Traffic Control Neuromorpher Verification Plan

Team members: Kyle Fesmire, Shreyas Sundararaman, Emre Ozsahin, Dharna Pahuja

Design Specific Success Criteria

1. Demonstrate via System Verilog test bench the ability to correctly function neural network.
2. Demonstrate via System Verilog test bench the ability to make traffic decisions based on previous data.
3. Demonstrate via System Verilog test bench the ability to ensure safety during emergencies.
4. Demonstrate via System Verilog test bench the ability to ensure efficiency for pedestrians and cars in the intersection.
5. Demonstrate via System Verilog test bench the ability to test the weather conditions on traffic decision making.
6. Demonstrate via System Verilog test bench the ability to adapt to varying pedestrian and car traffic conditions in an intersection.
7. Demonstrate via System Verilog test bench ability of the hardware to make reasonably quick decisions.

Verification Plan Summary

What to Verify	Design Module(s) involved	Verification Procedure Summary	DSSC(s) Proved	Use in Final Demo	Comments
Correct response to varying weather inputs	Weather Sync Block, Weather Scoring Block	Scoring Test (trigger inputs with traffic, pedestrian and weather values)	DSSC 5	Only if can't show using top level	Testing varying weather conditions vs normal pedestrian and traffic conditions
Correct response to varying pedestrian and traffic inputs	Ped counter, Ped scoring block, Traffic counter, Traffic scoring	Scoring Test (trigger inputs with traffic, pedestrian and weather values)	DSSC 6	Only if can't show using top level	Testing varying pedestrian and traffic values vs normal weather conditions
Correct Neural network response	Neural networks and Neural network database	Apply training data and ensure the Neural Network converges to multiple sets of training data	DSSC 1	Yes	Results will be dependent on the training data we give
Correct response to emergency situation	Top Level	Trigger Emergency Situation	DSSC 3	Yes	
Correct direction change	Decision Block	Load traffic heavily in one direction to force a direction change	DSSC 4 & 6	Only if can't show using top Level	
Correct timing change	Decision Block	Induce timing increase or decrease by varying real time traffic inputs	Weather Sync Block, Weather Scoring BlockDSSC 4 & 6	Only if can't show using top Level	
Decisions made will be based on consultation with the database	Weather Sync Block, Weather Scoring Block, Decision Block, Database	Test inputs both similar and different to database values	DSSC 2 & 7Weather Sync Block, Weather Scoring Block	Yes	
Compare our	Top Level	Compare	DSSC 3, 4, 6, 7	Yes	

controller to traditional traffic control Systems		timing and safety criteria			

Detailed Verification Test Breakouts

Correct response to varying weather inputs

- Highest Level of Design Module involved:
  - Weather Sync Block, Weather Scoring Block
- Test bench Expectations:
  - Have temporary data registers compare calculated score values with expected score values
  - Test all possible combination of weather inputs
- No external or premade references are needed
- No pre/post processing
- Main Verification Test Steps:
  1. Generate pedestrian and car counts and weather inputs
  2. Calculate expected score for each of the inputs
  3. Compare the outputs with expected
  4. Repeat for all possible weather input combination

Correct response to varying pedestrian and traffic inputs

- Highest Level of Design Module involved:
  - Pedestrian counter, Pedestrian scoring block, Traffic counter, Traffic scoring
- Test bench Expectations:
  - Have temporary data registers compare calculated score values with expected score values
  - Test combination of pedestrian and traffic inputs
- No external or premade references are needed
- No pre/post processing
- Main Verification Test Steps:
  1. Generate inputs for the pedestrian and car counts
  2. Calculate scores
  3. Compare output from scoring blocks to expected values
  4. Repeat for varying loads of both pedestrians and cars
     - low cars frequency, low pedestrians frequency
     - med cars frequency, low pedestrians frequency
     - high cars frequency, low pedestrians frequency

Correct Neural network response

- Highest Level of Design Module involved:
  - Neural Networks
- Test Bench Expectations:
  - Ensure correct weights of the inputs
  - Vary inputs to generate correct outputs
- Reference: http://natureofcode.com/book/chapter-10-neural-networks/

- No pre/post processing
- Main Verification Test Steps:
  1. Assign randomized weights to the inputs initially
  2. Give inputs to neural networks and check the outputs
  3. Calculate the difference between expected and calculated output
  4. Ensure the modification of the weights results in the expected output

Correct response to emergency situation

- Highest Level of Design Module involved:
  - Top level
- Test Bench Expectations:
  - Ensure the chip correctly responds to an emergency
- No external or premade references
- No pre/post processing
- Main Verification Test Steps:
  1. Assert emergency variable over multiple inputs
  2. Ensure correct output (all lights are red)
  3. Ensure controller returns to normal function after emergency has cleared the intersection

Correct response to direction change

- Highest Level of Design Module involved:
  - Decision Block
- Test Bench Expectations:
  - Ensure the decision block correctly estimates the change in direction based on the change in pedestrian and traffic scores
- No external or premade references
- No pre/post processing
- Main Verification Test Steps:
  1. Increase traffic count by a considerable amount in one direction to ensure loading of traffic
  2. Check to ensure that direction in which red light is set has a higher traffic count than green light direction
  3. Ensure that direction change occurs

Correct response to timing change

- Highest Level of Design Module involved:
  - Decision Block
- Test Bench Expectations:
  - Ensure the decision block correctly estimates the change in timing based on the change in pedestrian and traffic scores
- No external or premade references
- No pre/post processing
- Main Verification Test Steps:
  1. Increase traffic count by a considerable amount in one direction to ensure loading of traffic
  2. Check to ensure that direction in which red light is set has a reasonably lower traffic count than green light direction
  3. Ensure that timing change occurs

Correct response to Database Consultation

- Highest Level of Design Module involved:
  - Weather Sync Block, Weather Scoring Block, Decision Block, Database
- Test Bench Expectations:
  - Ensure the decision block correctly refers to entries in the database and generates a valid estimated decision and similarity index
- No external or premade references
- No pre/post processing
- Main Verification Test Steps:
  1. Generate input values which are similar to entries in database
  2. Ensure that decision block picks up values from corresponding similar entries in order to ensure generation of correctly estimated decision
  3. Ensure that decision block correctly generates similarity index, upon which the block also correctly 'decides' to accept database generated value or neural network generated value

Considerable improvement in efficiency and safety over traditional traffic control system

- Highest Level of Design Module involved:
  - Top Level
- Test Bench Expectations:
  - Ensure that Neuromorpher system satisfies better timing and safety criteria than traditional timed traffic control logic
- No external or premade references
- No pre/post processing
- Main Verification Test Steps:
  1. Generate various input values
  2. Run input values through Neuromorpher and traditional traffic system and time accordingly
  3. Ensure that Neuromorpher performance better than traditional traffic system in catering to safety and efficiency optimizations