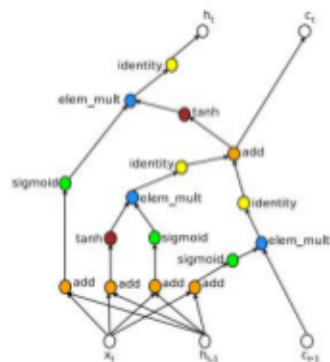
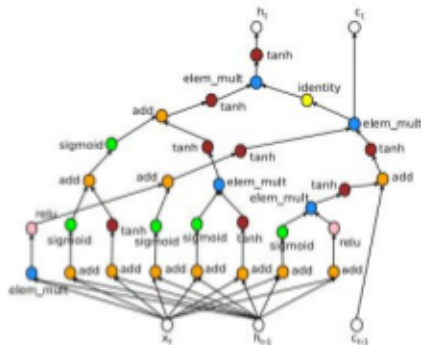


Penn Tree Bank Language Modeling Task

“Normal” LSTM cell



Cell discovered by architecture search



Model	Parameters	Test Perplexity
Mikolov & Zweig (2012) - KN-5	2M [‡]	141.2
Mikolov & Zweig (2012) - KN5 + cache	2M [‡]	125.7
Mikolov & Zweig (2012) - RNN	6M [‡]	124.7
Mikolov & Zweig (2012) - RNN-LDA	7M [‡]	113.7
Mikolov & Zweig (2012) - RNN-LDA + KN-5 + cache	9M [‡]	92.0
Pascanu et al. (2013) - Deep RNN	6M	107.5
Cheng et al. (2014) - Sum-Prod Net	5M [‡]	100.0
Zaremba et al. (2014) - LSTM (medium)	20M	82.7
Zaremba et al. (2014) - LSTM (large)	66M	78.4
Gal (2015) - Variational LSTM (medium, untied)	20M	79.7
Gal (2015) - Variational LSTM (medium, untied, MC)	20M	78.6
Gal (2015) - Variational LSTM (large, untied)	66M	75.2
Gal (2015) - Variational LSTM (large, untied, MC)	66M	73.4
Kim et al. (2015) - CharCNN	19M	78.9
Press & Wolf (2016) - Variational LSTM, shared embeddings	24M	73.2
Merity et al. (2016) - Zoneout + Variational LSTM (medium)	20M	80.6
Merity et al. (2016) - Pointer Sentinel-LSTM (medium)	21M	70.9
Zilly et al. (2016) - Variational RHN, shared embeddings	24M	66.0
Neural Architecture Search with base 8	32M	67.9
Neural Architecture Search with base 8 and shared embeddings	25M	64.0
Neural Architecture Search with base 8 and shared embeddings	54M	62.4

Table 2: Single model perplexity on the test set of the Penn Treebank language modeling task. Parameter numbers with [‡] are estimates with reference to Merity et al. (2016).