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Control of Pneumatic Artificial Muscles with SNN-based Cerebellar-like Model

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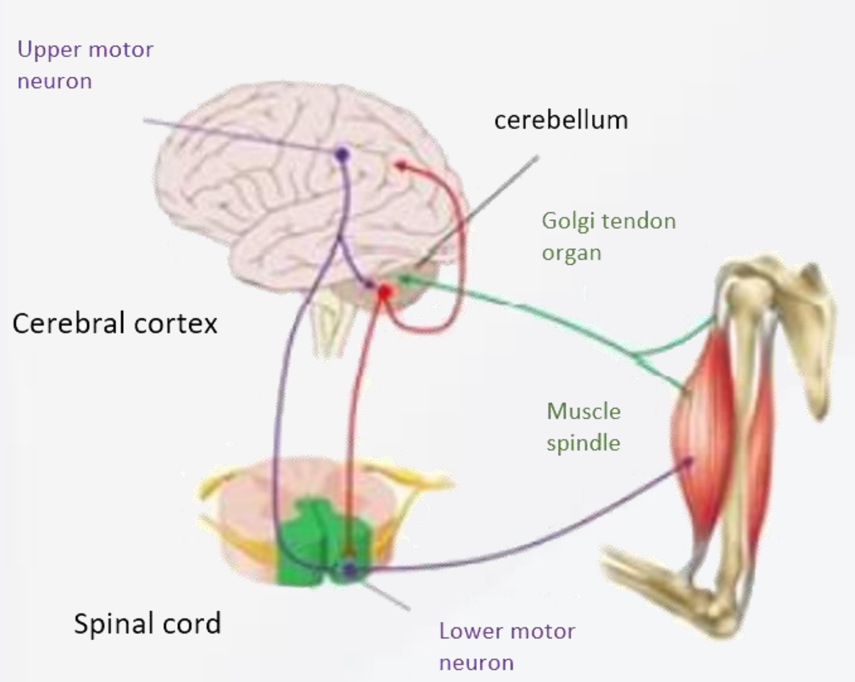
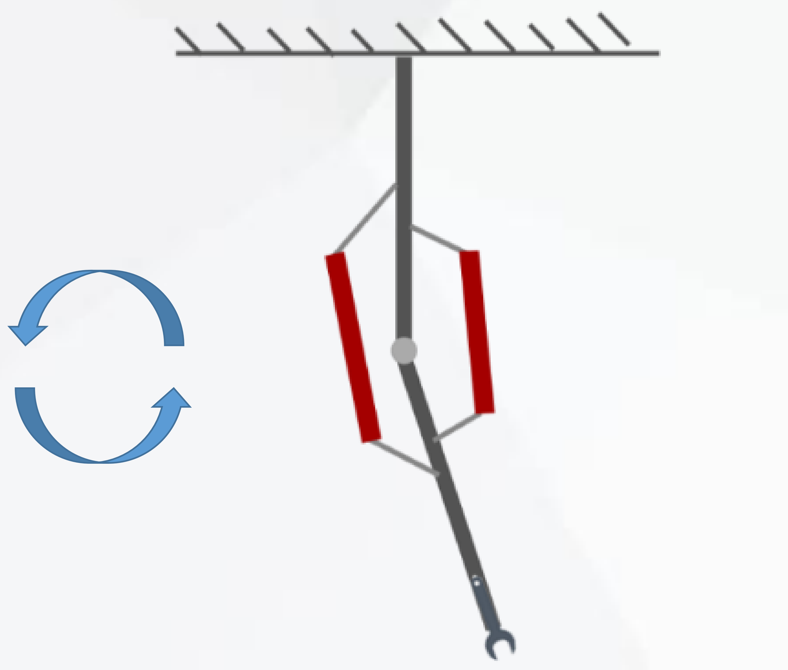
Introduction

Soft robotics technologies have gained growing interest in recent years, which allows various applications from manufacturing to human-robot interaction. Pneumatic artificial muscle (PAM), a typical soft actuator, has been widely applied to soft robots. The compliance and resilience of soft actuators allow soft robots to behave compliant when interacting with unstructured environments, while the utilization of soft actuators also introduces nonlinearity and uncertainty. Inspired by Cerebellum's vital functions in control of human's physical movement, a neural network model of Cerebellum based on spiking neuron networks (SNNs) is designed. This model is used as a feed-forward controller in controlling a 1-DOF robot arm driven by PAMs. The simulation results show that this Cerebellar-based system achieves good performance and increases the system's response speed



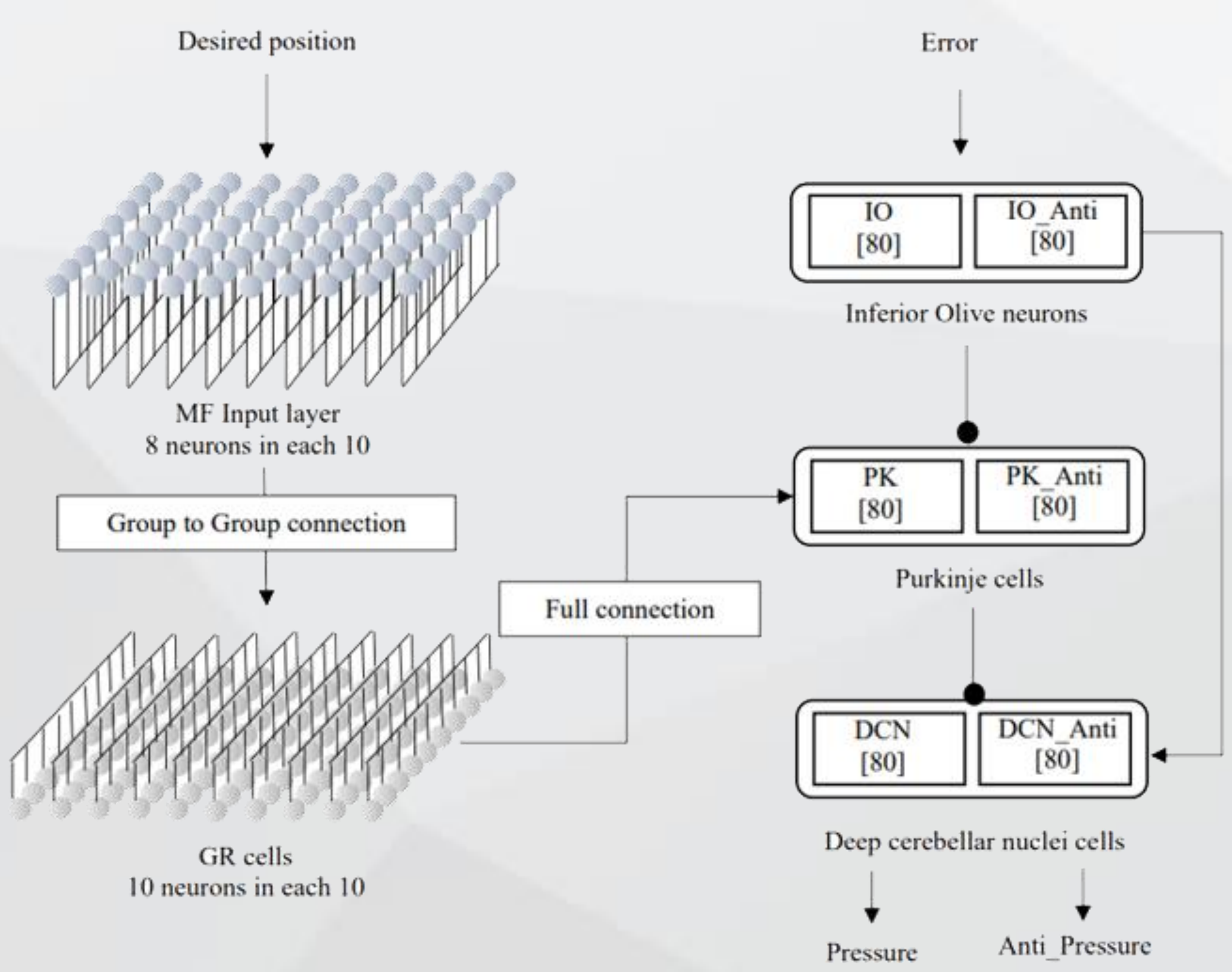
Cerebellum serves vital roles in human motion control



The robotic arm driven by two pneumatic artificial muscles

The Neural Network

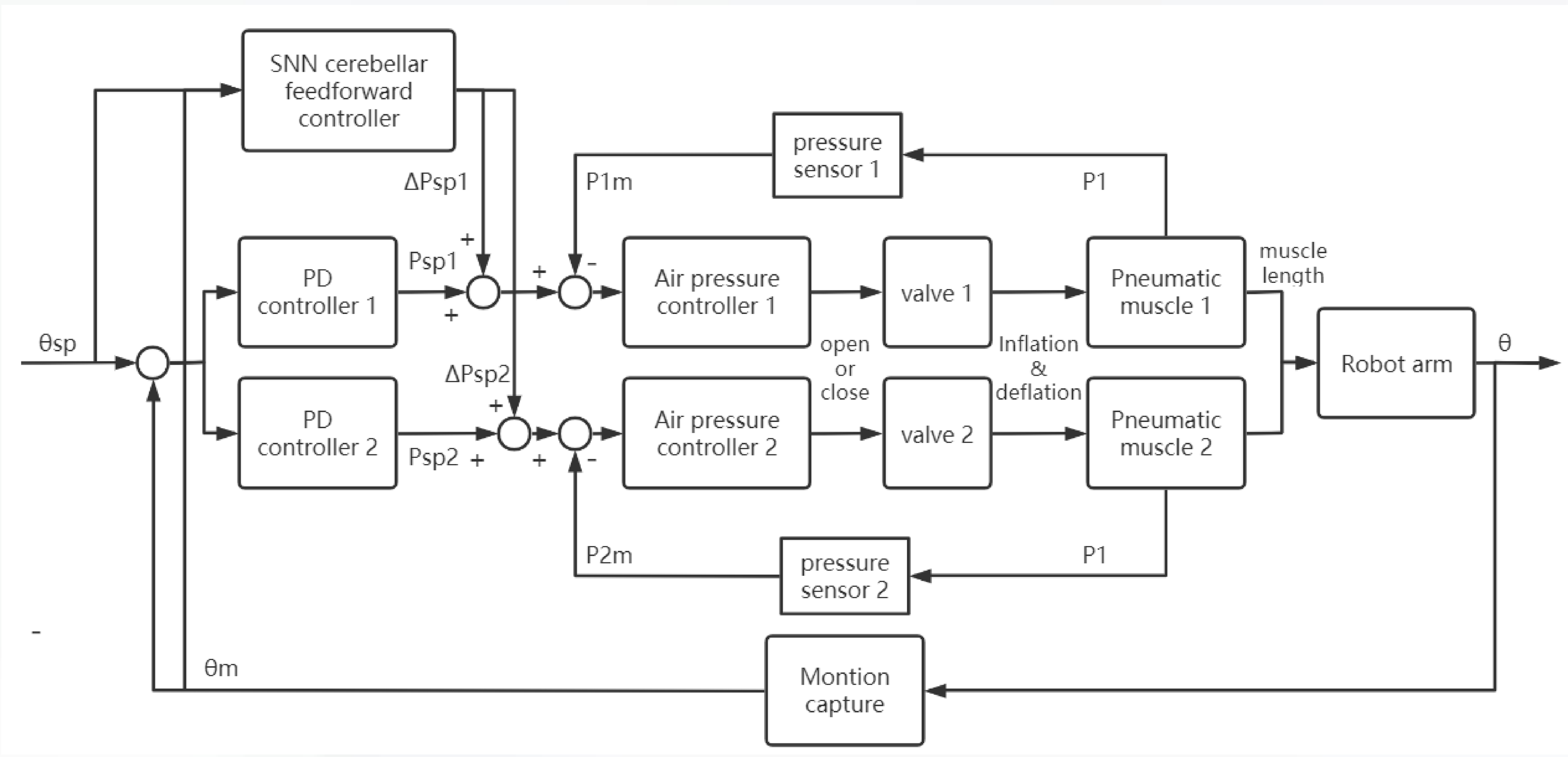
Here we use a real-time spiking neural network with a cerebellar-like structure that can obtain the inverse model of the Mckibben pairs to act as a feed-forward part of the controller. We use a set of spiking neurons as a basic unit of the network and imitate the structure of Cerebellar to build a neural network. The topology of the network is displayed.



Cerebellum-like neural network

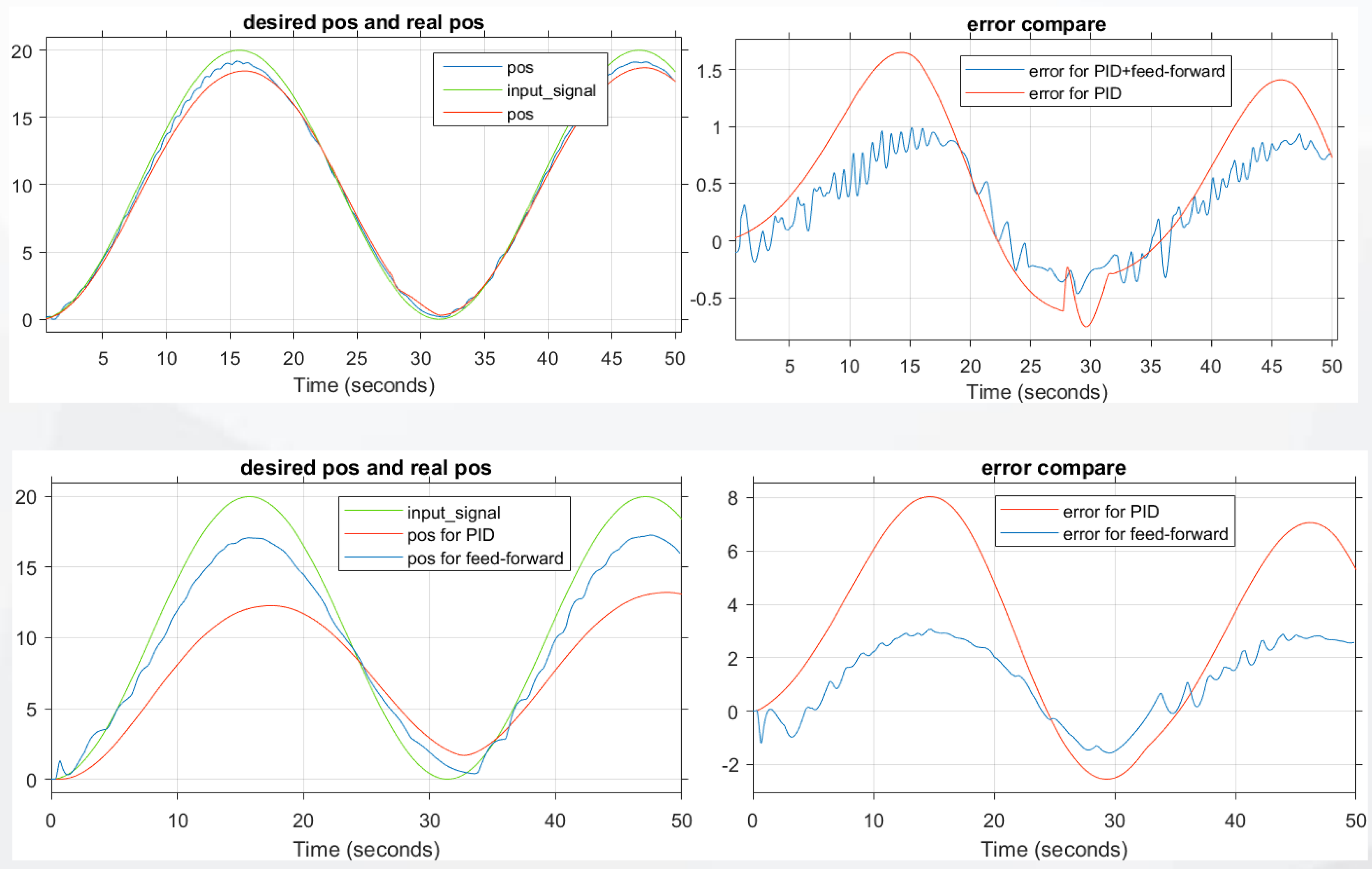
Control System

A cascade control method including a feed-forward part and a feedback part is applied in our system shown below. The block diagram of the feed-forward and feedback cascade control system directly controls the air pressure of the two pneumatic muscles by controlling opening and closing of the solenoid valves. The PID controllers in the outer loop is served as the main controller to obtain the precision of motion control. Cerebellum-inspired feed-forward controller contributes to improve the response speed and deal with the nonlinearity



the feed-forward and feedback cascade control system

Conclusions



Results for a controller with both feed-forward and feedback blocks and a controller with a single feed-forward block.

A controller with a PID feedback part and a feed-forward part built by the network is applied. The feedback controller is added to achieve the rapid response of the control system to disturbances. In order to test the trajectory tracking effect and the anti-interference effect of the end of the manipulator, a sinusoidal trajectory input is applied as the desired trajectory to analyze the control effect. Results show improvement in control accuracy comparing with the PID controller.