Department of

Electrical & Computer Engineering

North South University

Assignment 01

Submission Date: 03.01.22

Course Name: Modeling and Simulation

Course Code: CSE562

Submitted to

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Agent-based Modelling of Mycelium Growth

Project overview:

In this project, by creating some simple rules we show that how the mycelium grows and also how the nutrients spread through the hyphae inside the mycelium.

The Importance of the Work:

Mycelium is a type of fungus that produces mushrooms through a network of threads known as hyphae. Its hyphae, which are a web-like network of structures that make up mycelium, release enzymes that help the organism break down food sources. A fungus mycelium takes in nutrients from its surroundings. Mycelium's fast-growing fibers produce materials from leather to plant-based steak to support growing organs, and they're utilized for packaging, clothes, food, and construction. When used as a technology, mycelium aids in the replacement of fast accumulating plastics in the environment. Evocative Design uses mycelium as a bonding agent to hold wood particles together for paneling.

The parameters of the model:

The following parameters are used to build this model:

Patch: Liviness

Liviness: while branching, when new hyphae grows the occupied patches will be alive and be the part of the mycelium growth.

Agent: Hyphae, Nutrients

Hyphae: The edge of the mycelium

Nutrients: Absorb engyme from the environment

Slidders: Wiggle-Angle, Branch-time

Wiggle-angle: The pseudo-random movement of agent (new hyphae).

Branch-time: It controls when a new branch will appear.

How It Works:

When a spore lands on a suitable substrate in suitable conditions, it will germinate. The germination of a single germinated cell is the start of the mycelium. Mycelium is made up of the fungus's growing stem cells. Fungi are heterotrophs, meaning they must obtain energy from their surroundings. Mycelium grows by releasing enzymes from its hyphal tips, which break down and absorb the nutrients in the environment. As it expands, the cells will eventually branch and continue to branch, forming a massive, filamentous mycelial network. Multiple agents are included in the model. The hyphae and nutrients are created using NetLogo's built-in breed. Along with the specified characteristics, each breed has its own set of NetLogo variables. To disperse the nutrients throughout a hyphae we check for the maximum liveliness.

Some assumptions are made, there are things to notice:

1. First of all we setup the hyphae,
2. Then by clicking grow button the hyphae grows,
3. We can also set the wiggle-angle from the slider of the model to change the angles of the hyphae while branching,
4. Branch button will add hyphae branch, in this model random branches (1-3) will auto-genarate depending on the branch-time but we can also increase the number of branches every time by clicking the branch button,
5. The branch-time slider controls when there will be new branching with increasing time,
6. Setup nutrient button will set nutrients (intially we took nutrients=500) and each time we click on this button the nutrients increase,
7. The nutrients will flow through the hyphae (which has maximum variable liviness) after pressing the flow button

Observations:

Some interesting results are found after implementing the mycelium growth:

1. Here we monitor the number of Hyphae and Nutrients element in the model and it will update its value when the hyphae and nutrients increased.
2. Defining the wiggle angle we should keep it low to maintain the mycelium growth order if the wiggle angle is too big there will be a chaotic situation between the agents. So we keep the wiggle angle within 2 to 10.

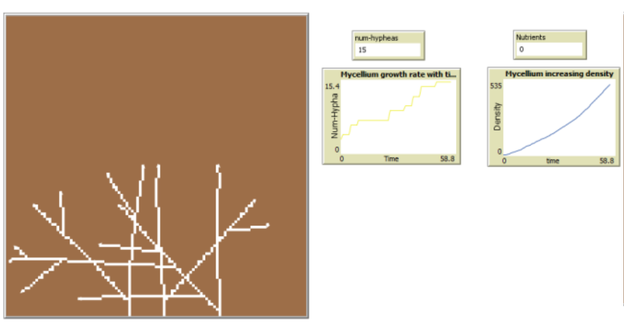

Figure 1: For wiggle angle = 2 and ticks =56

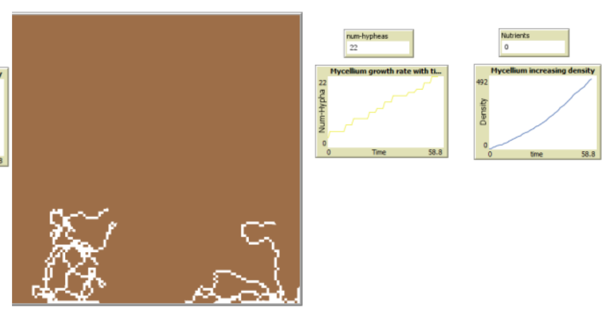

Figure 2: For wiggle angle = 68 and ticks = 56

3. When we select the Setup-Nutrients button, we can see that the amount of nutrients in the environment increases, and when we press the Flow button, the nutrients spread over the hyphae branches. When the number of nutrients is large, the flow of nutrients is also rapid; nevertheless, when the number of nutrients is little, the flow of nutrients becomes slow.

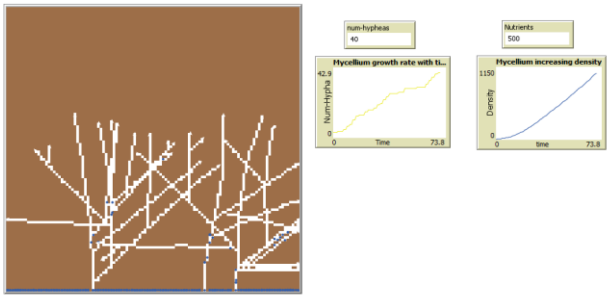

Figure 3: For nutrients= 500 and ticks = 70

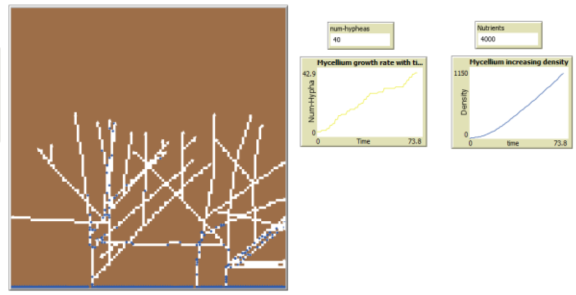

Figure 4: For nutrients= 4000 and ticks = 70

4. The Mycellium growth rate plot to watch the increasing Mycellium growth over time where the monitor represnts the increasing rate of mycelium growth with time.
5. The Mycellium increasing density plot to watch how the patches become alive for increasing agent size over time.

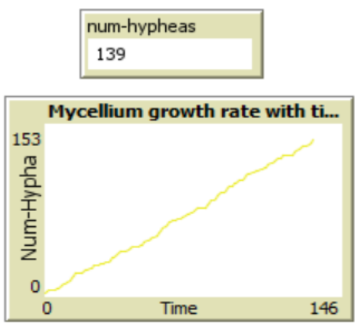

Figure 5: Plot shows number of hyphae and monitor shows the growth rate of mycelium with time

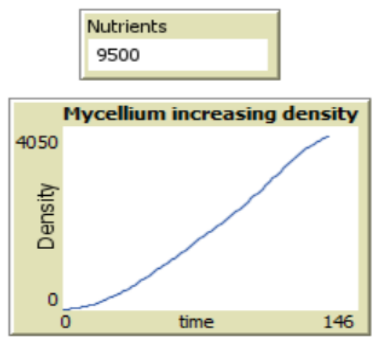

Figure 6: Plot shows nutrients number and the monitor shows the mycelium increasing density with time

Conclusion:

This model simulates how mycelium grows and appears under microscopical observation. This model may be expanded by varying the nutrients and observing how mycelium development changes. Moreover, we may experiment with different environmental factors like soil, grass, and so on, and see how they affect hyphae growth to achieve a more realistic picture.