

REVIEW for final qualifying work  
Tikhonov Alexander Vladimirovich  
"Mathematical and computer modeling of  
complex dynamical systems"

Presented for defense graduation work Tikhonov A.V. is devoted to the problems of modeling complex dynamical systems particularly probe-forming systems focusing a particle beam with given characteristics on a communication target. Such systems represent rather complex systems consisting of a sufficiently large number of control systems: sensors, several quadrupole lenses, apertures, possibly an "oblique quadrupole" and other elements (for example, corrective sextupoles), etc. By controlling the variable characteristics of the elements, you can achieve the necessary properties of the beam. Since such systems are highly precise, the problems of detecting undesirable deviations of control parameters are extremely urgent in such systems. For this, in the modeling process, it is important to strictly observe the necessary and sufficient requirements for accuracy and speed of calculations, which is not always possible to achieve using classical modeling approaches. The development of artificial neural networks allows (using artificial intelligence methods) modeling of a dynamic system at a qualitatively new level, and can compensate these deviations by generating additional changes to system parameters.

The developed model is based on an artificial neural network approach, the implementation of which provides a good opportunity to determine the quality of the system's functioning in model time mode and, as a result of the analysis, to set the behavior and rules of parts of the whole network. As a result of the experiments, the dependences of the system on the indicated parameters were revealed. As a result of the research, special software was developed (using Python and the Keras framework). Since the particle beam control system is a distributed system with a sufficiently complex control concept, it can be hoped that neural networks will allow the construction of effective control systems. We must note that neural networks demonstrate sufficient efficiency in distributed complex systems (in particular, in accelerator plants of various configurations and applications), since they are distributed systems, which positively affects their extensibility and speed of calculations due to parallel data processing.

It should be noted that Alexander Vladimirovich coped with the task. The conducted numerical experiments demonstrated the ownership of the software product and understanding of the essence of the results. I believe that the final qualification work Tikhonov A.V. It is an independent scientific research, and in general, deserves an excellent rating.

Assigned Professor, Head of the Department of Computer Modeling and Multiprocessor Systems, Doctor of Physics and Mathematics of sciences.

A handwritten signature in black ink, appearing to read 'S.N. Andrianov', written in a cursive style.

S.N. Andrianov