Centrality in Spatio-Temporal Networks

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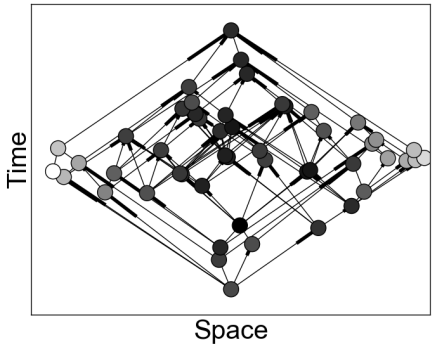
Centrality is a useful and commonly used network measure to help identify 'important' nodes in a network, but which measure we use must be informed by what we mean by 'important', and therefore by the underlying system whose topology the network represents.

Much recent research has considered networks to have an underlying geometry where each node's co-ordinates determine which others it is connected to. In simple examples centrality measures unsurprisingly pick out nodes nearest the center of the geometry they lie in.

The underlying premise behind geometric networks is that nodes should connect to those which are similar to them in some co-ordinate system. For some networks time can be a natural co-ordinate that doesn't correspond to similarity. For example in citation networks information from far away fields takes longer to reach researchers than information in fields they follow more closely. In such networks time is important and can be considered as part of the network geometry, but is to be treated differently to co-ordinates representing similarity. These networks have causal constraints and form directed acyclic graphs. There can still be an underlying geometry, but it is not just a spatial geometry, but a space-time.

We consider the simplest such case, where networks have the geometry of causal connections in Minkowski space. We show that here, traditional centrality measures no longer identify the spatial centre of the network. In the causal set approach to quantum gravity, spacetime is made up of discrete elements whose causal connections form a network, and we will use results and adapt techniques from this theory to devise new centrality measures which are appropriate for networks embedded in time.



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