



**CALIFORNIA STATE SCIENCE FAIR
2008 PROJECT SUMMARY**

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Project Title Artificial Neural Networks that Decode Commands Embedded in the Temporal Density of Neural Spike Sequences	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The objective is to design Artificial Neural Units that decode commands encoded in the temporal density of neural spike sequences (each unit decodes one command) and to use them in an Artificial Neural Network to decode a multitude of such commands</p> <p>Methods/Materials The proposed solution involved: (1) Artificial Neural Units (ANUs), based on a very simple version of the integrate-and-fire model, designed to fire when the temporal spike density in their input exceeds a certain value; (2) Extended Artificial Neural Units (XANUs) made of ANUs and XOR operators, designed to fire when the temporal spike density of the input is bounded within a range of values; and (3) A network of command tuned XANUs that can decoded a number of different commands. A home PC was used running MS-Windows XP, MatLab for performing simulations, and the Minstorms NXT development platform to create a simple robotics application.</p> <p>Results Guidelines for choosing the various ANU and XANU parameters and the linear XANU network were introduced. Unit and network functionality were demonstrated with matlab simulations. Three spike sequences were considered for encoding a single command, and single and two command sequences were employed for simulations. Loss of spikes was also explored with simulations. Loss of the first or the third spike did not affect the performance of the XANUs. However, loss of the second spike did when it altered the spike density enough to be outside a XANU#s sensing range. The simple robot application was created, downloaded on the robot, and ran successfully.</p> <p>Conclusions/Discussion Decoding commands embedded in spike sequences could play an important role in the design and implementation of prosthetic limbs. Neural signals from the brain could be used to move artificial limbs, if they were decoded appropriately. The work in this project is only a proof of concept of such decoding devices. It illustrates how we can use ANNs to perform this type of temporal decoding reliably. ANUs are extremely simple and the XOR operator is a common component of minimal complexity. This makes the solution very attractive for hardware implementation. The potential for future work is tremendous. More complex ANUs with more inputs, more involved input path characteristics, and more complex network topologies could be used to enhance the operation of the ANUs, the XANUs, and the Artificial Neural Networks.</p>	
Summary Statement Decoding commands embedded in spike sequences can play an important role in interfacing brain signals to artificial limbs and the presented artificial neural network illustrates one way to design and implement such an interface.	
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