New approach to study the dynamics of growth of microscopic fungi of the background data object

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Abstract. This article presents a new approach for the development of mathematical models of ecological systems on the basis of application of the Lee algebra. The resulting models are investigated on the property of controllability on compact Lee groups and used to analyze the growth of microscopic soil fungi. Deterministic equation Mono counted the growth of fungi, depending only on their biomass, excluding the input data (temperature, pressure, acidity, heavy metals, pollutants, etc.). Proposed models allow us to calculate the dynamics of the increase or decrease in the complex process of fungal growth, depending on the size of their mycelial biomass and taking into account the above input.
[Shuakayev M.K., Nazarbekova K.T., Nazarbekova S.T., Kanaev A.T., Ahtaeva N.Z., Begenov A., Nesterova S.G., Mamurova A.T. **New approach to study the dynamics of growth of microscopic fungi of the background data object.** *Life Sci J* 2014;11(9s):295-298] (ISSN:1097-8135). http://www.lifesciencesite.com. 61

Keywords: Manifold, Stochastic Bilinear System, ecological systems, the growth of fungi, micromycetes, parameters of control

Introduction

Known, that modern mathematical models in ecology can be divided into three classes [1]. First - descriptive models: regression and other empirically established quantitative relationships are not applying for disclosure mechanism described process. They are usually used to describe the individual processes and dependencies and included as fragments in the simulations.

Second - quality models that are built in order to clarify the dynamic mechanism of the process under study are able to reproduce the observed dynamic effects in the behavior of systems, such as oscillatory behavior of the biomass or the formation of inhomogeneous structures in space. Typically, these models are not too bulky, measurable qualitative study with analytical and computer methods. Third grade - this simulation models of specific environmental and ecological and economic systems. This models taking into account all available information about the object. The purpose of constructing such models - detailed forecasting the behavior of complex systems, or solution to the optimization problem of their operation.

The better studied complex ecological systems, the more fully it can be justified by a mathematical model. Provided close connection observations and experimental study of mathematical modeling of the mathematical model can serve as a necessary intermediate stage between the experimental data and is based on the theory they studied processes. To solve practical problems, you can use all three types of models. It is particularly important questions identifiability (matching the real system) and handling of such models. This paper discusses the challenges of the third direction. We analyzed the results of Alekseev V.V. In his article he examines the Mono's equation to determine the rate of growth of fungi by increasing the biomass of the starting material [2]. In our opinion, the equation used has some significant drawbacks. In this equation does not account laid random factors that occur in nature.

Materials and methods

Objects of research - soil microscopic fungi disturbed lands. Ecology of soil micromycetes connected with the study of population dynamics of specific fungal populations directly in natural habitats, including exposed to heavy metals (HM). Focusing on the nature of the population dynamics, can answer the question of what determines the fate of the object, as well as to solve the problem of application management desirable and undesirable populations. Recently formed from the number of stable species to heavy metals, which may not be safe for plants of phytoremediation. We attempted to develop a mathematical model to study the abundance of soil microscopic fungi.

Therefore, this theoretical article proposes new approaches not only for the research of Stochastic Bilinear Systems on Compact manifolds, which are strictly mushrooms - spheroid types based on random processes, which will inevitably affect the growth of the individual concerned, but also to explore some of the problems of mycology in general.

The mathematical model presented in this paper, in contrast to the Mono`s equation, which determines the growth of the fungus directly correlated with an increase in its size only fungus that takes, in our opinion, is much less time-consuming process in experimental and pilot studies. Thus, according to the mathematical description of the configuration of the fungus, we restore the original stochastic vector fields Bilinear System whose parameters are uniquely determined by the results of the initial data spheroid fungus by class skew-symmetric matrices form Lie algebra and therefore can easily construct and Lie group.

In their further research, the derived class of Stochastic Bilinear Systems, the authors intend to use exclusively to modern analytical methods and stochastic analysis apparatus algebras and Lie groups without the use of any numerical methods, which radically spoil the desired end result.

Results and discussion

We consider linear analytic stochastic systems in the form of Ito

$$dx = f(x)dt + g(x)dw \qquad (1.1)$$

In [3, p. 69] formulated a criterion for a state X of system (1.1) to an arbitrary manifold $M=\{x:\varphi(x)=0\}$ with probability one, if the conditions

$$G\cdot\varphi=0, \qquad (1.2)$$

$$(F+\frac{1}{2}G^2)\varphi=0, \qquad (1.3)$$

where

$$F(x)=f_1(x)\frac{\partial}{\partial x_1}+\cdots+f_n(x)\frac{\partial}{\partial x_n}$$

$$G(x)=g_1(x)\frac{\partial}{\partial x_1}+\cdots+g_n(x)\frac{\partial}{\partial x_n}, \qquad (1.4)$$

Note that conditions (1.2) and (1.3) allow us to find, respectively, vector field g (x) an *f(x)* d and yet finding *f(x)* of equation (1.3) is very time-consuming. It is therefore necessary to develop an algorithm for finding the vector field *f(x)* or the simplest manifolds.

Behavior State Stochastic Bilinear System on an n- dimensional Sphere S^{n-1}

We consider the Stochastic Bilinear System of the form

$$dx = Axdt + BxdW(t), \qquad (1.5)$$

where A, B – matrixes of dimensional nxn, *W(t)* – standard Wiener`s process .

Let equation (5) is defined on the manifold $S^{n-1}-n$ -dimensional sphere

$$S^{n-1}=(x:\varphi(x)=\sum_{i=1}^{n}x_i^2-1=0) \qquad (1.6)$$

Parameters *A* and *B* of system (1.5) are unknown. You must find them. Formulate solutions for the following theorem.

Theorem. Let the vector fields $Ax, Bx: R^n \to R^n$ is analytic and $S^{n-1}-n$ -dimensional sphere defined by (1.6). Then the state $X(t)$ of equation (1.5) belongs to varieties S^{n-1} with probability one, if the matrix B and $\left(A+\frac{B^2}{2}\right)$ - skew - symmetric and expressed by the following expressions:

$$B=\begin{bmatrix} 0 & -b_{21} & \cdots & -b_{n1} \\ b_{21} & 0 & \cdots & -b_{n2} \\ \cdots & \cdots & \cdots & \cdots \\ b_{n1} & b_{n2} & & 0 \end{bmatrix}$$

$$A=\begin{bmatrix} -\sum_{i=1}^{n}b_{11}^2-\frac{1}{2} & -a_{21}-\sum_{i=1}^{n}b_{k1}b_{k2} & \cdots & -a_{n1}-\sum_{i=1}^{n}b_{k1}b_{kn} \\ a_{21} & -\sum_{i=1}^{n}\frac{b_{k2}^2}{2} & \cdots & -a_{n2}-\sum_{i=1}^{n}b_{k2}b_{kn} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & -\sum_{i=1}^{n}\frac{b_{kn}^2}{2} \end{bmatrix} \qquad (1.7)$$

Proof: From (1.2) the matrix B is represented in the form (1.7).

Matrix A from the condition (1.3), after simple transformations, we obtain the following relations :

$$a_{ii}=-\sum_{j=1}^{n}\frac{b_{ij}^2}{2} \quad (i,j=1,2,\ldots,n) \qquad (1.8)$$

$$a_{ij} = -a_{ji} - \sum_{k=1}^{n} b_{ki} b_{kj}$$
$$(i \neq j, \ \ i, j = 1, 2, \ldots, n)$$

Thus we obtain a matrix A in the form (1.7).

Thus, according to condition (1.2) and (1.3), found matrices A and B in the form (1.7).

Obviously, the skew-symmetric matrix B is turned. Now check on the condition of skew - symmetric matrix, i.e. $(A + \frac{B^2}{2})$

$$(A + \frac{B^2}{2}) = (-A - \frac{B^2}{2}) \qquad (1.9)$$

Similarly, we calculate $-(A + \frac{B^2}{2})$, we conclude that the matrix $(A - \frac{B^2}{2})$ is skew-symmetric, i.e.

$$(A + \frac{B^2}{2}) = K_C, \qquad (1.10)$$

where K_C - is skew-symmetric matrix.

Then the matrix A is found in the following form

$$A = -\frac{B^2}{2} + K_C \qquad (1.11)$$

Thus, theorem 1 is proved. For n = 2, we get the result [3].

Commenting results for biological systems. In this work we review microscopic fungi that was described by system of equations (1.6), where vector of state X(t) has three components, which are changing the lengths of the source object in three-dimensional coordinate system. In the deterministic case, the system of equations (1.6) means the rate of change in the growth of fungi. For them there was build mathematical model that controls dynamic growth of fungi, vested by systems (1.5) with parameters (1.7).

The resulting model was introduced to analyze process of fungi's growth by increasing or decreasing of its size. We suggest to investigate this difficult processes of growth not only by initial sizes of fungi, but also by biomass, that calculates by increasing the volume to density of fungi.

The important problem to analytical investigation of a system (1.5) with hash (1.7) is analyzing of controllability property. In [4] considered the analytical control systems defined on an analytic manifold. In particular, we investigated the relation between the properties of reachability and controllability. Class right invariant control systems defined on compact manifolds, which form a Lie group, are manageable because they have the ability to reach.

Based methods [4-6], we can explore the property of controllability of the system (1.5) on compact Lie groups. Inputs of the system (1.5) are the following random processes: metabolizm product; biomass concentration; pressure and temperature. In this case the system (1.5) can be used as research has kinetics equations. In [4] considered the analytical control systems defined on an analytic manifold. In particular, we investigated the relation between the properties of reachability and controllability. Class right invariant control systems defined on compact manifolds, which form a Lie group, are manageable because they have the ability to reach.

Thus, it is shown that the properties of reachability and controllability on compact Lie groups coincide. This is proved for the class of symmetric systems Lobry[5]. The problem of stochastic controllability and observability were researched in [6]. Consequently, on the based methods [4-8], we can explore the property of controllability of the system (1.5) on compact Lie groups.

In [9-14] investigated the problem of stabilization for different classes of bilinear systems. In [15-20] proposed algorithms problems stochastic study of controllability and observability for a class of biological systems of bilinear type, generalizing the result of [21]. Very simply, you can apply the results of this work to investigate the problem for filtering biological systems, using the result of [22].

We make a number of observations for the application of these results to the research of fungi. We assume that the manifold of the form (1.7) is spheroid type of fungi .Parameters of the system (1.5) is defined by (1.7), i.e. based on the initial dimensions mentioned fungi .We need to make these processes more controllable in the future, then the system will have more essential properties that will help to develop condition of environment. We should pay attention that mathematical model concerns to new class of Volterra's "victim-predator" or "micromycetes - pollutans". So we need to investigate the system for controllable parameters, it is important thing to get optimal and controllable parameters of the system.

Conclusion

This work suggests mathematical model of the ecological system that was derived on the basis of initial diversity of soil microscopical fungi. The model describes dynamic increasing or decreasing of fungi's growth depending on entry data. There were used algorithms of controllability investigation on the basis of Lee's algebra. Results derived from this work approach of theoretical of fungi's growth processes, which, can be used for analyze, correction of all process. Investigation of this direction are in process and difficult structure of fungi will be taken as initial object

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5/29/2014