Lab 4
Artificial Neural Networks and Deep Architectures

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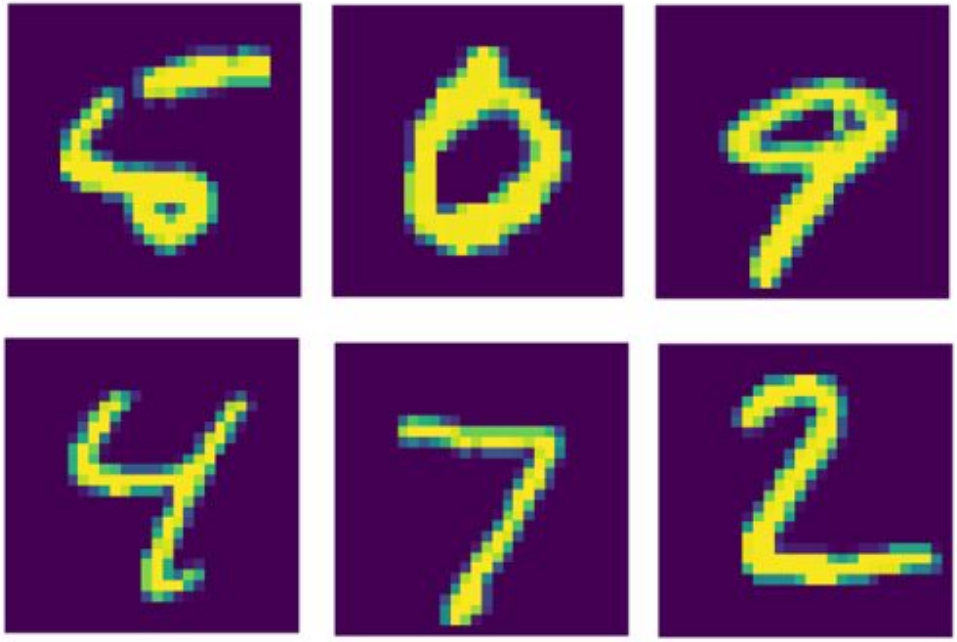
RBM for Recognising MNIST Images



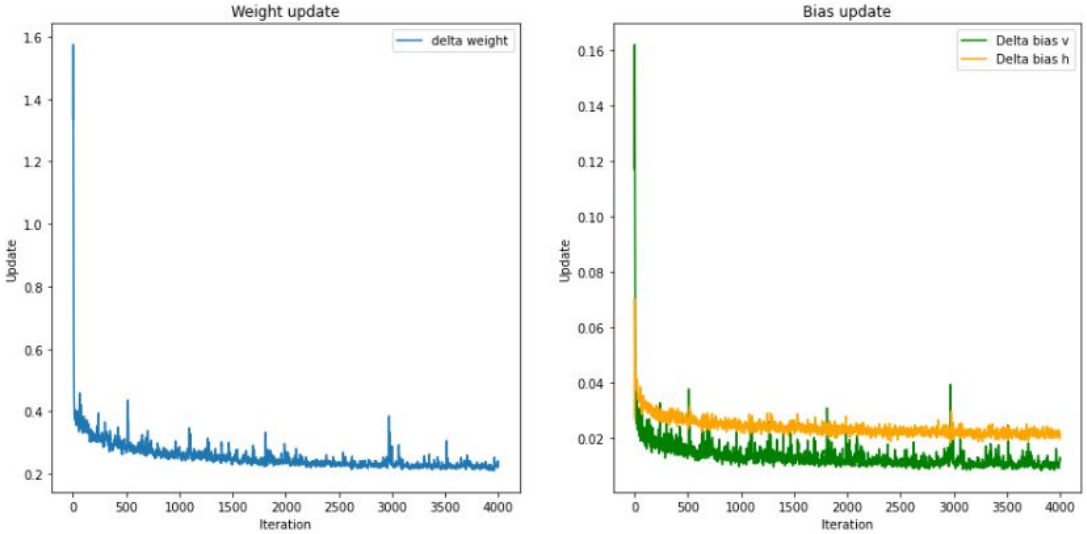
MNIST Data Set

Training and test sets consisting of handwritten digits:

Training set: 60.000 images

Test set: 10.000 images

Convergence of the Training Process

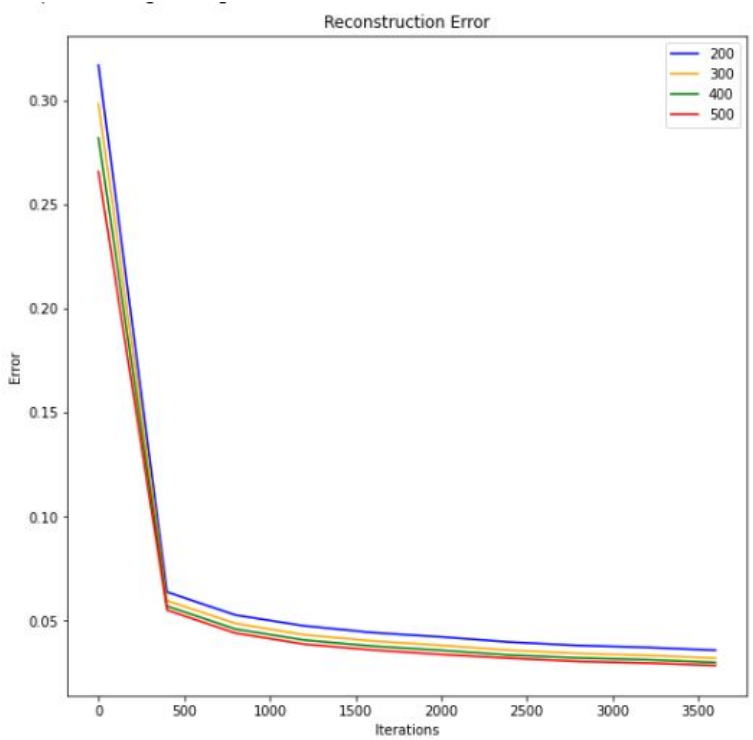


Iterations	4000
Hidden units	500
Batch size	20

As the training process goes on, the updates of both weights and biases decrease.

Steepest decay in the first 400 iterations.

Reconstruction Error



Different Number of Units

Same behaviour as weights and biases: steepest decay in the first 400 iterations.

The reconstruction error has very similar values for different numbers of units, however **as the units increase, the error decreases.**

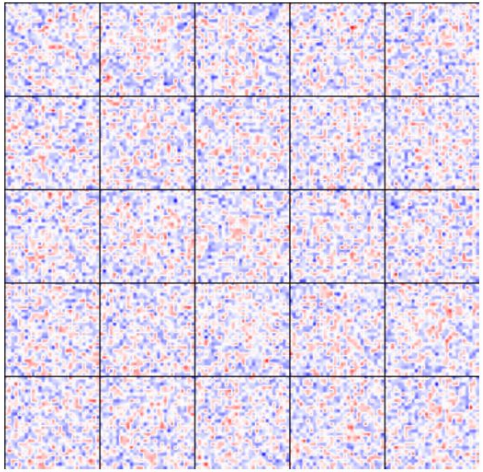
Digits Reconstruction with RBMs

Iterations	4000
Hidden units	500
Batch size	20

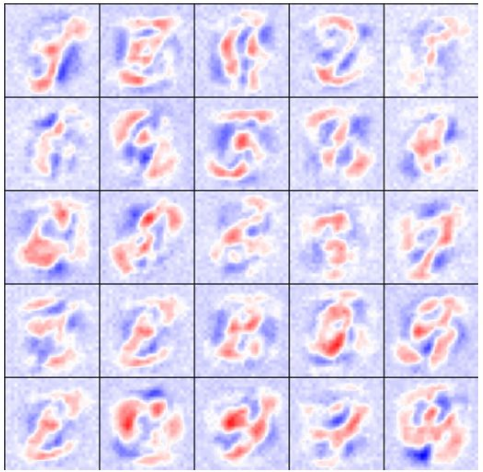
The digits are discernible, however loops tend to be quite unclear and noisy

Receptive Fields

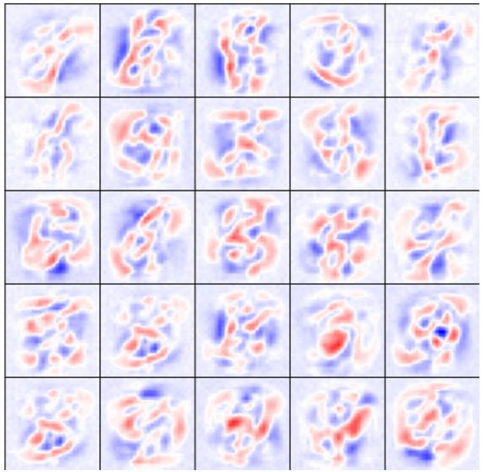
Receptive fields initialization



Receptive fields after 400 iterations



Receptive fields after 3600 iterations

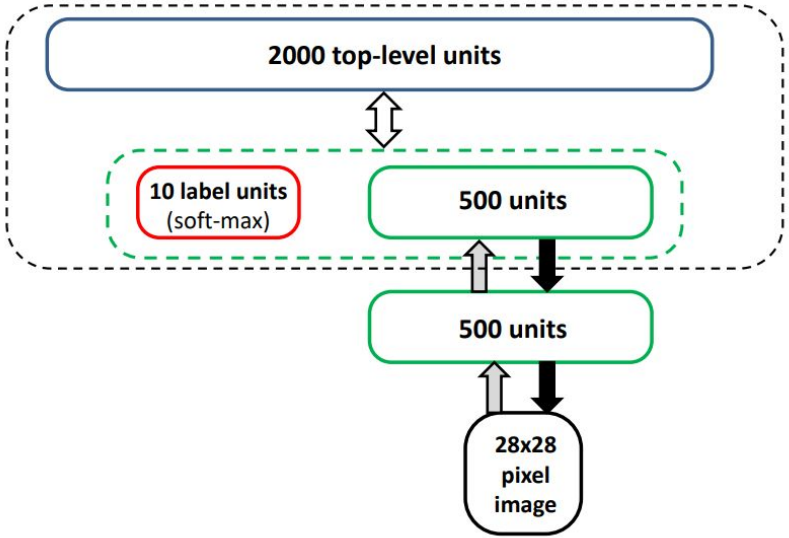


Iterations	4000
Hidden units	500
Batch size	20

Each unit specializes in recognising specific patterns.

The patterns are discernible after 400 iterations, but after 3600 they are more defined.

Deep Belief Nets



RBM_3

DBNs

Stacking of several **RBMs**

Pre-trained using an **unsupervised** greedy layer-wise training

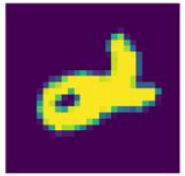
Top layer is trained in a supervised way

Digits Recognition with DBNs

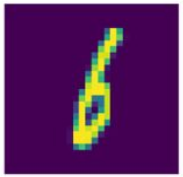
HIGH CERTAINTY

Predicted: 2 with 99.99% certainty
True label: 2

Predicted: 4 with 99.99% certainty
True label: 4



Predicted: 4 with 99.99% certainty
True label: 2



Predicted: 1 with 99.99% certainty
True label: 6

LOW CERTAINTY

Predicted: 7 with 32.38% certainty
True label: 7

Predicted: 2 with 29.85% certainty
True label: 2

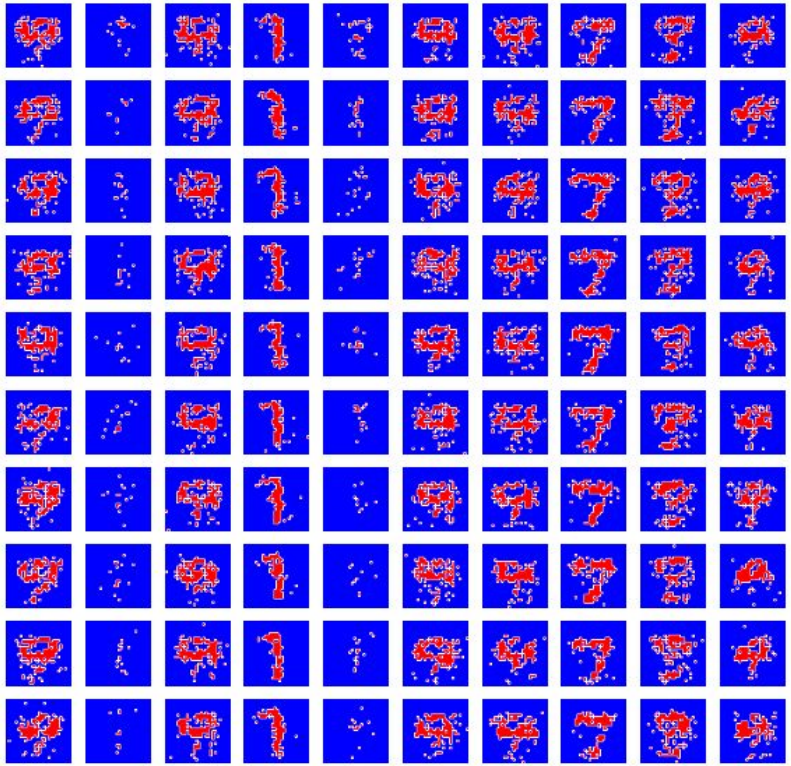
Predicted: 3 with 32.77% certainty
True label: 2

Predicted: 4 with 24.53% certainty
True label: 2

Data set	Accuracy
Train	89.86
Test	90.02

Among the digits that have been wrongly recognized there are some ambiguous and some unrecognizable digits also for humans

Digits Generation with DBNs - samples

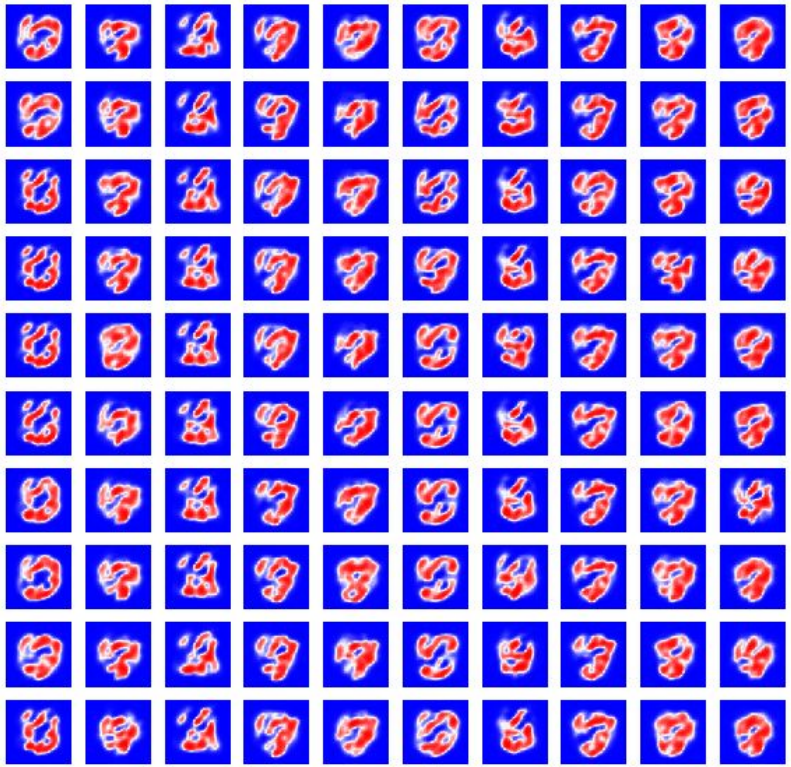


Generation of 10 images per digit

We clamp the chosen label at the *pen+lbl* level, use alternating Gibbs sampling in top layer and then process it top to bottom.

Except for 7, the generated digits are not recognizable but have some **patterns** corresponding to the original digits.

Digits Generation with DBNs - probabilities



Generation without sampling

We used a different network with a longer pre-training.

We generated digits using the probabilities in the top to bottom processing instead of the samples.

Final Remarks

- RBMs simple architecture allows us to investigate the way that the hidden layer learns by looking at the receptive fields

- DBNs combine unsupervised and supervised techniques in order to both recognize and generate images

- DBNs should ideally be fine-tuned after the pre-training

Thank you!