RAT MANN: Rage Against the Multi-Level Adaptive Neural Network

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Problem Definition & Background

Neuromorphic computing, a subcategory of artificial intelligence and machine learning, is typically difficult for the everyday person to comprehend, for it is a fairly new field of technology that requires a background in calculus, physics, biology, circuit theory, and programming. The ultimate goal of RAT MANN is to provide the everyday person a means to understand the complexities and importance of neuromorphic computing while simultaneously providing a fun and interactive experience. It also aims to spark an interest in those who use it, especially those part of the younger crowd, in the hopes that they may pursue an education in AI/computer engineering and contribute to the field later on in life.

Requirements Specification

1. The game must be playable by a human player and an AI player.
2. The game must have a scoring system that demonstrates the effectiveness of the network;
3. The system must be able to be powered by a single wall plug for portability.
4. The system must work together cohesively, so the hardware must successfully interact and affect the game state.
5. The game state must be displayed on the left hand screen using either the pygame or pyglet rendering library, and the score and an image of the current network topology displayed on the right hand screen.
6. Each round of the game must be able to be run manually, with specified arguments such as the song and the DANNA2 network to be used.
7. The arcade game must have a finished and attractive appearance, adequate to be utilized as a laboratory demo or taken to conferences.

Stretch Goals

1. The system starts the game on startup without user input.
2. **The player will be able to select between multiple songs for each round.**
3. The right hand screen will display a live demonstration of the operation of the neural network, instead of a still image.

Technical Approach

RAT MANN takes the form of a small arcade cabinet. The hardware components include a Raspberry Pi, five buttons for playing the game, two LCD screens, speakers, and LEDs that will display the neural network's moves. The software component of the game utilizes OpenAI Gym-style environment, and is written in python. This environment represents the rhythm game in an abstract form. Notes are represented as bit strings that are given a distance from the "strum area" that continuously decreases. This environment is contained in a higher-level module that interfaces with both the neuromorphic network and the user's input via the Pi's GPIO pins.

Embodiment Design

- Game Environment
  - Initialization Function
    - Sets up the game based on the indicated song choice
    - Initialize visual notes array and other important information
  - Step Function
    - Moves notes based on the following equation: $s = \frac{v * 240}{n * bpm * dt}$
    - Calculates reward based on the distance the note is from the end of the track that the player or network indicated
    - Also returns whether the game is over or not as a boolean
- Wrapper Environment for neuromorphic neural network training
- Visualization program (game)
  - Utilizes Pyglet python library to generate graphics, import images, and handle movement of graphic objects.
  - Handles game state switching: menu, to gameplay state, back to menu.
  - See Figure 1 for images of gameplay.
- Hardware-Software Integration
  - Raspberry Pi python GPIO library used to communicate with button peripherals.
    - Includes functions to read button presses and light up arcade button LEDs.
  - Bash shell scripts used to run code on startup.
- Hardware and Housing
  - See Figure 2 for images of the housing.

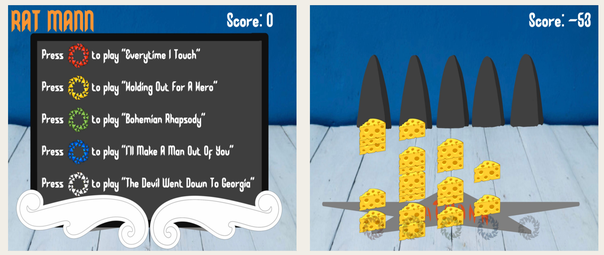

Figure 1: RAT MANN Gameplay

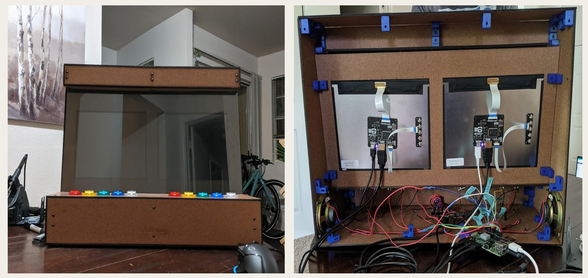

Figure 2: Arcade-Style Housing and Internal Supports

Deliverables

- OpenAI Gym/Model Interface
- Guitar Hero OpenAI Gym Application
- Electrical Circuitry
- Firmware Code
- "Arcade-style" Housing

Test Plan

OpenAI Gym Interface Test Matrix

Test	Experiment Results
Use of a "brute force" model to ensure that the environment functions as intended	Successful
Application can be played by TENNLab Neuromorphic models, and efficiency scores can be generated	Successful
Application can be played and scored with another open source model compatible with OpenAI Gym	Successful

Playable App Test Matrix

Test	Experiment Results
Application generates a sequence of notes along with a song	Successful
Application receives input (from keyboard or buttons)	Successful
Application generates a score based on actual input combined versus expected input	Successful
Application counts points for button presses that occurred within the time threshold	Successful
Application and graphics run smoothly on the Raspberry Pi	Needs work

Project Management

Date	Milestone
1-Oct-20	Define the project and engineering characteristics
15-Nov-20	Budget for hardware determined, game environment created
15-Dec-20	Initial hardware build, initial housing build, initial firmware complete
15-Jan-21	Gaming application complete
15-Jan-21	Firmware code complete
15-Jan-21	Final changes to housing complete
20-March-21	Hardware testing and validation, testing with firmware, on partially assembled design. Start building interfaces between hardware, firmware, software
14-Apr-21	Networks able to be trained and play the game
20-Apr-21	Hardware circuit fully assembled
24-Apr-21	Full system integration firmware code complete, begin debugging and testing
26-Apr-21	Anticipated project completion (senior design requirement)
4-May-21	Complete documentation

Budget

Category	Part	Price
Electrical		
Computing	Raspberry Pi 4 model B, 4GB	$55.00
	64GB Samsung SD Card	$16.00
Cables	Micro HDMI to HDMI Cable (2)	$17.90
Display	Pimoroni HDMI 10" LCD Screen Kit (2)	$279.50
Audio Related	3" Diameter Speaker, 4 Ohm 3 Watt (2)	$3.90
	Stereo Audio Amplifier, MAX98306	$8.95
Buttons	LED Arcade Buttons (10)	$25.00
Power Supply	Three outlet extension cord	$3.47
	5V wall adapter (3)	$3.00
	Micro-B USB to USB cables (2)	$6.00
	USB-C USB to USB cables (1)	$5.00
Mechanical		
Mechanical Hardware	4-40 button head hex drive screws	$11.34
	4-40 low strength steel hex nuts	$0.89
	Heavy Duty Rubber Bumpers	$15.24
	M2.5 Button Head Hex Drive Screw	$8.46
	Brass M2.5 Standoffs Black Plated	$6.25
Building Materials	1/8"x2'x4' Tempered hardboard (2)	$7.96
	High-Strength Gorilla Glue, 4 oz	$8.28
	Clear Glass	$5.34
	Blacktop Black Core Matboard	$11.89
	Total	**$499.37**

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REFERENCES:
github.com/mstanto4/SeniorDesign
neuromorphic.eecs.utk.edu/
gym.openai.com/

Topic	Unsatisfactory	Below Expectations	Meets Expectations	Possible	Awarded
Problem Definition & Background	Not included or revisions ignored	Further revision or update necessary	Appropriately revised and updated	**5**	
Requirements Specification	Not included or revisions ignored	Further revision or update necessary	Appropriately revised and updated	**5**	
Technical Approach	Not included	Incl. but project overview and decomposition are insufficient	Good birds-eye view of approach and sufficient decomposition	**5**	
Design Decision Identification	Not included	Major design decisions left unaddressed; or things falsely identified as design decisions	All major design decisions identified	**5**	
Design Concepts	Alternate concepts not developed	At least two concepts considered but concepts not fully developed or obvious alternatives were neglected.	Multiple concepts considered. Concepts fully developed. All obvious concepts considered.	**20**	
Concept Evaluation	Concepts left unevaluated	Concepts evaluated but only qualitatively.	Concepts evaluated using sound technical reasoning, including calculations were appropriate	**20**	
Concept Selection	Not included	Concepts selected but insufficiently justified	Sound selection decisions utilizing concept selection methodology taught in class	**10**	
Deliverables, Project Management & Budget	Not included or revisions ignored	Further revision or update necessary	Appropriately revised and updated	**5**	
Slide Quality	Unorganized. Impossible to follow.	Slides wordy or hard to follow.	Slides visually stimulating. One idea per slide. Good use of images.	**5**	
Delivery	Talking to the screen.	Low energy but at least facing audience.	Dynamic and engaging.	**5**	
Professionalism	Wrong business attire. Late. Egregious typos in slides	Correct business attire. Some typos in slides that indicate last-minute scrambling.	Correct business attire. Slides proofread, loaded and ready to go at start.	**5**	
Response to Questions	Unresponsive or defensive	Answered questions but with some rambling.	Answered questions concisely and correctly	**5**	
Timeliness	10 min > time > 18 min	10 min < time < 13 min or 15 min < time < 18 min	13 min < time < 15 min	**5**	