Appendix 12a

REVIEW

of dissertation for the acquisition of:

educational and scientific degree " doctor "	Х
scientific degree "Doctor of Science"	
	the true is indicated by the sign "X"

Author of the dissertation:

		Xie		Junhong	
academic	scientific	name	middle name	last name	workplace
position	degree				

Topic of the dissertation:

Intelligent Model-Based Control of Nonlinear Systems

Scientific area:

5	Technical Sciences
code	name

Professional area:

5.2	Electrotechnics, Electronics and Automation
code	name

Scientific specialty:

Automation	Control	Theory
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The review was written by:

Associated Professor	doctor	Plamen	Vasilev	Vasilev	UCTM
academic position	scientific degree	name	middle name	last name	workplace

<u>1. Completion of the provided documents:</u>

A) The dissertation and the competition documents are in full compliance with the Regulations.	4 points	x
B) The documents are complete but do not fully comply with the requirements of the Regulations.	2 points	
C) The documents are not completed in accordance with the requirements of the Regulations.	0 points	

one of the answers
given is marked with the
sign "X"

Missing documents and violated standards must be described if response C is marked.

The competition documents are drawn up in accordance with the Regulations for the Acquisition of Scientific Degrees and Occupation of Academic Positions of the UCTM.

2. Meeting the minimum requirements under the Regulations:

A) The candidate meets the minimum requirements	20 points	Х
B) The candidate doesn't meet the minimum requirements	0 points	
		one of the answers given is marked with the sign "X"

It must be filled in if answer B is marked. The publication activity of the candidate is analyzed. The response of the results achieved (quoted) is analyzed.

The publication activity on which the dissertation of M. Eng. Xie Junhong is based is estimated at 60 points, which exceeds the minimal requirements of the Regulations – 30 points. One of four publications is co-authored with the two supervisors of the PhD student, the remaining three are co-authored with one of the supervisors, and in two of them there is a third co-author. In two of the publications, the PhD student is in first place, and in the other two – in second place. All four publications are indexed in Scopus.

3. The relevance of the topic of the dissertation:

 A) The topic is relevant and new (there are no known results on the topic by other authors) 	8 points	Х
B) The topic is relevant and results from other authors are known	6 points	
C) The topic is not relevant, but results from other authors are known	2 points	
D) The topic is not relevant and no results from other authors are known	1 point	
E) The topic does not correspond to the level of dissertation	0 points	
		one of the answers given is marked with the sign "X"

The evaluation of the relevance of the dissertation must be substantiated

The relevance of the dissertation topic is determined by the fact that in the field of modern control theory of complex nonlinear systems, new intelligent methods based on neural networks and machine learning are constantly being developed.

4. Knowledge of the problems, subject of research in the dissertation:

 A) The doctoral student knows in detail the achievements of other authors on the topic of the dissertation 	8 points	х
B) The doctoral student is partially familiar with the achieved results on the topic of the dissertation	4 points	
C) The doctoral student has no prior knowledge of the status of the problems in the dissertation	0 points	
		one of the answers given is marked with the sign "X"

The evaluation must be substantiated if answer C is marked.

The PhD student demonstrates detailed knowledge of the current state of research on the topic of her dissertation, which is very well demonstrated in the detailed literature review and has contributed to conducting scientific research at a high level. This is evident from the fact that the dissertation discusses and cites 172 foreign authors related to the topic of the dissertation, 166 of which are in the literature review.

5. Type of research:

A) Theoretical	4 points	
B) Applied	4 points	
C) Theoretical with application elements	4 points	Х
D) It does not correspond to the level of dissertation	0 points	
		one of the answers given is marked with the sign "X"

The level of research must be substantiated if answer D is marked.

The research is clearly formulated - in the field of the scientific specialty " Automation Control Theory" and aims to synthesize a model-predictive controller based on a neural network, which is theoretically applicable to various complex nonlinear systems - Hindmarsh-Rose model, chaotic systems of the "master-slave" type, as well as for the purpose of controlling a tubular reactor using Gaussian processes. All studies aim to prove the applicability of the developed NMPC controller on simulations of the mentioned systems and models.

6. Objectives of the research:		
A) Realistic and of scientific and / or applied interest	8 points	x
B) Realistic, but not of scientific and / or applied interest	3 points	
C) Unattainable (unrealistic)	0 points	
		one of the answers given is marked with the sign "X"

Objectives must be specified. The type of the set objectives must be justified.

The set goals are related to the development of intelligent methods for optimal model-predictive control of complex nonlinear systems. To achieve them, several types of complex nonlinear systems have been considered (Hindmarsh-Rose neuron model, master-slave system and continuous non-isothermal tubular reactors with ideal displacement). Several tasks have been formulated, which include the development of new intelligent methods that combine model-predictive control, sliding mode control and adaptive control with some of the machine learning methods (deep neural networks, Gaussian processes), and their application to the above-mentioned classes of complex nonlinear systems.

7.Methods of research:

A) Adequate to research and set objectives	8 points	Х
B) Partially appropriate, enabling part of the scientific objectives and / or applications to be achieved	4 points	
C) Inappropriate methods	0 points	
		one of the answers given is marked with the sign "X"

Methods must be specified. The type of methods used is justified.

The used methods are model predictive control, sliding mode control and adaptive control in combination with some of the machine learning approaches that have been applied to modeling and controlling complex systems. An explicit nonlinear predictive controller based on deep neural networks for the Hindmarsh-Rose neural model is developed. A new scheme for controlling the synchronization of master-slave systems with an exponentially perturbed sliding mode neural controller is proposed and the stability of the closed system is proven. A new modeling and adaptive optimal control approach for tubular reactors based on Gaussian processes is developed. The Gaussian process modeling approach is applied to obtain a set of nonlinear autoregressive models (NARX models). The identified models are used to synthesize an adaptive model predictive controller to achieve optimal reactor performance despite changes in inlet temperature.

8. Contributions of the dissertation:

A) With lasting scientific and / or applied response, they form the basis for new research and applications	20 points	
B) They are of significant scientific and / or applied interest, complete and / or summarize previous research	16 points	х
C) They are of scientific and / or applied interest	12 points	
D) Lack of significant contributions	8 points	
E) Lack of contributions	0 points	
		one of the answers given is marked with the sign "X"

Contributions must be specified. The type of results achieved must be justified.

The dissertation contains scientific contributions related to the development of new methods for controlling complex nonlinear systems and scientific and applied contributions related to the application of these methods to specific classes of such systems.

- 1. An explicit nonlinear model predictive (NMPC) controller based on deep neural networks (DNN) has been synthesized for optimal control of the Hindmarsh-Rose neural model. (scientific and applied)
- 2. A new exponentially perturbed sliding mode control law has been proposed for synchronizing master-slave systems, by synthesizing a disturbance observer and using radial basis function neural networks (RBF-NN) with adaptive weights to describe uncertainty in the dynamics of the systems. (scientific and applied)
- 3. A supervisory system for static and dynamic optimization of a tubular reactor has been developed. (scientific-applied)
- 4. A new approach for modeling and adaptive optimal control of tubular reactors based on Gaussian processes has been developed. (scientific)

9. Evaluation of the compliance of the dissertation summary with the dissertation:

A) Full compliance	4 points	х
B) Compliance of the main parts	2 points	
C) Lack of compliance of the main parts	0 points	
		one of the answers given is marked with the sign "X"

The evaluation must be substantiated if answer C is marked.

10. Participation of the doctoral student in the achievement of the results of the dissertation:

A) The doctoral student has at least an equal participation	8 points	х
B) The doctoral student has secondary participation	5 points	
C) The participation of the doctoral student is unnoticeable	0 points	
		one of the answers given is marked with the sign "X"

Critical notes must be provided if one of the items B or C is marked.

One of the four publications is co-authored by both of the doctoral student's supervisors, the remaining three are co-authored by one supervisor, and in two of them there is a third co-author. In two of the publications, the doctoral student is in first place, and in the other two - in second place. All four publications are indexed in Scopus.

11. Critical notes:

A) Lack of critical notes	8 points	Х

B) Critical notes of a technical nature	7 points	
C) Critical notes that would partially improve the results achieved	4 points	
D) Significant critical notes	0 points	
		one of the answers given is marked with the sign "X"

Critical notes must be provided if one of the answers C or D is marked.

12. Conclusion

A) The evaluation of the dissertation is POSITIVE	This evaluation is assigned to a total number of at least 65 points	Х
B) The evaluation of the dissertation is NEGATIVE	This evaluation is assigned to a total number below 65 points	
		one of the answers given is marked with the sign "X"

To be filled in at the request of the reviewer

Xie Junhong has an asset of 96 points, which exceeds the required minimum of 65 points. Her dissertation contains modern and significant scientific and scientific-applied achievements. The importance of the dissertation is great, especially in finding and applying the control theory methods for increasingly complex objects and systems. My assessment of the dissertation is **"POSITIVE"** and I confidently propose to the scientific jury to vote with **"YES"** for awarding M. Eng. Xie Junhong the educational and scientific degree "doctor" in professional field 5.2 "Electrotechnics, Electronics and Automation" in the scientific specialty "Automation Control Theory".

16.05.2025	The review was written by:	
date		signature