# CS 241 Honor Project Project

Li-Wei Huang

# Project Topic: Handwriting Digit Recognition

Multi-Threaded Artificial Neural Network with Back-Propagation Algorithm

#### Handwriting digit:

ヹ	0	4	/	9
8	-	m,	-	4
<b>(w</b>	ک	3	6	1
7	J	8	6	9
Y	0	9	/	1



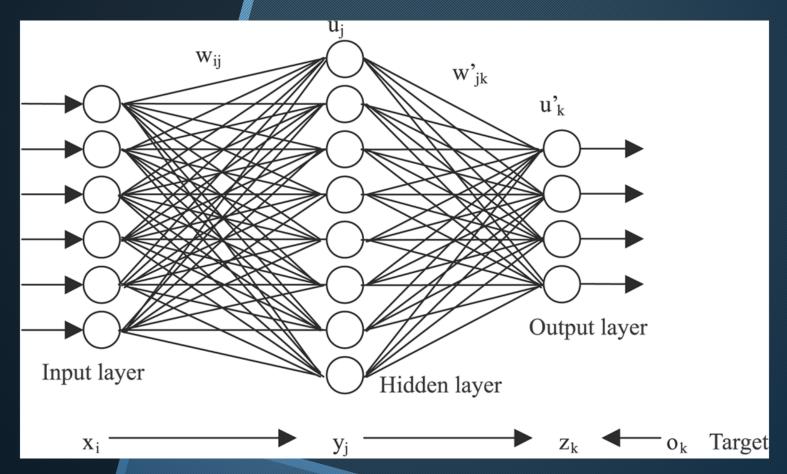
Source: MNIST database, 60000 images

### Handwriting digit:



#### The Basics of ANN

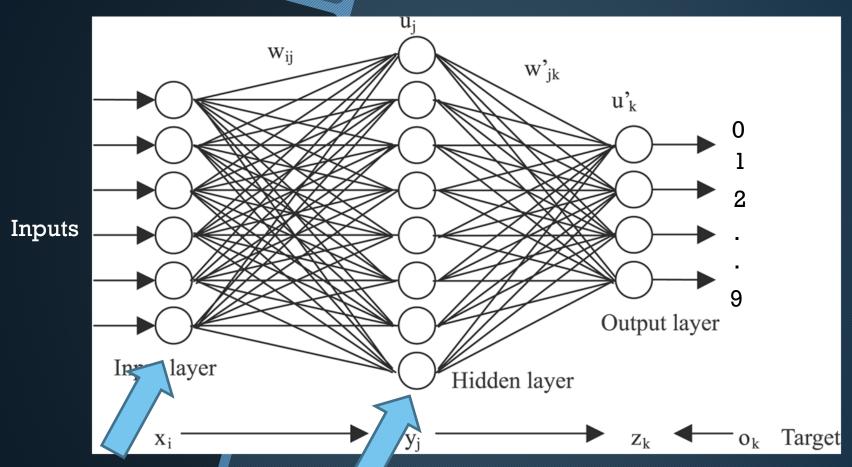
- Inspired by biological neural networks
- Nodes -> Neurons



ANN

300 Neurons

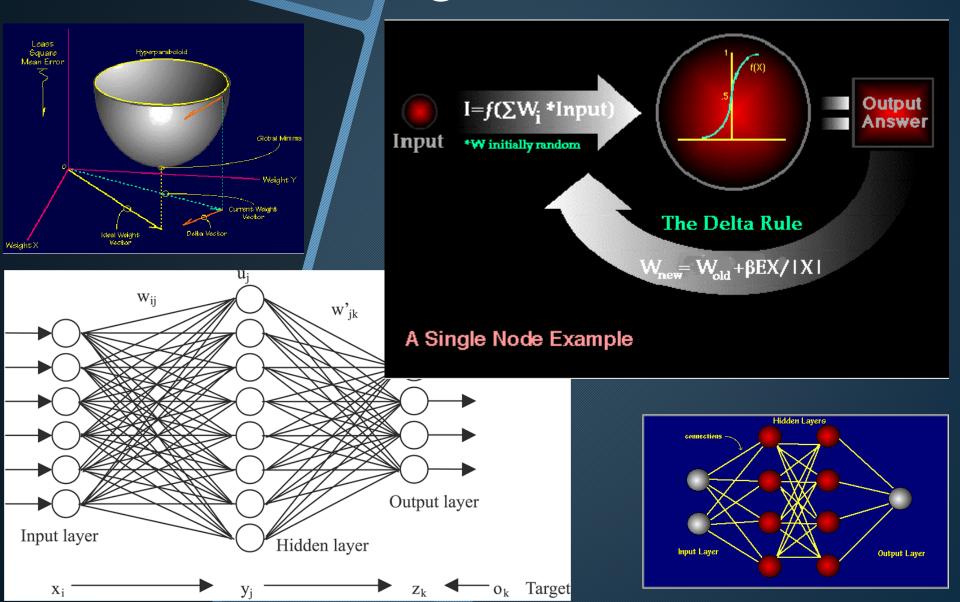
Outputs



Bias (1)

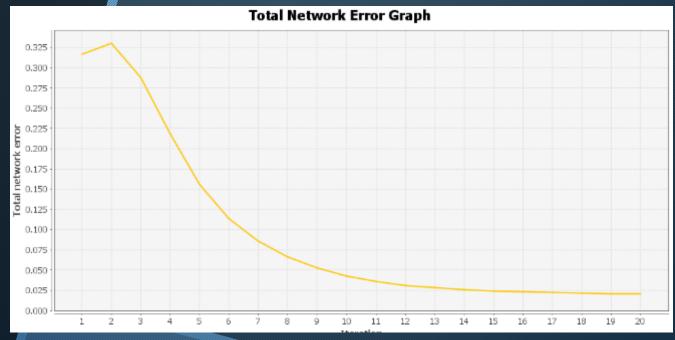
Bias (1)

## ANN training - Matlab



#### ANN demo





#### ANN weights

- Input to Hidden Layer
- Hidden Layer to Output
- -----Massive data
- ------Heavy Calculation

#### ANN weights

- Training Set: 600,000 Images
- Learning Rate: 0.1
- Beta: 0.01 (scaling factor in Sigm Func)
- MAX\_Iterations: 100

- Calculations: over 1\*10^14
- (including forward & backward propagation)
- Running Time: over 3 hours!

#### ANN weights!

~/nn241/main.c (Lab14) - Sublime Text 2 (UNREGISTERED) File Edit Selection Find View Goto Tools Project Preferences Help **OPEN FILES** × mandelbrot.cpp  $\{0.479360635, 0.891066607, 0.66479329, 0.558980688, 0.777702684, 0.475318762, 0.571195965, 0.488964857, 0.74422291, 0.45688709, 0.824476719, 0.2749369635, 0.894064857, 0.74422291, 0.45688709, 0.824476719, 0.2749369635, 0.488964857, 0.74422291, 0.45688709, 0.824476719, 0.2749369635, 0.488964857, 0.74422291, 0.45688709, 0.824476719, 0.2749369635, 0.488964857, 0.74422291, 0.488964857, 0.74422291, 0.488964857, 0.74422291, 0.488964857, 0.74422291, 0.488964857, 0.7442291, 0.748964857, 0.7442291, 0.748964857, 0.7442291, 0.748964857, 0.7442291, 0.748964857, 0.7442291, 0.748964857, 0.7442291, 0.748964857, 0.7442291, 0.748964857, 0.7442291, 0.748964857, 0.7442291, 0.748964857, 0.748964857, 0.7442291, 0.748964857, 0.74$ × testicsy  $\{0.501396069, 0.780951712, 0.276216373, 0.503429886, 0.757193096, 0.459032998, 0.943808299, 0.442426603, 0.13132777, 0.181766971, 0.109919688, 0.10991968, 0.10991968, 0.109919688, 0.109919688, 0.1099196$ × wel.csv  $\{0.920797555, 0.407762439, 0.938341106, 0.238771164, 0.827535374, 0.827744504, 0.800702189, 0.146594834, 0.184596473, 0.53742521, 0.46944027, 0.38471164, 0.3847164, 0.3$ × we2.csv {0.537530852,0.134034852,0.736455131.0.538196675,0.332694479,0.536677425,0.531491366,0.526879156.0.755153787,0.014521986,0.983593078, × mandelbrot-main.cpp {0.654684939,0.253938297,0.197453602,0.278691933,0.945931928,0.833382642,0.182410075,0.995514155,0.986665333,0.401111949,0.908224827, × mv-mult-main.cpp  $\{0.12167968, 0.273643798, 0.978089305, 0.299816423, 0.298720324, 0.552341407, 0.631018287, 0.844814979, 0.102674129, 0.830414643, 0.527494502, 0.844814979, 0.8448149,$  $\{0.886370591, 0.501261521, 0.411806999, 0.773323714, 0.998560908, 0.705409703, 0.266073419, 0.04996503, 0.49441906, 0.460050498, 0.676676956, 0.4941906,$ × mandelbrot.h  $\{0.852435153, 0.638448465, 0.518366225, 0.425097086, 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0.782359211, 0.879558821, 0.521395838, 0.017129773, 0.242153513, 0.848245861, 0.861114357, 0.242153513, 0.$ t3-main.c t3.c {1,357770487.0.374944034.0.662828736.0.25141496.0.350085667.-0.091193496.0.819632542.0.151497052.0.412929114.0.486659983.1.480437487.0  $\{0.514629375, 0.65449145, 0.693169685, -0.022087478, 0.595114555, 0.258978953, 0.87391538, 0.49308644, 0.203595604, 0.535018959, 1.234954705, 0.203595604, 0.203595604, 0.535018959, 1.234954705, 0.203595604, 0.2035960404, 0.20359604, 0.20359604, 0.20359604, 0.20359604, 0.20359604, 0.20359604, 0.20359604, 0.20$ t4-main.c  $\{0.953024108, 0.724442734, 0.879154277, 0.05921853, 1.058443361, 0.666909935, 0.743727714, -0.05536877, 0.216244605, 0.692807893, 0.873849\}$ t4 c  $\{0.675586248, 0.351325855, 0.26861951, 0.674425575, 1.496932869, -0.077068655, 1.176477871, -0.372371941, 0.859167169, 0.549059278, -0.16172380\}$ t5-main.c  $\{0.631134947, 0.089070455, 0.710021136, 0.249752954, 1.014193317, 0.747416215, 0.682341141, 0.250260292, 1.007841701, 0.805988686, -0.155771753\}$  $\{1.020367934, -0.058045854, 0.233805001, 0.947007507, 0.674492611, 0.774453014, 1.013671052, 0.655381604, 1.05024528, 0.0901561, 0.505647116, 0.50$ t6-main.c  $\{0.3200354, 0.525345513, 0.187810136, 0.649420125, 0.380734644, 0.306623643, 0.217523387, 0.820314715, 0.980433357, 0.694638749, 0.599462087, 0.820314715, 0.980433357, 0.694638749, 0.599462087, 0.820314715, 0.980433357, 0.694638749, 0.599462087, 0.820314715, 0.980433357, 0.694638749, 0.599462087, 0.820314715, 0.980433357, 0.694638749, 0.599462087, 0.820314715, 0.980433357, 0.694638749, 0.599462087, 0.820314715, 0.980433357, 0.694638749, 0.599462087, 0.820314715, 0.980433357, 0.694638749, 0.599462087, 0.820314715, 0.980433357, 0.694638749, 0.599462087, 0.820314715, 0.980433357, 0.694638749, 0.599462087, 0.820314715, 0.980433357, 0.694638749, 0.6946490, 0.694638749, 0.694638749, 0.694638749, 0.694638749, 0.694638749, 0.694638749, 0.694638749, 0.694638749, 0.694638749, 0.694638749, 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Snaces: 4

#### Digit Master







#### --examples

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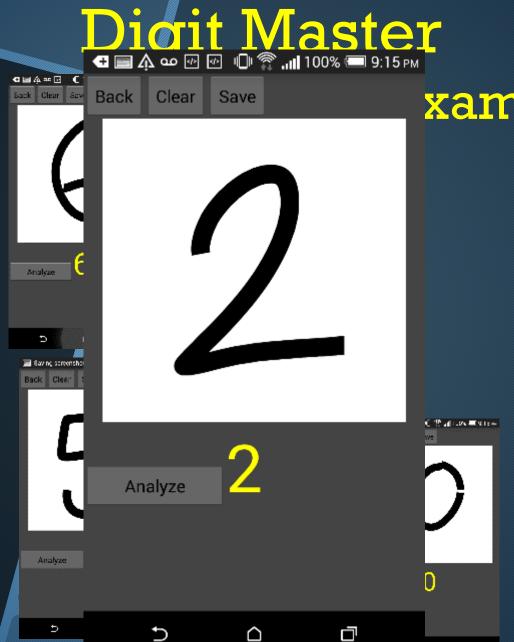
Back Clear Save









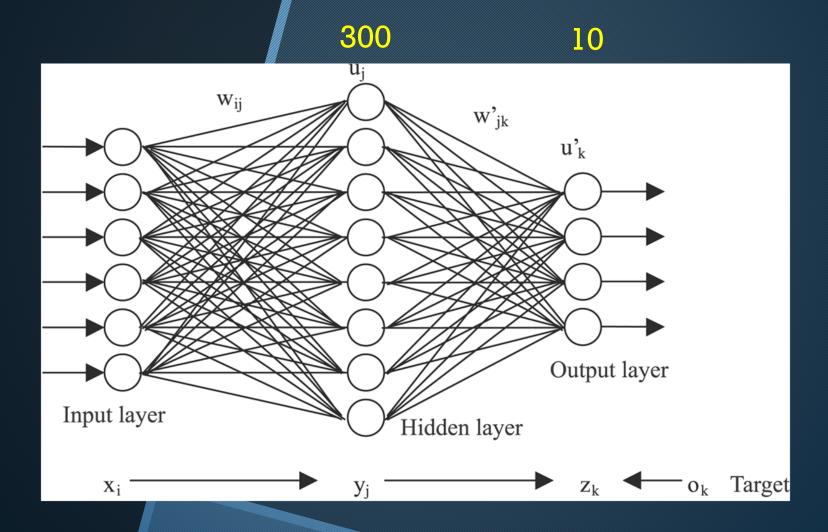


#### xamples





## Digit Master Multi-Threaded



## Digit Master What's more?

```
If (Image Recognition is Right)
Skip this;
else{
    Make as wrong;
    Select the right answer
    Save the image with target;
    Send to Server;
    Server get Image;
}
```

After N time:

Server combine all the images and re-run the training process;

#### Self Learning! Keep Learning!

