# Neural Network

## Competitive Learning using unsupervised learning

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# Adaptive Resonance Theory (ART)

- It is based on competition and uses unsupervised learning model.
- ART is always open to new learning adaptive without losing the old patterns resonance.
- Basically, ART network is a vector classifier which accepts an input vector and classifies it into one of the categories depending upon which of the stored pattern it resembles the most.

# ART Operating Principal

- The main operation of ART classification can be divided into 3 phases –
- **Recognition phase** – The input vector is compared with the classification presented at every node in the output layer. The output of the neuron becomes “1” if it best matches with the classification applied, otherwise it becomes “0”.
- **Comparison phase** – In this phase, a comparison of the input vector to the comparison layer vector is done. The condition for reset is that the degree of similarity would be less than vigilance parameter.
- **Search phase** – In this phase, the network will search for reset as well as the match done in the above phases. Hence, if there would be no reset and the match is quite good, then the classification is over. Otherwise, the process would be repeated and the other stored pattern must be sent to find the correct match.

# Architecture of ART1

- It is a type of ART, which is designed to cluster binary vectors. We can understand about this with the architecture of it.
- It consists of the following two units –

1. **Computational Unit** – It is made up of the following –

- Input unit (F1 layer) – It further has the following two portions –
- F1(a) layer Input portion – In ART1, there would be no processing in this portion rather than having the input vectors only. It is connected to F1b layer interface portion.
- F1(b) layer Interface portion – This portion combines the signal from the input portion with that of F2 layer. F1b layer is connected to F2 layer through bottom up weights $b_{ij}$ and F2 layer is connected to F1(b) layer through top down weights $t_{ji}$.

# Architecture of ART1

- Cluster Unit ($F_2$ layer) − This is a competitive layer. The unit having the largest net input is selected to learn the input pattern. The activation of all other cluster unit are set to 0.
- Reset Mechanism − The work of this mechanism is based upon the similarity between the top-down weight and the input vector. Now, if the degree of this similarity is less than the vigilance parameter, then the cluster is not allowed to learn the pattern and a rest would happen.

**2. Supplement Unit** − Actually the issue with Reset mechanism is that the layer **$F_2$** must have to be inhibited under certain conditions and must also be available when some learning happens. That is why two supplemental units namely, **$G_1$** and **$G_2$** is added along with reset unit, **R**. They are called **gain control units**. These units receive and send signals to the other units present in the network. **'+'** indicates an excitatory signal, while **'–'** indicates an inhibitory signal.

# Architecture of ART1

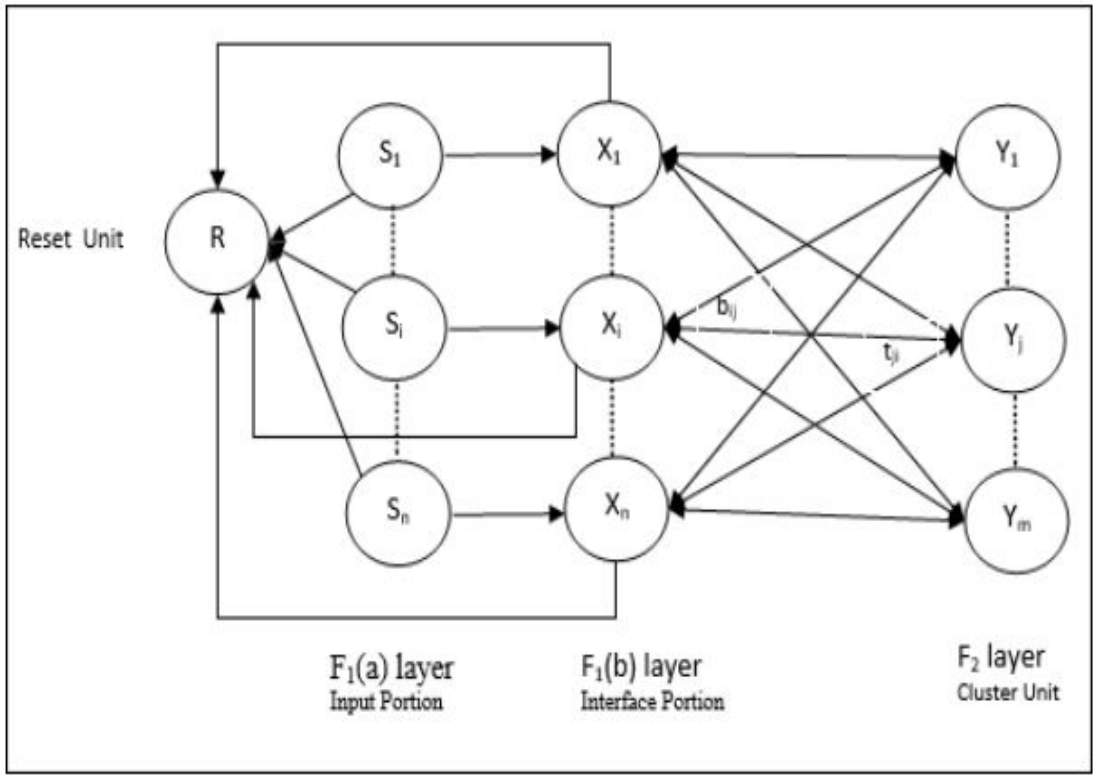


Figure: Basic structure of ART1

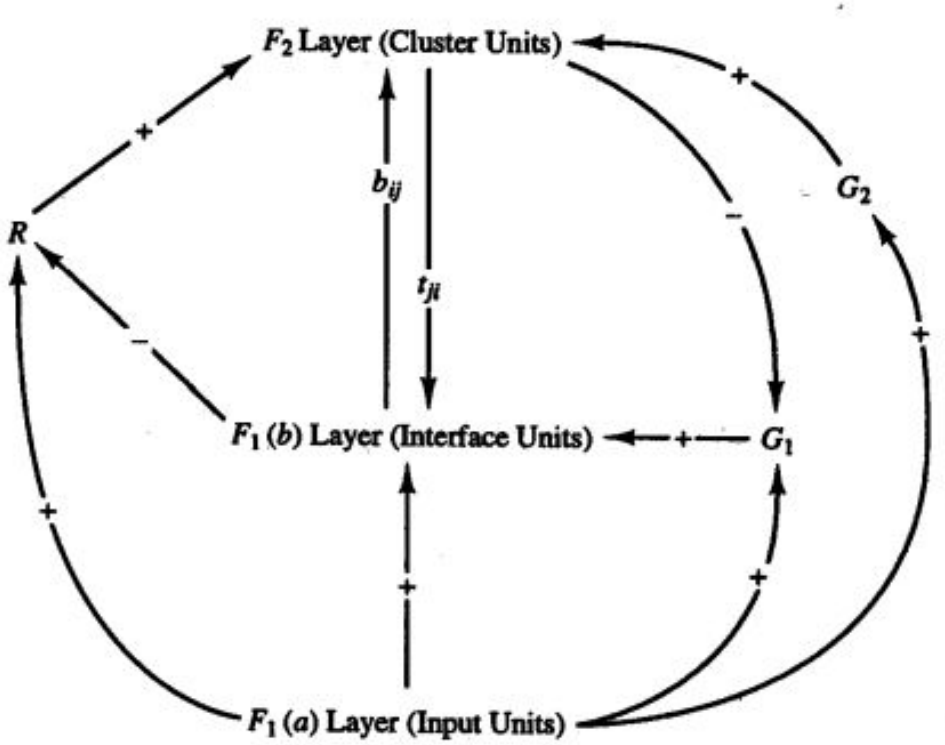


Figure: Supplementary units of ART1

# Algorithm of ART1

- **Parameters Used**
- Following parameters are used −
- n − Number of components in the input vector
- m − Maximum number of clusters that can be formed
- $b_{ij}$ − Weight from F1b to F2 layer, i.e. bottom-up weights
- $t_{ji}$ − Weight from F2 to F1b layer, i.e. top-down weights
- ρ − Vigilance parameter
- ||x|| − Norm of vector x

# Algorithm of ART1

- **Algorithm:**
- Step 1 – Initialize the learning rate, the vigilance parameter, and the weights as follows –

$$\alpha > 1 \; and \; 0 < \rho \leq 1 \qquad 0 < b_{ij}(0) < \frac{\alpha}{\alpha - 1 + n} \; and \; t_{ij}(0) = 1$$

- Step 2 – Continue step 3-9, when the stopping condition is not true.
- Step 3 – Continue step 4-6 for every training input.
- Step 4 – Set activations of all F1(a) and F2 units as follows

  F2 = 0 and F1(a )= input vectors

# Algorithm of ART1

- Step 5 – Input signal from F1a to F1b layer must be sent like

$$s_i = x_i$$

- **Step 6** – For every inhibited $F_2$ node
- Step 7 – Perform step 8-10, when the reset is true.
- Step 8 – Find J for $y_J \geq y_j$ for all nodes j
- Step 9 – Again calculate the activation on F1b as follows: $x_i = sitJi$
- Step 10 – Now, after calculating the norm of vector x and vector s, we need to check the reset condition as follows –
- If ||x||/ ||s|| < vigilance parameter ρ,then inhibit node J and go to step 7
- Else If ||x||/ ||s|| ≥ vigilance parameter ρ, then proceed further.

# Algorithm of ART1

- Step 11 – Weight updating for node J can be done as follows –

$$b_{ij}(new) = \frac{\alpha x_i}{\alpha - 1 + ||x||} \qquad t_{ij}(new) = x_i$$

- **Step 12** – The stopping condition for algorithm must be checked and it may be as follows –
- Do not have any change in weight.
- Reset is not performed for units.
- Maximum number of epochs reached.

*** Self Study : ART2

# THE END