An application of neighbourhoods in digraphs to the classification of binary dynamics

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Goal

To classify binary dynamics on a network. Our main application is to classification of activity on the Blue Brain Project reconstruction of a small section of a rat’s connectome.

- The representing graph is directed with no self-loops, no multiple edges in the same direction.
- The vertices represent neurons and the edges synaptic connections.

TOPOLOGY AND DIRECTED GRAPHS

We consider the closed neighbourhood (tribe) of a vertex \( v_0 \) (its chief) in a digraph \( G \) as computational units.

We realise it topologically by the directed flag complex: ordered simplicial complex where a \( k \)-simplex is a \( (k+1) \)-directed clique in \( G \).

A \((k+1)\)-directed clique is an ordered set of vertices \( (v_0, \ldots, v_k) \) such that there is an edge from \( v_i \) to \( v_j \) in \( G \) whenever \( 0 \leq i < j \leq k \).

LOCAL PARAMETERS

Our approach is Stay Local (to keep with the times):

- select a small number of tribes that are champions with respect to a sorting parameter;
- restrict to specific subcomplexes of each of the tribes;
- compute the value of a given feature parameter for those subcomplexes.

ACTIVITY AND METHODS

The 8 stimuli activity data: each experiment has a time period of 200 milliseconds and is repeated 557 times for each stimulus in a random sequence \( \implies \) a big matrix of the recorded activity.

Our pipeline extracts combinatorial/topological information from the active subtribes of the selected tribes and creates a feature vector for a support vector machine.

RESULTS AND ANALYSIS

One of our validation tests - “tribes” with same chief but different members.

Classification results

**Further reading**

  https://arxiv.org/abs/2104.06519
- Associated data and visuals: https://homepages.abdn.ac.uk/neurotopology/neighbourhoods