GRANT: Ground Roaming Autonomous Neuromorphic Targeter

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Background

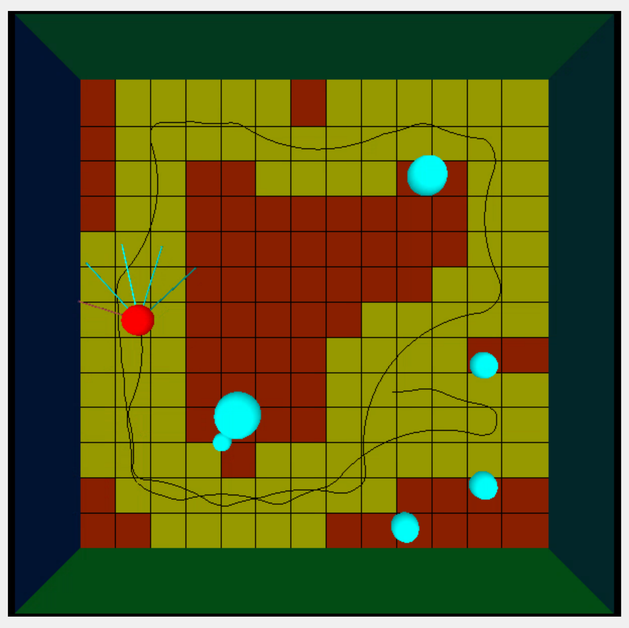
DANNA2

DANNA2 (Dynamic Adaptive Neural Network Array 2) is TENNLab's newest evolution of discrete digitial spiking neural network models. DANNA2 incorporates aspects of TENNLab's other models: NIDA DANNA, and mrDANNA. This model utilizes a rectangular grid of DANNA2 core elements, where each element contains an accumulate and fire neuron as well as up to 24 synapses. It is implemented in hardware on an FPGA.

Project Motivation

The main push for this project is to create a successor to the previous autonomous robot from TENNLab, NeoN[1]. We improve upon NeoN in the following areas:

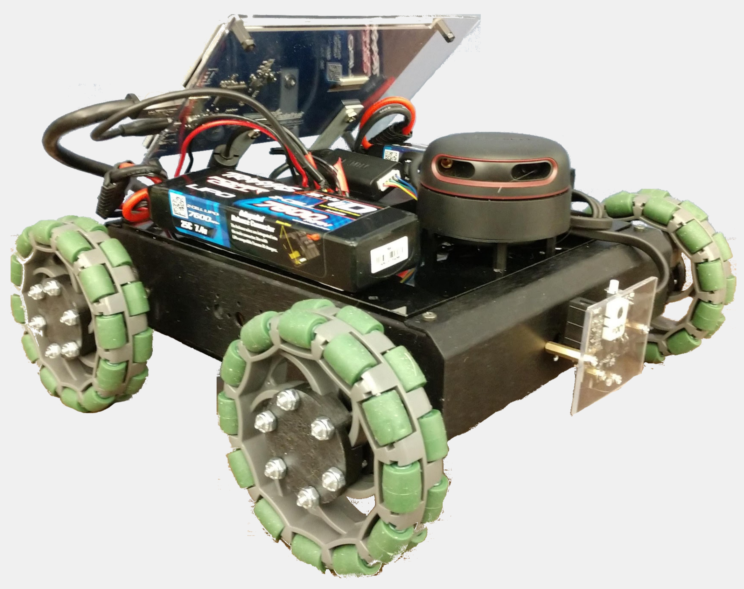
- Self-navigate using new DANNA2
- Increased visibility with better LiDAR
- Reconfigurable networks
- Deploy better performing networks



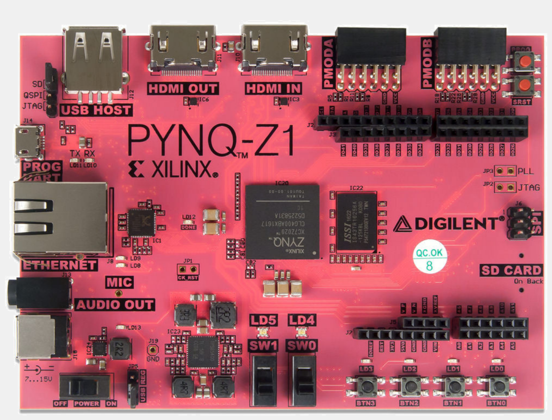
Design Overview

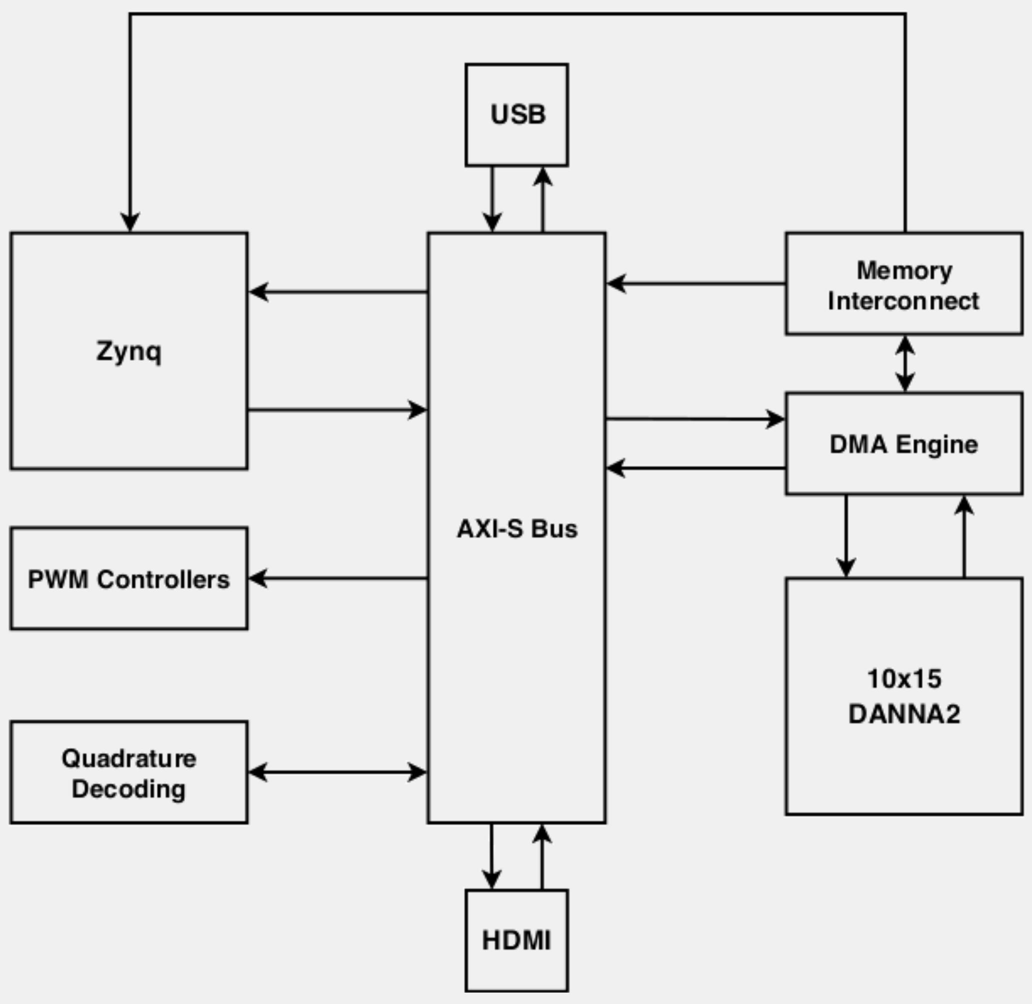
Materials

- Pynq Z1 FPGA board
- RPLIDAR-A2
- Pixy2 Camera
- 7.4V Lipo Batteries
- 7" LCD Display
- Frame with motors / encoders



Digital Design

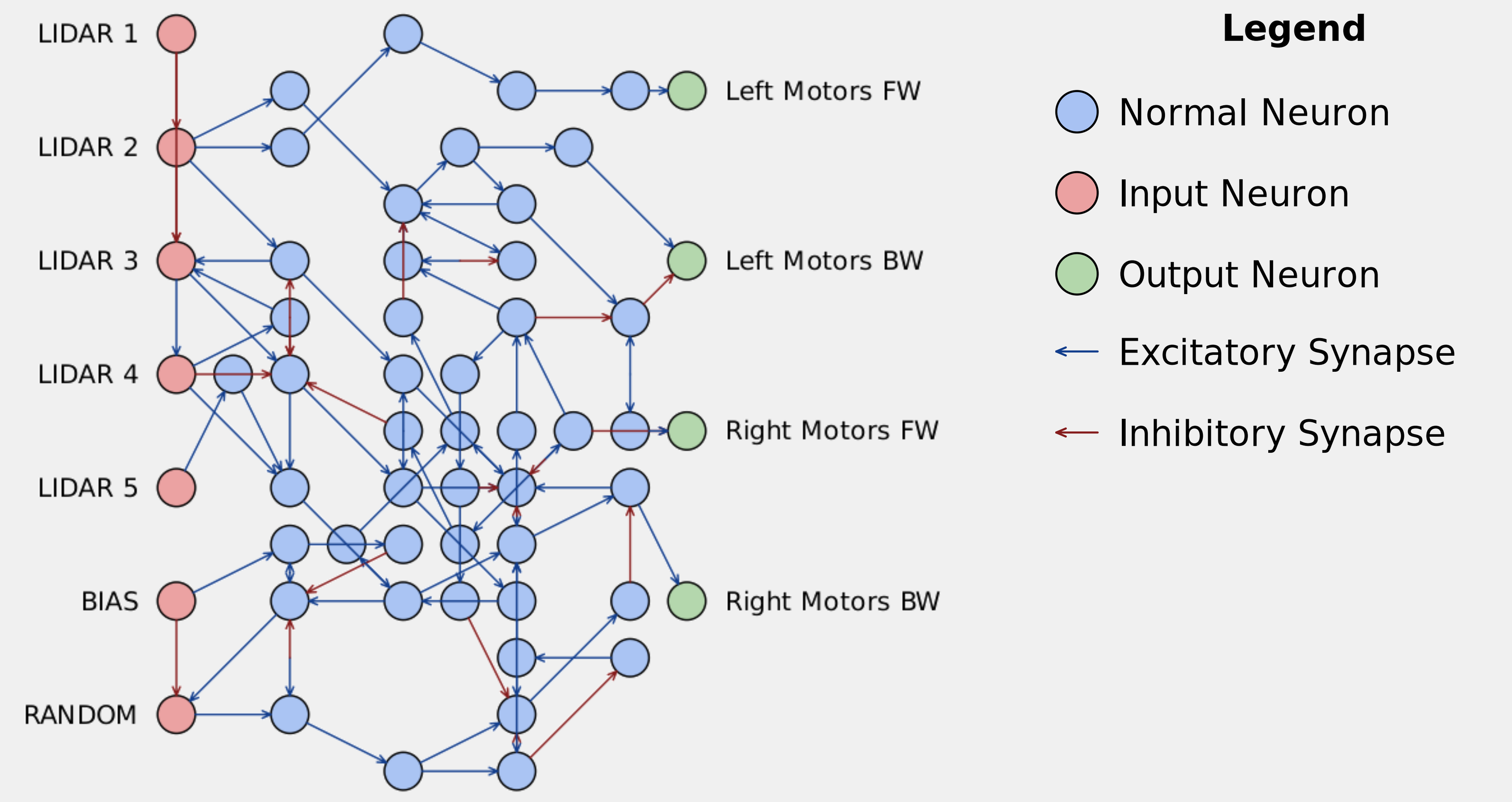




The robot communicates with its peripherals via AXI4-Stream. The sensors are connected through USB and the encoders are directly connected to hardware quadrature decoding blocks on the FPGA. Similarly, the motor controllers are connected to hardware PWM controllers on the FPGA.

The DMA is used to send 512-bit packets to the network and to receive the 512-bit packets output packets from the network. These output packets can then be parsed and acted upon by the Zynq processing core.

Network Details



DANNA2 Inputs

- **LIDAR:** Five LIDAR lines are read such that distance measurements of 1 meter or greater result in zero fire weight and measurements of 0.3 meter or less result in maximum fire weight
- **BIAS:** Bias receives a constant small fire weight to ensure that the network always gets some input
- **RANDOM:** The random input gets a random fire weight that is used to create more variation in the network output and discourage deterministic decisions that may cause GRANT to get stuck in loops

DANNA2 Outputs

The network outputs are used to control the speed of the left and right motors. Each fire on a forward (FW) output increases the power of the motor by 10%, and each fire on a backward (BW) output decreases the power of the motor by 10%. The motors have default power of 50% forward to encourage forward movement.

Training DANNA2

The DANNA2 network was trained through Evolutionary Optimization (EO) using the TENNLab EONS software framework[2]. This allows many networks to compete simultaneously and only lets the best survive to reproduce for the next generation. The network is trained to maximize grid coverage and to avoid obstacles.

Conclusions and Future Work

We have trained well performing networks for DANNA2 that roam and avoid obstacles. GRANT has fewer limitations than its predecessor NeoN and is much more configurable for new applications. Currently, work is in progress to create networks for object targeting in a field of obstacles which will futher solidify the potential of DANNA2 as an embedded chip for neuromorphic robots.

Acknowledgements

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Visit our website at neuromorphic.eecs.utk.edu

References

[1] Mitchell, J. P., Bruer, G., Dean, M. E., Plank, J. S., Rose, G. S., & Schuman, C. D. (2017). NeoN: Neuromorphic control for autonomous robotic navigation. 2017 IEEE International Symposium on Robotics and Intelligent Sensors (IRIS).

[2] J. Plank, C. Schuman, G. Bruer, M. Dean and G. Rose, "The TENNLab Exploratory Neuromorphic Computing Framework" in IEEE Letters of the Computer Society, vol. , no. 02, pp. 17-20, 2018.