Hopfield Network

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1 Introduction

Hopfield network is a model of recurrent artifcial neural networks implementing an autoassociative memory. Hopfield network provides a model for understanding human memory. This model exploits an analogy to energy states in physics (Ising Model). Like a physical system, the network seeks its lowest energy state and with the iteration procedure converges to the stable state.

The Hopfield network is able to memorize and next reproduce the information on the base of a noisy input signal. The Hopfield net consists of a number of elements, each connected to every other element. It has the following characteristics:

- Recurrent network, weights with w_{ij}
- Symmetric weights, ie. $w_{ij} = w_{ji}$, no self-connections $w_{ii} = 0$
- It's possible to store memory items in the weights W of the network and use it as associative memory

Each element in the Hopfield Network has threshold unit and based on the weighted sum of its inputs and the threshold the state is updated or not.

$$s_i = \begin{cases} 1, & if \ \sum_j w_{ij} s_j \geq \theta \\ -1, & \text{otherwise.} \end{cases} \tag{1}$$

where

- w_{ij} is the weight of the connection of unit j to unit i
- s_i is the state of unit i
- θ is the threshold value of unit i

The input can be values x $\in$ {0,1} in unipolar case or x $\in$ {-1,1} in bipolar case. Input to the network is an unknown object which proceeds to a loop. The first iteration's output is used as the new input for the next iteration. The loop is being repeated until it converges on a stable state or a cycle of length two is achived.

2 Algorithm Implementation

In Figure 1 is presented the Graphical User Interface of the application written in Java. It gives the possibility to read input data from the file or right from the User Interface. The input data may be in either unipolar or bipolar form. Next the test data should be provided in the corresponding field (either unipolar or bipolar).

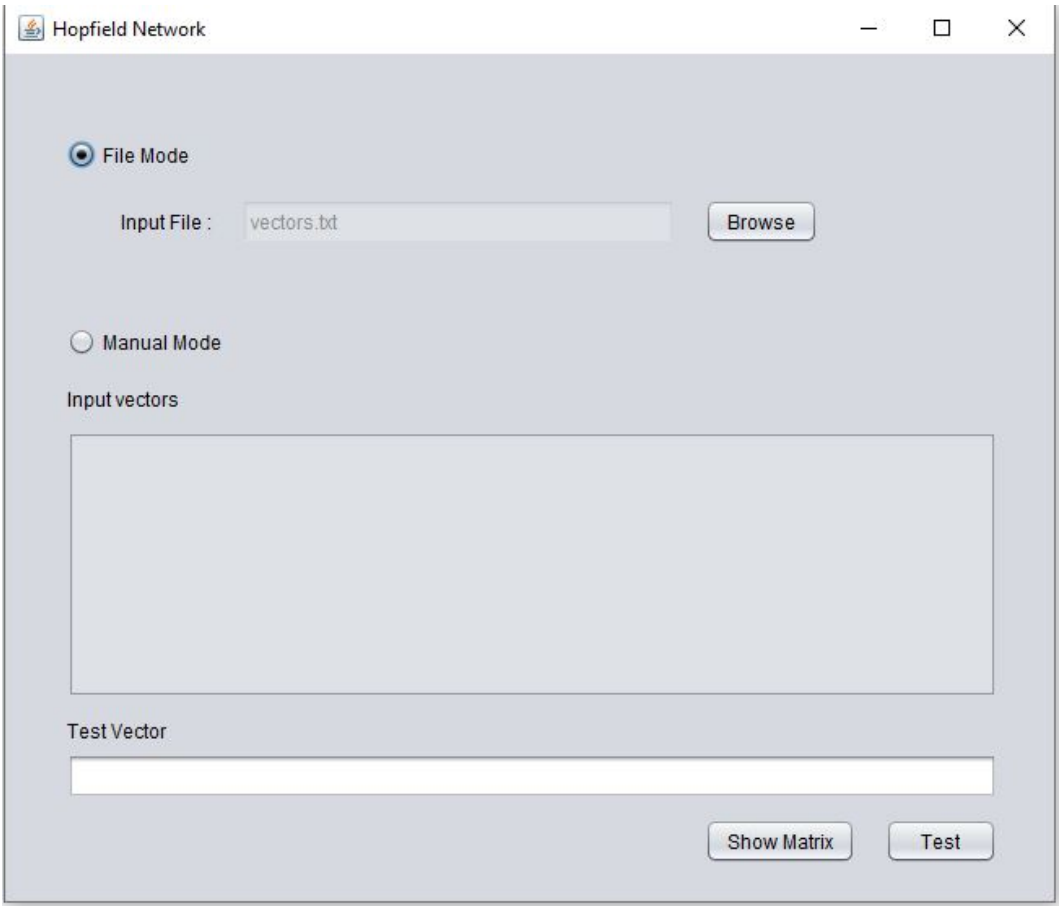

Figure 1: The Graphical User Interface of the application

2.1 Reading from Input File

This mode is chosen by default when the application runs.

In order to choose the File input mode one should click on the button "File Mode". Then the proper file should be chosen by clicking the "Browse" button. After this step the test vector should be input in the "Test Vector" field.

In order to execute the application it is required to use proper format of the input data. Otherwise an error massage will be shown, similar to the message "Input vector is not valid".
The first line of the file must include the number of the vectors m and the size of the vectors n separated by a single space. Then m vectors are to be placed in next m rows each of size n. The vectors may be in either unipolar or bipolar form. After the application is filled in with valid data one can execute it by pressing the "Test" button.

Input file example :

```
3 4
1 0 0 1
0 1 0 1
1 0 1 1
```

2.2 Reading from Manual Input

The manual input method is chosen by clicking the "Manual Mode" button. Next, the input area will be enabled and the input vectors should be provided. The format is similar to the file mode format but without the first row containing the vector number and size.

Manual input example:

```
1 0 0 1
0 1 0 1
1 0 1 1
```

The test vector should be input in an identical way as in File mode, by typing in the "Test Vector" field.

2.3 Execution

In the first step the algorithm will calculate the Hopfield Matrix based on the input vectors. Then it will multiply the matrix by the test vector and in a loop will use the output as the new input for the multiplication. The loop will continue until the output vector doesn't change anymore or a cycle of length 2 is obtained. The result of the execution will be presented as a message.

2.4 Show Weight Matrix

Once the "Test" button is pressed the Weight Matrix is calculated and by the use of "Show Matrix" button can be presented.

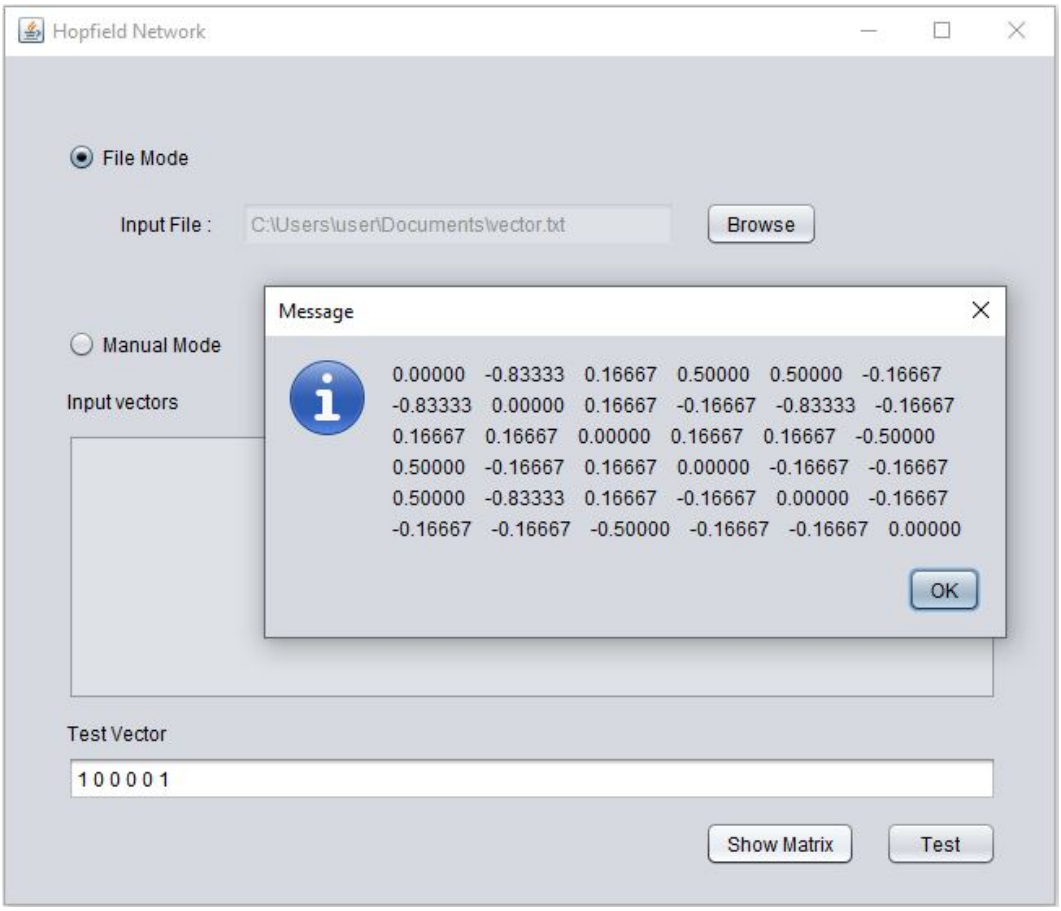

Figure 2: Weight Matrix