Knowledge spread and use of biotechnology in the cataclysm survival

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Summary: Agent-Based Modeling (ABM), a relatively new computational modeling paradigm, is the modeling of phenomena as dynamical systems of interacting agents. Another name for ABM is individual-based modeling.
Model described in this paper represents scenarios where spread of knowledge is analyzed and how the use of biotechnology is applied so knowledge can survive the cataclysm. The growth of general knowledge and knowledge in biotechnology, and their correlation, is presented through a NetLogo model and simulation.
Keywords: *agent-based modelling, model simulation, biotechnology knowledge, cataclysm, survival of knowledge*

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I. INTRODUCTION

"At its simplest, biotechnology is technology based on biology—biotechnology harnesses cellular and biomolecular processes to develop technologies and products that help improve our lives and the health of our planet."
[https://appliedbiotechnology.wisconsin.edu]
Biotechnology is an expansive field, founded on human curiosity and ingenuity, and offers the opportunity to solve the world's most pressing problems in healthcare, agriculture, and industry. Our whole life is based on biotechnology. For our survival, biotechnology is essential. For this reason, we need to be informed and knowledge of it must be disseminated. Today, biotechnology is dictated by the technology around us. But technology will not mean anything to us if there are no people who know about it because man is the one who thinks and comes to solutions. However, for the use of biotechnology to survive cataclysm, knowledge must first be disseminated among humans and through biotech centers. By acquiring general knowledge, automatically at some level, people acquire knowledge of biotechnology. Therefore, it seems that knowledge spreads when individuals visit biotech centers and stay there for a while. As biotech centers are a major source of dissemination of knowledge about biotechnology, it is quite natural to expect that the level of knowledge offered at the biotech center plays an important role in the survival of biotechnology. To become a biotechnologist, someone must acquire even other knowledge, but to in lesser extent. This paper will primarily use models that will facilitate understanding of the complexity of the interaction between knowledge dissemination among different individuals and their impact on society. Modeling is the development of a model as a representative of a system. Simulation can be defined as experimenting or executing a model. Agent-Based Models are computer models that attempt to capture the behavior of individuals within an environment. [Agent-Based Modeling and Simulation: Franziska Klügl, Ana L.C. Bazzan]

II. SIMULATION MODEL

Through an agent-based simulation model we can monitore the progress of knowledge of each individual and everyone in the biotechnology center. Simulation is based on agents and biotechnology centers in this model. In fact, agents are a group of people who show the actual behaviour of people in the domain of gathering knowledge. After completing the training in the knowledge centers, the agents are given the opportunity to join at one of the biotechnology centers. To enter in the biotechnology center the agent's minimum level of knowledge is set on 40%, but it can be changed on slider. Otherwise agents with knowledge below a defined treshold stay in education center. Also, if they are 14 fields away from the center, and there are no more than 6 people in the center to work, they can hook up. The number of agents is variabile, it means that growth and decline of population are involved in the model. Each agent has a set of parameters that influence the acquisition of knowledge this biotological knowledge such as the learning ability, learning williness, but they express their desire for biotechnology centers when they are entering them. Agent's age is between 18 and 70 years, and after, agent gets in the biotechnology center he stays there until he dies. It's important to note that in this model, the time changes by one month per tick, so that is the way the model keeps the track of the age of agents. Each agent also has ability to learn, and we explain that as some randomly generated numeric value in the predetermined interval and this can be changed in model settings. Learning ability is a permanent value, once it is set it keeps its value for the agent throughout his life. Just like learning ability, learning williness has also permanent value throught his life which is randomly generated. Two agents can expand their knowledge when they meet each other. One with higher level of knowledge transfers knowledge to an agent with lower level of knowledge, a very small part, because biotechnology center is responsible for that. Biotechnology centres are places where agents collect their knowledge. Each center when it is created gets basic values, just like the level of knowledge biotechnology center and initionaly created three agents in center. The level of knowledge that is offered at the center is parameter that is not closely related to each agent. In this paragraf it will be explained how to acquire the knowledge in biotechnology center. First, it's calculate the absorbance factor based on employee's ability willingness to learn. Both variales are are bounded by the values 0 and 100, so the calculated factor has a value between 0 and 1. After that, the factor multiplies the knowledge that the biotechnology center is able to offer employee's each year. And then calculated value is normalised. Knowledge growth is calculated on the way that number 42 divide by number of working years and add number 3 on the calculated value. At the end total knowledge growth it's calculated on the way that we multiply calculated knowledge to apsorb normalised with knowledge growth.

E_{LA} – Employee's learnig ability

E_{LW} – Employee's learning willingness

BC_K – Biotechnology center's knowledge

BC_{Ky} – Biotechnology center's available knowledge per year

KTA_F – Calculated knowledge absorbance factor

KTA– Calculated knowledge to apsorb

$KTA_{normalised(a,b)}$ – Calculated knowledge to apsorb normalised

WY- Number of working years

KG - Knowledge growth

KG_T – Total knowledge growth

$$BC_{K_y} = \frac{BC_K}{10}$$

$$KTA_F = \sqrt{(E_{LA} * E_{LW})} * 100$$

$$KTA = BC_{Ky} * KTA_F$$

$$KTA_{normalised(a,b)} = (b-a)\frac{KTA - min(KTA)}{max(KTA) - min(KTA)} + a$$

$$KG = \frac{42}{WY} + 3$$

$$KG_T = KTA_{normalised(a,b)} * KG$$

III. IMPLEMENTATION

For modeling and simulation instances which are subject of this work is used tool called NetLogo. NetLogo is programming environment intended to make multiagent simulations and it is used for fast and simple making models which simulate different natural and social instances. Every NetLogo model has two main parts – user interface and programming code. The user interface is used to activate models and to adjust parameters as well for a visual demonstration of model while is code in separated different part. Beside these two parts, every model has information box with description of made model and instructions for its use. User interface is base of every NetLogo model. At the interface there is a box which visually displays the appearance of the model the user is developing. Beside the visual bow which shows the environment, at the interface is also possible to put some different types of control for managing or adjusting different parameters of the model. Those controls can be a button for starting a simulation or a value of certain variable whose value can be managed by a slider or a simple switch. It is also possible to enter manually a value of certain variables or simply show their value at the interface and if necessary, plot them on the graph.

NetLogo models code is in a separated window. All of the procedures which are executing during performance of model are defined in this part. During the writing of code it is possible to check correctness of written code by pressing a check button. In a case of mistake, incorrect part of a code is marked and description of the mistake is printed to the user. This makes it easy to check the written program. Every NetLogo model contains four basic types of agents: turtles, patches, links and observer. Turtles are the most important agents inside a model. They have possibility of movement around the world and interaction with other agents and the most important part during development of same simulation is about their behavior. Inside the model there are two types of agents: agents with the general knowledge and agents with the biotechnological knowledge. The simulation aims is to show how much of biotechnological knowledge is enough to subsist after a cataclysm. Agents are described by attributes: the age, the general knowledge and the biotechnological knowledge. The agent must have at least 30% of the general knowledge so he can study biotechnology which is going to get in the education center and after which he is going to be able to join the biotechnological center. By the time certain number of agents die in age 65-75, so it creates certain number of new agents and in that way population grows.

The settings of the simulation and the initial values are adjusted by controls which are at the user interface. The time is defined by ticks, respectively one tick is one month. New technology centers are created when at least three agents with biotechnological knowledge meet, if technology center remains without the agents it disappears within three years. Starting a cataclysm is being done by a button at the user interface, and in that moment certain number of agents, education and technology centers disappear, depends on how many of them is determined to be killed, by a slider. At the user interface there are more charts which show data about the average general knowledge and the average biotechnological knowledge of people over 30 years of age. Beside the charts, there are some more important parameters at the user interface: the number of people, the number of education centers, the number of technology centers, the number of students, the number of people who work in technology centers, the current level of knowledge, the number of people who finished their studies.

Initial values in the model are not permanent but variable on the basis of which some different analysis are done depending on input data. By the slider is possible to find some input data: the number of residents, the number of centers. There are also some sliders which refer to cataclysm respectively are used to determine how many killed people are going to be educated, uneducated, how many educational and technology centers are going to be ruined.

Beside this, on the main display there are also main components: educational centers, technology centers and agents. In the beginning of the simulation the biggest number of agents is around the educational centers, after when they acquire certain level of the general knowledge, they pass to the technology centers. In the technology centers they continue to acquire biotechnological knowledge depending on the level of knowledge of that center. Educational and technology centers are different by the charts, so the educational centers have a look of a blue house and the technology centers have a look of a blue cube. Agents are different by the colors, every color determines category which they belong to. Agents shown by the yellow color are the agents who are not educated and they are not in the educational centers. Agents shown by the red color are students and they can be found in the educational centers. The green color represents the agents who finished their education in the educational centers three years, while agents shown by the blue color finished five years and the purple eight years.

IV.RESULTS

Simulation results will show us the behaviour during the cataclysm. Parameters which model is using are percentage of basic knowledge acquired in the educational centre, willingness to learn, ability to learn and percentage of the biotechnological knowledge acquired in technological centre.Input of the different values for the above mentioned parameters will show us expected behaviour of the model. In the following articles will demonstrate two scenarios. Initial values of the parameters which are applied on both scenarios are: number of populations 850, number of educational centres 20, number of technological centres 20 and minimal willingness to learn 25. Cataclysm is executing at the moment when number of the agent's population is between 1,500 and 1,600. Cataclysm is killing 50 uneducated and 90 educated agents (figure 1). Question which is being set for us at this moment "WIll the usage of the biotechnological knowledge survive the cataclysm"? Then, if knowledge recovers at what point it will be, will it be the same with respect to the population when the cataclysm occurred, or will the population need to increase twice as much to reach the level of knowledge when the cataclysm occurred. The scenario that will be shown first is the worst case scenario, which means that biotechnological knowledge did not survive if the number of people with biotechnological knowledge over 55 after a certain time after cataclysm was percentage drastically smaller than at the moment when cataclysm occurred. Variable parameter reduction percentage of technology center knowledge level in this case is 70. And average time spent in the center is 10 years. Population number at the time of the cataclysm was 1548 and number of people with the level of biotechnical knowledge above 55 was 139 that is 8.9%. At the end of the measurement population number was 1970 and number of people with the level of biotechnical knowledge above 55 was 32 that is 1.6%. Level of average knowledge of people older than 30 years at the time of cataclysm was 359, and at the end of measurement it was 156. The conclusion after examining the worst-case scenario is that knowledge did not survive, and it grows very slowly with given variable parameters. The best case is one that shows in what conditions the number of people with the level of biotechnological knowledge over 55 is the same or higher in compare to population number before cataclysm and after the reconstruction. Variable parameter reduction percentage of educational center knowledge level in this case is 40. Population number at the time of the cataclysm was 1526 and number of people with the level of biotechnological knowledge above 55 was 109 that is 7.1%. At the end of the measurement population number was 1140 and number of people with the level of biotechnical knowledge above 55 was 100 that is 8.77%.The conclusion after examining the best-case scenario is that biotechnological knowledge did survive given that the average knowledge after a cataclysm on a population of 1140 people is 100, and the average knowledge before the cataclysm on a population of 1526 people was 109.

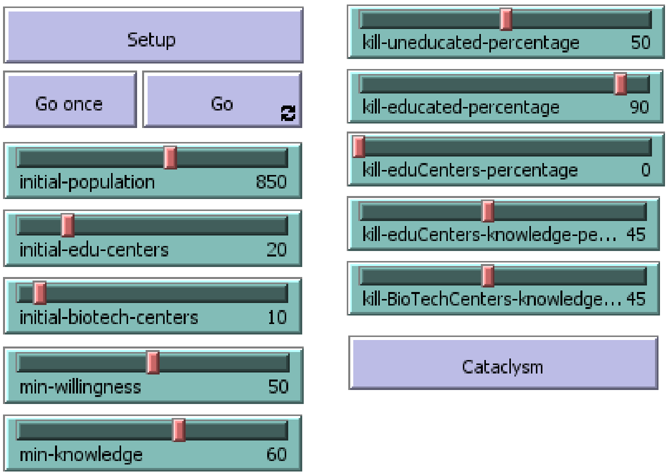

Figure 1. Initial parameters for best-case scenario

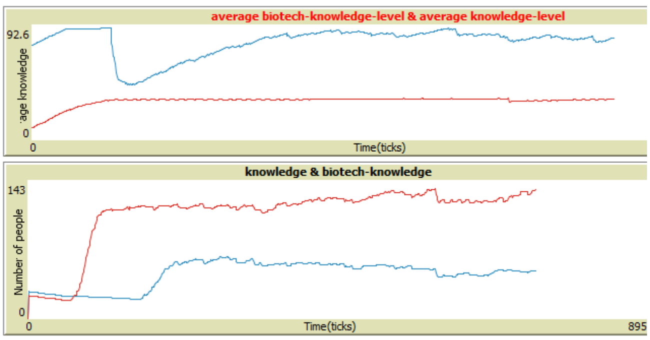

Figure 2. Best-case scenario for simulation results before cataclysm

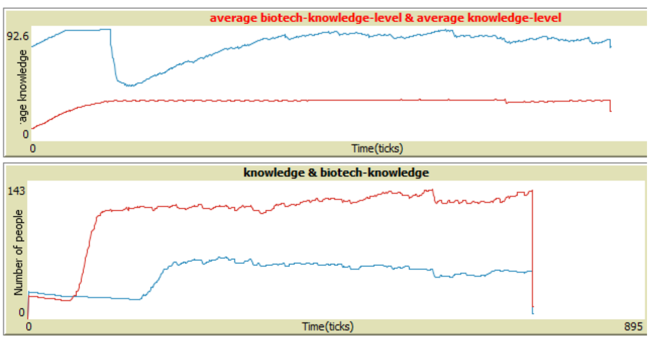

Figure 3. Best-case scenario results during cataclysm

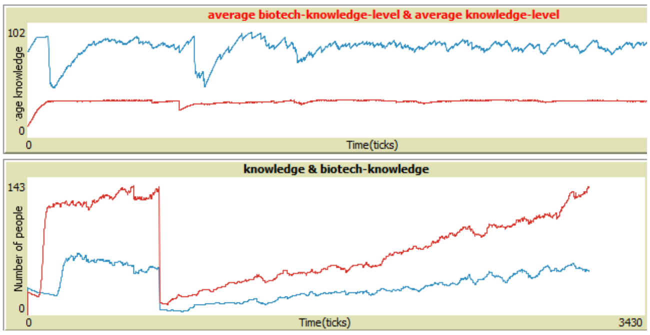

Figure 4. Best-case scenario for simulation results after cataclysm

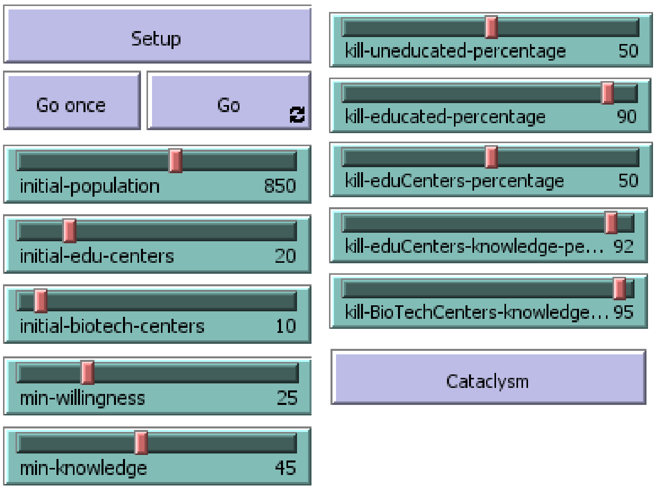

Figure 5. Initial parameters for worst-case scenario

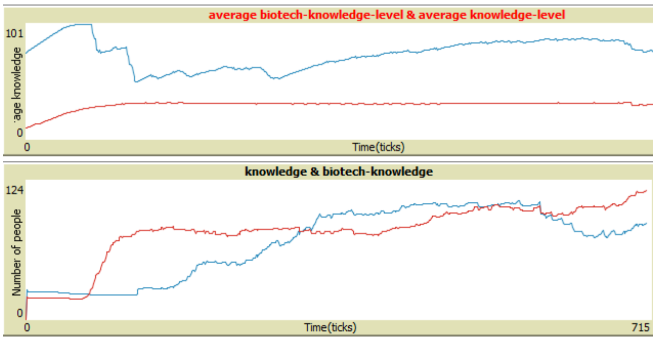

Figure 6. Worst-case scenario for simulation results before cataclysm

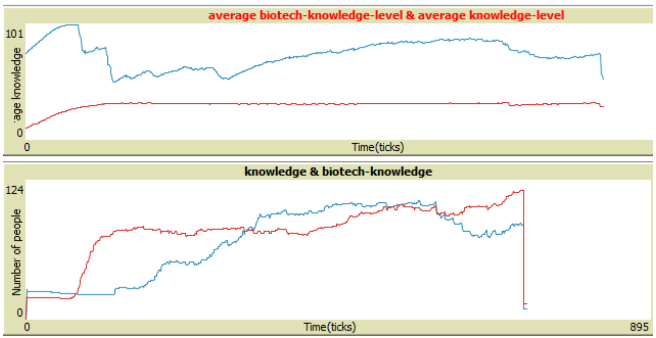

Figure 7. Worst-case scenario results during cataclysm

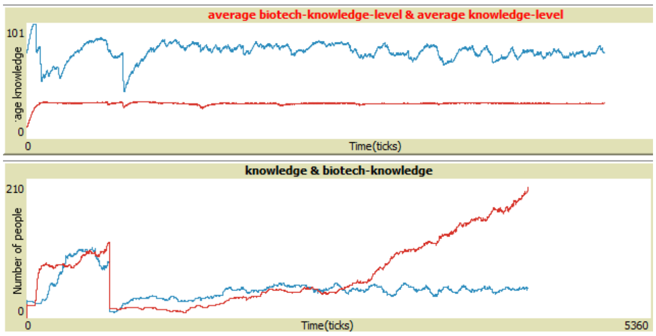

Figure 8. Worst-case scenario for simulation results after cataclysm

V.DISCUSION

Developing realistic models can be used for a better understanding, prediction, and control of such processes.

In this model, simulated human beings are modeled as agents, interacting with some of the center's officials as well as with their environment.

We are really interested in how much knowledge about biotechnology needs to be disseminated in order to its use remain viable even after the cataclysm.

The core idea here is to use simulated agents for producing a phenomenon that shall be analyzed, reproduced, or predicted.

In order to survive cataclysm, biotechnology requires education and years of hard work in a relevant field. Educational conditions require a bachelor's degree which is obtained in educational centers and the percentage of willingness to study biotechnology. The percentage of willingness will be initially allocated to the agent randomly in the range of 0 to 100.

After the approaching to the technological center agent knowledge will be increased by 10% for each of the first 6 years. After 6 years of education Agent will remains to work in the center to continue with his education and to share knowledge with other agents.

We can consider that biotechnology survived the cataclysm in the case to continue with knowledge sharing and usage in the same or almost the same volume as it was before the cataclysm.

We have random values: the ability to learn, the desire to learn, and the level of knowledge of the center. Combining those random values together with the number of years spent in the education center, and the level of initial knowledge of the agent, we get the agent's knowledge.

VI.CONCLUSION

Biotechnology refers to the application and manipulation of technology that reflects biological processes upon whole or part of a living thing in their natural form, in order to produce a product, a system, a new environment, or to solve problems (Moreland, Jones & Cowie, 2006).

Biotechnology could mean a great many variety of things and each of those can hold field branches as well. Some of the examples for biotechnology categories include genetically modified organisms in agriculture, antibody technologies, biopharmaceuticals, emerging technology, gene therapy, genetic engineering, molecular biology, research and development, environment/industrial biotechnology, enzymes, genomics, informatics, biomaterials etc. The model based on the agents is model which represents a set of individual agents and their behavior. Agents have their characters, rules in making decisions, possibility of interaction with other agents in the system and the environment on the basis of which they can change and adjust their behavior. Agents behavior is described by simple rules of behavior and mutual interactions with other agents. For the needs of this research is developed simulation model in the software NetLogo, ver. 6.1.1. which gives possibility to accompany the main data on the basis of which we get the results. The big number of input data which affect the result of the simulation is included in the observed model. Of course, like every other model, observed model does not pretend to include all the real factors which affect increasing of the biotechnological knowledge too, but with the right choice of factors it is provided summing all of the main elements which can affect the possibility of agents to acquire knowledge.

A selection of factors which will influence of dissemination of knowledge, and also the interrelation of these factors is one of the most difficult process in creating a model. Created model needs to be simple and needs to cover basic and crucial elements by which knowledge in a biotechnology center is expanded, so the results can copy an actual image.

Simulation results of biotechnology knowledge's expansion show that model can successfully generate different scenarios of knowledge expansion through movements of agents in biotechnology centers. Basic parameters, referring to biotechnology centers and people in that which are acquiring knowledge, are: the ability to learn, a desire to learn and a level of knowledge of the center. Individually, these parameters don't mean much, but by combining them we get a basic knowledge of an agent.

The purpose of this model is to see how much knowledge needs to be widespread so it could survive after cataclysm, actually which is the lowest knowledge threshold so it can be restored at the end. To outcome of the cataclysm is influenced by lots of factors, not just by number of people which will survive, because with a very small number of people with high level of knowledge, it is possible to restore knowledge through a certain number of years. Generally, the presented model is a prototype which can be used as an example for testing possible outcomes in a case of cataclysm with variations in model setting. The simulation results can help in improving dynamic understanding of biotechnology's knowledge expansion.

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