General-Purpose Robotic Controller for Neuromorphic Neural Net Models

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Abstract

The fields of neuroscience and biomimetic robotics research, development, and system design is expanding rapidly. As the need for smarter controls increases the complexity of developed models and controls bring a greater need for testing and simulating. Increasingly complex models demand more from simulation and model testing. Today’s software capabilities that are developed to handle such simulations and tests are growing in step with the hardware and robotic structural development, yet there is a gap in the integration of these two systems. There is a lack of systems that can load built neural control networks, process the simulation of created network and operate the robotic controls and sensor interfacing with speed that allows for real-time analysis and operation. This missing fast general-purpose controller is making research and development of biomimetic systems expensive not only in the microcontroller devices themselves, but in the time it takes to run a system, then scale results to a reasonable real world speeds. This complexity alone makes it unreasonable to expect new research students or enthusiasts to be able to get up to speed and start making research contribution in a reasonable amount of time.

This research project is to investigate, design, build, and test a general purpose, parallel processing microcontroller for use in neural robot control. The controller will be centered around a multi-core SoC that may interface with a user's computer to load biological neuron simulations from animatlab. It will run the loaded neural calculations in parallel processes through a GPU/CPU SoC, neuromorphic processing unit, or FPGA SoC, which will output serial or parallel communication to 20+ motors, servos, solenoid valves, or other actuators. The microcontroller must also be able to receive 40+ sensor inputs for use in the control algorithms. The major goals of this research is to perform fast neural simulations and to optimize the communication between the processing unit and the robot's sensors and actuators. This will enable Portland State University's Agile and Adaptive Robotics Lab to investigate the neural control of balance and walking using robot systems in real time.

The presented devices are not only from a wide variety of companies and price ranges, but also from a range of functional operating architectures. This style of analysis allowed for the ability to understand which type of processing unit would fulfill the requirements of the developing system. The requirements are from the view of functional operation, student research technical understanding and ramp-up time to be able to use the device, and if not only research students could operate it but also experienced researchers who are using older systems or more complex models.

Requirements:

* Must be capable of running AnimatLab
* Fast processing speeds capable of real-time robotic control with spiking and non-spiking neural net models
* Parallel processing capability
* 100+ General Purpose Input Output interface ports, expandable if necessary
* Ease of use for new and experienced researchers alike
* Easily interface-able and upgradable with capable of legacy as newer devices come out
* Inexpensive to moderately priced for unit, less than $300

With the above requirements taken into consideration and all the data from the options shown to the left, the unit that fits the best would be NVIDIA’s Jetson TX1 single board computer with accompanying development kit. This device has a well-established community of developers as well the supported development software of CUDA make the development of the robotic interfacing system easier for the continued growth of the whole computing device. The other consideration that made the Jetson TX1 a clear choice was its price, processing speed, legacy to the more capable device Jetson TX2, and its default operating system of Linux allows operation Animatlab directly on the computer

Once the choice of utilizing the NVIDIA Jetson TX1 development board and kit was finalized the workflow process was designed to be as non-disruptive to the systems in place as possible. The switch to using the new board and system should be as easy as possible so that researchers from all levels of experience could easily transition to this system. The real change comes from running all systems on the Jetson TX1 instead of linking two application program interfaces through a virtual port and then outputting that information to the robotic controller via Ethernet.

* The new system will focus on upgrading the performance of the processing speed, running as close to real-time as possible.
* The Jetson TX1 will be stripped of all unused applications to stream line and focus all power toward running the generated models and robotic controls.
* As the models grow in complexity and the need for a camera becomes evident, the operating software will be built to run custom computer vision models built through neuromorphic neural net models.
* Once the system has been full built and vetted it will be available for other universities, research teams and other entities to use it in their studies as well.