Machine Learning

ASSIGNMENT

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Roll no : 29

S7 CSE

Quantum Resonant Neural Network (QRNN)

A next-generation neural network framework with a Resonant Activation Function designed to capture complex, non-linear patterns in data.

Overview

The Quantum Resonant Neural Network (QRNN) introduces a novel activation function inspired by resonance and wave interference, unlocking deeper pattern recognition capabilities beyond traditional ReLU or sigmoid functions.

This project demonstrates:

A custom resonant activation function.

Flexible neural network design.

Transparent training logs.

Real-world and synthetic data demos.

Core Innovation: Resonant Activation Function

[f(x) = e^{-0.5x^2} \cdot \sin(5x)]

This activation combines Gaussian damping with sinusoidal oscillations, allowing neurons to resonate with specific input frequencies — mimicking quantum-like energy state interactions.

```
Inline double resonant_activation(double x) {
  return exp(-0.5 * x * x) * sin(5 * x);
}
```

Why it's powerful:

- Captures both localized and periodic features.
- Enables finer gradient flow in hidden layers.
- Ideal for data with oscillatory or multi-modal patterns.

Features

Custom Resonant Activation:
Captures complex input-response relationships that standard activations miss.

Flexible Network Architecture:
Supports configurable layers — from simple 3–3–3 layouts to deeper multi-layer designs.

Forward & Backward Propagation:
Implements end-to-end training using backpropagation.

Detailed Training Logs:
Shows per-sample insights — input, predicted output, expected label, and error.

Quick Start

Compile the demos

g++ -o working_demo.exe working_demo.cpp

g++ -o test_real_data.exe test_real_data.cpp

Run the demos

.\working_demo.exe

.\test_real_data.exe

Example Output

Input: [4.0 25.0 16.0]

Label: [2.0 5.0 4.0]

Output: [1.991425 4.902081 3.931862]

Error: [0.008575 0.097919 0.068138]

Training successful

Project Structure

File	Description
network.h	Core neural network and training logic
model.h	Defines architecture (layers, weights, etc.)
resonant_activation.h	Implements the resonant activation function

File	Description
working_demo.cpp	Demo using sample synthetic data
test_real_data.cpp	Demo using real-world dataset

How It Works

1. Input Layer: Feeds input features into the network.
2. Hidden Layers: Transforms data using the *resonant activation function*.
3. Output Layer: Produces predictions.
4. Training: Backpropagation minimizes error between predicted and target values.
5. Logging: Displays progress and per-epoch metrics.

Conceptual Visualization

Sensor Data → [Inputs]

↓

Hidden Neurons (Resonant Activation)

↓

[Outputs]

↓

Backpropagation → Weight Updates → Learning

Future Enhancements

- Extend to multi-frequency resonant activations
- Integrate quantum-inspired parameter tuning
- Visualize resonance surfaces in 3D
- GPU acceleration support

Contributors

Developed with by Fiero Jain and contributors exploring the frontier of AI + Quantum-inspired computing.

License

“Where classical neurons learn from data, resonant neurons *feel* the patterns.”

Input: [-5688.600000 6915.400000 5386.000000]

label: [8293.200000 3589.600000 -7162.200000]

Error: [0.271265 0.034120 -0.912079]

Training successful

0

Input: [106.600000 606.400000 -1714.400000]

label: [-342.200000 7086.000000 -2209.400000]

Error: [-0.004865 3.813036 -0.081074]

Training successful

1

Input: [2974.600000 -1378.400000 3496.800000]

label: [3114.400000 -7754.800000 -373.200000]

Error: [0.043625 -1.688601 0.000152]

Training successful

2

Input: [3980.400000 -8479.400000 -1827.200000]

label: [-2085.600000 -2104.200000 -2959.400000]

Error: [0.074789 0.078164 -0.506154]

Training successful

3

Input: [4289.800000 -598.800000 3174.600000]

label: [2147.400000 9846.000000 -6627.200000]

Error: [-0.020663 0.890948 -0.000973]

Training successful

4

Input: [412.200000 9171.200000 5788.600000]

label: [-342.200000 -7210.000000 -2548.400000]

Error: [0.000273 -2.018399 -0.029648]

Training successful

5

Input: [3179.200000 -1919.200000 -3078.400000]

label: [1332.200000 3154.800000 3602.600000]

Error: [-0.002090 -0.085024 0.772408]

Training successful

6

Input: [-6939.400000 -8304.400000 -6553.400000]

label: [-1752.000000 2442.800000 9576.000000]

Error: [-0.003421 -0.006270 1.420375]

Training successful

7

Input: [-6347.000000 5516.400000 1802.400000]

label: [-2242.800000 -8036.600000 -8740.000000]

Error: [0.007856 -1.572208 -0.032038]

Training successful

8

Input: [3179.200000 2727.000000 -6713.600000]

label: [-342.200000 -5603.000000 -8995.200000]

Error: [0.000068 0.238486 -0.871444]

Training successful

9

Input: [412.200000 323.600000 5257.800000]

label: [6124.200000 -3527.000000 2079.800000]

Error: [0.359208 -1.454931 0.068733]

Training successful

10

Input: [106.600000 -524.400000 -8305.800000]

label: [882.800000 -6116.000000 4107.200000]

Error: [-0.003944 -0.549326 0.385282]

Training successful

11

Input: [412.200000 606.400000 -8289.400000]

label: [-342.200000 2523.400000 5119.600000]

Error: [-0.002294 0.001759 0.772228]

Training successful

12

Input: [2974.600000 -3275.800000 3496.800000]

label: [-2085.600000 -4812.200000 2245.000000]

Error: [0.008370 -0.992519 0.033268]

Training successful

13

Input: [4289.800000 -4938.200000 3393.000000]

label: [-7725.000000 -5196.800000 -2379.000000]

Error: [0.093227 -0.812557 0.018436]

Training successful

14

Input: [-3387.200000 3360.400000 -6713.600000]

label: [-7725.000000 7059.200000 -4064.800000]

Error: [-0.175635 0.721563 -0.046469]

Training successful

15

Input: [2974.600000 9010.800000 -2698.000000]

label: [-7725.000000 3800.800000 -786.800000]

Error: [-0.785457 0.376416 -0.000220]

Training successful

16

Input: [2974.600000 6556.800000 2084.200000]

label: [-3132.000000 -1389.200000 -5071.400000]

Error: [-0.153205 0.000530 -1.342837]

Training successful

17

Input: [3719.600000 -2471.000000 -7856.400000]

label: [-3879.400000 1350.000000 -3950.600000]

Error: [-0.352350 0.050368 -0.582570]

Training successful

18

Input: [412.200000 -8304.400000 3496.800000]

label: [-342.200000 7934.200000 -9069.800000]

Error: [0.000198 0.172688 -2.048271]

Training successful

19

Input: [6426.200000 4371.200000 5740.200000]

label: [3114.400000 -9825.800000 -219.000000]

Error: [0.017743 -1.824765 0.000017]

Training successful

20

Input: [4235.600000 -4714.600000 5279.400000]

label: [9537.800000 -8260.600000 1808.800000]

Error: [0.761550 -0.011077 -0.007335]

Training successful

21

Input: [2974.600000 -6649.000000 6726.800000]

label: [1764.600000 4414.600000 -1791.400000]

Error: [-0.026783 0.628838 -0.030953]

Training successful

22

Input: [412.200000 -6649.000000 -1714.400000]

label: [-1752.000000 -1248.800000 3653.600000]

Error: [-0.018805 -0.010080 0.875195]

Training successful

23

Input: [412.200000 323.600000 -6713.600000]

label: [-342.200000 4563.200000 -6596.000000]

Error: [-0.001308 0.702629 -0.385692]

Training successful

24

Input: [3179.200000 -598.800000 -8814.400000]

label: [7739.000000 -4477.000000 -5031.000000]

Error: [0.736461 -0.062725 -0.082729]

Training successful

25

Input: [412.200000 9208.400000 -3208.600000]

label: [-8827.800000 8786.000000 -7612.600000]

Error: [-0.157606 1.442848 -0.122649]

Training successful

26

Input: [-3387.200000 -598.800000 9596.200000]

label: [-9388.800000 -5170.800000 4633.800000]

Error: [-0.798075 0.032012 0.074101]

Training successful

27

Input: [6103.400000 9010.800000 -5858.000000]

label: [-7725.000000 7922.800000 8858.800000]

Error: [-0.290286 0.267754 0.901386]

Training successful

28

Input: [2974.600000 4835.800000 -8231.800000]

label: [1764.600000 -1605.200000 -1819.200000]

Error: [0.175688 0.110362 -0.531013]

Training successful

29

Input: [-5688.600000 -7329.800000 5740.200000]

label: [-1041.800000 174.200000 -6321.800000]

Error: [0.002339 0.000031 -0.722880]

Training successful

30

Input: [412.200000 9010.800000 -5426.000000]

label: [1520.000000 2068.200000 -6931.400000]

Error: [0.001661 0.038212 -0.475057]

Training successful

31

Input: [412.200000 7701.600000 -5426.000000]

label: [1764.600000 -7483.000000 3515.600000]

Error: [-0.020186 -0.849526 0.686022]

Training successful

32

Input: [-5688.600000 4371.200000 -9357.600000]

label: [8293.200000 7754.600000 -6446.000000]

Error: [0.775412 0.395640 -0.186985]

Training successful

33

Input: [2974.600000 -455.400000 -8814.400000]

label: [-1752.000000 -3317.800000 5465.400000]

Error: [-0.015517 -0.080966 0.603830]

Training successful

34

Input: [3179.200000 4417.200000 7145.600000]

label: [-7725.000000 3254.200000 -3694.600000]

Error: [-1.486124 0.053823 -0.028079]

Training successful

35

Input: [3719.600000 -2667.600000 3496.800000]

label: [6124.200000 6378.600000 8886.400000]

Error: [-0.175681 -0.159373 0.827657]

Training successful

36

Input: [2974.600000 9010.800000 -2264.200000]

label: [-1752.000000 6482.200000 1085.600000]

Error: [-0.015526 0.810832 -0.002476]

Training successful

37

Input: [412.200000 -3275.800000 6726.800000]

label: [-2085.600000 -8260.600000 -195.800000]

Error: [0.021446 -2.227170 0.000261]

Training successful

38

Input: [3179.200000 8089.000000 5386.000000]

label: [-1752.000000 7559.000000 7823.800000]

Error: [0.007368 -0.356408 -0.356717]

Training successful

39

Input: [3179.200000 4972.400000 6726.800000]

label: [-7725.000000 3944.000000 3268.000000]

Error: [-0.919613 0.046215 0.032350]

Training successful

40

Input: [3179.200000 -1378.400000 -4424.400000]

label: [2147.400000 -4686.800000 -7612.600000]

Error: [0.017872 0.191815 -0.891428]

Training successful

41

Input: [3179.200000 -598.800000 -5027.600000]

label: [-2242.800000 7934.200000 7835.000000]

Error: [-0.022251 -0.128323 1.132170]

Training successful

42

Input: [412.200000 4945.600000 5788.600000]

label: [9537.800000 9070.400000 -6627.200000]

Error: [0.259606 0.238979 -1.530172]

Training successful

43

Input: [106.600000 -2667.600000 -4424.400000]

label: [-2085.600000 9070.400000 8474.600000]

Error: [-0.094238 2.084252 1.981840]

Training successful

44

Input: [412.200000 8024.800000 -1827.200000]

label: [8293.200000 -54.600000 6812.400000]

Error: [1.272064 -0.000009 0.551657]

Training successful

45

Input: [-6347.000000 -4938.200000 8619.600000]

label: [-1752.000000 3154.800000 620.200000]

Error: [-0.057126 0.547743 -0.000039]

Training successful

46

Input: [2974.600000 8900.000000 5279.400000]

label: [6124.200000 7435.400000 -1361.400000]

Error: [0.021418 0.551382 -0.012700]

Training successful

47

Input: [4235.600000 606.400000 -5027.600000]

label: [-9388.800000 4902.800000 -4906.600000]

Error: [-1.079980 0.718384 -0.053928]

Training successful

48