Lab 3
Artificial Neural Networks and Deep Architectures

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Convergence and Attractors

```
Patterns
 [[-1 -1  1 -1  1 -1 -1  1]
 [-1 -1 -1 -1 -1  1 -1 -1]
 [-1  1  1 -1 -1  1 -1  1]]
```

```
Distorted Patterns
 [[ 1 -1  1 -1  1 -1 -1  1]
 [ 1  1 -1 -1 -1  1 -1 -1]
 [ 1  1  1 -1  1  1 -1  1]]
```

Retrieved
Not Retrieved
Retrieved

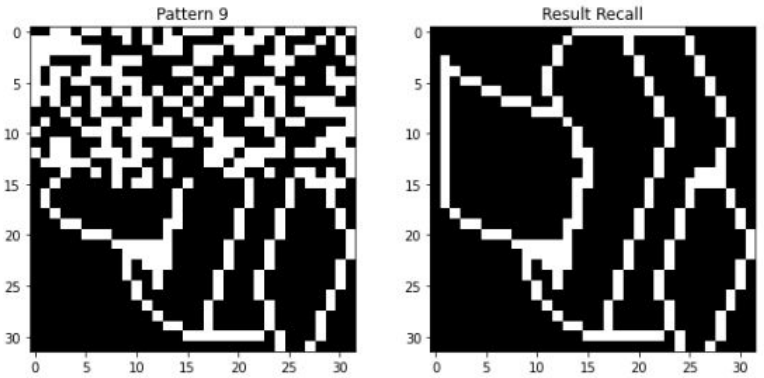
```
Very Distorted Patterns
 [[ 1  1 -1 -1 -1  1 -1  1]
 [ 1  1  1 -1 -1 -1  1 -1]
 [ 1 -1 -1  1 -1  1 -1 -1]]
```

Not Retrieved
Not Retrieved
Not Retrieved

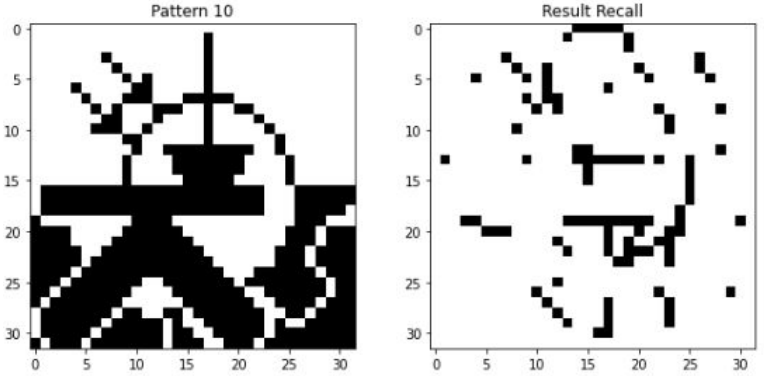
Attractors

```
The attractors are:  14
[[-1 -1 -1 -1 -1  1 -1 -1]
 [-1 -1 -1 -1  1 -1 -1 -1]
 [-1 -1  1 -1 -1  1 -1  1]
 [-1 -1  1 -1  1 -1 -1  1]
 [-1 -1  1 -1  1  1 -1  1]
 [-1  1 -1 -1 -1  1 -1 -1]
 [-1  1  1 -1 -1  1 -1  1]
 [-1  1  1 -1  1 -1 -1  1]
 [ 1 -1 -1  1  1 -1  1 -1]
 [ 1  1 -1  1 -1  1  1 -1]
 [ 1  1 -1  1  1 -1  1 -1]
 [ 1  1 -1  1  1  1  1 -1]
 [ 1  1  1  1 -1  1  1  1]
 [ 1  1  1  1  1 -1  1  1]]
```

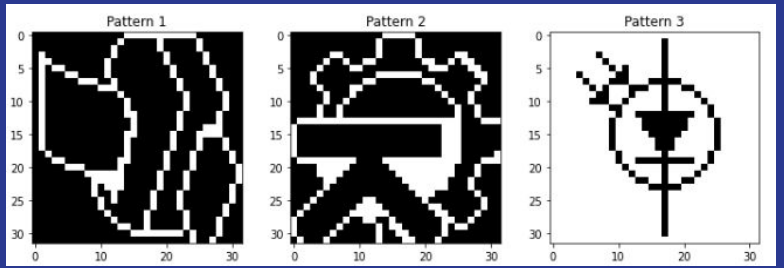
Synchronous Update



After 2 iterations



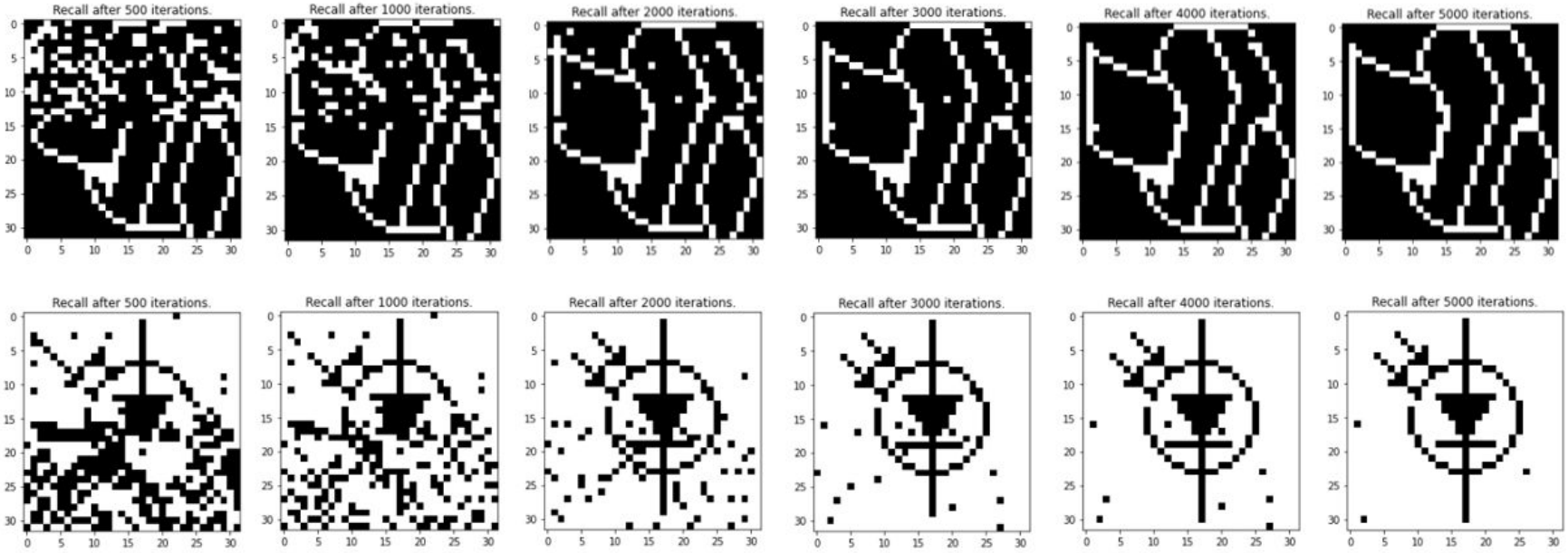
After 3 iterations



Very good at completing degraded patterns due to noise

Difficulties when the pattern is a mix of two stored patterns

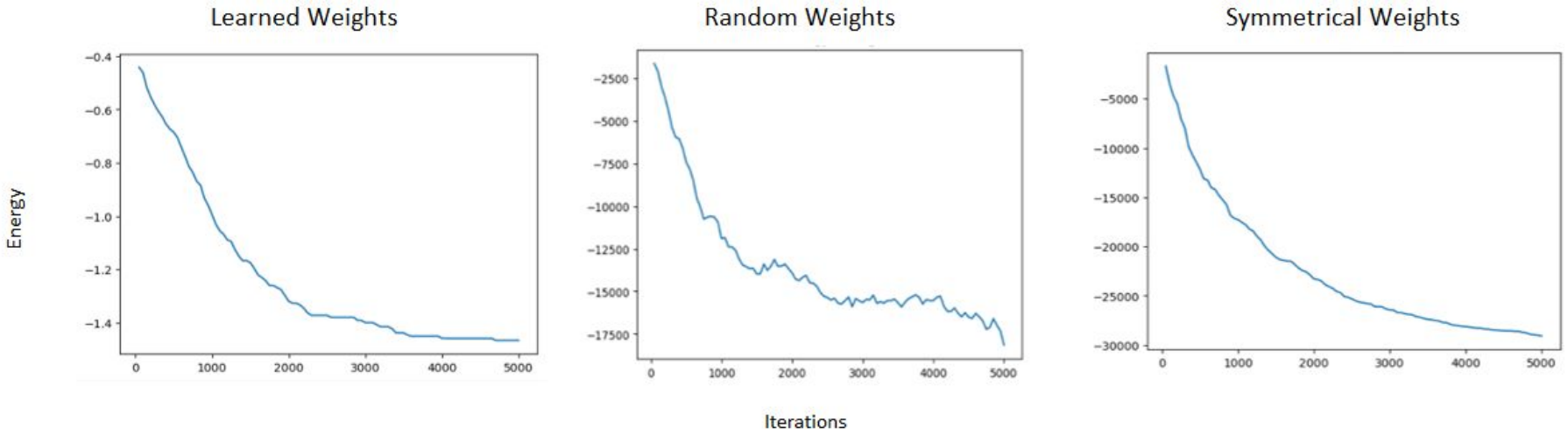
Asynchronous Update



For the completion of a degraded pattern produces the **same output** as the synchronous update.

For the retrieval of the mixed pattern, the asynchronous manages to **succeed.**

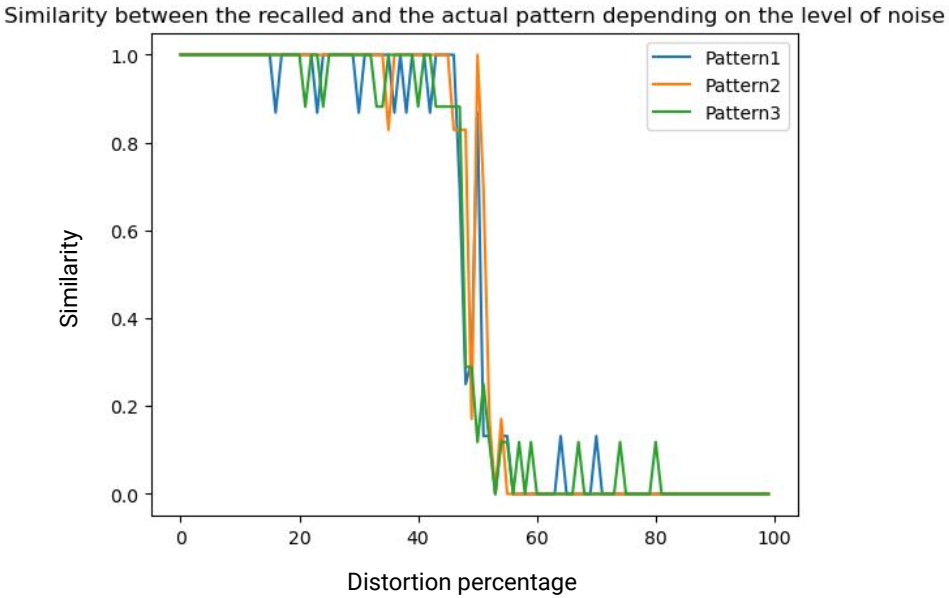
Energy



With the learned weights, the energy term only decreases throughout the recall.

That property remains with any symmetric weight matrix, but not with any random matrix

Distorsion Resistance

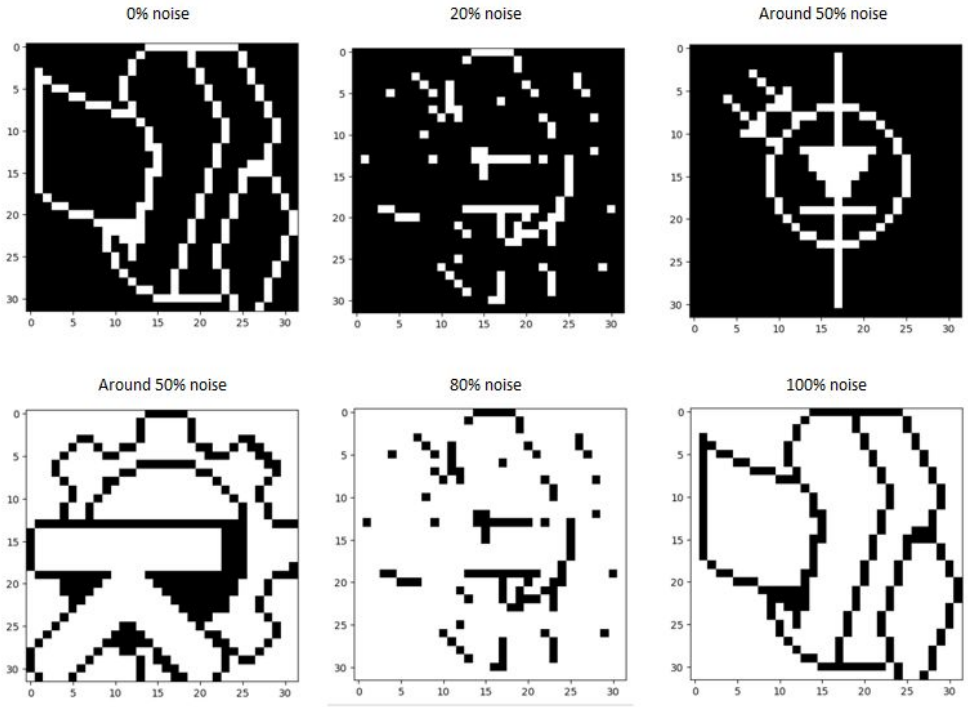


Noisy Data

We give each pixel a probability *p* of flipping.

We see that the model can properly **recover patterns with up to 40%** of flipped pixels.

Distorsion Resistance



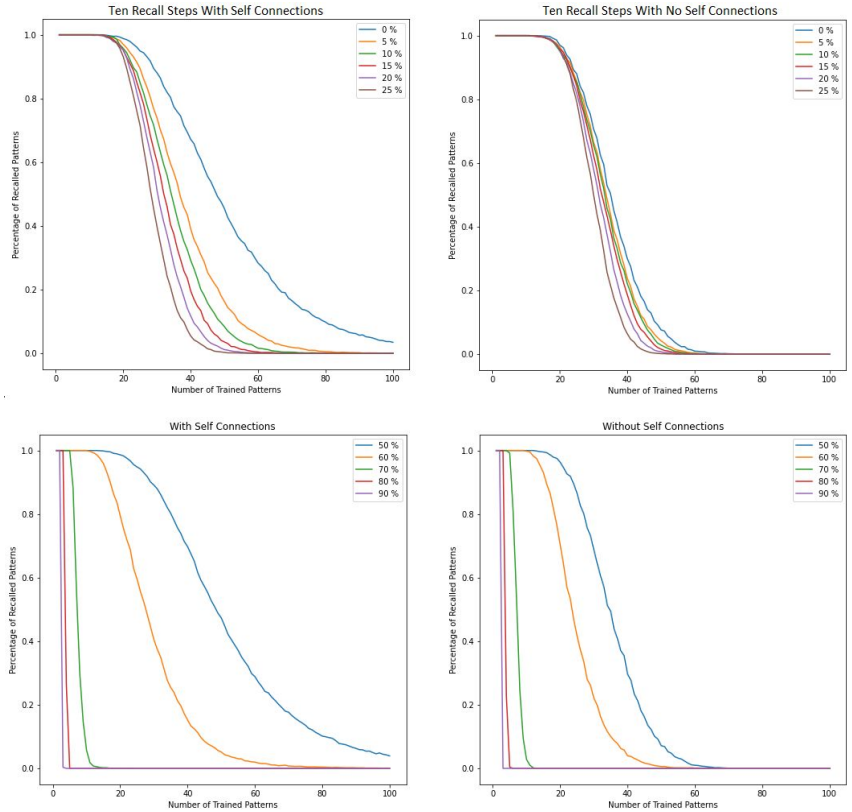
Reached attractors

With a low level of noise the model **restores the actual image**.

With around 50% of noise it **can reach any attractors** (random image).

With a high percentage of flipped pixels it **converges towards the mirror image** of the actual pattern.

Capacity

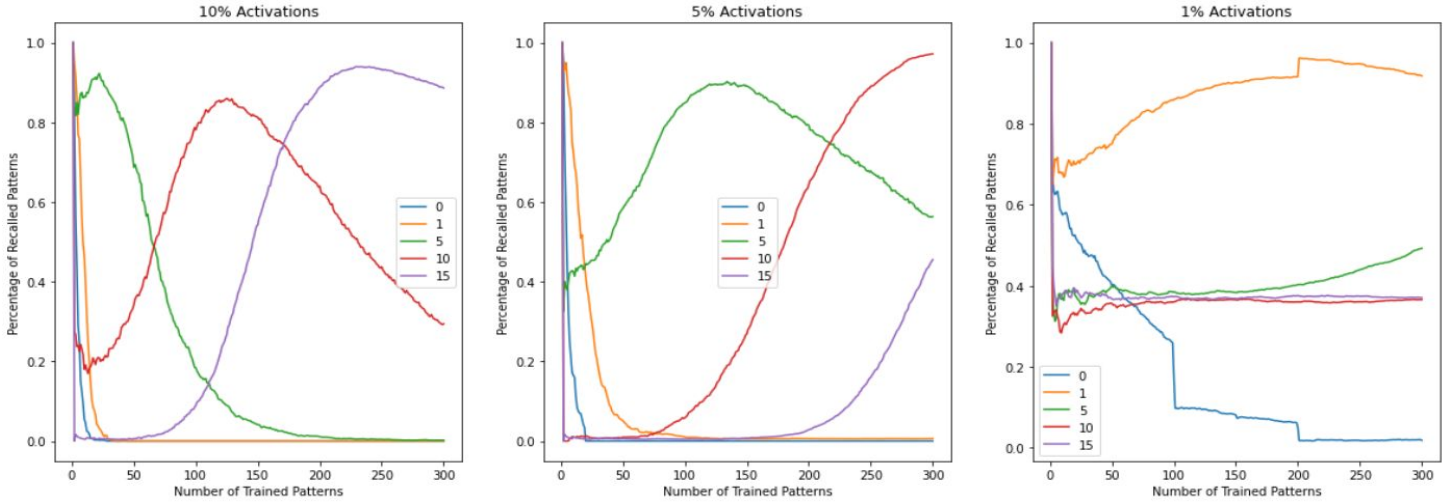


Different Levels of Noise

The network performs better with self connections in the weights and not noisy data, however **no self connections** give a **more consistent performance** with different noise levels.

There is a **large loss in capacity** when the **data is biased**. With 70% of one color, barely 20% of the patterns could be stored compared to 50%.

Sparse Patterns



It seems that there are peaks where the performance is the best.

Location and width of peaks depend on both activity and bias.

Final Remarks

- The asynchronous update is slower than the synchronous, but it could eventually lead to recall patterns that the synchronous is not able to
- The network is able to restore images with a fair amount of distortion as long as the amount of images saved is within the capacity
- The capacity of the network drops off quickly after a certain point

Thank you!