Toward a manifold encoding neural responses

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Understanding circuit properties from physiological data presents two challenges: (i) recordings do not reveal connectivity, and (ii) stimuli only exercise circuits to a limited extent. We address these challenges for the mouse visual system with a novel neural manifold obtained using unsupervised algorithms. Each point in our manifold is a neuron; nearby neurons respond similarly in time to similar parts of a stimulus ensemble. This ensemble includes drifting gratings and flows, i.e., patterns resembling what a mouse would "see" running through fields.

Regarding (i), our manifold differs from the standard practice in computational neuroscience: embedding trials in neural coordinates. Topology matters: we infer that, if the circuit consists of separate components, the manifold is discontinuous (illustrated with retinal data). If there is significant overlap between circuits, the manifold is nearly-continuous (cortical data). Regarding (ii), most of the cortical manifold is not activated with conventional gratings, despite their prominence in laboratory settings. Our manifold suggests organizing cortical circuitry by a few specialized circuits for specific members of the stimulus ensemble, together with circuits involving 'multi-stimuli'-responding neurons.

To approach real circuits, local neighborhoods in the manifold are identified with actual circuit components. For retinal data, we show these components correspond to distinct ganglion cell types by their mosaic-like receptive field organization, while for cortical data, neighborhoods organize neurons by type (excitatory/inhibitory) and anatomical layer. In summary: the topology of neural organization reflects well the underlying anatomy and physiology of the retina and the visual cortex.

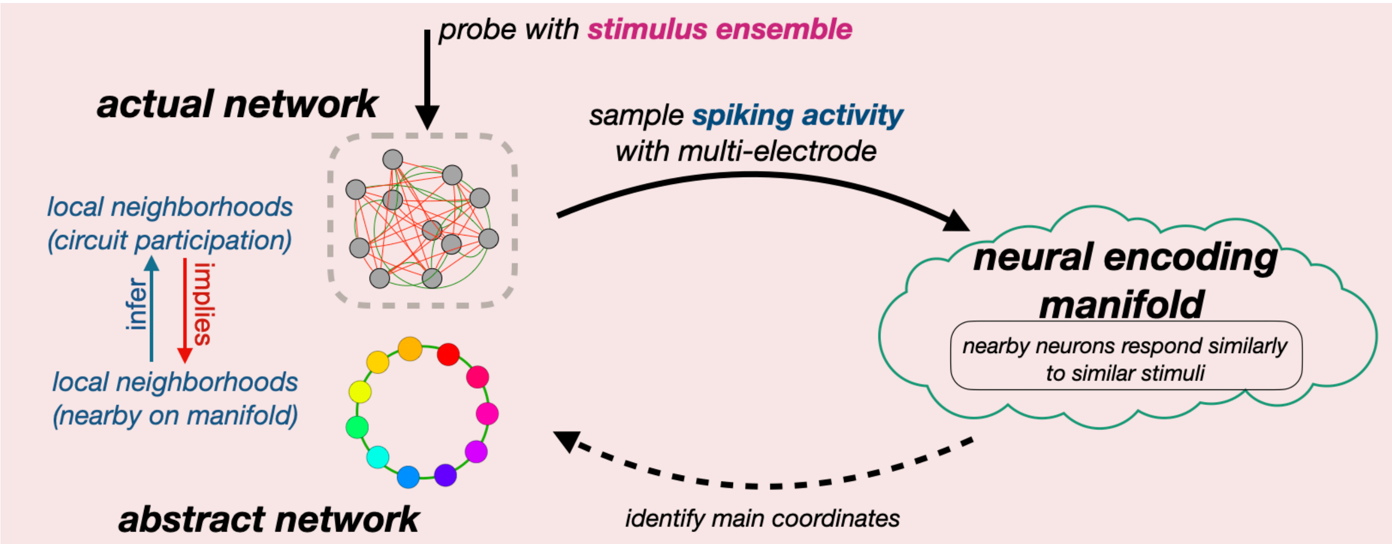

Figure 1. Summary of our approach.

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