Using Stochastic Computing to Reduce the Hardware Requirements for a Restricted Boltzmann Machine Classifier

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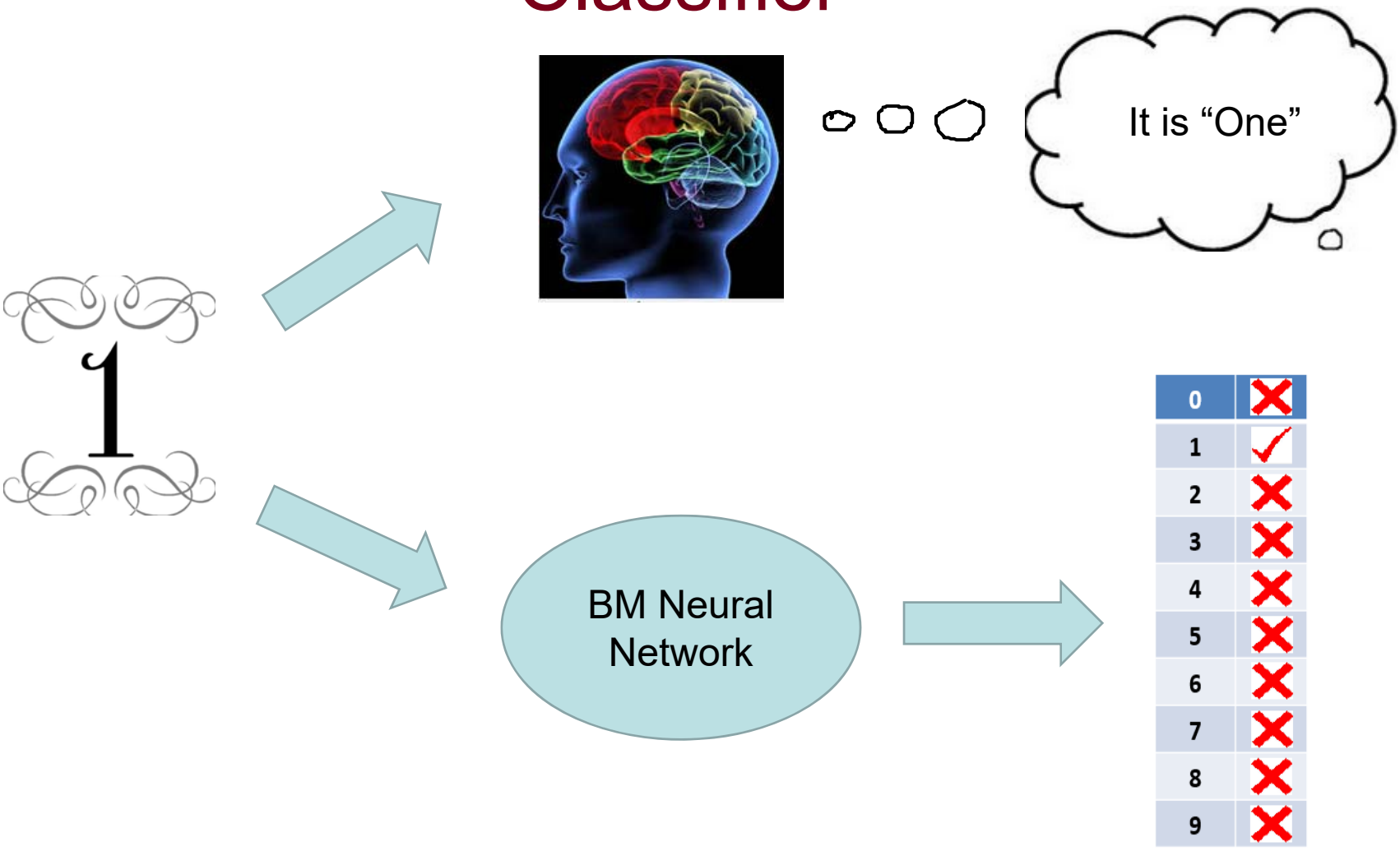
Overview

- Restricted Boltzmann Machine classifier
- Stochastic computing
- Results

Restricted Boltzmann Machine Classifier



BM Structure

Input:
28 x 28 = 784 pixels

Weight

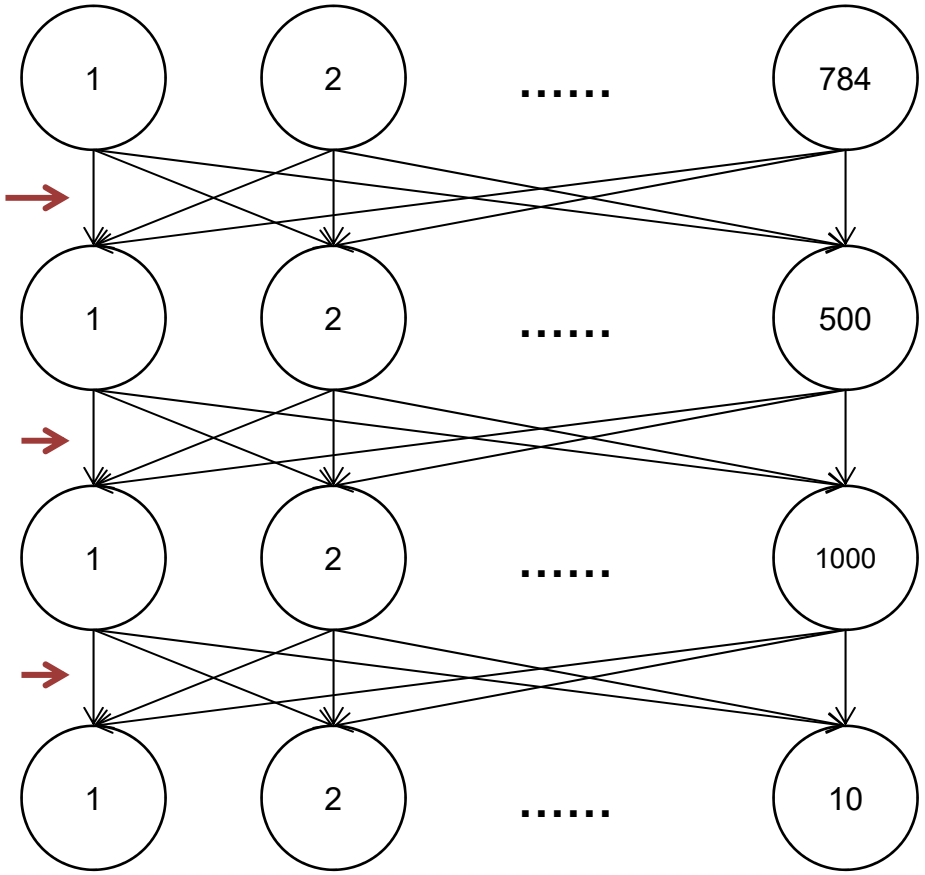
1st Hidden Layer

Weight

2nd Hidden Layer

Weight

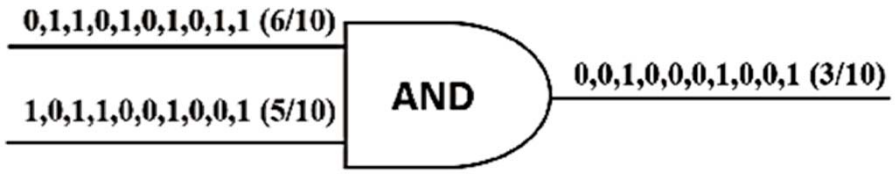
Outputs:
ten labels from 0 to 9.



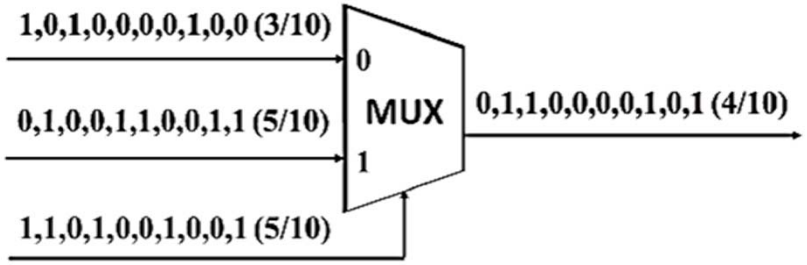
Stochastic computing

Background: Stochastic Computation

- Complex operations can be performed with very simple logic.



An example of multiplication using an AND gate



An example of scaled addition using a MUX unit

A reduction in area of 50x or 100x compared to conventional implementations is common.

Stochastic computation components

- Sigmoid function, Tanh(x)
- Matrix multiplication: Uni-pos-neg adder
- Unipolar/Bipolar multiplication
- Unipolar/Bipolar addition

Results: Error rate and speed

Table I. Error rate comparison

Sizes	Conventional	Stochastic			
		512	1024	2048	4096
$100 \times 200 \times 10$	1.96%	10.06%	5.72%	3.91%	3.14%
$200 \times 400 \times 10$	1.35%	7.93%	4.24%	3.08%	2.35%
$300 \times 600 \times 10$	1.17%	6.33%	2.92%	1.80%	1.80%
$400 \times 800 \times 10$	1.10%	4.17%	2.37%	1.52%	1.34%
$500 \times 1000 \times 10$	0.98%	5.10%	2.32%	1.64%	1.32%

Table II. Speed comparison

Size	CPU(s)	FPGA(s)	Speedup
$100 \times 200 \times 10$	$6.2*10^{-3}$	$8.561*10^{-6}$	724.2
$200 \times 400 \times 10$	$7.8*10^{-3}$	$9.682*10^{-6}$	805.6
$300 \times 600 \times 10$	$9.2*10^{-3}$	$9.797*10^{-6}$	939.1
$400 \times 800 \times 10$	$1.32*10^{-2}$	$1.025*10^{-5}$	1287.8
$500 \times 1000 \times 10$	$1.66*10^{-2}$	$1.077*10^{-5}$	1541.3

Result: Fault tolerance

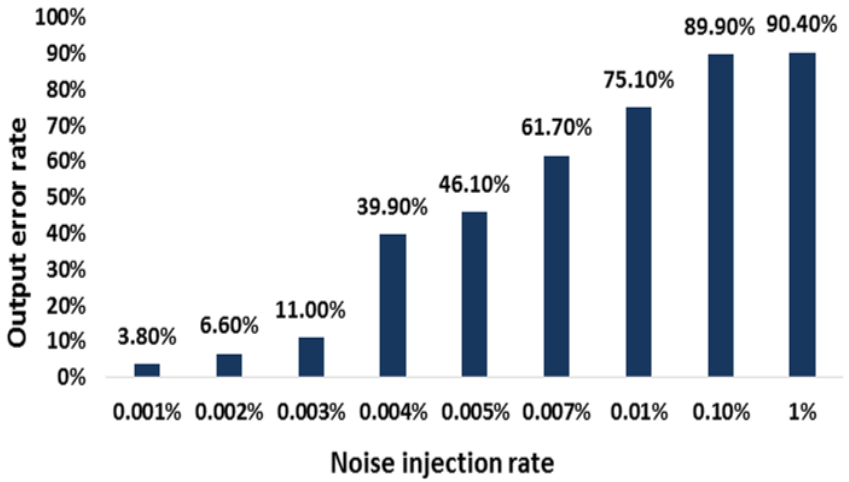


Figure1: Output error rates obtained from injecting different rates of faults into the conventional architecture

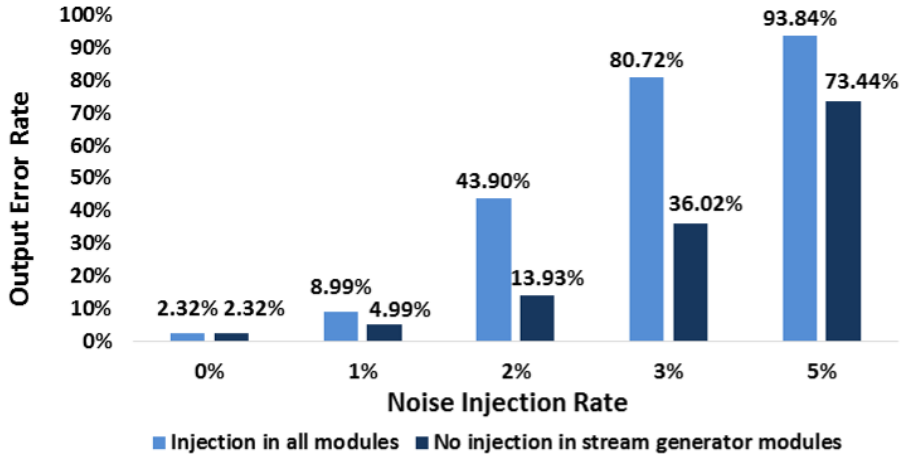


Figure 2: Output error rates obtained from injecting different rates of faults into the stochastic architecture

- Stochastic architecture to gracefully tolerate about a 1%-2% fault rate in its internal computing circuits.

Thanks!
Q&A: please go to my poster section