Communicability, geometry and navigation in (brain) networks

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I will start this workshop with some introductory concepts about algebraic network theory, such as the concepts of walks, its counting and relation to the spectra of adjacency matrix. Therefore, the students do not need previous knowledge of algebraic network theory but basic elements of graph theory and linear algebra. I will then motivate and introduce the concept of communicability functions in networks. The motivation will be focused on the problem of navigability on brain networks and how unplaussible it is that such navigation occurs through shortest paths. I will illustrate the concept from several examples on the use of communicability in brain networks. I will then introduce some excercises for the students to perform calculations using Matlab.

In the second part of the workshop I will motivate and introduce the concepts of communicability distances and angles and show how they induce an embedding of the network into a hyperspherical Euclidean space. I will then illustrate some properties of these geometric parameters on networks and how do they differentiate from other metrics, like the shortest path distance. I will then motivate and introduce the concept of graph geometrization and how we can obtain shortest communicability paths in a network. For this, I will conduct some experiments on the computers for the students to perform their own calculations. I will use again Matlab for doing the excercises.

Finally, I will motivate and introduce the concept of network bypasses. I will show how information in a network preferentially avoids the hubs by using alternative routes which we will call bypasses. I will introduce how to detect such bypasses and illustrate its calculation for some real-world networks.

The main reference for the minicourse will be:
Estrada & Knight: A First Course in Network Theory
https://www.amazon.es/First-Course-Network-Theory/dp/0198726465