ID2223 Project

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Project Description

- Predict the solar radiation near Earth surface

Data Samples

- **0.4 million samples**
- A typical sample looks like

lev	p	T	q	lwhr
0	19.231	-80.0	0.0	0.122
1	57.692	-80.0	0.0	0.451
2	96.154	-70.874	0.029	-1.229
3	134.615	-51.083	0.262	-2.732
4	173.077	-36.489	0.977	-3.429
5	211.538	-25.816	2.211	-3.574
6	250.0	-17.87	3.756	-3.536
7	288.462	-10.404	5.431	-3.802
8	326.923	-6.608	4.226	-2.198
9	365.385	-2.388	8.776	-4.203
10	403.846	1.264	10.375	-3.567
11	442.308	4.462	11.895	-3.146
12	480.769	7.318	13.347	-2.829
13	519.231	9.903	14.733	-2.598

Data Samples

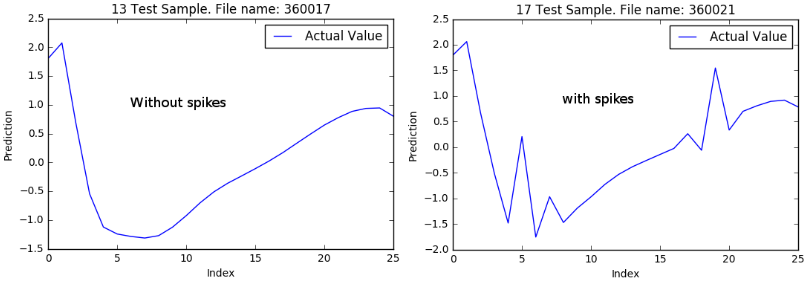


Figure 1: Data Samples

Solution

- Regresstion Problem
  - with 26 outputs
- Could be implemented using
  - Multivariate Regression
  - **Feed Forward Neural Networks**
  - **Convolution Neural Networks**

Feedforward Neural Network

- Feedforward neural networks with a single hidden layer can approximate continuous functions
- This can be efficient to replace an analytical model

Feedforward Neural Network Model

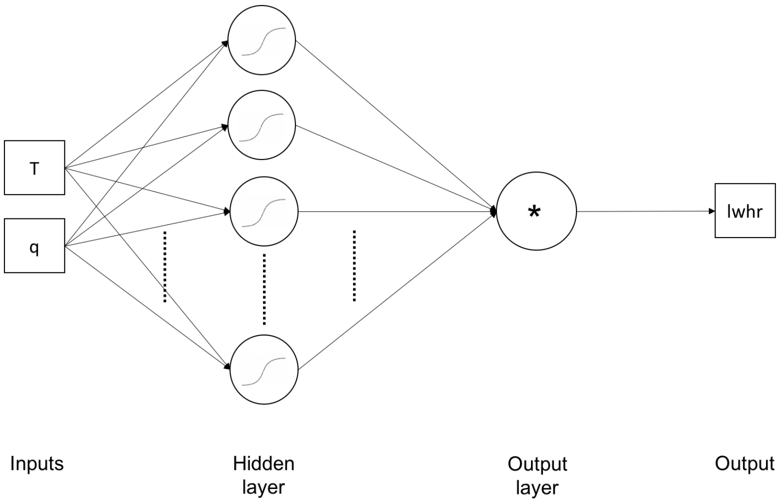


Figure 2: Architecture of feedforward neural network

Feedforward Neural Network Setup

- Training data set size 1,400,000 (70%).
- Test data set size 600,000 (30%).
- Max number of Epochs 14000
- Batch Size 100
- Weights and biases are initialized to zeros

Evaluation

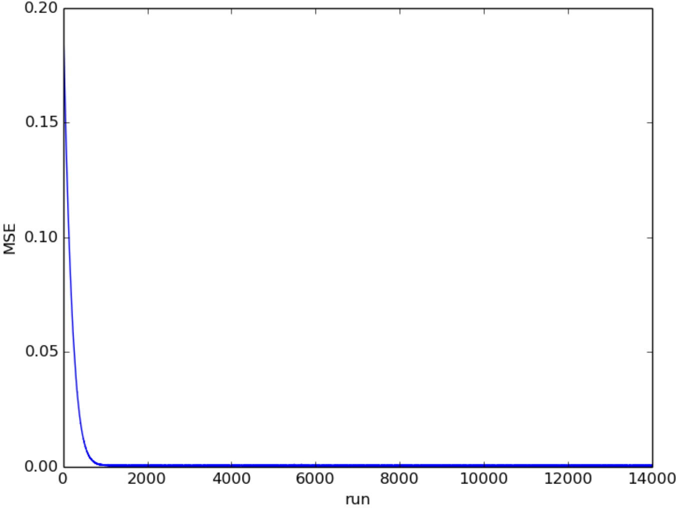


Figure 3: MSE of the FFN

Evaluation

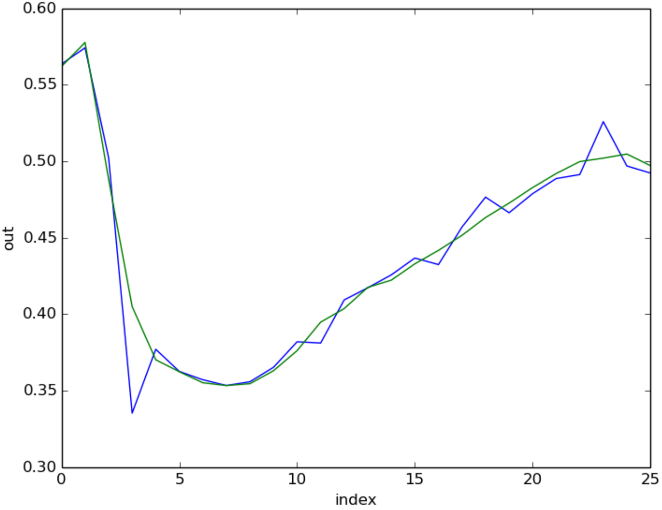


Figure 4: MSE of the FFN

Discussion

- low MSE
- does not capture the spikes

Convolution Neural Network

- Spikes are more affected by adjacent values
- To try to capture the spikes we opt to CNNs
- Kernels within CNN can detect local patterns

Input

- The input can be morphed into 26 x 2 matrix
  - did not produce very promising results, as pooling can not shink the width of the input matrix.
    - Min MSE observed was 0.3

1	1
2	2
3	3
4	4
5	5
.	.
.	.
.	.

Figure 5: 26x2 Input Matrix

Input (Cont'd)

- The input can be morphed into 8 x 8 matrix
  - padding is needed as there are only 52 input features

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	0	0	0	0
0	0	0	0	0	0	0	0

Figure 6: 8 x 8 Input Matrix

Convolution Neural Network Model

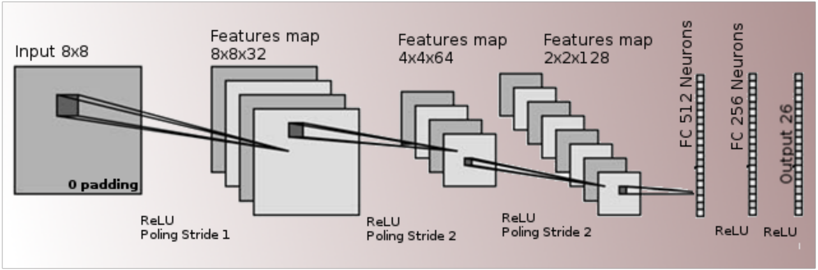


Figure 7: Architecture of convolution neural network

Model Complexity

Layer	Size	Memory	Weights	Bias
Input	8x8x1	64	0	0
CONV	8x8x32	8x8x32 = 2048	2x2x1 x 32 = 128	32
POOL	8x8x32	8x8x32 = 2048	0	0
CONV	8x8x64	8x8x64 = 4096	2x2x1 * 64 = 256	64
POOL	4x4x64	4x4x64 = 512	0	0
CONV	4x4x128	4x4x128 = 2048	2x2x1 * 128 = 512	128
POOL	2x2x128	2x2x128 = 512	0	0
FC	1x512	512	2x2x128x512 = 262144	512
FC	1x256	256	512x256 = 131072	256
OUT	1x26	26	26x256 = 6656	26

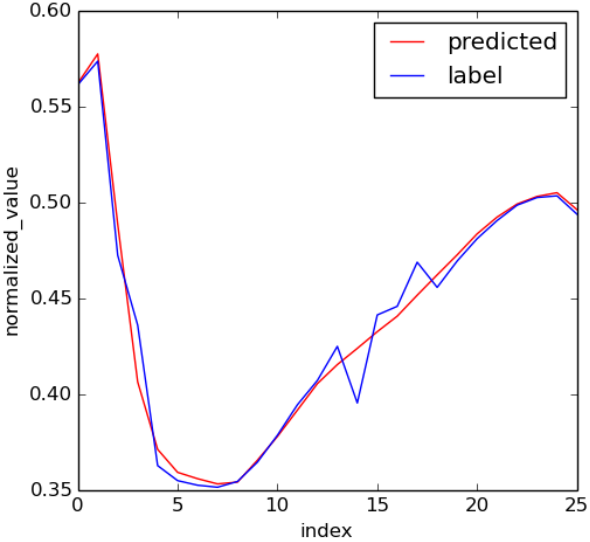
Total memory = 413908 x 4 bytes (*float32*) x 2 (back propagation) = 3311264 = 3.1 Megabytes

Evaluation Setup

- Training data set size 300,000 (75%).
- Test data set size 100,000 (25%).
- Inputs are normalized using max-min scaling
  - $X_{norm} = (X - X_{min}) / (X_{max} - X_{min})$
  - $X_s = (X - Input_{mean}) / (Input_{std})$
- Learning Rate 0.001
- Dropout 0.95
- Max number of Epochs 120000
- Batch Size 3
- Weights were randomly initialized such that the random numbers had *mean=0.1* and *stddev=0.3*
- Bias were also randomly initialized such that the random numbers had *mean=0* and *stddev=0.03*

Results

- MSE drops to 0.003 but the network failed to predict the spikes



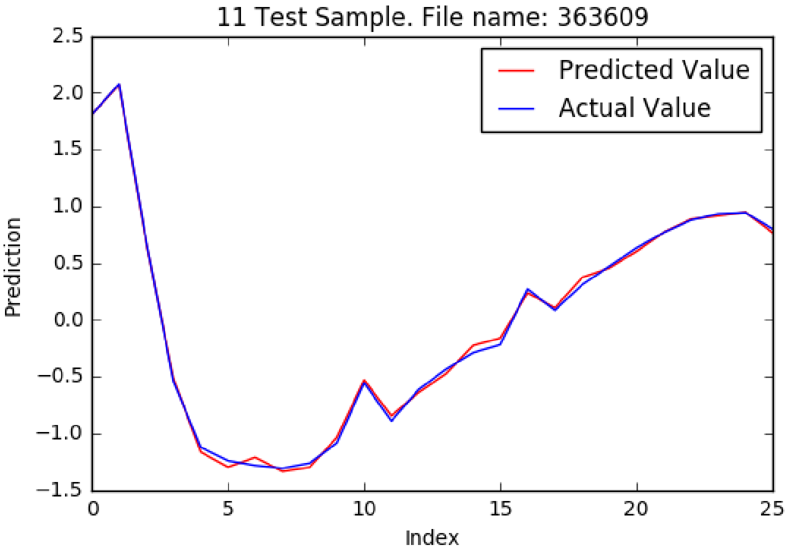
Dying ReLU Problem

- Inaccurate data.
  - Rounding Errors
- "ReLU units can be fragile during training and can "die". For example, a large gradient flowing through a ReLU neuron could cause the weights to update in such a way that the neuron will never activate on any datapoint again." [1]

[1] http://cs231n.github.io/neural-networks-1/

Solution Leaky ReLU

- Use a Leaky ReLU
  - Slop 0.001



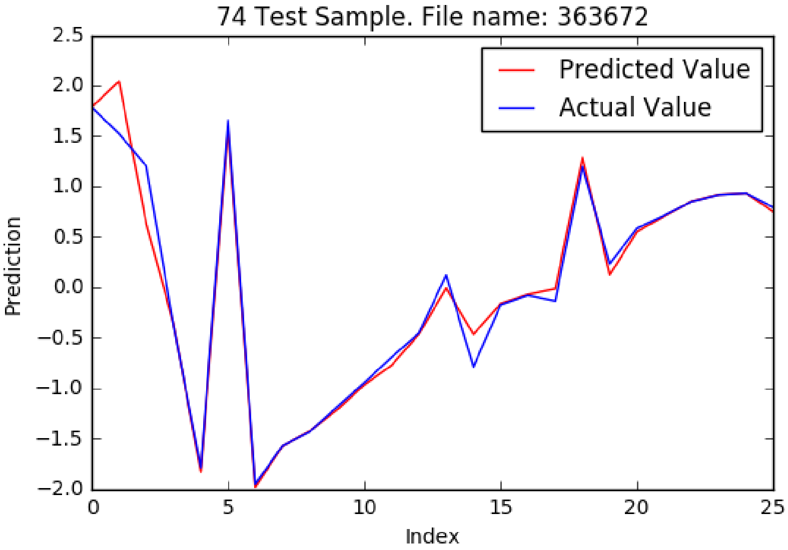


Figure 10: Sample output

Questions ?