Input-Driven Dynamic Attractors

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In traditional models of attractor neural networks, such as the Hopfield, Boltzmann, and analog-digital ring network, inputs are available to the network either once or continuously. The intrinsic dynamics cause the network activity to converge to a "stable" state which can be a fixed point, a limit cycle, or a chaotic attractor. We suggest to incorporate the *timing* of inputs as a crucial parameter of the neural dynamics. This leads to a novel paradigm to study dynamic input-driven attractors in recurrent neural networks. In this paradigm the network accepts inputs periodically as opposed to initially or constantly. In between iterations where inputs are accepted the network activity evolves according to the recurrent dynamics. This characterizes a number of perceptual systems including vision where visual scenes are processed and fed to downstream systems discretely at a rate of 10-50 Hz [1] and olfaction where 40 Hz gamma oscillations in the olfactory bulb/antennal lobe lead to a fixed point only for longer odorant presentations [2].

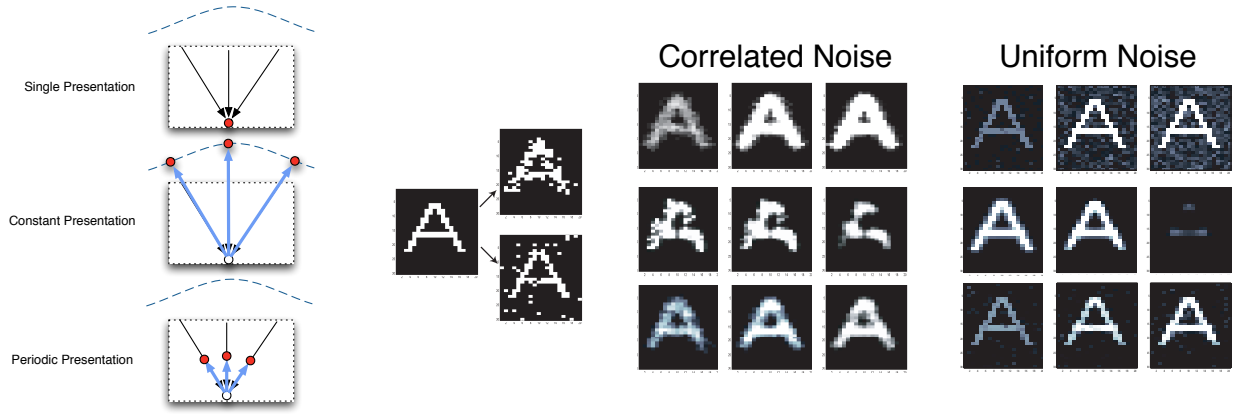

Figure 1: (left) Periodic inputs create new attractors. The dotted line represents possible inputs. Only periodic inputs generate multiple attractors in the network attractor space. (right) An example for visual memory with two types of noisy inputs: correlated and uniform: (top) constant presentation, (middle) initial presentation, (bottom) periodic window.

We argue that applying our paradigm to existing network architectures allows networks that previously had a small number of available attractors (even none) to develop many dynamic attractors depending on the specific input patterns. We also demonstrate that the paradigm can suggest new architectures and introduce an attractor based network that accepts noisy inputs in a periodic window and uses competing excitatory and inhibitory dynamics to produce low noise models of the inputs which are input-driven stable states.

References

[1] Is perception discrete or continuous. VanRullen, R. & Koch, C., *TRENDS in Cog. Sci.* 7(5): 207-213, 2003.

[2] Transient dynamics versus fixed points in odor representations by locust antennal lobe projection neurons. Mazor, O. & Laurent, G., *Neuron*. 48:661-673, 2005.