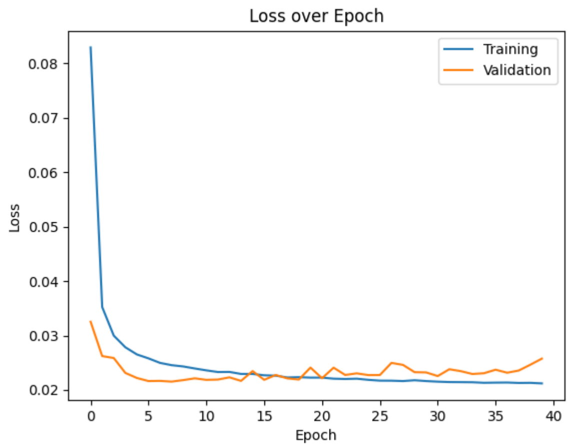
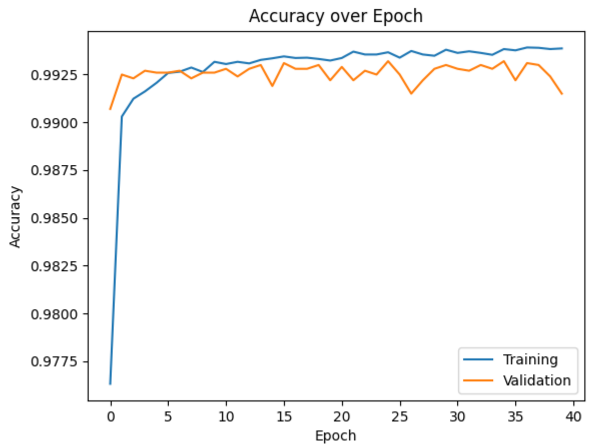
DLCV - Soucasse Bastien - Provost Iantsa - Lab3

1. Single Neuron

1.2. Default Batch Size

Batch Size	Activation	Optimizer	Loss	Accuracy	Time
32	Sigmoid	Adam	0.0232	99.31%	465.82s

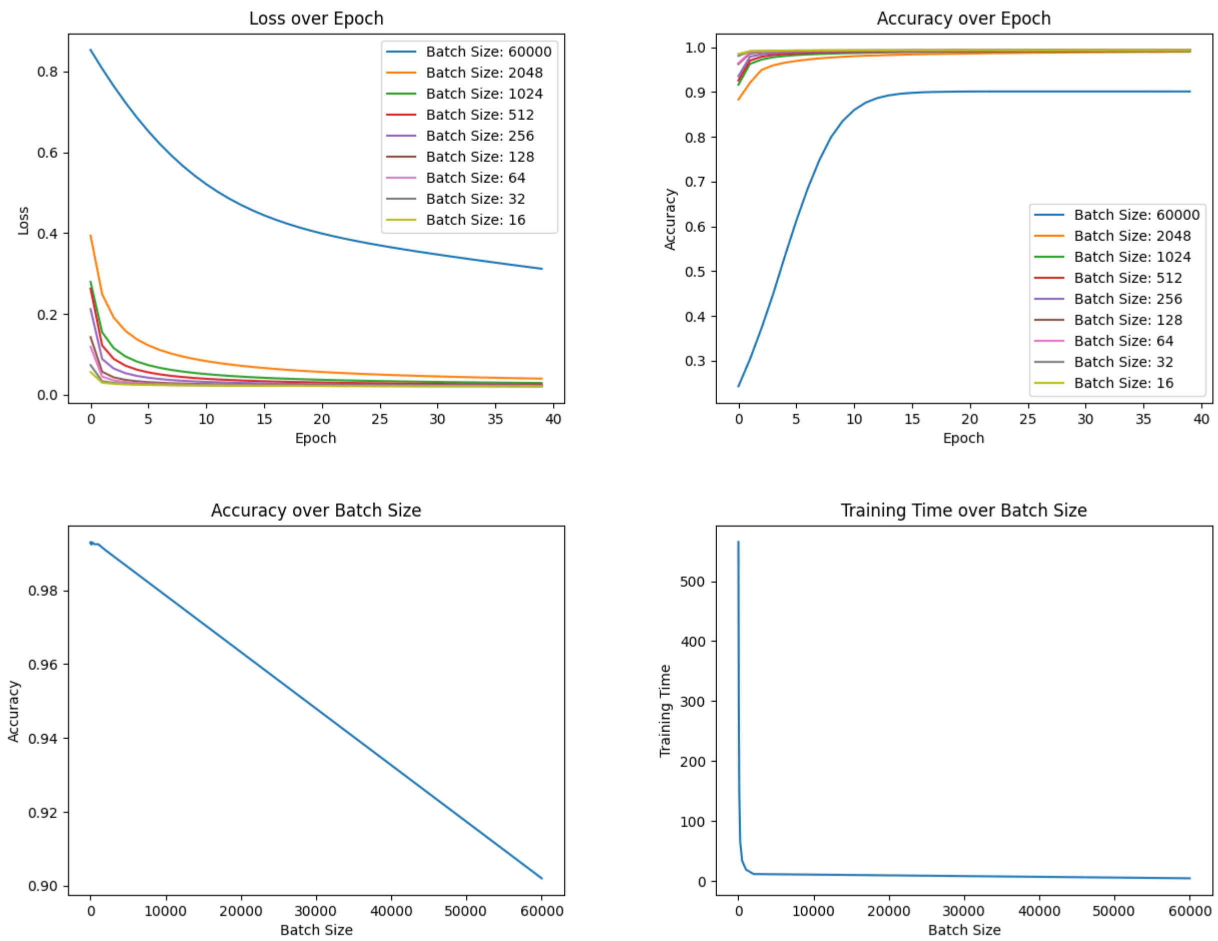




After 40 epochs, the loss and accuracy tends to stabilize and going further wouldn't be useful.

1.3. Different Batch Sizes

Batch Size	Loss	Accuracy	Time
60000	0.3035	90.20%	4.38s
2048	0.0333	99.08%	11.50s
1024	0.0244	99.25%	18.89s
512	0.0222	99.25%	33.66s
256	0.0214	99.30%	64.63s
128	0.0227	99.24%	147.17s
64	0.0235	99.25%	291.96s
32	0.0232	99.31%	465.82s
16	0.0243	99.29%	565.27s



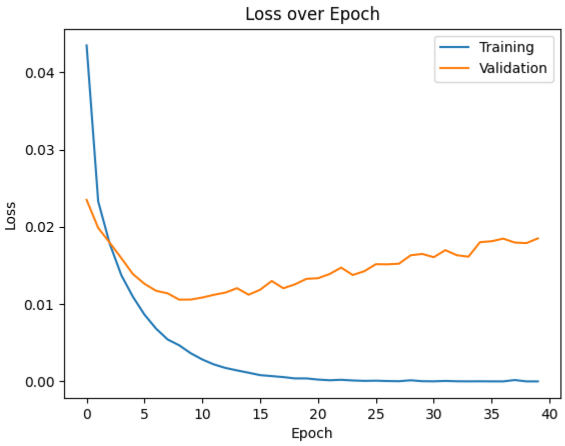
We can see that smaller batch sizes give better results but take much longer. A good compromise would be around 32, as the results are nearly the same as smaller values, but the execution time remains acceptable.

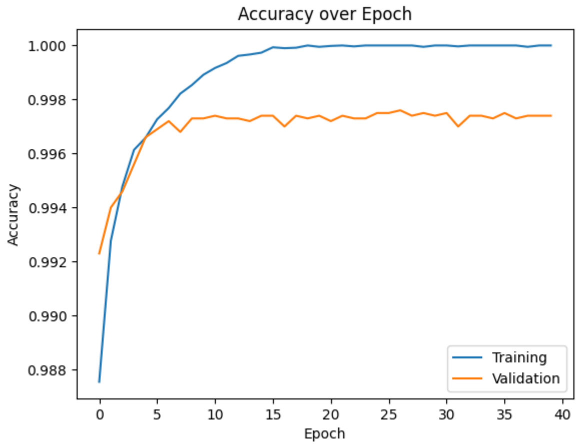
Conclusion: We will keep the 32 one for our next models.

2. A Neural Network with One Hidden Layer

2.2. Default Network

HL Units	Activations	Optimizer	Loss	Accuracy	Time
64	Sigmoid, Sigmoid	Adam	0.02	99.77%	320s

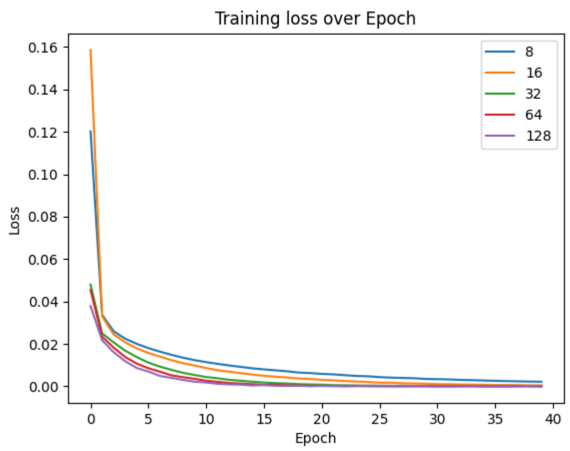


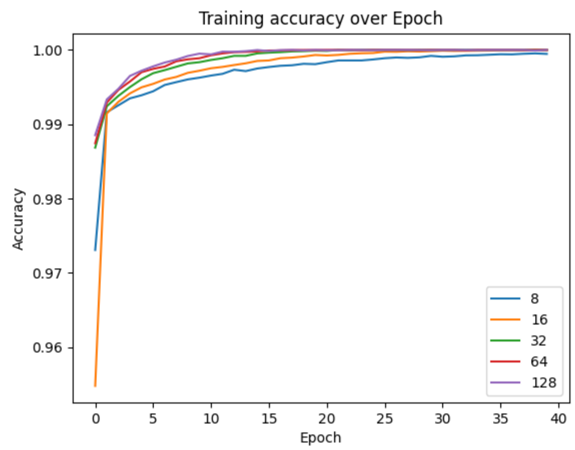


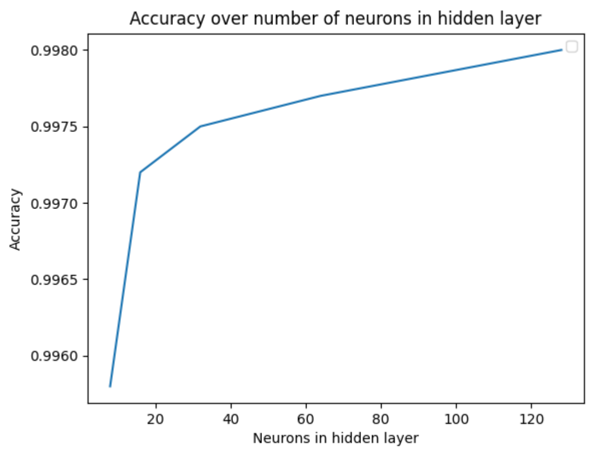
This first model provides more than acceptable results, with a 99.77% accuracy. Let's see how the number of neurons on the hidden layer, and the activation functions, affect its performance.

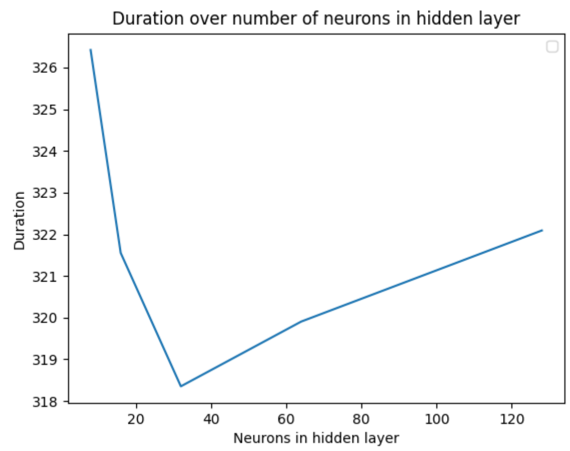
2.3. Different numbers of neurons on hidden layer

HL Units	Loss	Accuracy	Time
8	0.02	99.58%	326s
16	0.02	99.72%	322s
32	0.02	99.75%	318s
64	0.02	99.77%	320s
128	0.01	99.80%	322s









Looking at the model accuracy plot (third figure), it appears that the more neurons on hidden layer, the better the model. But actually, the other plots and the table shows that the results are fairly similar, whether on loss, accuracy or time.

Indeed, the 128-unit model gives the highest accuracy, but it's not significantly higher than the other ones for us to say this model is THE best one.

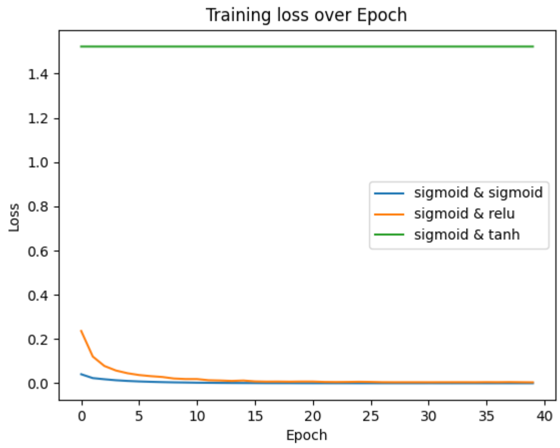
Conclusion: For this model, the number of neurons in the hidden layer is not a significant hyperparameter. As a consequence, we may choose the one that gives the best accuracy (here the 128-unit one) since they all take a similar amount of time.

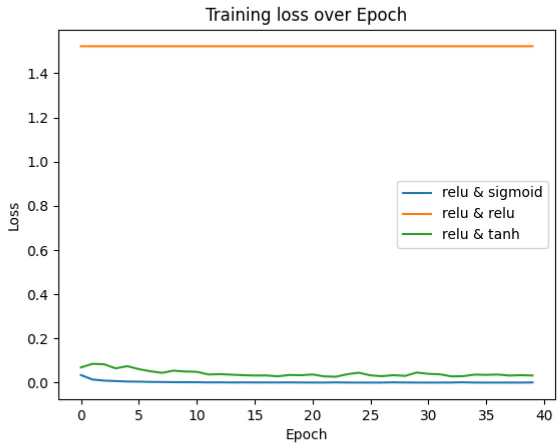
2.4. Different activation functions

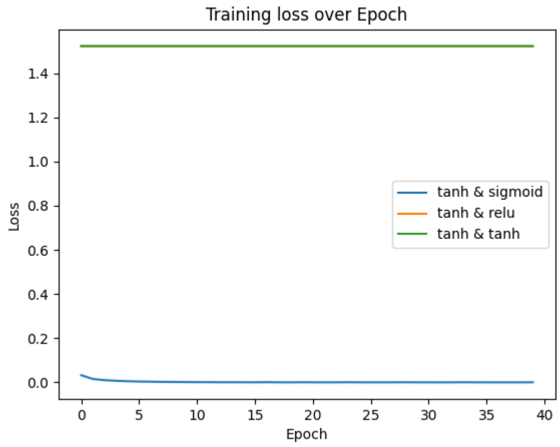
N.B.: We won't try Softmax on last layer because it's only relevant on multiclass classification.

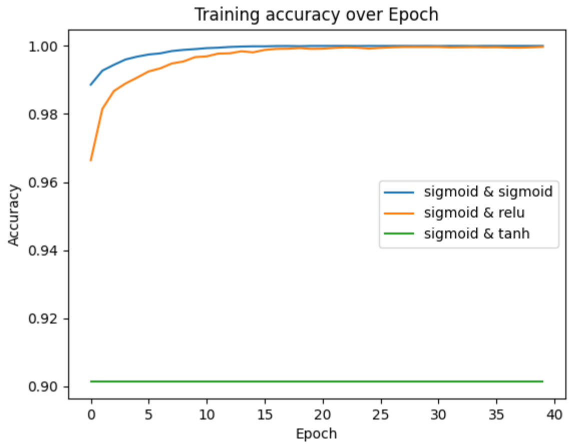
Activations	Loss	Accuracy	Time
Sigmoid, Sigmoid	0.02	99.77%	320s
Sigmoid, ReLU	1.51	90.20%	340s
Sigmoid, Tanh	0.02	99.68%	340s
ReLU, Sigmoid	0.02	99.81%	325s

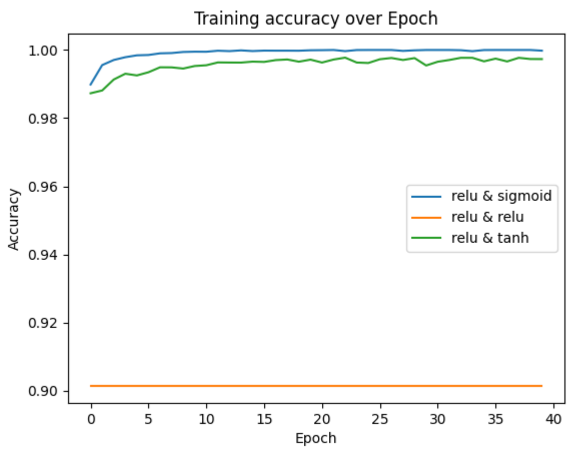
Activations	Loss	Accuracy	Time
ReLU, ReLU	1.51	90.20%	333s
ReLU, Tanh	1.51	90.20%	338s
Tanh, Sigmoid	0.02	99.81%	338s
Tanh, ReLU	1.51	90.20%	343s
Tanh, Tanh	0.03	99.58%	344s

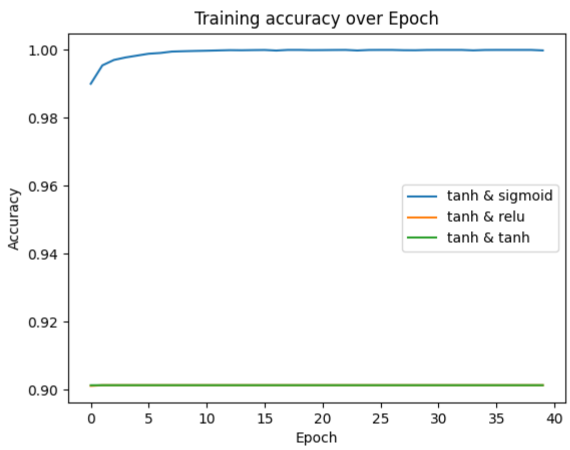


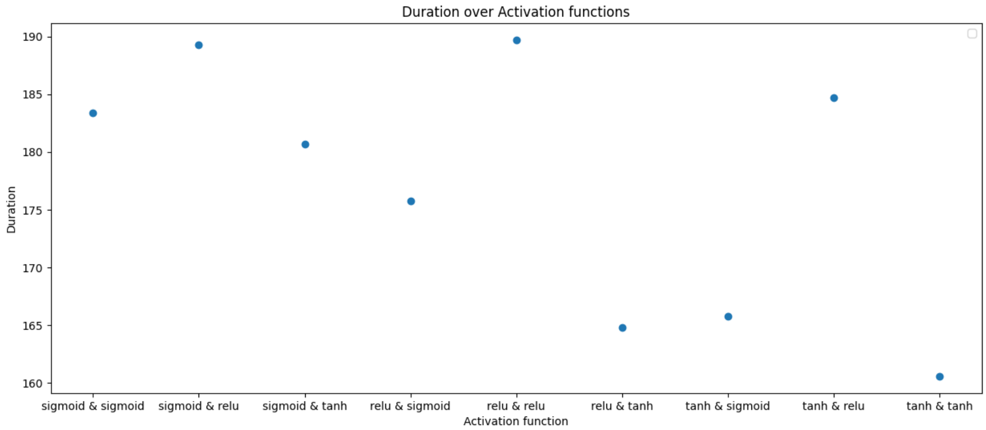












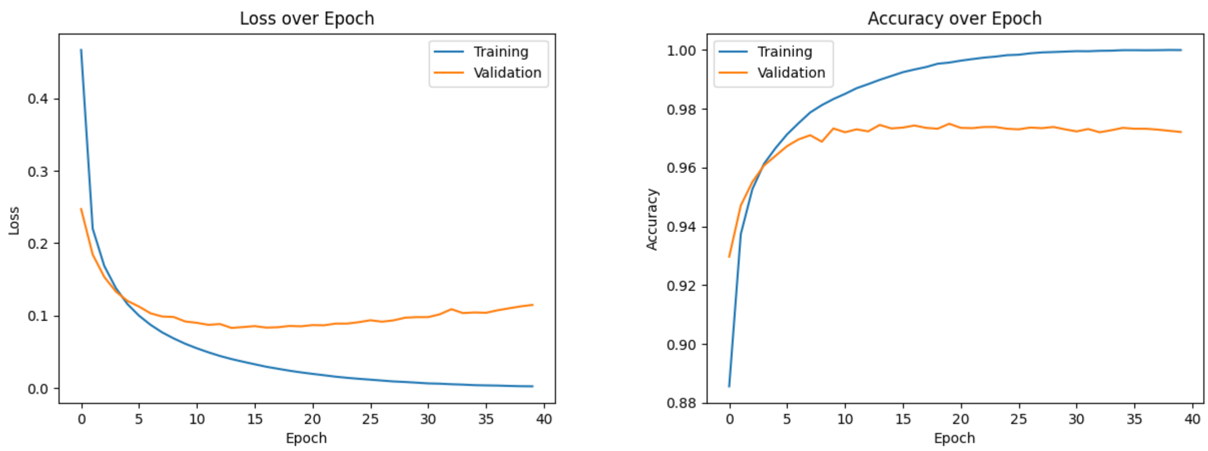
This time, we observe 2 categories. On one hand, models with an accuracy around 90%. On the other hand, models with one around 99%. Actually, the members of each category are not constant over the different executions, which makes it difficult to figure out.

Conclusion: A configuration that always gives good performances is the (sigmoid, sigmoid) one, that's why we should choose it, out of "security".

3. Multiclass Neural Networks

3.2. Default Network

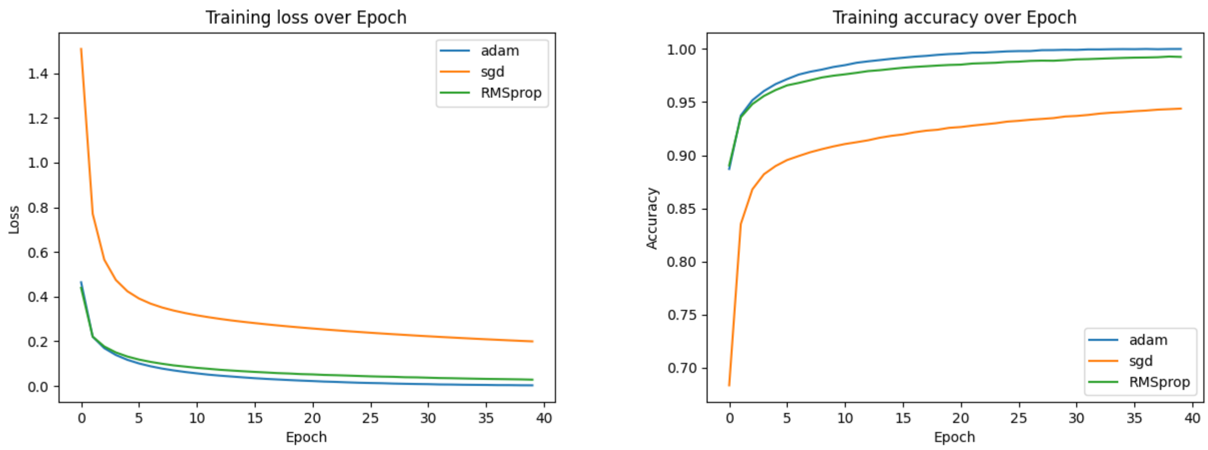
Optimizer	Activations	Loss	Accuracy	Time
Adam	Sigmoid, Softmax	0.1117	97.31%	516.73s

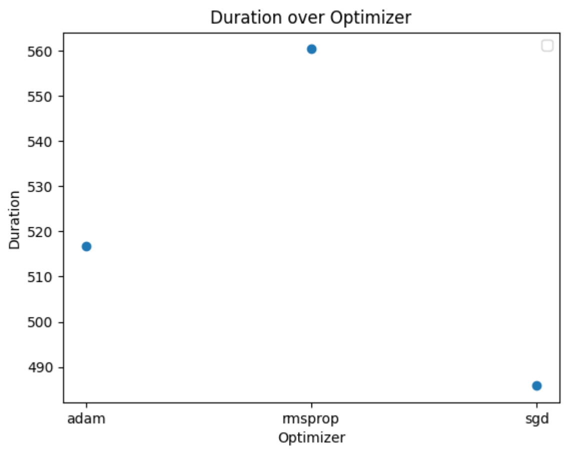


This first multiclass model provides very good results, with a 97.31% accuracy. Let's see how the different optimizers affect its performance.

3.3. Different optimizers

Optimizer	Loss	Accuracy	Time
Adam	0.1117	97.31%	516.73s
RMSprop	0.1087	97.46%	560.40s
SGD	0.1971	94.21%	485.83s





It is obvious that the SGD optimizer is beaten by the two others, in accuracy and time. Even though Adam and RMSProp have similar and high accuracies, RMSProp is about one minute shorter, which makes RMSProp the best one.

Conclusion: RMSProp is the best optimizer out of the three optimizers tested.

4. Best Network

After all the tests done in the previous section, let's gather the best hyperparameter to (hopefully) create the best model.

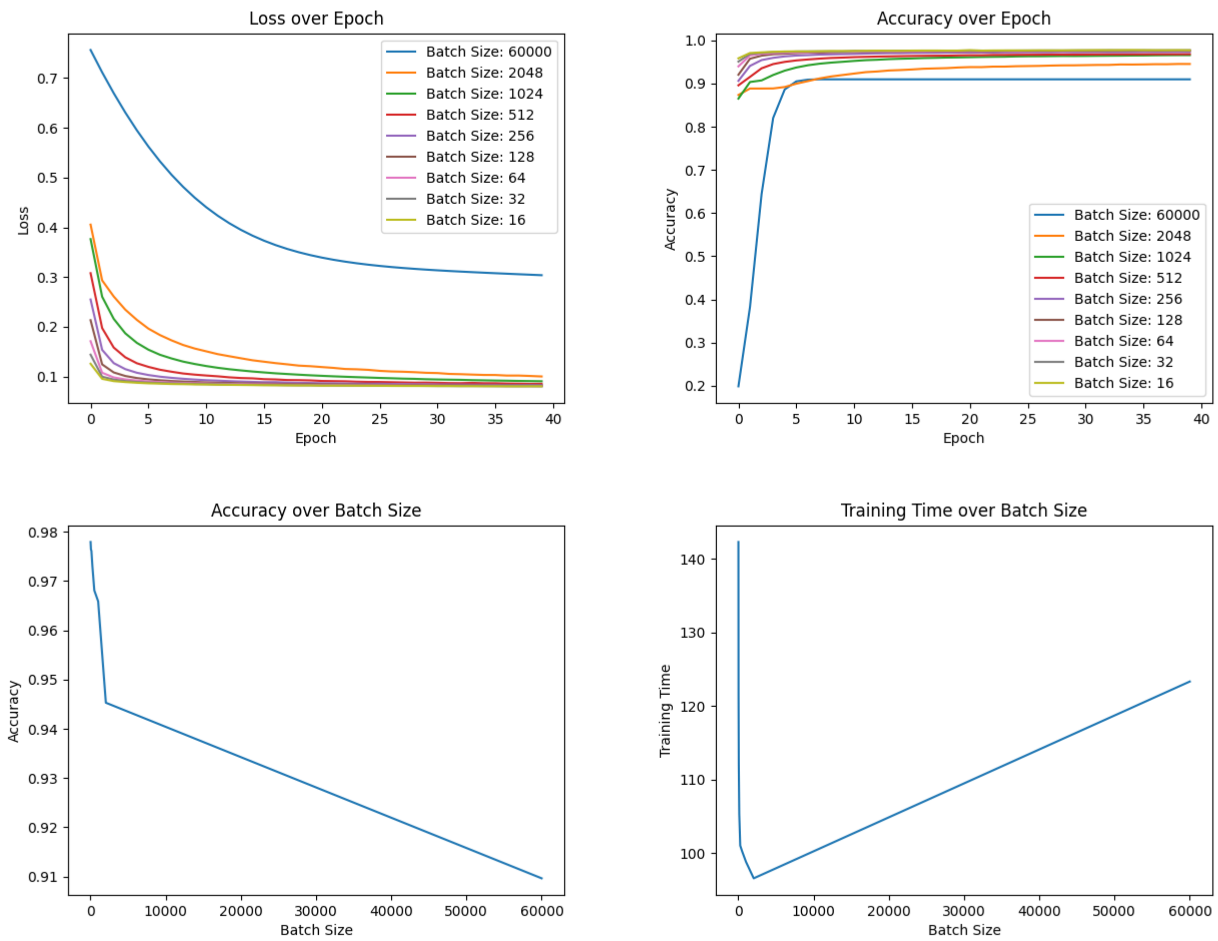
Batch Size	HL Units	Activations	Optimizer	Loss	Accuracy	Time
32	128	Sigmoid, Softmax	RMSProp	0.0934	97.82%	561.08s

For a multiclass model, this is the best model we've had.

PyTorch

Binary Classification: Single Neuron

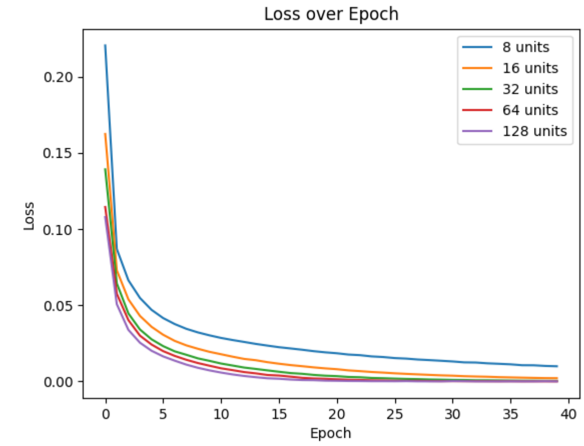
Batch Size	Loss	Accuracy	Time
60000	0.3027	90.97%	123.33s
2048	0.1008	94.53%	96.60s
1024	0.0904	96.59%	98.84s
512	0.0845	96.81%	100.26s
256	0.0822	97.31%	101.05s
128	0.0807	97.61%	105.33s
64	0.0799	97.64%	112.18s
32	0.0790	97.74%	121.56s
16	0.0787	97.79%	142.27s

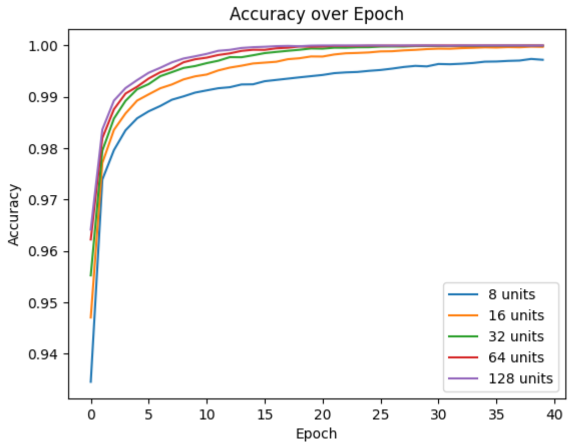


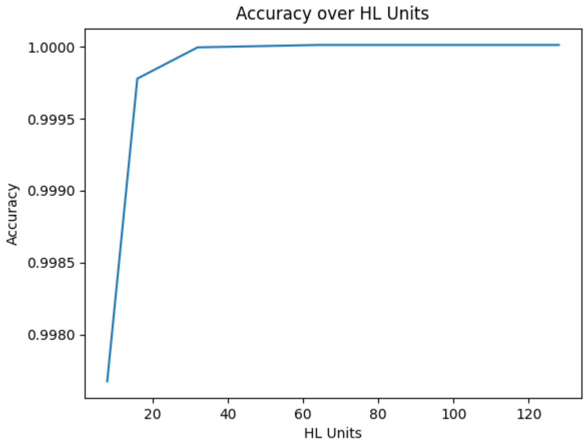
Binary Classification: Hidden Layer

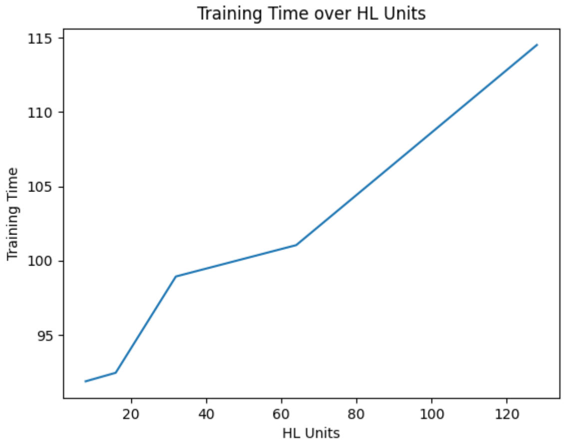
Hidden Layer Units (HLU)

HLU	Loss	Accuracy	Time
8	0.0091	99.75%	92.47s
16	0.0024	99.97%	96.81s
32	0.0002	100.00%	99.41s
64	0.0000	100.00%	102.66s
128	0.0001	100.00%	119.12s



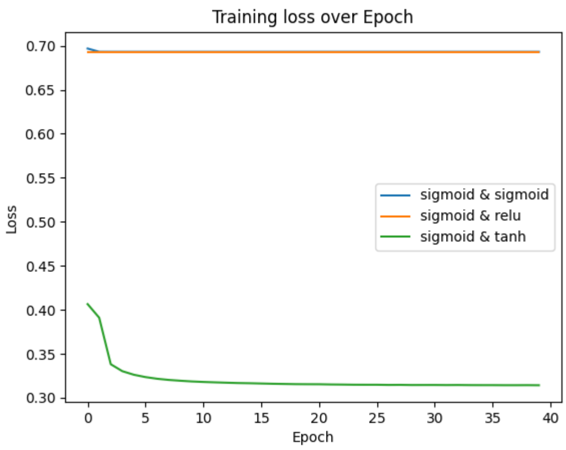


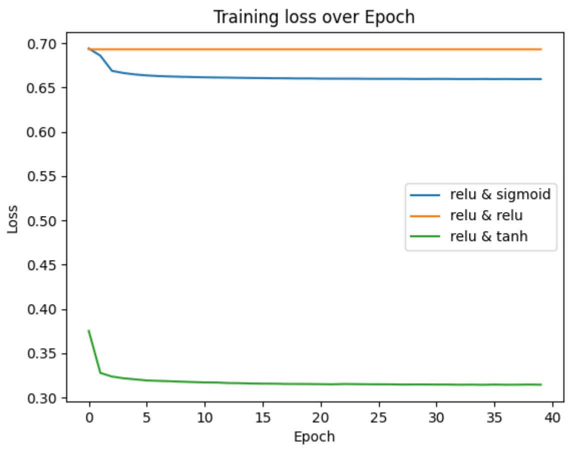


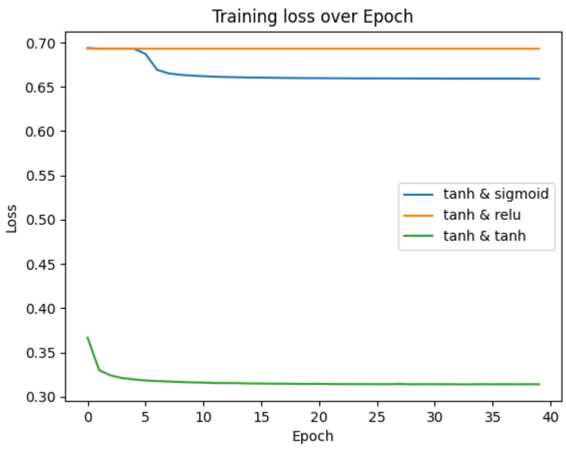


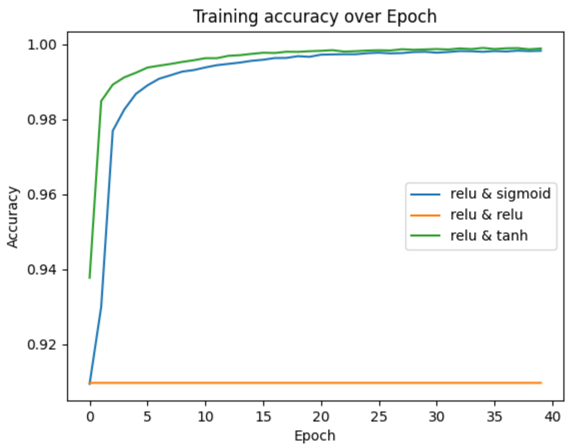
Activation Functions (AF)

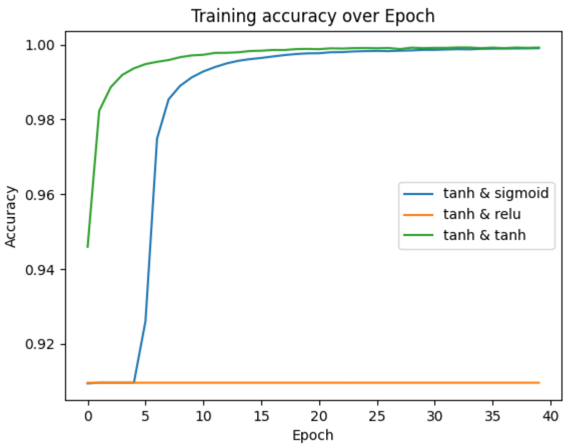
Activations	Loss	Accuracy	Time
Sigmoid, Sigmoid	0.6931	90.96%	98.03s
Sigmoid, ReLU	0.6931	90.96%	99.16s
Sigmoid, Tanh	0.3141	99.92%	99.76s
ReLU, Sigmoid	0.6595	99.85%	100.56s
ReLU, ReLU	0.6931	90.96%	101.15s
ReLU, Tanh	0.3145	99.90%	100.69s
Tanh, Sigmoid	0.6592	99.91%	100.64s
Tanh, ReLU	0.6931	90.96%	100.78s
Tanh, Tanh	0.3140	99.92%	102.01s

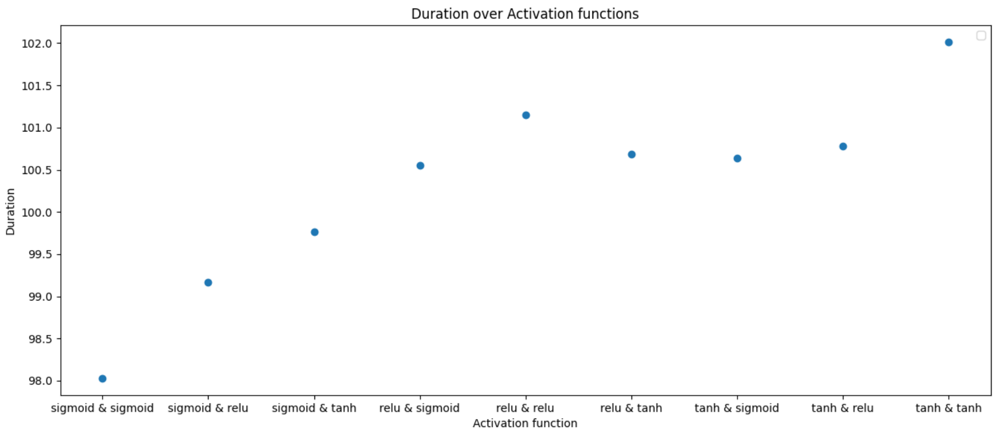

Training loss over Epoch
Loss
Epoch
sigmoid & sigmoid
sigmoid & relu
sigmoid & tanh


Training loss over Epoch
Loss
Epoch
relu & sigmoid
relu & relu
relu & tanh


Training loss over Epoch
Loss
Epoch
tanh & sigmoid
tanh & relu
tanh & tanh


Training accuracy over Epoch
Accuracy
Epoch
relu & sigmoid
relu & relu
relu & tanh


Training accuracy over Epoch
Accuracy
Epoch
tanh & sigmoid
tanh & relu
tanh & tanh


Duration over Activation functions
Duration
sigmoid & sigmoid
sigmoid & relu
sigmoid & tanh
relu & sigmoid
relu & relu
relu & tanh
tanh & sigmoid
tanh & relu
tanh & tanh
Activation function

Multiclass Classification

Optimizer	Loss	Accuracy	Time
Adam	1.4708	99.12%	97.29s
RMSprop	1.4701	99.16%	96.68s
SGD	2.2037	23.30%	96.39s