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Short Communication

Creation of an artificial intelligence system for analysis of theoretical Current-Voltage Curves

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Abstract

We have developed the "Deep learning for CVC 0.1" software package, which contains databases and knowledge bases of theoretical Current-Voltage Curve (CVC) using the method of deep machine learning (Deep learning). The developed software package allows you to simulate mass transfer in Electromembrane Systems (EMS), which has a single interface with a built-in help system, analysis and synthesis of current-voltage characteristics. The software package was implemented using the software platform for computer modeling of physical processes COMSOL Multiphysics 5.5 and the application development environment COMSOL Multiphysics Application Builder, Java, Python, using the libraries OpenCV, TensorFlow, Keras.

Introduction

The CVC (current-voltage characteristic, I-V characteristic) is the most important integral characteristic of transfer processes in electromembrane systems. The study of experimental CVC. Shows the complex, unsteady, and unstable behavior of the CVC. However, a theoretical study of the CVC has not yet been carried out. This is due to the fact that, on the one hand, to calculate one I-V characteristic, it is required (indicate the time) and therefore costs (hundreds of thousands of dollars to indicate how much). On the other hand, it is necessary to use methods that adequately reflect the unsteady and unstable behavior of the CVC in time. For the first time, we were able to solve these problems in a complex using a specially created system of artificial intelligence.

Used methods and results

The software package (program) "Deep learning for CVC 0.1" created by us allows you to get images that simulate the studied processes in the EMC [1-4], calculate all relevant characteristics, including the CVC [5-8], generate reports, and get an animated interpretation of the process studied in time .

The program "Deep learning for CVC 0.1" (Figure 1), containing databases and knowledge bases of theoretical current-voltage characteristics for deep machine learning, allows you to select specific sections of the CVC, for example, the section of the beginning of electroconvection [2-8] at the Cation Exchange Membrane (CEM) which begins with dfikom (beginning) and ends with dfiaom (the beginning of electroconvection at the Anion Exchange Membrane (AEM)), the plot of the beginning of electroconvection at the AOM, the site of the beginning of the interaction of electroconvection vortices at the CEM and AEM, and others. In these areas, the software package allows you to conduct Fourier and Wavelet analyses, identify the trend, subtract the CVC from the trend, calculate the fluctuations amplitude, determine the main and accompanying fluctuation frequencies, use the results to record the "restored" CVC (I – V characteristic) and compare it with the real one, find the dependence of the CVC on the parameters of the problem with the approximation condition.

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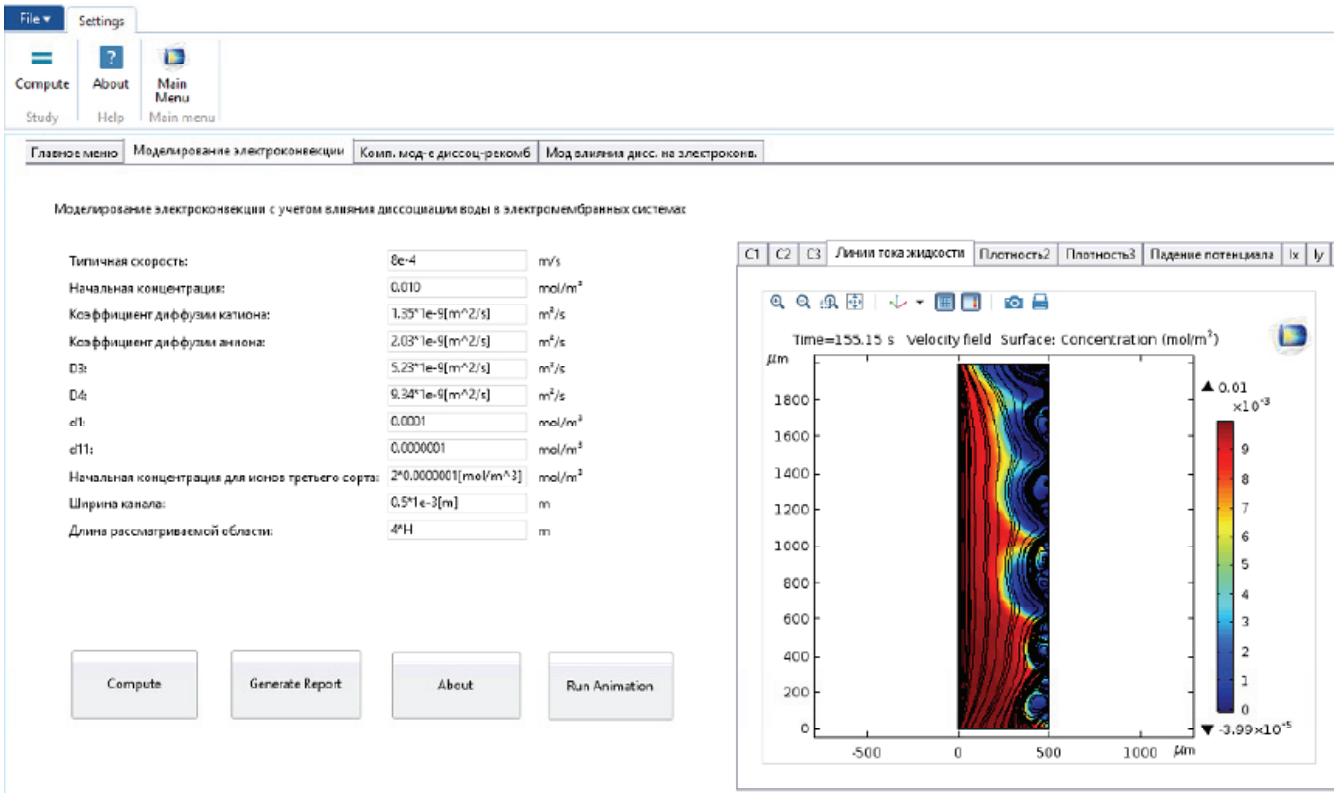

Figure 1: The window of the created application with the open tab "Modeling electroconvection".

Moreover, the created program allows one to calculating critical currents (Ikom, Iaom, etc.), Hurst indicators for each section of the current – voltage characteristic, Lyapunov, associated frequencies, vibration amplitudes, and tilt angles in the first and second sections.

The artificial intelligence systems created under the project, for example, Deep Learning Neural Networks, allow you to recreate the CVC (I – V characteristics) according to specified parameters and approximate for a given time interval, recognize critical values, predict mass transfer in EMC subject to modification of the main system parameters.

During the project implementation, convolutional neural networks (CNNs) trained by the classical method of back propagation of errors, deep controlled recurrent neural networks (Depth Gated RNN) with custom behavior, including long-term short-memory networks (LSTM), as well as multilayer perceptron networks with dozens of tens hidden layers and hundreds of elements in them, trained by the methods of gradient descent, Levenberg-Markar and others with cross-batch state conservation (Cross-Batch Statefulness).

Conclusion

The developed app "Deep learning for CVC 0.1" is a flexible system, a scientific toolkit for conducting new scientific research in the field of application of artificial intelligence methods, which allows to obtain 2D, 3D images simulating these processes, including calculation and visualization of all physicochemical characteristics, adjustment whose parameters allows us to obtain a solution that meets the actual conditions of the experiments. For all created programs that make up the software package, there are certificates of state registration [8].

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