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Steps Toward Knowledgeable Neuroprostheses

Patrick M. Pilarski and Craig Sherstan

Dept. of Medicine and Dept. of Computing Science, University of Alberta, Edmonton, Alberta, Canada

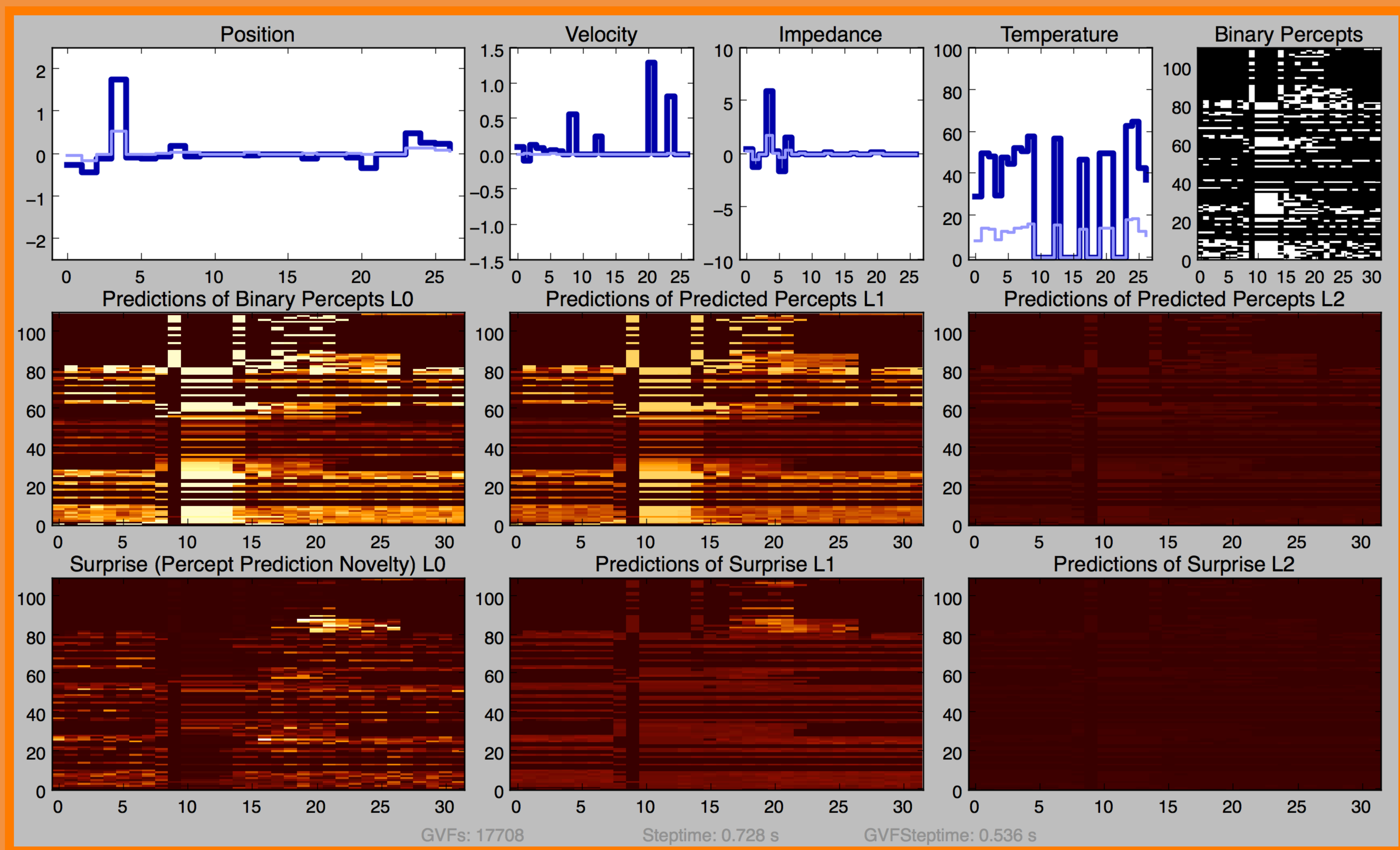
NUS National University of Singapore

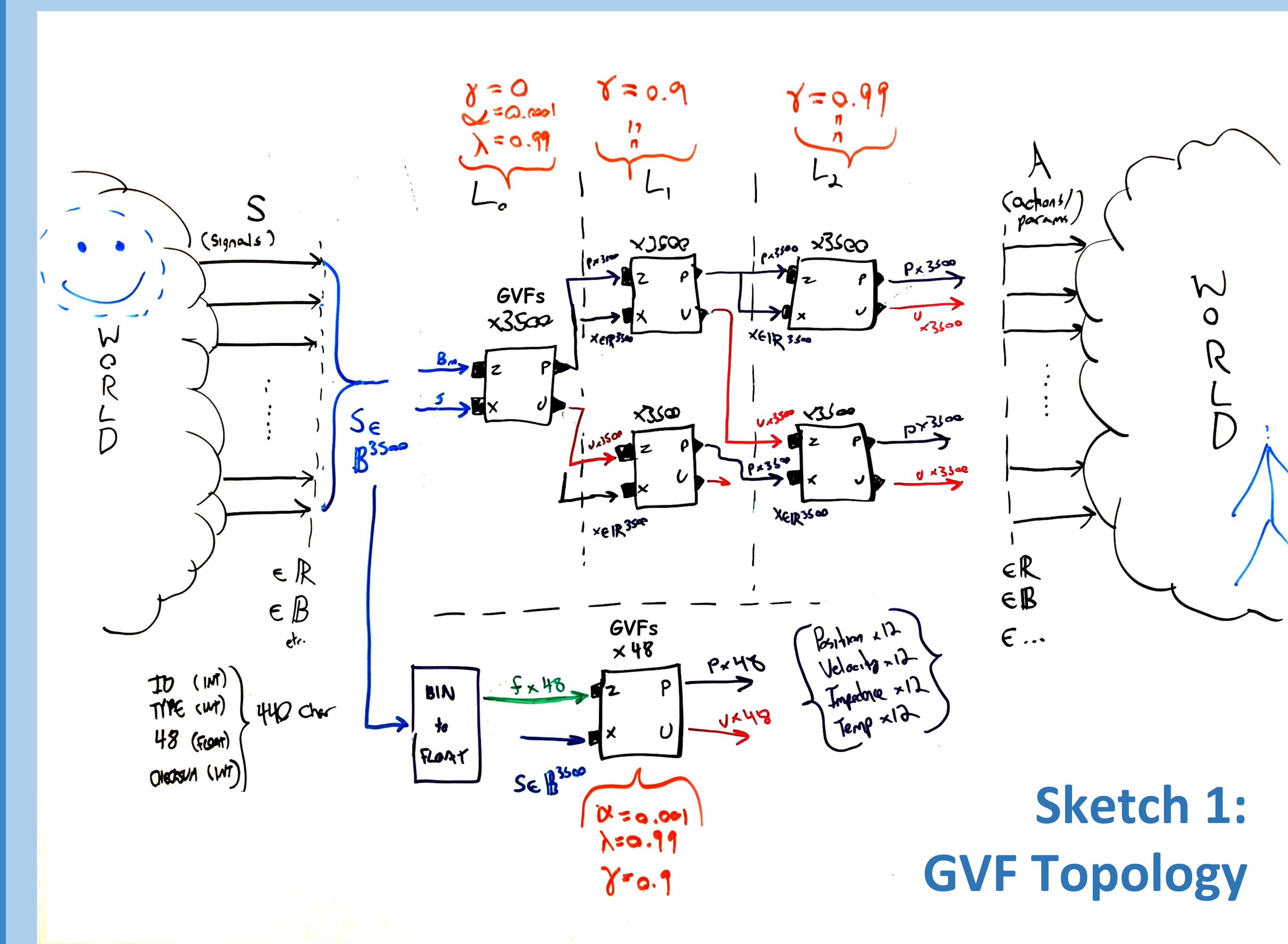
SINAPSE THINK BIG think different

Abstract: Advanced neuroprosthetic devices demonstrate an impressive capacity for both actuation and sensation, providing numerous controllable degrees of freedom and reportable sensory percepts. When linked to the human body by way of invasive and non-invasive brain-body-machine interfaces, neuroprostheses promise to greatly improve life for users by extending their capacity to engage with and interpret the world around them. In this work, ***we demonstrate how a prosthetic device can build up diverse knowledge during its ongoing operation so as to better support its user***. Specifically, we show that a device can learn and update 18k different temporally extended predictions per second about a sensorimotor data stream, significantly extending past work on real-time knowledge acquisition during prosthetic control.

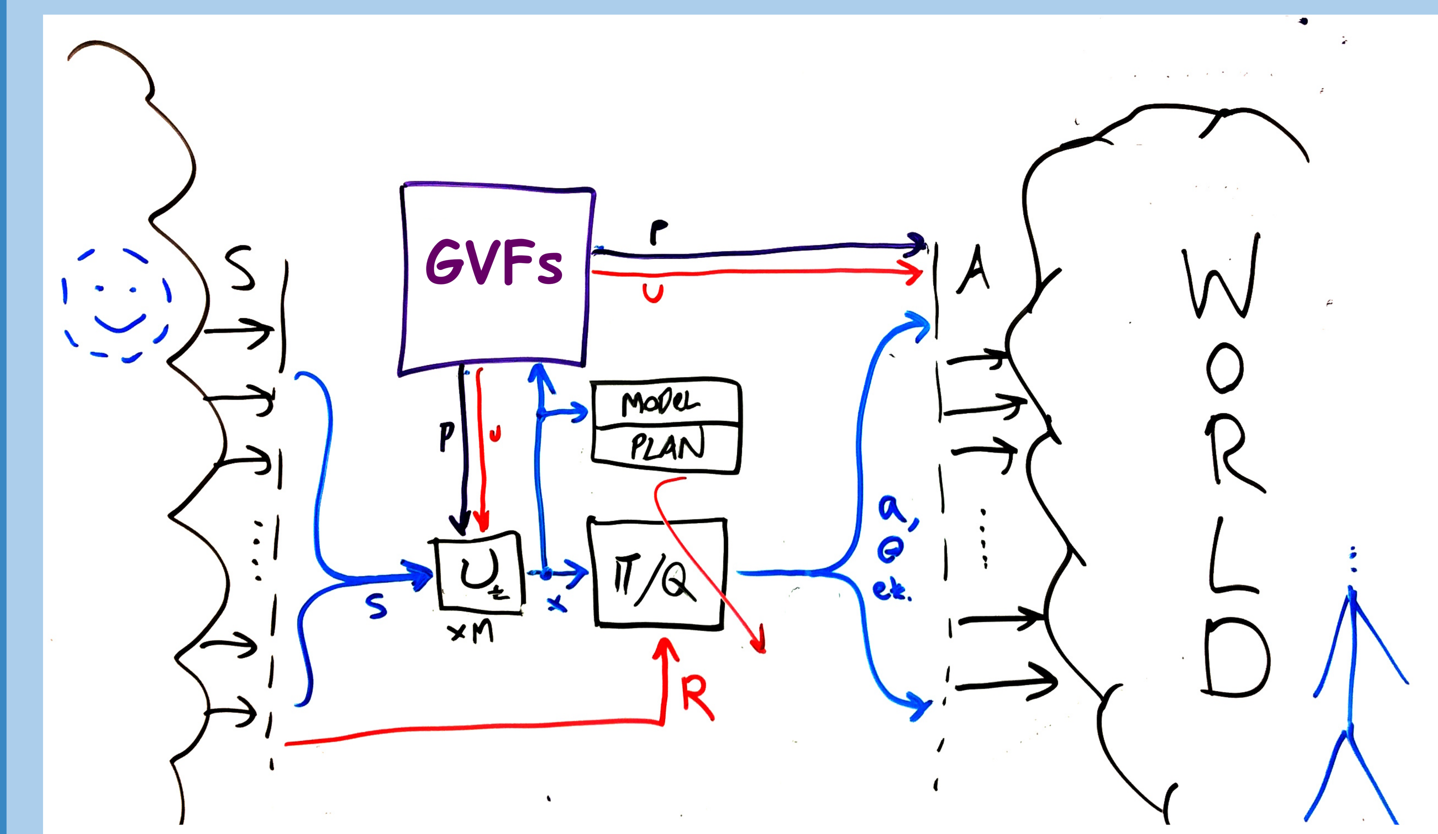
Methods & Results: A topology of ***General Value Functions*** (GVFs) was made to forecast binary percepts streaming in real time from a Modular Prosthetic Limb.

- During cyclic motion, the arm was perturbed by human interactions, such as shaking its hand or placing heavy objects in its palm.
- Within 6min of learning, the system was able to build up ***consistent forecasts*** of the data stream, ***detect unexpected errors (surprise)*** in its forecasts due to perturbations, and forecast future prediction errors ***(predictions of surprise)***.
- The resulting GVF topology forms a diverse, multi-timescale ***predictive state representation*** that can be used to inform and improve limb control.





Sketch 1: GVF Topology



Sketch 2: Integrating Predictions with Control

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Web: http://www.ualberta.ca/~pilarski Email: pilarski@ualberta.ca