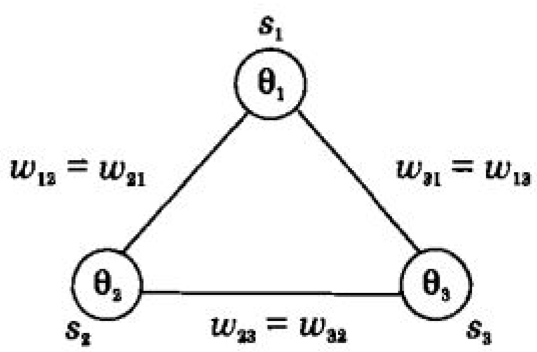
SRIP Project 4 Documentation Hopfield model for pattern storage task

Task allotted

1. In the virtual-labs repository, artificial-neural-networks-iiith lab, the task was to resolve Issue No: 202
2. Issue No: 202 was to Convert the following experiment to JavaScript. Link to the experiment:- http://cse22-iiith.vlabs.ac.in/exp5/Objective.html?domain=Computer%20Science&lab=Artificial%20Neural%20Networks%20Virtual%20Lab

Experiment Explanation

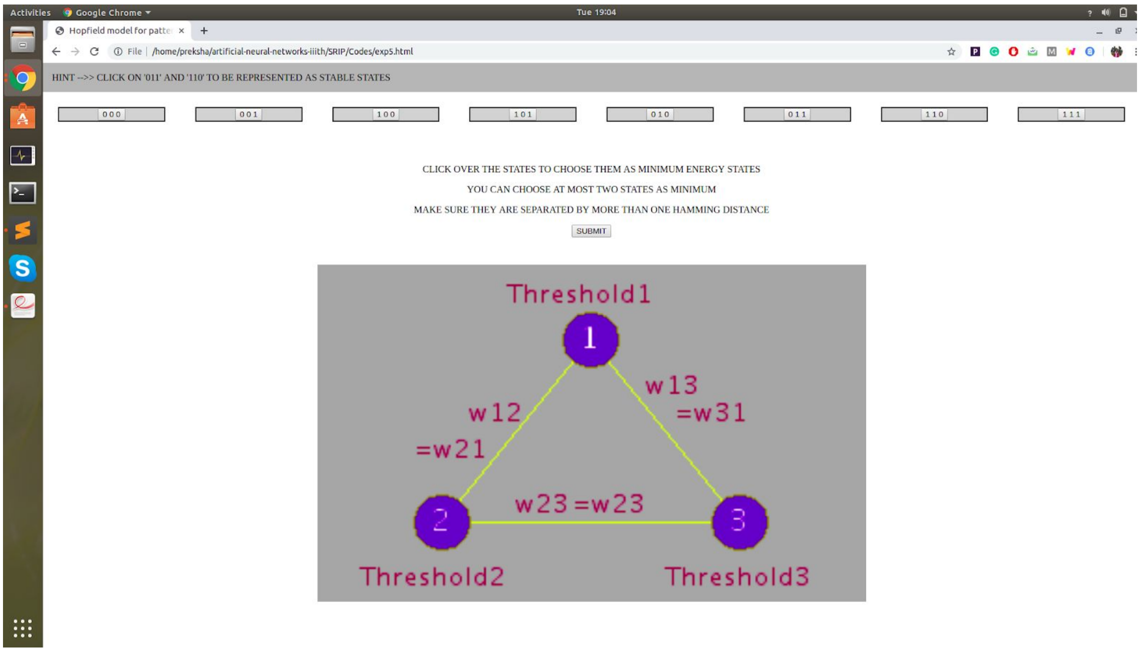
- The main objective of this experiment is to understand and analyze the pattern storage task using a 3-unit discrete Hopfield network model.
- Initially, 2 states are selected which will be the two patterns to be stored in a 3-unit binary network.
- The 3-unit feedback network has symmetric weights wij = wji. The units have a threshold value of theta i, i = 1, 2, 3 and a binary (0, 1) output function.
- The figure shows a 3-unit feedback network with symmetric weights Wij, threshold values theta i and the output states si, i = 1, 2, 3



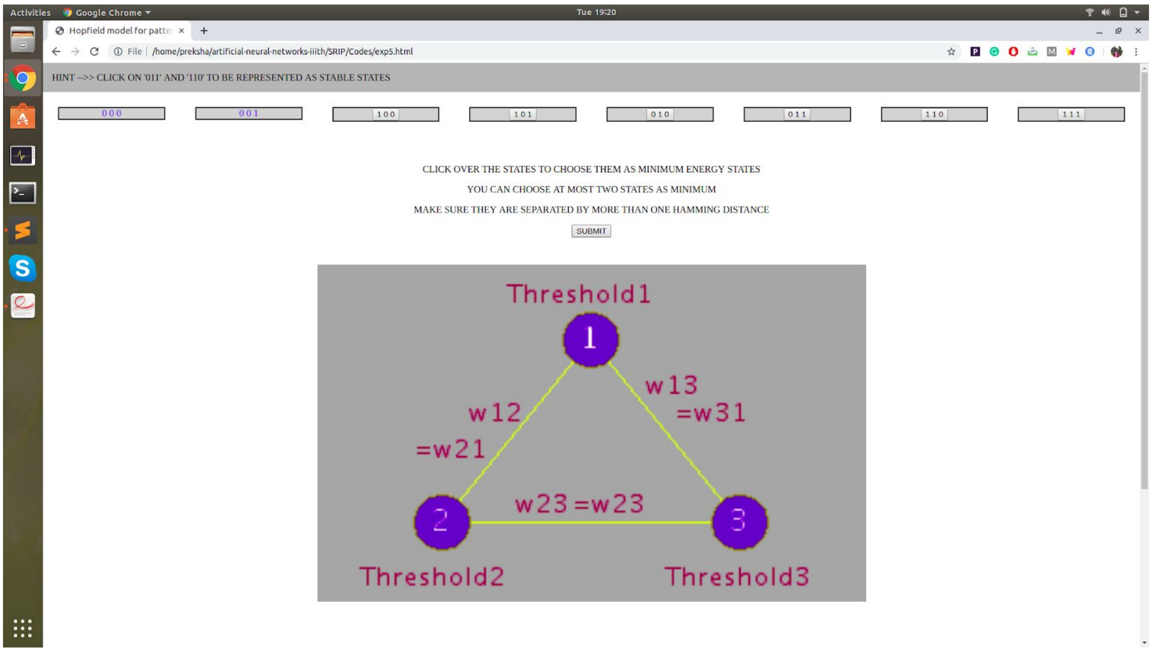
- The energy analysis of the Hopfield network shows that the energy of the network at each state either decreases or remains the same as the network dynamics evolves. In other words, the network either remains in the same state or moves to a state having lower energy.
- The transition from any state to the next state can be computed using the state update equation.
- The experiment runs until the system reaches a stable state. The stable states are always at the energy minima so that the transition to any of these states is always from a state with a higher energy value than the energy value of the stable state.
- The patterns can be stored at the stable states by design.
- Overall the pattern storage is a Hard problem.

How to Run the Experiment

1. My forked repository(https://github.com/prekshap24/artificial-neural-networks-iiith) contains a folder named "SRIP".
2. SRIP folder contains a folder named as Codes and Libraries. Codes contain all the files containing code for the experiment written in JavaScript, HTML, CSS. Libraries contain JavaScript libraries used in the codes.
3. The Codes folder contains 3 files. To run the experiment, simply run the exp5.html file by clicking on it.
4. The experiment will open in the browser.

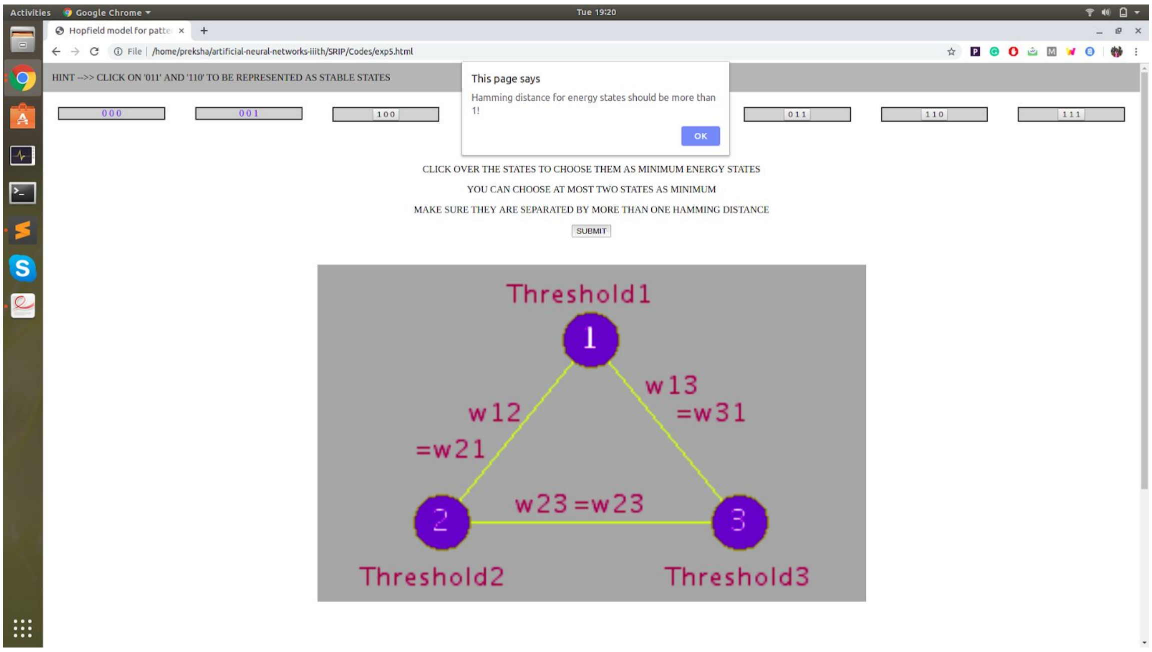


5. Initially click over the states to choose them as minimum energy states.
6. Choose 2 states which will be the two patterns to be stored in a 3-unit binary network. Make sure of them being apart for a Hamming distance more than 1. The chosen states will be highlighted blue.

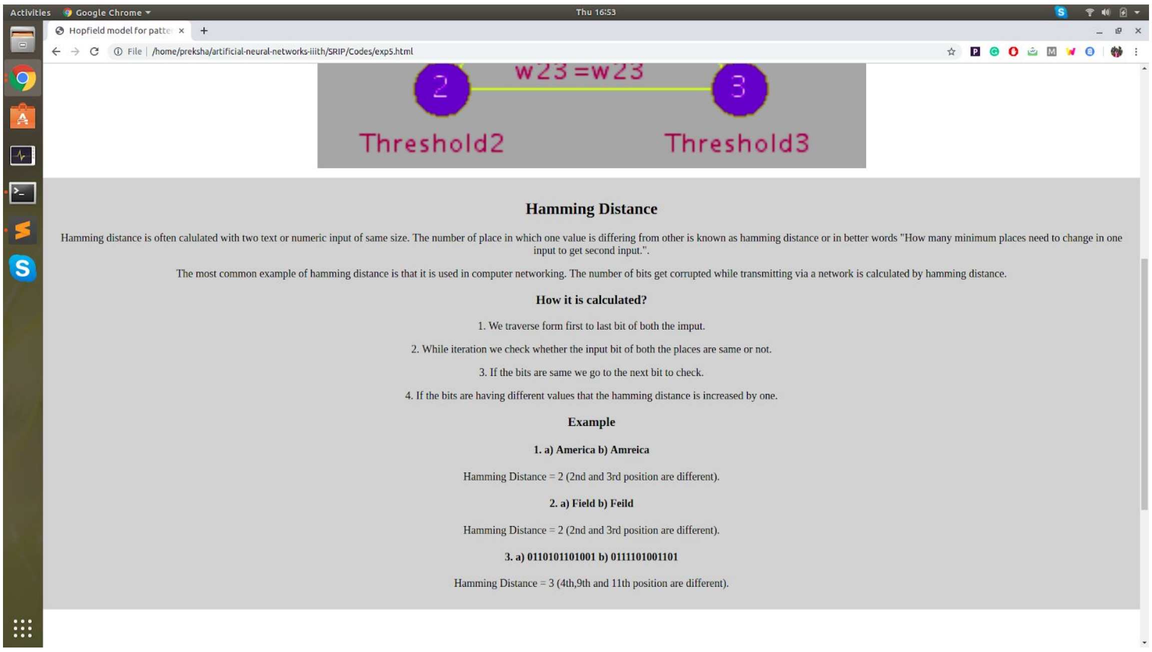


7. Click on the ‘Submit’ button.

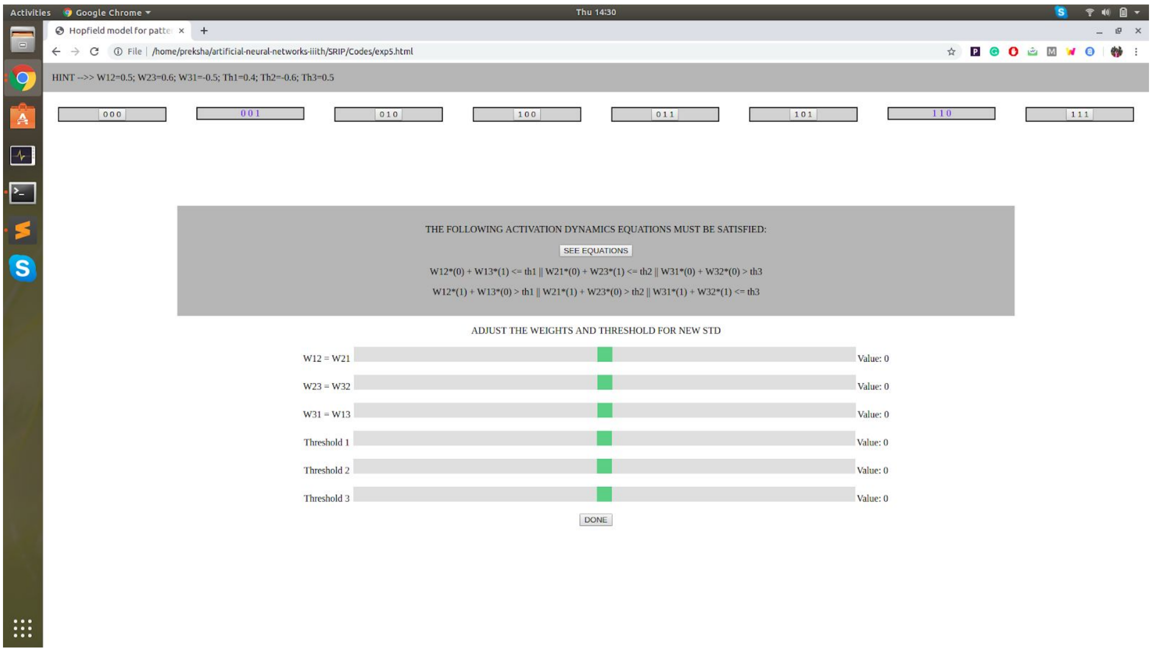
8. If Hamming distance is less than 2, then an alert box will appear displaying the message as follows.



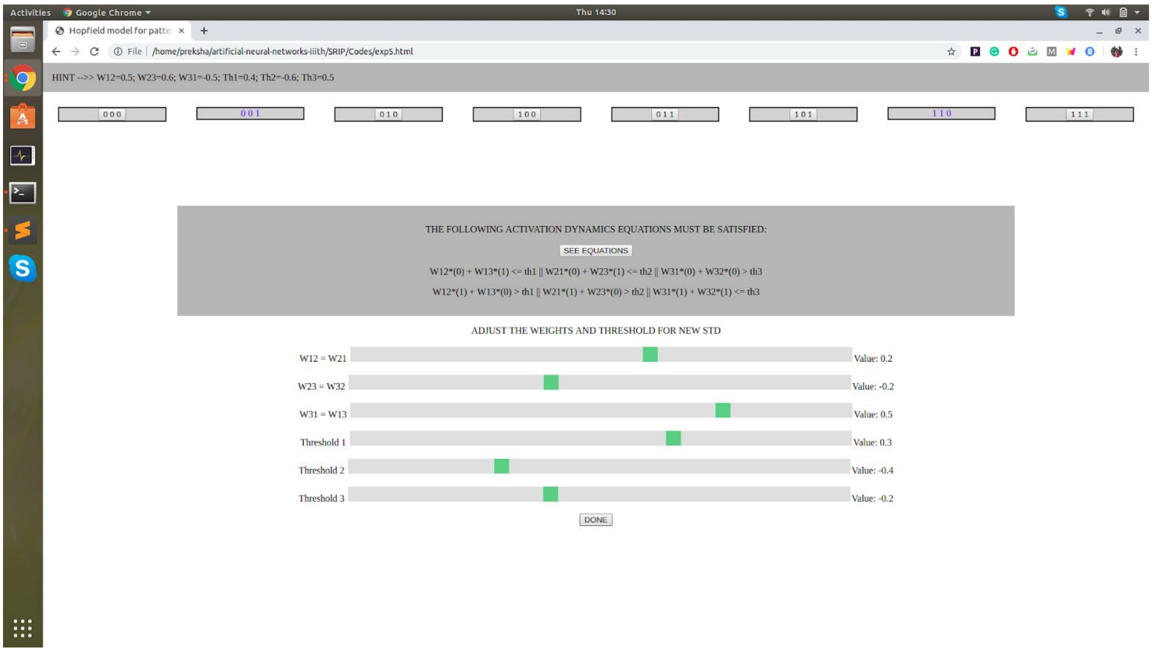
9. To see how to calculate the hamming distance see the Hamming Distance write-up given at the bottom of the page.



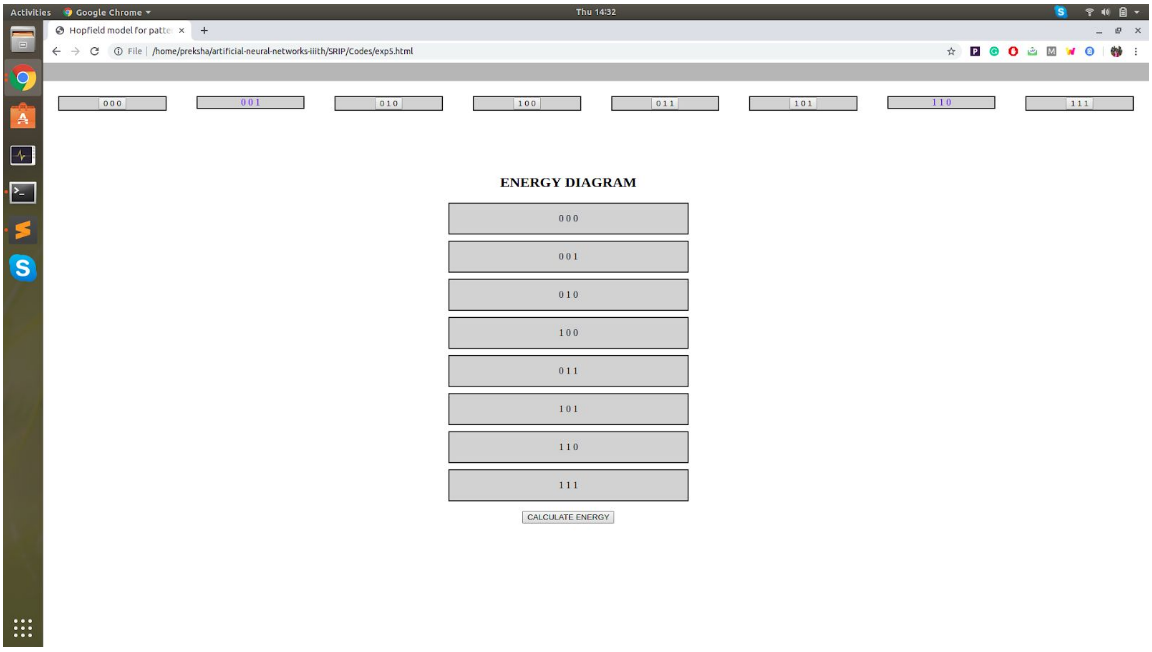
10. If Hamming distance is greater than 1 then the next window will appear. Click on the ‘See Equations’ button to see the corresponding equations.



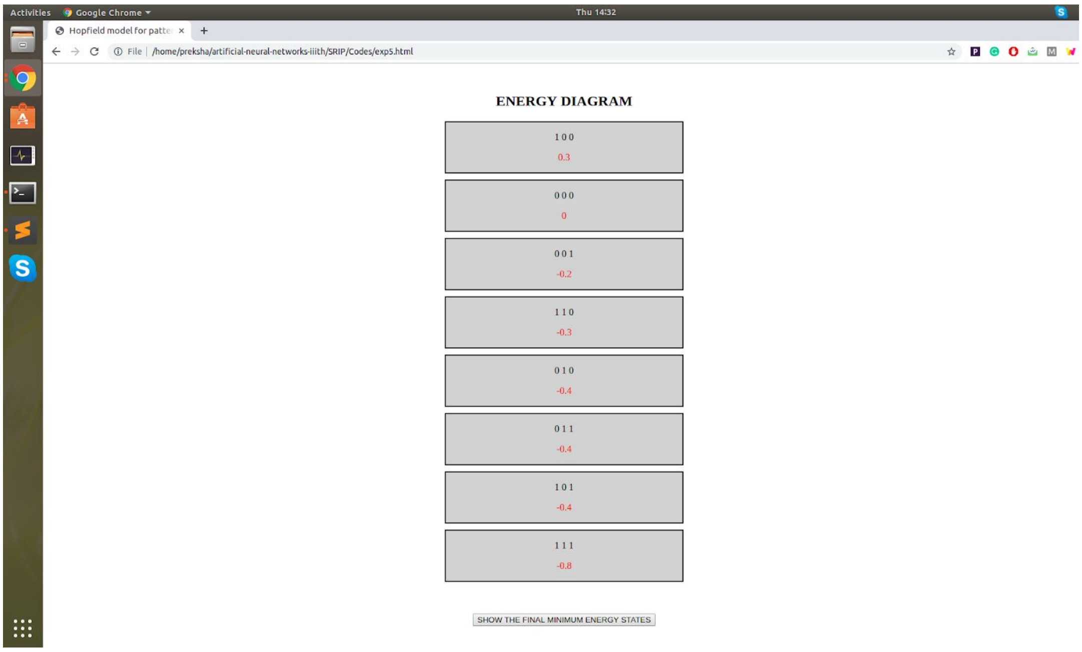
11. Select the value of weights and the threshold for the 3 nodes by sliding the slider. The range of the slider is [-1, 1]



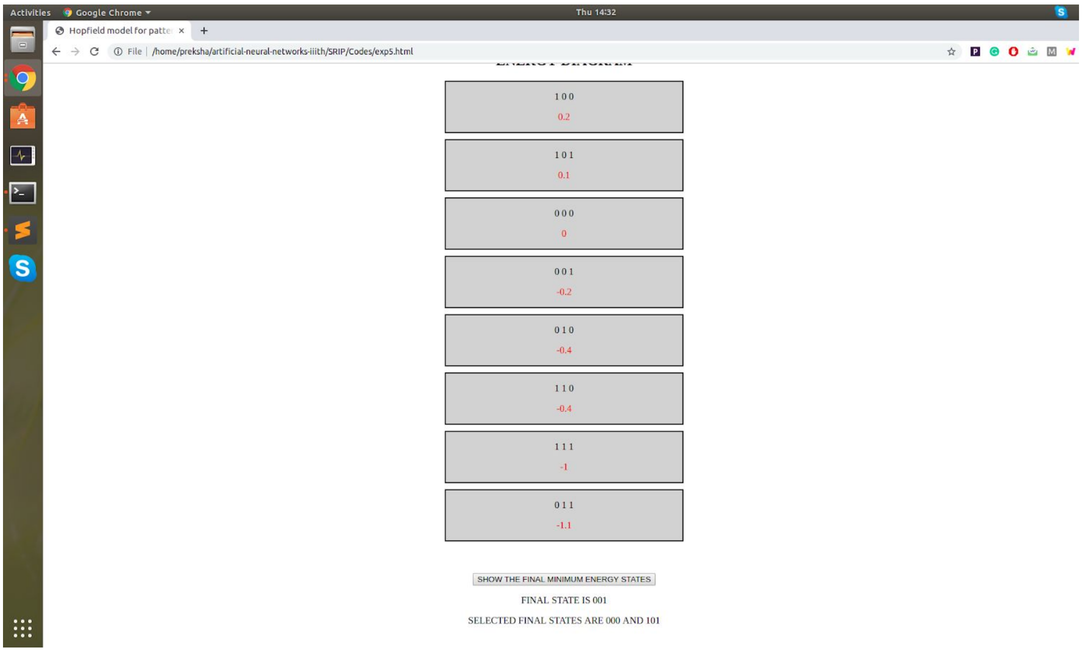
12. Click on the ‘Done’ button. Next page will appear.

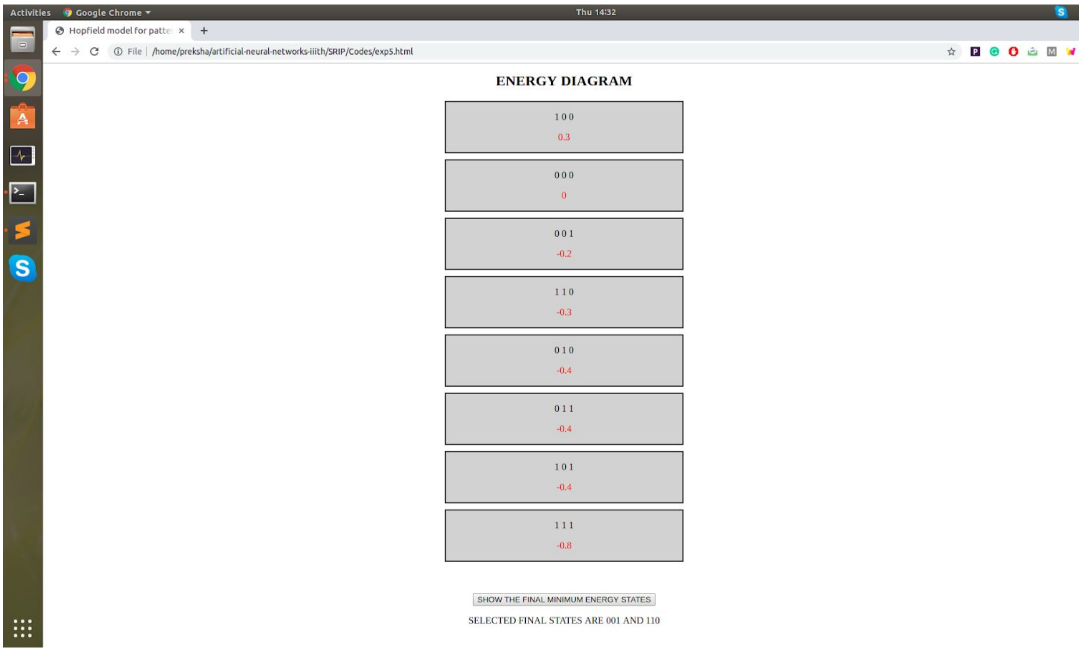


13. Then click on the ‘Calculate Energy’ button to display the energies of every state.



14. Now to see the final minimum energy states, click on the ‘Show the final minimum energy states’ button. If any other state exists apart from the selected states then it would be displayed.





Formulas used in the Experiment

- The state update for the unit i is governed by the following equation

$$s_i(t+1) = 1, \quad \text{if} \quad \sum_j w_{ij}\, s_j(t) > \theta_i$$

$$= 0, \quad \text{if} \quad \sum_j w_{ij}\, s_j(t) \le \theta_i$$

- The energy at any state (s1 s2 s3) of the network is given by

$$V(s_1\, s_2\, s_3) = -\frac{1}{2} \sum_i \sum_j w_{ij}\, s_i\, s_j + \sum_i s_i\, \theta_i$$

- Let 010 and 111 be the two patterns to be stored in a 3-unit binary network. Then at each of these states, the following activation dynamics equations must be satisfied:

$$f\left(\sum_j w_{ij}\, s_j - \theta_i \right) = s_i, \quad i = 1, 2, 3$$