References for the lecture on motor control

Peter Latham, 13 November 2018

The endpoint analysis was proposed by (mainly) Emilio Bizzi in a series of paper. A pretty clear explanation can be found here,

> Bizzi E, Hogan N, Mussa-Ivaldi FA, Giszter SF. Does the nervous system use equilibrium-point control to guide single and multiple joint movements? *Behavioral and Brain Sciences* **15**:603-613 (1992)

You can find it by typing "Does the nervous system use equilibrium-point control to guide single and multiple joint movements?" into google scholar.

Reservoir state computing was first proposed by Jaeger and Haas in this now classic paper,

> H. Jaeger, H. Haas. Harnessing nonlinearity: predicting chaotic systems and saving energy in wireless communication. *Science* **304**:78-80 (2004).

I have the vague memory that Jaeger and Haas were the first to propose this kind of computing. However, Wolfgang Maass seems to have published a paper two years earlier, under the name liquid state computing,

> W. Maass, T. Matschlager, H. Markram. Real-time computing without stable states: a new framework for neural computation based on perturbations. *Neural Comput.* **14**:2531-2560 (2002)

so maybe Maass was first. As an aside, the idea simply does not work in spiking networks (contrary to many claims), mainly because they're very chaotic while reservoir computing requires operation on the edge of chaos. For why spiking networks are chaotic, see

> Edward Wallace, Hamid Reza Maei, and Peter E. Latham. Randomly connected networks have short temporal memory. *Neural Comput.* **25**:1408-1439 (2013)

> Michael London, Arnd Roth, Lisa Beeren, Michael Hausser and Peter E. Latham. Sensitivity to perturbations *in vivo* implies high noise and suggests rate coding in cortex. *Nature* **466**:123-127 (2010)

Both can be found on my website, http://www.gatsby.ucl.ac.uk/∼pel/publications.html .

Because spiking networks don't really work for reservoir computing, people turned to rate networks (following the original Jaeger and Haas approach). The most famous of these, at least most famous to neuroscientists, is David Sussillo Larry Abbott's "FORCE" learning paper,

> David Sussillo and L.F.Abbott. Generating coherent patterns of activity from chaotic neural networks. *Neuron* **63**:423-425 (2009).