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An improved deep learning method for predicting DNA-binding proteins based on contextual features in amino acid sequences

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ABSTRACT

[With the explosively increased amount of newly discovered proteins, predicting the function of these proteins from amino acid sequences](#) is becoming one of the main challenges in functional annotation of genomes. [Nowadays a number of computational approaches have been developed to predict DNA-binding proteins effectively and accurately from amino acid sequences, such as SVM, DNABP and CNN-RNN. However, these methods do not consider the context in amino acid sequences, which](#) makes it difficult for them to capture sequence features adequately. [In this paper, we propose CNN-BiLSTM, a new method for predicting DNA-binding proteins, elaborately reconciling convolution neural network and bi-directional long short-term memory recurrent](#) neural network. CNN-BiLSTM can explore the potential contextual relationships of amino acid sequences to obtain more features than traditional models. [The experimental results show that the predication accuracy of the proposed CNN-BiLSTM method on the test set is 96.5%, which is 7.8% higher than that of SVM, 9.6% higher than that of DNABP and 3.7% higher than that of CNN-RNN respectively. Being tested on 20,000 independent samples provided by UniProt](#) that weren't involved in model training, the accuracy of CNN-BiLSTM is 94.5%, [which is 12% higher than that of SVM](#), 4.9% higher than that of DNABP and 4% higher than that of [CNN-RNN](#) respectively. [The model training process is visualized and compared with that of CNN-RNN, and it is found that the training process of CNN-BiLSTM support better generalization from the training data set, which shows that CNN-BiLSTM has a wider range of adaptations to protein sequences. On the independent samples set, CNN-BiLSTM presents better credibility](#), for its predicted scores are closer to the labels of the samples than those of CNN-RNN. [Therefore, the proposed CNN-BiLSTM is a more powerful method for identifying DNA-binding proteins.](#)

ATTACHMENTS

[model structure.pdf](#)

Keywords: deep learning , DNA binding proteins , contextual features

GUIDELINES

This is a method of recognizing DNA binding proteins by deep learning.

MATERIALS

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SAFETY WARNINGS

Pay attention to the proper use of the computer.

BEFORE START INSTRUCTIONS

What you need to prepare:

Python 3

TensorFlow

Keras

1 Prepare the dataset:

[In the process of extracting protein data from UniProt, we](#) removed those sequences with length less than 50 or greater than 1,280 amino acids, resulting in 17,651 [DNA-binding protein](#) sequences are selected as positive samples. At the same time, we got 50,500 non-DNA-binding protein sequences as negative [samples](#) in UniProt that are 50 to 1,280 in length. We took 500 sequences from both positive and negative samples as independent test samples, respectively. [For the remaining 17,151 positive and 50,000 reverse samples, we randomly selected 85% of them as training sets and the remaining 15% as test sets to participate](#) in model training.

2 Build model:

The deep learning model is composed of four parts: coding layer, embedding layer, convolution layer and Bi-LSTM layer. The coding layer represents each [amino acid](#) as a particular number. The embedding layer translates amino acid sequences into continuous [vectors](#). The convolution layer consists of two convolutions and two maximal pooling operations. The mission of the Bi-LSTM layer [is](#) to grasp the context features of amino acid sequences. We use the Keras platform to build this model.

3 Model training:

The data is trained in the built model, and this process is carried out on the GPU. At the end of this process, we get a DNA binding protein predictor.