

# DEEP BELIEF NETWORK

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Greeshma K

Vishnu N M

Anjush R

Cochin University of Science and Technology

# INTRO

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- Deep Belief Network is energy based Generative model.
- What is a Generative model?

- A deep belief network is a stack of multiple Restricted Boltzmann Machine (RBM) structures.
- Each of these RBMs consists of a visible layer and a hidden layer. The visible layer accepts the input from the previous layer, while the hidden layer stores the processed output.

- A Restricted Boltzmann Machine is a two-layer probabilistic neural network.
- Its first layer (visible layer) interacts with the raw data, and the second (hidden layer) learns high-level features from the first one.
- They are called 'Restricted' since the connections only exist between neurons in subsequent layers.

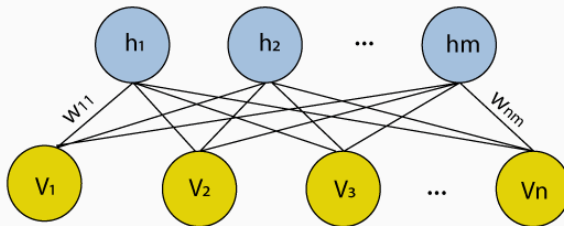


Figure 1: RBM

Energy function of RBM

$$E(v, h) = - \sum_{i \in v} a_i v_i - \sum_{j \in h} b_j h_j - \sum_{i,j} v_i h_j w_{ij} \quad (1)$$

Probability distribution

$$p(v, h) = \frac{1}{Z} \sum_h e^{-E(v, h)} \quad (2)$$

## STRUCTURE OF DBN

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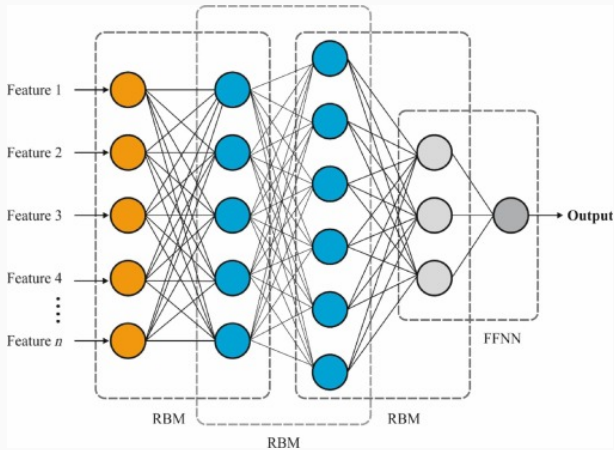


Figure 2: DBN

## DBN TRAINING

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- Layer-wise Unsupervised Learning.
- Greedy layer wise Learning.
  - Initialize the first layer: Train the first layer as a standalone model using an unsupervised learning algorithm. This layer learns to extract low-level features from the input data.
  - Initialize the second layer: Once the first layer is trained, fix its weights and train the second layer in a similar manner, using the output of the first layer as input. This process continues for subsequent layers.

- Add a suitable classifier to the end of this DBN, such as Back Propagation Network. We use gradient-descent algorithm to revise the weight matrix of the whole network.
- Fine-tuning with labeled data (supervised learning) minimize the overall error.

# TRAINING IN DBN

