Boundary-aware node centralities for spatial graphs

Supervisor: David B. Blumenthal

Node centrality measures such as closeness, betweenness, eigenvector, or PageRank[1] centrality are standard tools to quantify the importance of individual nodes in a network. Consequently, they are also widely used to analyze spatial graphs derived from tissue sections (e.g., spatial k-nearest neighbor graphs[2] computed based on spatial omics data[3]). However, when using node centrality measures to quantify node importance in such spatial graphs, they tend to prioritize nodes in the center of the graph and de-prioritize nodes that are close to the boundary of the tissue section. This is a problem, because the boundary is very often an arbitrary artifact of the tissue sample collection protocol (e.g, a small skin section was cut out of an arbitrary section of a larger skin area of interest) and should hence not affect node importance quantification.

The proposed project should address this problem through the following steps:

1. Mathematical formulation of one (or several) boundary-aware node centrality measures for spatial graphs. For instance, such a measure could correct for the de-prioritization of nodes at the boundary or it could quantify the minimal distance from the boundary required to ensure that the boundary no longer distorts the obtained node centralities.
2. Implementation of the new boundary-aware node centrality measure in Python or any other programming language.
3. Proof-of-concept validation using spatial graphs derived from spatial omics data.

Requirements

- Very strong conceptualization and modeling skills.
- Prior knowledge in mathematical graph theory is a plus.
- Basic programming skills in Python or any other programming language.

Depending on the results, continuation of the project in the context of a MSc thesis is possible.

References

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