ANNOTATIONS OF THE PRESENTED MATERIALS

of Chief Assistant Doctor PETAR IVANOV KOPANOV
for participation in a contest to be appointed the academic position of Associate Professor
in the area of higher education: **4. Natural sciences, mathematics and informatics**
professional field: **4.5. Mathematics (Probability Theory and Mathematical Statistics)**

**** The order of the annotations of the presented materials corresponds the order of the publications in the list of scientific works for participation in the contest.***

SCIENTIFIC ARTICLES AND REPORTS

1. Ravi Agarwal, Snezhana Hristova, Donal O'Regan and **Peter Kopanov.** Stability Analysis of Cohen–Grossberg Neural Networks with Random Impulses, Mathematics 2018, 6, 144; doi:10.3390/math6090144 (Web of Science, IF=1.105, Q1; SCOPUS, SJR=0.244)

The Cohen and Grossberg neural networks model is studied in the case when the neurons are subject to a certain impulsive state displacement at random exponentially-distributed moments. These types of impulses significantly change the behavior of the solutions from a deterministic one to a stochastic process. We examine the stability of the equilibrium of the model. Some sufficient conditions for the mean-square exponential stability and mean exponential stability of the equilibrium of general neural networks are obtained in the case of the time-varying potential (or voltage) of the cells, with time-dependent amplification functions and behaved functions, as well as time-varying strengths of connectivity between cells and variable external bias or input from outside the network to the units. These sufficient conditions are explicitly expressed in terms of the parameters of the system, and hence, they are easily verifiable. The theory relies on a modification of the direct Lyapunov method. We illustrate our theory on a particular nonlinear neural network.

2. Agarwal, R.; Hristova, S.; O'Regan, D.; **Kopanov, P**. p-Moment Mittag–Leffler Stability of Riemann–Liouville Fractional Differential Equations with Random Impulses. Mathematics 2020, 8, 1379.(Web of Science, IF=1.747, Q1; SCOPUS, SJR=0.0.299)

Fractional differential equations with impulses arise in modeling real world phenomena where the state changes instantaneously at some moments. Often, these instantaneous changes occur at random moments. In this situation the theory of Differential equations has to be combined with Probability theory to set up the problem correctly and to

study the properties of the solutions. We study the case when the time between two consecutive moments of impulses is exponentially distributed. In connection with the application of the Riemann–Liouville fractional derivative in the equation, we define in an appropriate way both the initial condition and the impulsive conditions. We consider the case when the lower limit of the Riemann–Liouville fractional derivative is fixed at the initial time. We define the so called p-moment Mittag–Leffler stability in time of the model. In the case of integer order derivative the introduced type of stability reduces to the p–moment exponential stability. Sufficient conditions for p–moment Mittag–Leffler stability in time are obtained. The argument is based on Lyapunov functions with the help of the defined fractional Dini derivative. The main contributions of the suggested model is connected with the implementation of impulses occurring at random times and the application of the Riemann–Liouville fractional derivative of order between 0 and 1. For this model the p-moment Mittag–Leffler stability in time of the model is defined and studied by Lyapunov functions once one defines in an appropriate way their Dini fractional derivative.

3. R. Agarwal1, S. Hristova, D. O'Regan, **P. Kopanov**, Impulsive differential equations with Gamma distributed moments of impulses and p-moment exponential stability, Acta Mathematica Scientia, Issue 4, Vol.37, 2017, pp. 985-997 (WoS, IF=0.661, Q3; SCOPUS, SJR=0.582)

Differential equations with impulses at random moments are set up and investigated. We study the case of Gamma distributed random moments of impulses. Several properties of solutions are studied based on properties of Gammma distributions. Some sufficient conditions for p-moment exponential stability of the solutions are given.

4. **Petar Kopanov,** Jordan Stoyanov, Lin's condition for functions of random variables and moment determinacy of probability distributions, Comptes rendus de l'Acad´emie bulgare des Sciences, Tome 70, No 5, 2017 (WoS, IF=0.270, Q4; SCOPUS, SJR=0.021)

If $f = F'$ is the density of a random variable X with distribution function F and f is positive and smooth, Lin's condition is defined as follows: $-xf'(x)/f(x) \nearrow \infty$ as $x \to \infty$. This condition is essentially involved, together with other conditions such as divergent Krein integral or fast growth rate of the moments, in deciding whether or not F is unique in terms of its moments (M-determinate) or non-unique (M-indeterminate). We analyze frequently used non-linear functional transformations of X and clarify whether or not Lin's condition is preserved. Then we show that for a positive random variable X and any fixed integer $n \geq 2$, the power X^n and the product $X_1 \cdot \cdot \cdot X_n$ of n independent copies of X, share the same moment-determinacy property.

5. J.M. Stoyanov, G.D. Lin, **P. Kopanov.** New checkable conditions for moment determinacy of probability distributions, Theory of probability and its applications, 65(3), 634-648, 2020. (WoS, IF=0.485, Q4; SCOPUS, SJR=0.479)

We have analyzed some conditions which are essentially involved in deciding whether
or not a probability distribution is unique (moment-determinate) or nonunique (moment-indeterminate) by its moments. We suggest new conditions concerning both absolutely continuous and discrete distributions. By using the new conditions, which are easily checkable, we either establish new results or extend previous ones in both the Hamburger case (distributions on the whole real line) and the Stieltjes case (distributions on the positive half-line). Specific examples illustrate the results as well as the relationship between the new conditions and previously available conditions.

6. Snezhana Hristova, **Peter Kopanov**. Stability of neural networks with random impulses, Dynamic Systems and Applications, 27, No. 4 (2018), 791-801 ISSN: 1056-2176 (WoS, IF=0.5, Q4)

One of the main properties of solutions of neural networks is stability and often the direct Lyapunov method is used to study stability properties. We consider the Hopfield's graded response neural network in the case when the neurons are subject to a certain impulsive state displacement at random exponentially distributed moments. It changes significantly the behavior of the solutions because they are not deterministic ones but they are stochastic processes. We examine the stability of the equilibrium of the model. Some sufficient conditions for p-moment stability of equilibrium of neural networks with time varying self-regulating parameters of all units and time varying functions of the connection between two neurons in the network are obtained. These sufficient conditions are explicitly expressed in terms of the parameters of the system and hence they are easily verifiable. We illustrate our theory on a particular nonlinear neural network.

7. R. Agarwal1, S. Hristova, D. O'Regan, **P. Kopanov,** P-moment exponential stability of differential equations with random noninstantaneous impulses and the erlang distribution, International Journal of Pure and Applied Mathematics, Volume 109 No. 1 2016, pp.9-28, ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version), url: http://www.ijpam.eu, doi: 10.12732/ijpam.v109i1.3 (SCOPUS, SJR=0.142)

In some real world phenomena a process may change instantaneously at uncertain moments and act non instantaneously on finite intervals. In modeling such processes it is necessarily to combine deterministic differential equations with random variables at the

moments of impulses. The presence of randomness in the jump condition changes the solutions of differential equations significantly. The study combines methods of deterministic differential equations and probability theory. In this paper we study nonlinear differential equations subject to impulses occurring at random moments. Inspired by queuing theory and the distribution for the waiting time, we study the case of Erlang distributed random variables at the moments of impulses. The p-moment exponential stability of the trivial solution is defined and Lyapunov functions are applied to obtain sufficient conditions. Some examples are given to illustrate the results.

8. R. P. Agarwal, S. Hristova, D. O'Regan, **P. Kopanov.** p-Moment Exponential Stability of Differential Equations with Random Impulses and the Erlang Distribution. Mem. Differential Equations Math. Phys. 70 (2017), pp. 99-106. (WoS, SCOPUS, SJR=0.269)

The investigation of differential equations with random impulses combines ideas in the qualitative theory of differential equations and probability theory. The p-moment exponential stability of the solutions is defined and studied when the waiting time between two consecutive impulses is Erlang distributed. The study is based on the application of Lyapunov functions. Some examples are given to illustrate the results.

9. Ravi Agarwal, Snezhana Hristova, Donal O'Regan, and **Peter Kopanov** Differential equations with random Gamma distributed moments of non-instantaneous impulses and p-moment exponential stability, Demonstratio Mathematica, Volume 51, Issue 1, Pages 151–170, ISSN (Online) 2391-4661 (WoS, SCOPUS, SJR.0.333)

Nonlinear differential equations with impulses occurring at random time and acting noninstantaneously on finite intervals are studied. We consider the case when the time where the impulses occur is Gamma distributed. Lyapunov functions are applied to obtain sufficient conditions for the p-moment exponential stability of the trivial solution of the given system.

10. S. Kapralov, S. Bouyuklieva, **P. Kopanov,** Conference: 11th International Conference on Education and New Learning Technologies (EDULEARN) Location: Palma, SPAIN Date: JUL 01-03, 2019, Edulearn19: 11th international conference on education and new learning technologies Book Series: EDULEARN Proceedings Pages: 9964-9970 Published: 2019 (WoS)

Mathematics and computer science education is of great importance to modern society. Unfortunately, the interest of young people in studying in these areas, especially in mathematics, is diminishing globally. Therefore, any attempt to stimulate this interest,

especially if it combines in some form of competition a necessity of knowledge both in mathematics and in programming, and thus provokes the interest of young people in their deeper and systematic study, should invoke serious interest from academia around the world. It is precisely such an experience, which has already proved to be successful, to be the CompMath student computer mathematics Olympiad. The article presents the Seventh consecutive Olympiads in Computer Mathematics. CompMath is an annual mathematical contest for university students. The main purpose of the competition is to raise students' interest in mathematics, computer algebra systems, and above all, to use these systems to solve mathematical tasks from practically all fields of purely theoretical as well as applied mathematics. This can be seen from the problems given at the contest. The competition serves as an excellent demonstration of the use of computer algebra systems for solving mathematical problems. The CompMath competition is unique. It has no equivalent on a global level and represents a major innovation in the field of education.

11. **Petar Kopanov**, Ivan Tchalakov, Donka Keskinova, Networks Approach in Modeling Sociological Agent as Combination of Non-Determined Stochastic Automata, Sociological Problems, 2010, Special Issue, ISSN-0324-1572, pp. 222-241

The paper applies the 'indirect network approach', developed earlier in the framework of Actor-Network Approach to the modeling a complex network dynamics. It attempts to avoid the idea of 'guidance' of a given form of (social) life being modelled, which has long been dominating in traditional sociology. Resent theories have demonstrated the fruitfulness of a different approach, considering social dynamics in terms of "praxis, not poiesis" (De Vrijs 2007). The sociological 'input' in the model we are developing consists in 1) pushing to its limits the idea of opportunistic evolution of given form of (social) life; 2) taking 'ex post' stand to the processes going on in it; 3) considering the properties of the identified entities as an outcome of the evolution and not as pre-given attributes, and 4) using specially designed and collected sociological data to verify the mathematical models. The paper attempts to model the agents, which take part in different sociological networks via formal methods of discreet mathematics and more precisely using the stochastic finite automata approach. The aim is to develop these models in the form of computer programs (software) and to test them on real sociological data. The paper presents the first step of the authors in the realization of these aims.

12. **Peter Kopanov**, Miroslav Marinov, On a Cumulative Distribution Function Related to the Bernoulli Process, Mathematics and Statistics 5(2): 74-77, 2017

We examine the properties of a cumulative distribution function which is related to the Bernoulli process. Results are shown and new ones are included. Most of them are

connected to the behaviour of the probability density function (derivative) of the given distribution.

13. **Peter Kopanov**, Ivan Tchalakov. 'Stacked' Actor-Networks and Their Computer Modelling: the Problem of Identity, International Journal of Actor-Network Theory and Technological Innovation, Volume 8, Number 4, 2017

The paper develops the mathematical basis of stacked actor-network (SAN) approach in modeling a socio-economic and cultural dynamics. It attempts to avoid the idea of 'guidance' of a given form of (social) life being modelled, which has long been dominating in traditional sociology. Using methods of discreet mathematics and stochastic finite automata approach, we provided initial mathematical formalization of agent and actor-network, the types of complexity in the actor-network and three basic types of graphs comprising SAN's minimal model, with further aim is to develop these models in the form of computer programs (software) and to test them on real sociological data.

14. Stefan Konsulov, Spas Konsulov, Karen Dzhambazov, **Petar Kopanov**. Comparison Between Coblation Assisted Tonsillectomy Versus Conventional Tonsillectomy Regarding the Postoperative Pain and Bleeding. International Journal of Otorhinolaryngology 2017; 3(1): 1-5

Background: The tonsillectomy is one of the most common surgical procedure in the world. Common complications are postoperative pain and bleeding. Coblation tonsillectomy is recent method of these surgical procedure and there are few publications in the literature and published information which are focused on the specific aspects of this surgical techniques or early postoperative complications. This study compare coblation and traditional tonsillectomy techniques in view of their advantages and complications. methods: In our prospective study type we include 60 children and adolescents, divided equally:30 conventional tonsillectomy versus 30 surgically treated with Coblation II system Arthrocare (Smith and Nephew). We compared the postoperative pain and intraoperative bleeding in the patients underwent surgery within conventional method versus coblation assisted tonsillectomy. To measure the pain we used visual-analogue scale of Wong-Baker with face expressions (0 no hurt; 10-hurts worst). We follow-up the level of pain in the day 1,2 and 7 after the surgery Estimated blood loss for coblation tonsillectomy was calculated by deducting the total amount of blood in suction jar with estimate saline used for the surgery. Results: Average age of participants surgically treated with conventional method group are 6,87±3,01. In the group where we used coblation method the average age of participant were 8.16±4,74. We found statistically significant differences (p-value<0.0001) in these parameters in both surgical techniques: the pain is less weak in intensity in the patients treated with the Coblation method in all the three days. In regard of intraoperative bleeding we found statistically significant difference between both methods (p-value -

*9.3132*10^{-10}). The average bleeding in the conventional method is 97,5 ml ±12,12 ml, comparing with the coblastion-assisted tonsillectomy the average intraoperative bleeding is 27,1 ml ±14,28 ml. Conclusions: This study revealed a significantly less intraoperative or postoperative complications and morbidity in coblation tonsillectomy in comparison with traditional method. Coblation was associated with less pain and quick return to normal diet and daily activity. These findings addressed coblation tonsillectomy as an advanced method.*

15. **Peter Kopanov**, Ivan Tchalakov. Towards of Quantitative Model of Stacked Actor- Network Dynamics. International Journal of Actor-Network Theory and Technological Innovation (IJANTTI) 9(2), 2017, pp.42-62

This article further develops the stacked actor-networks (SAN) approach in modelling socio-economic and cultural dynamics.Following the Lee and Schiesser application of differential equation analysis in biological and social sciences, the authors used a basic SAN model. This model is composed of three subnetworks where each two subnetworks dominate over the third one to build a quantitative description that identifies three stable states in the dynamics of their interactions – cyclical development, linear, and exponential growth. Describing the latter, the notion of 'technology growth' is introduced that bears on the pattern of hyper-fast growth.

16. **Peter Kopanov**. A counterexample of the statement P = NP. Journal of Scientific Research and Studies Vol. 5(2), pp. 31-33, February, 2018

In this paper, it is shown that the classes of P and NP do not coincide by constructing a relatively simple example of unsolvability in polynomial time in a particular well-known NP-complete problem. For a particular NP-complete problem, a random process is constructed that generates a solution with random numbers. Such a solution cannot be found with a polynomial algorithm, but it can be verified with one if it is known. In this way, the impossibility of equality P = NP is shown.

17. **Peter Kopanov**, Miroslav Marinov, Atakan Salimov, On the existence of moments in Cauchy-like distributions induced from the tan function, SCIREA Journal of Mathematics. Vol. 4 , No. 1 , 2019 , pp. 1 - 4 .

In this paper we consider cases of the existence of the moments of functions of random variables supported on a bounded interval. Our attention is restricted to the tan

function, as a generalization of the Cauchy distribution which is infact the result of applying this function to a uniformly distributed variable.

18. **Peter Kopanov**, Universe's challenges: What is next?, *SCIREA Journal of Astronomy*. Vol. 3 , No. 1 , 2019 , pp. 13 – 17

In this paper we consider a quantitative relationship between the probabilistic standard normal distribution and the distribution of matter and energy in the Universe, according to the observations from the Planck cosmic laboratory.

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The city of Plovdiv **/Chief Assistant Doctor Petar Kopanov/**