SUM Approximation (LSTM) NN, Nano-Level Structure

Since the SUM Approximation NN is the LSTM Network, the Network on -the nano level is interpreted as the LSTM cell see the figure below. The defined uses as inputs the two contemporaneous bits of $X1$ and $X2$ and output k-th bit of Y in the $Y = X1 + X2$. The cell inputs and outputs are the variables in R. The detailed description of the LSTM cell shown in the figure below.

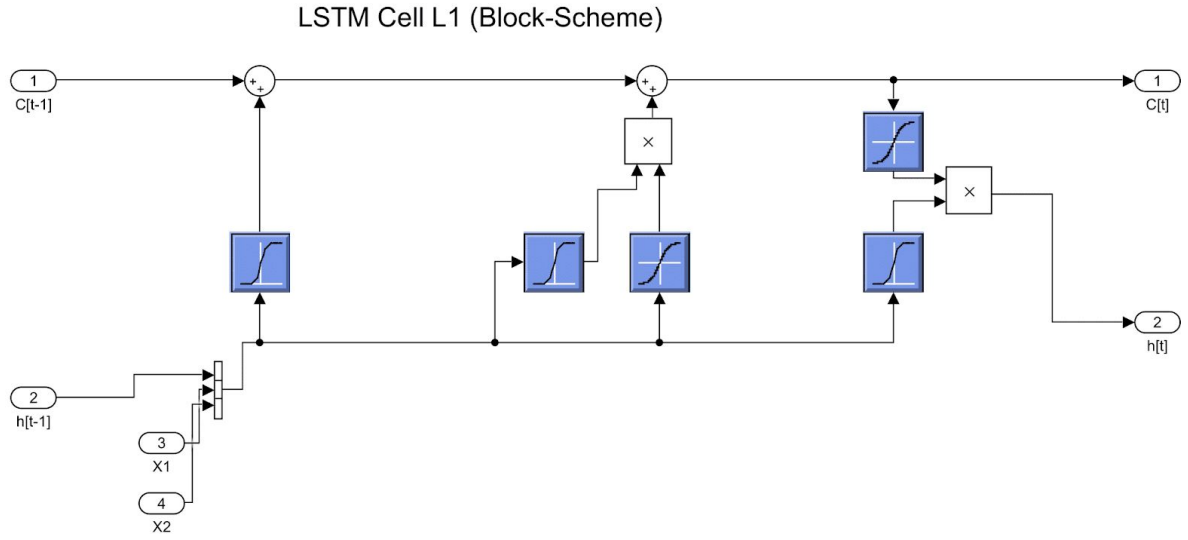


Fig. 1.6 XOR and AND Neural Networks, nano-level

Let us get focused how the higher level is methodologically described.

SUM Approximation (LSTM) NN, Micro-Level Structure

The structure of the LSTM Network is displayed in the block-schemes below. See the L0 and L1). From the two block-schemes shown below, the 32-bit input of the $X1$ and $X2$ are transferred to 32-bit output Y (in this case the bit equivalents in R are considered).

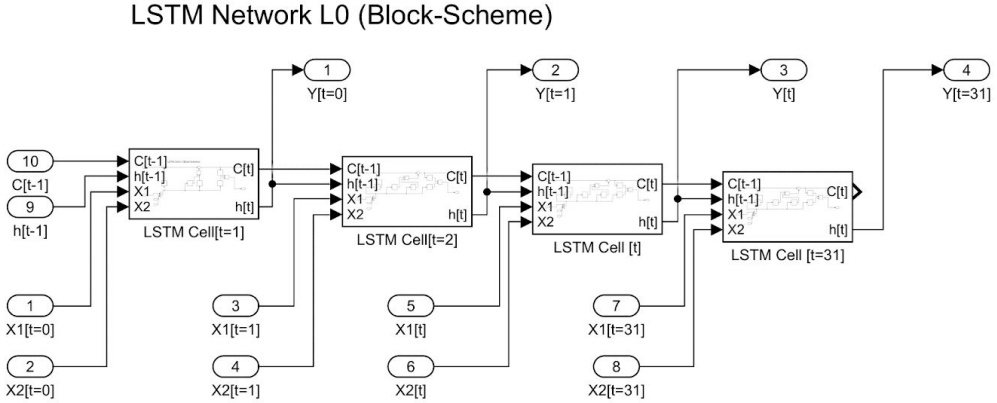
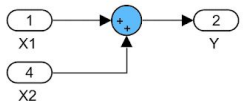
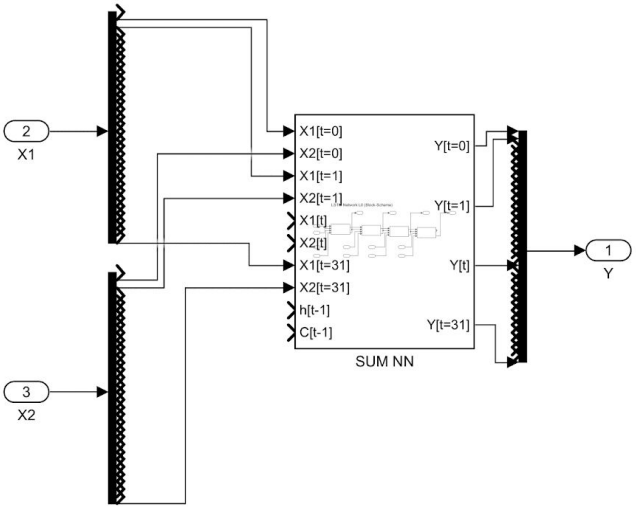


Fig. 2.1. SUM Neural Networks, LSTM Cells aggregated (micro-level)



SUM (As displayed)



SUM Overloaded
(Block-Scheme)

Fig. 2.2. SUM Neural Networks, LSTM Cells aggregated (view outside the block)

From the bloch-schemes in Fig. 1.8-1.9 the submission is performed from lower to higher bits using the 32 cell LSTM Neural Network with 1-to-1 relation, same as it is done by using bitwise addition by column method.

SUM Approximation (LSTM) NN, Results

The LSTM model is trained accordingly methodology: (the higher bits are obtained from the lower bits in the LSTM 1-to-1 sequences, the (two) 32 bit sequences $X1$ and $X2$ in the input gives 32 sequence Y in the output. The data is trained over the 10^5 sequences (may be reduced). The perfect accuracy (100%) is obtained on the both training and validation sets.

The (two integer number) SUM operator is overload using the LSTM Neural Network. Perfect accuracy (100%) reached in the both training and test sets on small number of observations.

Training on single CPU.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Validation Accuracy	Mini-batch Loss	Validation Loss	Base Learning Rate
1	1	00:00:44	51.46%	50.02%	0.6954	0.7041	0.0100
1	50	00:02:38	59.57%	60.13%	0.6926	0.6926	0.0100
2	100	00:04:33	68.07%	72.43%	0.6145	0.6086	0.0100
3	150	00:06:32	99.98%	100.00%	0.0521	0.0471	0.0100
3	200	00:08:57	100.00%	100.00%	0.0045	0.0044	0.0100
4	220	00:09:36	100.00%			0.0032	0.0100

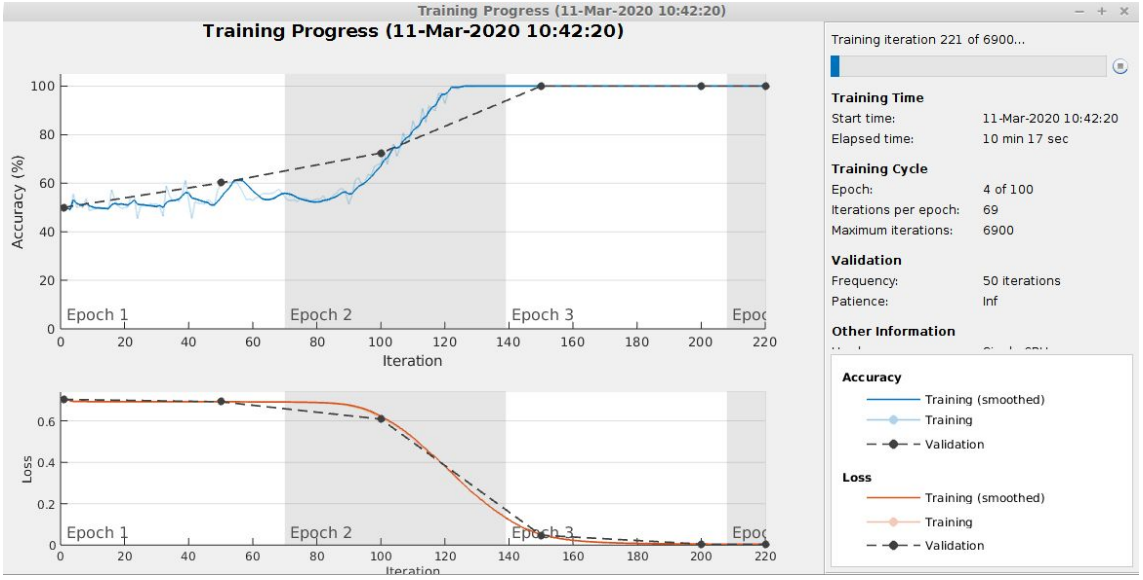


Fig. 2.3. SUM Neural Networks (LSTM), accuracy in the training and validation sets (perfect match)