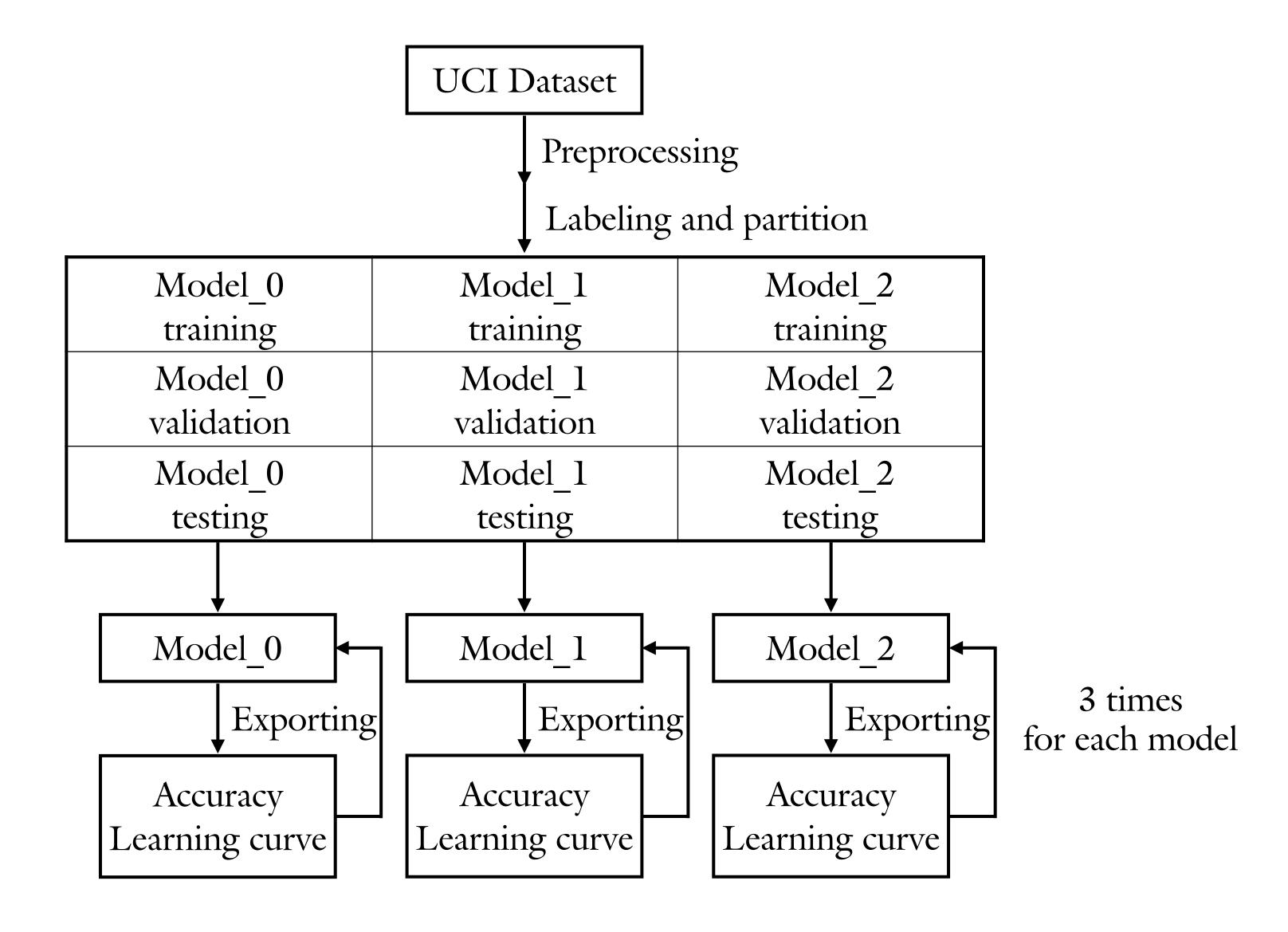
A Comprehensive Trial of Functions in Model

Candidate Functions

- 1. Activation function of Convolution layer(AC): relu, selu, elu, softplus, exponential
- 2. Activation function of Full connection layer(AF): softmax, sigmoid
- 3. Optimizer: sgd, adam, admax, adagrad, adadelta, nadam, rmsprop

Implementation of replacing functions



| Layer | # | size | activation |
|-------------|-------|------|------------|
| ZeroPadding | | 2, 2 | |
| Conv2D | 16 | 5, 1 | i |
| ZeroPadding | | 2, 2 | |
| MaxPooling | | 5, 1 | |
| ZeroPadding | | 2, 2 | |
| Conv2D | 32 | 5, 1 | i |
| ZeroPadding | | 2, 2 | |
| MaxPooling | | 5, 1 | |
| ZeroPadding | | 2, 2 | |
| Conv2D | 64 | 5, 1 | i |
| ZeroPadding | | 2, 2 | |
| MaxPooling | | 5, 1 | |
| ZeroPadding | | 2, 2 | |
| Conv2D | 128 | 5, 1 | i |
| Dropout | 0.5 | | |
| Flatten | | | |
| Dense | 2/7/6 | | j |

Regularizer=12

Loss=categorical cross entropy

Optimizer=k

Epochs=300

Batch size=64

 $\forall i \in \{relu, selu, elu, softplus, exponential\}$

 $j \in \{softmax, sigmoid\}$

 $k \in \{sgd, adam, admax, adagrad,$

 $adadelta, nadam, rmsprop\}$

Results of Model_0

Testing Accuracy over 97.5% and without severe overfitting

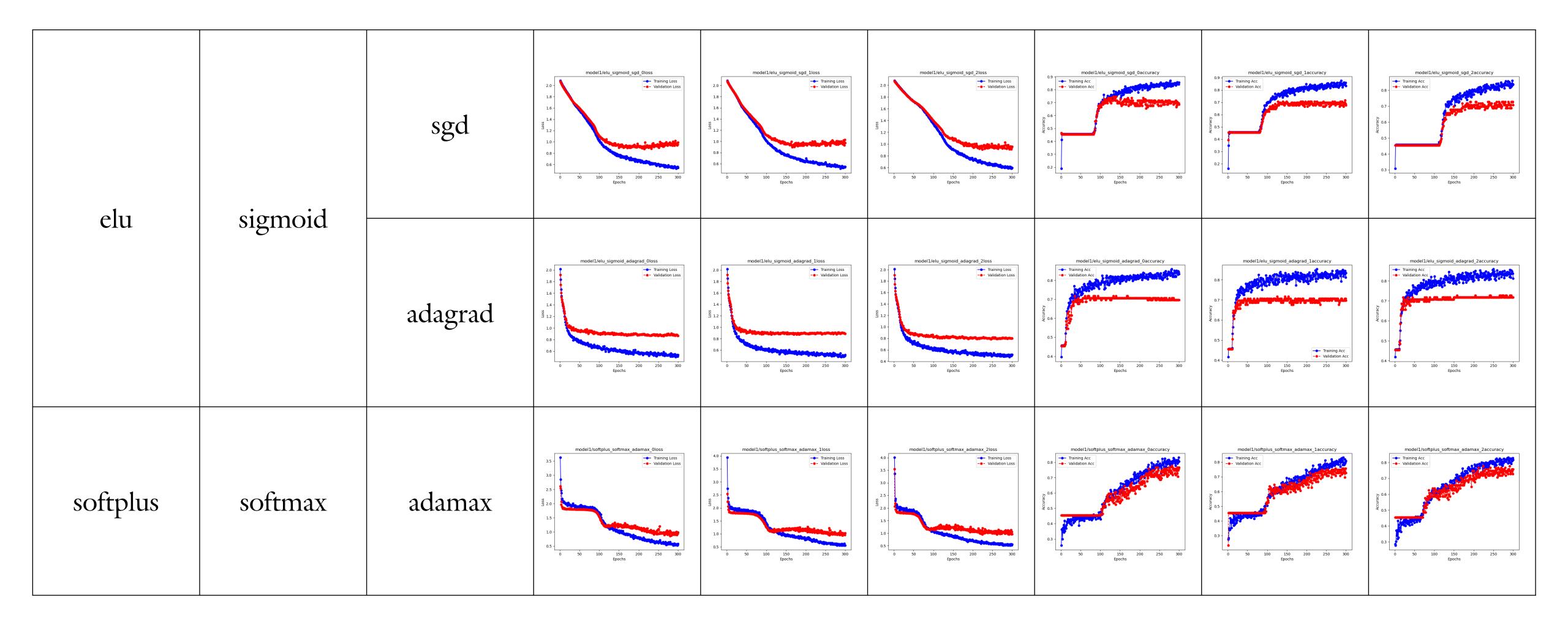
| AC | AF | Optimizer | Training Accuracy | Testing Accuracy |
|----------|------------|-----------|-------------------|------------------|
| | o often av | sgd | 98% | 98.7% |
| relu | softmax | adagrad | 98.7% | 98.3% |
| reiu | oiomoid | sgd | 96.7% | 97.7% |
| | sigmoid | adagrad | 98% | 98.3% |
| selu | sigmoid | adagrad | 100% | 98% |
| elu | softmax | adagrad | 99% | 97.7% |
| | sigmoid | adagrad | 99.7% | 98% |
| softplus | softmax | adamax | 99% | 98% |

| relu | softmax | sgd | model0/relu_softmax_sgd_0loss | model0/relu_softmax_sgd_1loss | model0/relu_softmax_sgd_2loss 0.7 - Training Loss - Validation Loss 0.5 - Validation Loss 0.7 - Validation Loss 0.7 - Validation Loss 0.8 0.4 - 0.3 - 0.2 - 0.1 - 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 | model0/relu_softmax_sgd_0accuracy 0.9 0.8 0.6 0.5 0.5 0.7 0.6 0.5 0.7 0.6 0.5 0.7 0.7 0.7 0.8 0.8 0.8 0.9 0.9 0.9 0.9 0.9 | 0.9 0.6 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 | 0.9 - Training Acc 0.6 - Training Acc 0 50 100 150 200 250 300 |
|----------|---------|---------|--|---|--|---|--|--|
| | | adagrad | model0/relu_softmax_adagrad_0loss 0.7 Training Loss Validation Loss 0.6 0.5 Validation Loss 0.7 | modelO/relu_softmax_adagrad_lloss 0.7 | model0/relu_softmax_adagrad_2loss 0.7 - Training Loss Validation Loss 0.5 - Validation Loss 0.5 - Validation Loss 0.7 - Training Loss Validation Loss 0.5 - Validation Loss | model0/relu_softmax_adagrad_Oaccuracy 1.0 0.9 0.7 0.6 Training Acc Validation Acc Epochs | 0.95 - 0.95 - 0.95 - 0.97 - 0.90 - 0.95 - 0. | model0/relu_softmax_adagrad_2accuracy 1.0 0.9 0.8 0.6 0.5 0.5 0.5 0.5 0.5 0.5 0.5 |
| | sigmoid | sgd | model0/relu_sigmoid_sgd_0loss 0.7 0.6 0.5 0.4 0.3 0.2 0 50 100 150 200 250 300 Epochs | model0/relu_sigmoid_sgd_1loss 0.7 | model0/relu_sigmoid_sgd_2loss Training Loss Training Loss Validation Loss 0.5 0.5 0.7 0.6 0.5 0.7 0.7 0.7 0.8 0.9 0.9 0.9 0.9 0.9 0.9 0.9 | model0/relu_sigmoid_sgd_0accuracy Training Acc Validation Acc 0.8 0.6 0.5 0.6 0.5 0.6 0.5 Epochs | model0/relu_sigmoid_sgd_laccuracy 1.0 Training Acc 0.9 0.8 0.7 0.8 0.7 0.4 0.3 0.2 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.9 | 0.9 - Validation Acc - |
| | | adagrad | model0/relu_sigmoid_adagrad_Oloss 0.7 Training Loss Validation Loss 0.5 Validation Loss 0.1 | model0/relu_sigmoid_adagrad_1loss 0.7 - | model0/relu_sigmoid_adagrad_2loss 0.7 - Training loss Validation Loss 0.5 - Validation Loss 0.7 - Validation Loss 0.8 0.4 - 0.3 - 0.1 | model0/relu_sigmoid_adagrad_0accuracy 0.95 0.90 0.85 0.80 0.75 0.70 0.65 0.60 0 50 100 150 200 250 300 | model0/relu_sigmoid_adagrad_laccuracy 1.00 - | 0.9 - Training Acc Validation Acc Construction Solution Construction C |
| selu | sigmoid | adagrad | model0/selu_sigmoid_adagrad_0loss 0.7 | model0/selu_sigmoid_adagrad_1loss 0.7 0.6 0.5 0.4 0.1 0.0 0.5 0.1 0.5 0.1 0.5 0.5 | model0/selu_sigmoid_adagrad_2loss 0.7 0.6 0.5 0.7 0.6 0.5 0.7 0.6 0.5 0.7 0.6 0.7 0.7 0.8 0.9 0.9 0.9 0.9 0.9 0.9 0.9 | model0/selu_sigmoid_adagrad_Oaccuracy 1.00 0.95 0.90 0.75 0.70 0.65 0 50 100 150 200 250 300 | model0/selu_sigmoid_adagrad_laccuracy 1.00 0.95 0.90 0.80 0.75 0.70 0.7 | model0/selu_sigmoid_adagrad_2accuracy 1.00 0.95 0.90 0.75 0.70 0.65 |
| elu | softmax | adagrad | model0/elu_softmax_adagrad_Oloss 0.7 | model0/elu_softmax_adagrad_lloss 0.7 | model0/elu_softmax_adagrad_2loss | model0/elu_softmax_adagrad_0accuracy 1.0 0.9 0.7 0.6 0 50 100 150 200 250 300 Epochs | model0/elu_softmax_adagrad_laccuracy 1.00 0.95 0.90 0.80 - | model0/elu_softmax_adagrad_2accuracy 1.00 0.95 0.85 0.75 0.70 0.65 0.60 50 100 150 200 250 300 Epochs |
| | sigmoid | adagrad | model0/elu_sigmoid_adagrad_0loss Training Loss Validation Loss 0.6 0.5 0.7 0.1 0 50 100 150 200 250 300 Epochs | model0/elu_sigmoid_adagrad_1loss 0.7 0.6 0.5 0.7 0.6 0.5 0.7 0.7 0.7 0.8 0.9 0.9 0.9 0.9 0.9 0.9 0.9 | model0/elu_sigmoid_adagrad_2loss 0.7 - Taining Loss - Validation Loss 0.5 - Validation Loss 0.7 - Taining Loss - Validation Loss 0.7 - Taining Loss - Validation Loss 0.7 - Taining Loss - Validation Loss 0.8 - Validation Loss 0.9 - Taining Loss - Validat | model0/elu_sigmoid_adagrad_0accuracy 1.00 0.95 0.90 0.85 0.80 0.75 0.70 0.65 0.70 0.65 0.70 0.65 0.70 0.70 0.70 0.70 0.70 0.70 0.70 0.7 | model0/elu_sigmoid_adagrad_laccuracy 1.0 0.9 0.7 0.6 Training Acc Validation Acc Epochs | model0/elu_sigmoid_adagrad_2accuracy 1.00 - |
| softplus | softmax | adamax | model0/softplus_softmax_adamax_0loss 3.0 - Training Loss - Validation Loss 2.5 - Validation Loss 3.0 - Training Loss - Validation Loss 5.0 - Validation Loss 5.0 - Validation Loss 6.0 - Validation Loss 6.0 - Validation Loss 6.0 - Validation Loss 7.0 - Validation Loss 8.0 - Validation Loss 9.0 - Validation Loss 6.0 - Validation Loss 9.0 - Validation Loss | model0/softplus_softmax_adamax_1loss 2.00 | model0/softplus_softmax_adamax_2loss Training Loss Validation Loss 1.5 1.0 0.5 0.0 50 100 150 200 250 300 Epochs | model0/softplus_softmax_adamax_0accuracy 1.0 0.9 0.8 0.6 0.5 0.7 0.6 0.5 100 150 Epochs 200 250 300 | 0.9 0.6 - 0.5 100 150 200 250 300 | model0/softplus_softmax_adamax_2accuracy 1.0 0.9 0.8 0.6 0.5 Training Acc Validation Acc Validation Acc Epochs |

Results of Model 1

Testing Accuracy over 80% and without severe overfitting

| AC | AF | Optimizer | Training Accuracy | Testing Accuracy |
|----------|---------|-----------|-------------------|------------------|
| olu | oiomoid | sgd | 87.3% | 81% |
| elu | sigmoid | adagrad | 87.3% | 85.3% |
| softplus | softmax | adamax | 86.3% | 84.7% |



Results of Model 2

Testing Accuracy over 70% and without severe overfitting

| AC | AF | Optimizer | Training Accuracy | Testing Accuracy |
|----------|------------|-----------|-------------------|------------------|
| | o of track | sgd | 76.3% | 71.3% |
| relu | softmax | adagrad | 81% | 70% |
| | sigmoid | adagrad | 80% | 70.7% |
| selu | softmax | sgd | 97.7% | 73% |
| | SOITHAX | adagrad | 91.3% | 71% |
| | sigmoid | sgd | 93.7% | 72.3% |
| elu | softmax | sgd | 86.3% | 70.6% |
| softplus | softmax | adamax | 73.7% | 69% |
| | sigmoid | adamax | 72% | 69% |

| relu | softmax | sgd | model2/relu_softmax_sqd_0loss | model2/relu_softmax_sgd_1loss Training Loss Validation Loss 1.6 1.2 1.0 0.8 0 50 100 150 200 250 300 Epochs | model2/relu_softmax_sgd_2loss 1.8 1.6 1.4 1.2 1.0 0.8 0 50 100 150 200 250 300 Epochs | model2/relu_softmax_sgd_0accuracy Training Acc Validation Acc 0.0 0.0 0.0 0.0 0.0 0.0 0.0 | 0.75 Training Acc Validation Acc 0.70 0.65 0.50 0.45 0.50 0.65 0.50 0.65 0.50 0.65 0.50 0.65 0.50 0.65 0.50 0.65 | model2/relu_softmax_sgd_2accuracy 7.75 Training Acc Validation Acc 0.65 0.50 0.45 0.40 0.355 0.50 0 |
|----------|---------|---------|---|--|--|--|--|--|
| | | adagrad | model2/relu_softmax_adagrad_0loss | model2/relu_softmax_adagrad_1loss | model2/relu_softmax_adagrad_2loss 1.8 | model2/relu_softmax_adagrad_0accuracy Training Acc Validation Acc 0.70 0.65 0.50 0.5 | model2/relu_softmax_adagrad_laccuracy Taining Acc Validation Acc 0.75 0.70 0.65 0.55 0.50 0.45 0.50 0.45 Epochs | model2/reiu_softmax_adagrad_2accuracy Training Acc Validation Acc 0.70 0.65 0.50 0.5 |
| | sigmoid | adagrad | model2/relu_sigmoid_adagrad_Oloss | model2/relu_sigmoid_adagrad_lloss 1.8 | model2/relu_sigmoid_adagrad_2loss Training Loss Validation Loss 1.6 1.4 3 1.2 1.0 0.8 0.50 1.50 2.00 2.50 3.00 Epochs | model2/relu_sigmoid_adagrad_0accuracy 0.75 0.70 0.65 0.50 0.5 | model2/relu_sigmoid_adagrad_laccuracy 7 Training Acc Validation Acc Validation Acc 0.70 0.65 0.50 0.45 0.40 0.50 100 150 200 250 300 | model2/relu_sigmoid_adagrad_2accuracy Training Acc Validation Acc 0.75 0.70 0.5 |
| selu | softmax | sgd | model2/selu_softmax_sqd_0loss | model2/selu_softmax_sgd_lloss 1.8 - Training Loss - Validation Loss 1.6 - Validation Loss 1.7 - Validation Loss 1.8 - Validation Loss 1.9 - Validation Loss 1.0 - Validation Loss 1.1 - Validation Loss 1.2 - Validation Loss 1.3 - Validation Loss 1.4 - Validation Loss 1.5 - Validation Loss 1.6 - Validation Loss 1.7 - Validation Loss 1.8 - Validation Loss 1.9 - Validation Loss 1.0 - Validation Loss | model2/selu_softmax_sgd_2loss Training Loss Training Loss Validation Loss 1.6 1.7 1.0 0.8 0.6 0.4 0.50 100 150 200 250 300 Epochs | model2/selu_softmax_sgd_0accuracy Training Acc Validation Acc 0.5 0.6 0.5 0.4 0 50 100 150 200 250 300 Epochs | model2/selu_softmax_sgd_laccuracy Training Acc Validation Acc 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0 | model2/selu_softmax_sgd_2accuracy Training Acc Validation Acc 0.9 0.7 0.0 0.7 0.0 0.0 0.0 0.0 |
| | | adagrad | model2/selu_softmax_edagrad_oloss 1.8 | model2/selu_softmax_adagrad_lloss 1.8 1.6 1.6 1.4 1.2 9 1.0 0.8 0.6 0.4 0 50 100 150 200 250 300 Epochs | model2/selu_softmax_adagrad_2loss Taining Loss Taining Loss Validation Loss 1.4 1.2 8 1.0 0.8 0.6 0.4 0 50 100 150 200 250 300 Epochs | 0.9 - Training Acc Validation Acc 0.5 - 0. | model2/selu_softmax_adagrad_laccuracy 0.9 Training Acc Validation Acc 0.6 0.5 0.5 0.6 0.5 0.6 0.7 0.6 0.7 0.6 0.7 0.6 0.7 0.7 | model2/selu_softmax_adagrad_2accuracy .99 Training Acc Validation Acc 0.50 100 150 200 250 300 Epochs |
| | sigmoid | sgd | model2/selu_sigmoid_sqd_0loss | model2/selu_sigmoid_sgd_1loss Training Loss Validation Loss 1.6 1.4 95 1.0 0.8 0.6 0.4 0 50 100 150 200 250 300 Epochs | model2/selu_sigmoid_sgd_2loss Training Loss Training Loss Validation Loss 1.6 1.4 1.2 3 1.0 0.8 0.6 0.4 0 50 100 150 200 250 300 Epochs | model2/selu_sigmoid_sqd_0accuracy 0.9 Training Acc Validation Acc 0.8 0.7 0.6 0.5 0.6 0.5 0.6 0.5 0.6 0.5 0.7 0.7 0.7 0.8 0.8 0.9 0.9 0.9 0.9 0.9 0.9 | model2/selu_sigmoid_sgd_laccuracy Training Acc Validation Acc 0.9 0.7 0.6 0.5 0.6 0.5 0.6 0.5 0.6 0.7 0.7 0.8 0.8 0.9 0.9 0.9 0.9 0.9 0.9 | model2/selu_sigmoid_sgd_2accuracy Training Acc Validation Acc 0.9 0.7 0.4 0.50 100 150 200 250 300 Epochs |
| elu | softmax | sgd | model2/elu_softmax_sgd_0loss 1.8 - | model2/elu_softmax_sgd_lloss 1.8 | model2/elu_softmax_sgd_2loss Training Loss 1.8 | model2/elu_softmax_sgd_0accuracy Training Acc Validation Acc 0.5 0.4 0 50 100 150 200 250 300 Epochs | model2/elu_softmax_sgd_laccuracy 0.9 Training Acc Validation Acc 0.5 0.4 0.5 0.5 0.6 0.7 0.7 0.7 0.7 0.7 0.7 0.7 | model2/elu_softmax_sgd_2eccuracy Training Acc Validation Acc 0.7 0.6 0.7 0.7 0.9 0.9 0.9 0.9 0.9 0.9 |
| softplus | softmax | adamax | model2/softplus_softmax_adamax_Oloss 3.0 2.5 1.5 1.0 50 100 110 100 110 100 10 | model2/softplus_softmax_edamax_lloss 3.0 | model2/softplus_softmax_adamax_2loss 3.5 3.0 2.5 3.0 0 50 100 150 200 250 300 Epochs | 0.75 model2/softplus_softmax_adamax_Oaccuracy Training Acc Validation Acc 0.60 0.60 0.50 0.50 0.50 0.50 0.50 0.5 | model2/softplus_softmax_adamax_laccuracy Training Acc Validation Acc 0.05 0.05 0.45 0.40 0.35 0.40 0.55 0.60 0.55 0.60 0.60 0.60 | model2/softplus_softmax_adamax_2accuracy Training Acc Validation Acc 0.4 0.50 100 150 200 250 300 Epochs |
| | sigmoid | adamax | model2/softplus_sigmoid_adamax_0loss 2.0 | model2/softplus_sigmoid_edamax_1loss | model2/softplus_sigmoid_adamax_1loss | model2/softplus_sigmoid_adamax_0accuracy 0.70 Training Acc Validation Acc 0.65 0.50 0.50 0.50 100 150 200 250 300 | model2/softplus_sigmoid_adamax_laccuracy Training Acc Validation Acc 0.65 0.50 0.50 0.50 100 150 200 250 300 | model2/softplus_sigmoid_adamax_laccuracy Training Acc Validation Acc 0.65 - 0.50 - |

Future Work

1. Testing candidate model with 1000 epochs

Model_0: relu+softmax+sgd, relu+sigmoid+sgd

Model_1: elu+sigmoid+sgd, elu+sigmoid+adagrad, softplus+softmax+adamax

Model_2: relu+softmax+sgd, relu+softmax+adagrad, relu+sigmoid+adagrad,

elu+softmax+sgd, softplus+softmax+adamax, softplus+sigmoid+adamax

2. Adjusting number of layer, number of kernel, and ratio of Dropout layer

of layer: ±[ZeroPadding/Conv2D/ZeroPadding/MaxPooling]

of kernel: [32, 64, 128, 256] so on and so forth

(:) of Dropout: $i \in \{0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6\}$