Modeling Fungal Network Growth

William Tickman

Fungal Networks are all around us and there is a reason why. Fungal Networks are very efficient at searching for food(growing), repairing and resource transport across the system because of their complex network structure. Fungal Networks are very complex dynamic and spatially expanding systems which makes them particularly difficult to model. I will, In short, describe how Fungal networks grow to give you an Idea as to the complexity. Fungal Networks start small at a core node and branch outward distributing resources from the core outward to the tips. Initial branches are very thin and tree -like so as to cover more area but as expansion progresses the inner thin branches begin to fuse and form stronger cords or they are recycled by the system and distributed. This causes the networks center to be densely connected while the periphery, searching tips, form a much more tree-like branching network. As the network searches further and further for more resources to no avail, it continues to thin out branches and eventually recycle them causing the networks core to become sparse. I also find it interesting that these fungi networks do not have a centralized decision system which means that the network is built off of a set of local rules which control the branching and growth through different factors like resource saturation or pull from neighbors.

As far as my research has taken me, there are many empirical fungal models that exist which in my mind lays the groundwork for creating simulated models!! Through this project I would like to create a fungal model that mimics the spread and behavior of some empirical models while only looking at very local neighbors to implement growth/recycling/fusing decisions in the networks system. The goal for this project is to create a spatially distributed temporal model that can accept and respond to its environment such as finding food and maybe as a stretch goal responding to destruction or even fight another fungal network. To determine the efficacy of my model I will compare it to empirical models both visually and to many various network measures outlined in different studies that are particularly indicative of fungal networks.

I do not anticipate this project to be fully successful. Realistically, I think it would be amazing if I was able to have my model interact with finding food. I anticipate that properly modeling the growth/fusion/recycle dynamics of a resource static fungal network will be very difficult but not impossible. Modeling branch fusion will likely be the most difficult aspect of this.

I will pulling fungal network data from multiple sources including articles on, “Growth-induced mass flows in fungal networks”, “Mesoscale analyses of fungal networks as an approach for quantifying phenotypic traits”, “Morphology and mechanics of fungal mycelium” and more. A complete list of resources used so far are listed below

Growth-induced mass flows in fungal networks:
https://royalsocietypublishing.org/doi/10.1098/rspb.2010.0735#d35333046e1290s
Mesoscale analyses of fungal networks as an approach for quantifying phenotypic traits:
https://www.biorxiv.org/content/10.1101/006544v4.full#T1
Biological solutions to transport network design:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2288531/

Morphology and mechanics of fungal mycelium | Scientific Reports:
https://www.nature.com/articles/s41598-017-13295-2
Spatial Networks: https://arxiv.org/pdf/1010.0302.pdf
Analysis of Fungal Networks:
https://www.researchgate.net/publication/257691675_Analysis_of_fungal_networks

Below is an empirical fungal network In which can more easily see how the system branches, recycles, and fuses.