project:

An Image Processing Application on QuickCog and Matlab: “Letter Recognition”

- classes: 7; samples: 126; features: 35
- I divide the whole data into 4 sets: learn (60 samples), test (54 samples), recognition (12 samples).

Learn

C_Wizard 3.0.0
File View Help

Learn | View | Test | Recognition

Controls

Learn Abort

First Sample: 1
Last Sample: 60
Iterations: 4
Time (sec.): 25,515

Neuron Growth

Committed Neurons Per Category

Category	Neurons
3	4
2	3
7	1
6	5
1	1
4	6
5	3

Category: 3
Neurons: 4

Data File Information

Data File Path: C:\Dokumente und Einstellungen\student\Desktop

Number of Samples: 60

Input Format: Binary ASCII

Zisc Information

Neurons Committed: 23

Clear Zisc

Minimum Influence Field: 2
Maximum Influence Field: 4096

Mode: RBF KNN

Test

C_Wizard 3.0.0
File View Help

View Learn Test Recognition

Controls

Progress bar: [-----]

Test [Test] First Sample: 1
Abort [Abort] Last Sample: 54

Iterations: 0 Time (sec.): 2,9531

Identified
Correct: 31 (57,40 %) Incorrect: 4 (7,407 %)

Uncertain
Correct: 3 (5,555 %) Incorrect: 3 (5,555 %)

Unidentified
13 (24,07 %)

Summary
Correct Id. 62 % Error(s) 12 % Unknown 24,07 %

Data File Information
Data File Path: C:\Programme\Silicon Recognition\C_Wizard\4
Number of Samples: 54
Input Format: Binary ASCII

Zisc Information
Neurons Committed: 23
[Clear Zisc]

Total Hits Per Category

Category: 3 Hits: 16

Category	Hits
3	16
2	7
7	4
6	9
1	8
4	6
5	6

Minimum Influence Field: 2
Maximum Influence Field: 4096
Mode: RBF KNN

Change Maxif and Minif

- Change the Maxif and Minif
- Maxif: 300,1000,2000,5000,10000.
- Minif: 0.1,0.001,1,5,10.
- If Maxif is small, the result will be worse.
- If Maxif is larger than 1000, the result is no change.
- Changing Minif makes no change.
- Keep the default Maxif and Minif.

Recognition

C_Wizard 3.0.0
File View Help

View Learn Test Recognition

Controls

Progress bar: [-----]

Classify (button) First Sample:
Abort (button) Last Sample:
Iterations: Time (sec.):

Identified Percentage %
Uncertain Percentage %
Unidentified Percentage %
Recognition Patterns Per Second

Data File Information

Data File Path:
Number of Samples:
Input Format: Binary ASCII

Zisc Information

Neurons Committed: **23**
Clear Zisc (button)

Minimum Influence Field: Mode: RBF KNN
Maximum Influence Field:

Total Hits Per Category Per Vector

Category:
Hits:
Vector:
Navigation: [K] [<] [>] [>|]

Bar chart showing hits per category (3, 2, 7, 6, 1, 4, 5) for vector 1. The y-axis ranges from 0.0 to 1.0. Category 3 has a hit of 1.0.

Result

- ZISC Result
- Identified: 62%
- Uncertain: 5.55%
- Unidentified: 24.07%
- Compare with QuickCog
- learn (60 samples), test (54 samples), <D:\Program Files\QuickCog\QuickCog.exe>
- Identified: 85.185 %
- Uncertain: 0%
- Unidentified: 14.81%

Conclusion

- The goal of the project is to classify data with the hardware neural network.
- I use the breast cancer data and the letter data I have used in the project of sensor signal processing in QuickCog.
- Compare with the software computing, the hardware neural network
- Don't need programming.
- Memory Requirements
 - 2 SRAM of 512Kx8-bit for general-purpose data storage
 - Flash EPROM to store a configuration file
- Running Time: Fast
- Real Time Application
 - Neural Network: Parallel Process
 - PC Programs: Sequential Computing

IMAGE PROCESSING

Thank You for your attention!