## References

- Christopher Manning, Mihai Surdeanu, John Bauer, Jenny Finkel, Steven Bethard, and David McClosky. The stanford corenlp natural language processing toolkit. In Proceedings of 52nd annual meeting of the association for computational linguistics: system demonstrations, pages 55–60, 2014.
- [2] Dzmitry Bahdanau, Kyunghyun Cho, and Yoshua Bengio. Neural machine translation by jointly learning to align and translate. arXiv preprint arXiv:1409.0473, 2014.
- [3] Minjoon Seo, Hannaneh Hajishirzi, Ali Farhadi, Oren Etzioni, and Clint Malcolm. Solving geometry problems: Combining text and diagram interpretation. In Proceedings of the 2015 Conference on Empirical Methods in Natural Language Processing, pages 1466–1476, 2015.
- [4] Keith Jones. Issues in the teaching and learning of geometry. In Aspects of teaching secondary mathematics, pages 137–155. Routledge, 2003.
- [5] Rahul Singhal, Martin Henz, and Kevin McGee. Automated generation of geometry questions for high school mathematics. In CSEDU (2), pages 14– 25, 2014.
- [6] Chamupathi Mendis, Dhanushka Lahiru, Naduni Pamudika, Supun Madushanka, Surangika Ranathunga, and Gihan Dias. Automatic assessment of student answers for geometric theorem proving questions. In 2017 Moratuwa Engineering Research Conference (MERCon), pages 413–418. IEEE, 2017.
- [7] Chris Alvin, Sumit Gulwani, Rupak Majumdar, and Supratik Mukhopadhyay. Synthesis of solutions for shaded area geometry problems. In *The Thirtieth International Flairs Conference*, 2017.

- [8] Mrinmaya Sachan and Eric Xing. Learning to solve geometry problems from natural language demonstrations in textbooks. In Proceedings of the 6th Joint Conference on Lexical and Computational Semantics (\* SEM 2017), pages 251–261, 2017.
- Risto Miikkulainen. Subsymbolic case-role analysis of sentences with embedded clauses. *Cognitive Science*, 20(1):47–73, 1996.
- [10] Lantao Yu, Weinan Zhang, Jun Wang, and Yong Yu. Seqgan: Sequence generative adversarial nets with policy gradient. In AAAI, pages 2852–2858, 2017.
- [11] Yizhe Zhang, Zhe Gan, Kai Fan, Zhi Chen, Ricardo Henao, Dinghan Shen, and Lawrence Carin. Adversarial feature matching for text generation. In Proceedings of the 34th International Conference on Machine Learning-Volume 70, pages 4006–4015. JMLR. org, 2017.
- [12] Jiaxian Guo, Sidi Lu, Han Cai, Weinan Zhang, Yong Yu, and Jun Wang. Long text generation via adversarial training with leaked information. In *Thirty-Second AAAI Conference on Artificial Intelligence*, 2018.
- [13] Matt J Kusner and José Miguel Hernández-Lobato. Gans for sequences of discrete elements with the gumbel-softmax distribution. arXiv preprint arXiv:1611.04051, 2016.
- [14] Massimo Caccia, Lucas Caccia, William Fedus, Hugo Larochelle, Joelle Pineau, and Laurent Charlin. Language gans falling short. arXiv preprint arXiv:1811.02549, 2018.
- [15] Geoffrey Hinton, Li Deng, Dong Yu, George Dahl, Abdel-rahman Mohamed, Navdeep Jaitly, Andrew Senior, Vincent Vanhoucke, Patrick Nguyen, Brian Kingsbury, et al. Deep neural networks for acoustic modeling in speech recognition. *IEEE Signal processing magazine*, 29, 2012.

- [16] George E Dahl, Dong Yu, Li Deng, and Alex Acero. Context-dependent pretrained deep neural networks for large-vocabulary speech recognition. *IEEE Transactions on audio, speech, and language processing*, 20(1):30–42, 2011.
- [17] Dan Cireşan, Ueli Meier, and Jürgen Schmidhuber. Multi-column deep neural networks for image classification. arXiv preprint arXiv:1202.2745, 2012.
- [18] Alex Krizhevsky, Ilya Sutskever, and Geoffrey E Hinton. Imagenet classification with deep convolutional neural networks. In Advances in neural information processing systems, pages 1097–1105, 2012.
- [19] Quoc V Le. Building high-level features using large scale unsupervised learning. In 2013 IEEE international conference on acoustics, speech and signal processing, pages 8595–8598. IEEE, 2013.
- [20] Yann LeCun, Léon Bottou, Yoshua Bengio, Patrick Haffner, et al. Gradientbased learning applied to document recognition. *Proceedings of the IEEE*, 86(11):2278–2324, 1998.
- [21] David E Rumelhart, Geoffrey E Hinton, Ronald J Williams, et al. Learning representations by back-propagating errors. *Cognitive modeling*, 5(3):1, 1988.
- [22] Paul J Werbos et al. Backpropagation through time: what it does and how to do it. *Proceedings of the IEEE*, 78(10):1550–1560, 1990.
- [23] Ilya Sutskever, Oriol Vinyals, and Quoc V Le. Sequence to sequence learning with neural networks. In Advances in neural information processing systems, pages 3104–3112, 2014.
- [24] Kyunghyun Cho, Bart Van Merriënboer, Caglar Gulcehre, Dzmitry Bahdanau, Fethi Bougares, Holger Schwenk, and Yoshua Bengio. Learning phrase representations using rnn encoder-decoder for statistical machine translation. arXiv preprint arXiv:1406.1078, 2014.

- [25] Fandong Meng, Zhengdong Lu, Mingxuan Wang, Hang Li, Wenbin Jiang, and Qun Liu. Encoding source language with convolutional neural network for machine translation. arXiv preprint arXiv:1503.01838, 2015.
- [26] Lili Mou, Rui Men, Ge Li, Yan Xu, Lu Zhang, Rui Yan, and Zhi Jin. Natural language inference by tree-based convolution and heuristic matching. arXiv preprint arXiv:1512.08422, 2015.
- [27] Lili Mou, Hao Peng, Ge Li, Yan Xu, Lu Zhang, and Zhi Jin. Discriminative neural sentence modeling by tree-based convolution. arXiv preprint arXiv:1504.01106, 2015.
- [28] Soroush Vosoughi, Prashanth Vijayaraghavan, and Deb Roy. Tweet2vec: Learning tweet embeddings using character-level cnn-lstm encoder-decoder. In Proceedings of the 39th International ACM SIGIR conference on Research and Development in Information Retrieval, pages 1041–1044. ACM, 2016.
- [29] Nal Kalchbrenner and Phil Blunsom. Recurrent continuous translation models. In Proceedings of the 2013 Conference on Empirical Methods in Natural Language Processing, pages 1700–1709, 2013.
- [30] Yoshua Bengio, Patrice Simard, Paolo Frasconi, et al. Learning long-term dependencies with gradient descent is difficult. *IEEE transactions on neural networks*, 5(2):157–166, 1994.
- [31] Sepp Hochreiter. Untersuchungen zu dynamischen neuronalen netzen. Diploma, Technische Universität München, 91(1), 1991.
- [32] Sepp Hochreiter and Jürgen Schmidhuber. Long short-term memory. Neural computation, 9(8):1735–1780, 1997.
- [33] Sepp Hochreiter, Yoshua Bengio, Paolo Frasconi, Jürgen Schmidhuber, et al. Gradient flow in recurrent nets: the difficulty of learning long-term dependencies, 2001.

- [34] Richard Socher, Eric H Huang, Jeffrey Pennin, Christopher D Manning, and Andrew Y Ng. Dynamic pooling and unfolding recursive autoencoders for paraphrase detection. In Advances in neural information processing systems, pages 801–809, 2011.
- [35] Richard Socher, Alex Perelygin, Jean Wu, Jason Chuang, Christopher D Manning, Andrew Ng, and Christopher Potts. Recursive deep models for semantic compositionality over a sentiment treebank. In *Proceedings of the* 2013 conference on empirical methods in natural language processing, pages 1631–1642, 2013.
- [36] Samuel R Bowman, Christopher Potts, and Christopher D Manning. Recursive neural networks for learning logical semantics. CoRR, abs/1406.1827, 5, 2014.
- [37] Mohit Iyyer, Jordan Boyd-Graber, Leonardo Claudino, Richard Socher, and Hal Daumé III. A neural network for factoid question answering over paragraphs. In Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP), pages 633–644, 2014.
- [38] Sainbayar Sukhbaatar, Jason Weston, Rob Fergus, et al. End-to-end memory networks. In Advances in neural information processing systems, pages 2440– 2448, 2015.
- [39] Jason Weston, Sumit Chopra, and Antoine Bordes. Memory networks. arXiv preprint arXiv:1410.3916, 2014.
- [40] Wojciech Zaremba and Ilya Sutskever. Learning to execute. arXiv preprint arXiv:1410.4615, 2014.
- [41] Kelvin Xu, Jimmy Ba, Ryan Kiros, Kyunghyun Cho, Aaron Courville, Ruslan Salakhudinov, Rich Zemel, and Yoshua Bengio. Show, attend and tell: Neural image caption generation with visual attention. In *International conference on machine learning*, pages 2048–2057, 2015.

- [42] Ankit Kumar, Ozan Irsoy, Peter Ondruska, Mohit Iyyer, James Bradbury, Ishaan Gulrajani, Victor Zhong, Romain Paulus, and Richard Socher. Ask me anything: Dynamic memory networks for natural language processing. In *International conference on machine learning*, pages 1378–1387, 2016.
- [43] Kyunghyun Cho, Bart Van Merriënboer, Dzmitry Bahdanau, and Yoshua Bengio. On the properties of neural machine translation: Encoder-decoder approaches. arXiv preprint arXiv:1409.1259, 2014.
- [44] Roee Aharoni and Yoav Goldberg. Morphological inflection generation with hard monotonic attention. arXiv preprint arXiv:1611.01487, 2016.
- [45] Minh-Thang Luong, Hieu Pham, and Christopher D Manning. Effective approaches to attention-based neural machine translation. arXiv preprint arXiv:1508.04025, 2015.
- [46] Ronald J Williams. Simple statistical gradient-following algorithms for connectionist reinforcement learning. *Machine learning*, 8(3-4):229–256, 1992.
- [47] Yoshua Bengio, Li Yao, Guillaume Alain, and Pascal Vincent. Generalized denoising auto-encoders as generative models. In Advances in neural information processing systems, pages 899–907, 2013.
- [48] Geoffrey E Hinton, Simon Osindero, and Yee-Whye Teh. A fast learning algorithm for deep belief nets. *Neural computation*, 18(7):1527–1554, 2006.
- [49] P Kingma Diederik, Max Welling, et al. Auto-encoding variational bayes. In Proceedings of the International Conference on Learning Representations (ICLR), 2014.
- [50] Ian Goodfellow, Jean Pouget-Abadie, Mehdi Mirza, Bing Xu, David Warde-Farley, Sherjil Ozair, Aaron Courville, and Yoshua Bengio. Generative adversarial nets. In Advances in neural information processing systems, pages 2672–2680, 2014.

- [51] Emily L Denton, Soumith Chintala, Rob Fergus, et al. Deep generative image models using aï£ij laplacian pyramid of adversarial networks. In Advances in neural information processing systems, pages 1486–1494, 2015.
- [52] Radu Florian, Hongyan Jing, Nanda Kambhatla, and Imed Zitouni. Factorizing complex models: A case study in mention detection. In Proceedings of the 21st International Conference on Computational Linguistics and the 44th annual meeting of the Association for Computational Linguistics, pages 473–480. Association for Computational Linguistics, 2006.
- [53] Radu Florian, John F Pitrelli, Salim Roukos, and Imed Zitouni. Improving mention detection robustness to noisy input. In *Proceedings of the 2010 Conference on Empirical Methods in Natural Language Processing*, pages 335–345. Association for Computational Linguistics, 2010.
- [54] Jing Jiang and ChengXiang Zhai. A systematic exploration of the feature space for relation extraction. In Human Language Technologies 2007: The Conference of the North American Chapter of the Association for Computational Linguistics; Proceedings of the Main Conference, pages 113–120, 2007.
- [55] Shubin Zhao and Ralph Grishman. Extracting relations with integrated information using kernel methods. In *Proceedings of the 43rd annual meeting* on association for computational linguistics, pages 419–426. Association for Computational Linguistics, 2005.
- [56] Ralph Grishman. Information extraction: Techniques and challenges. In International summer school on information extraction, pages 10–27. Springer, 1997.
- [57] Dmitry Zelenko, Chinatsu Aone, and Anthony Richardella. Kernel methods for relation extraction. *Journal of machine learning research*, 3(Feb):1083– 1106, 2003.
- [58] Yee Seng Chan and Dan Roth. Exploiting syntactico-semantic structures for relation extraction. In *Proceedings of the 49th Annual Meeting of the*

Association for Computational Linguistics: Human Language Technologies-Volume 1, pages 551–560. Association for Computational Linguistics, 2011.

- [59] Qi Li and Heng Ji. Incremental joint extraction of entity mentions and relations. In Proceedings of the 52nd Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers), pages 402–412, 2014.
- [60] Makoto Miwa and Yutaka Sasaki. Modeling joint entity and relation extraction with table representation. In Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP), pages 1858– 1869, 2014.
- [61] Makoto Miwa and Mohit Bansal. End-to-end relation extraction using lstms on sequences and tree structures. arXiv preprint arXiv:1601.00770, 2016.
- [62] Kai Sheng Tai, Richard Socher, and Christopher D Manning. Improved semantic representations from tree-structured long short-term memory networks. arXiv preprint arXiv:1503.00075, 2015.
- [63] Jiwei Li, Will Monroe, Alan Ritter, Michel Galley, Jianfeng Gao, and Dan Jurafsky. Deep reinforcement learning for dialogue generation. arXiv preprint arXiv:1606.01541, 2016.
- [64] Meishan Zhang, Yue Zhang, and Guohong Fu. End-to-end neural relation extraction with global optimization. In *Proceedings of the 2017 Conference* on Empirical Methods in Natural Language Processing, pages 1730–1740, 2017.
- [65] Hao Zhou, Yue Zhang, Shujian Huang, and Jiajun Chen. A neural probabilistic structured-prediction model for transition-based dependency parsing. In Proceedings of the 53rd Annual Meeting of the Association for Computational Linguistics and the 7th International Joint Conference on Natural Language Processing (Volume 1: Long Papers), pages 1213–1222, 2015.
- [66] Taro Watanabe and Eiichiro Sumita. Transition-based neural constituent parsing. In Proceedings of the 53rd Annual Meeting of the Association for

Computational Linguistics and the 7th International Joint Conference on Natural Language Processing (Volume 1: Long Papers), pages 1169–1179, 2015.

- [67] Oriol Vinyals, Alexander Toshev, Samy Bengio, and Dumitru Erhan. Show and tell: A neural image caption generator. In *Proceedings of the IEEE conference on computer vision and pattern recognition*, pages 3156–3164, 2015.
- [68] Zhen Yang, Wei Chen, Feng Wang, and Bo Xu. Improving neural machine translation with conditional sequence generative adversarial nets. arXiv preprint arXiv:1703.04887, 2017.
- [69] Xingxing Zhang and Mirella Lapata. Chinese poetry generation with recurrent neural networks. In Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP), pages 670–680, 2014.
- [70] Liqun Chen, Shuyang Dai, Chenyang Tao, Haichao Zhang, Zhe Gan, Dinghan Shen, Yizhe Zhang, Guoyin Wang, Ruiyi Zhang, and Lawrence Carin. Adversarial text generation via feature-mover's distance. In Advances in Neural Information Processing Systems, pages 4671–4682, 2018.
- [71] Ferenc Huszár. How (not) to train your generative model: Scheduled sampling, likelihood, adversary? arXiv preprint arXiv:1511.05101, 2015.
- [72] Samy Bengio, Oriol Vinyals, Navdeep Jaitly, and Noam Shazeer. Scheduled sampling for sequence prediction with recurrent neural networks. In Advances in Neural Information Processing Systems, pages 1171–1179, 2015.
- [73] Tong Che, Yanran Li, Ruixiang Zhang, R Devon Hjelm, Wenjie Li, Yangqiu Song, and Yoshua Bengio. Maximum-likelihood augmented discrete generative adversarial networks. arXiv preprint arXiv:1702.07983, 2017.
- [74] Kevin Lin, Dianqi Li, Xiaodong He, Zhengyou Zhang, and Ming-Ting Sun. Adversarial ranking for language generation. In Advances in Neural Information Processing Systems, pages 3155–3165, 2017.

- [75] Chris J Maddison, Andriy Mnih, and Yee Whye Teh. The concrete distribution: A continuous relaxation of discrete random variables. arXiv preprint arXiv:1611.00712, 2016.
- [76] Sidi Lu, Yaoming Zhu, Weinan Zhang, Jun Wang, and Yong Yu. Neural text generation: past, present and beyond. arXiv preprint arXiv:1803.07133, 2018.
- [77] Yaoming Zhu, Sidi Lu, Lei Zheng, Jiaxian Guo, Weinan Zhang, Jun Wang, and Yong Yu. Texygen: A benchmarking platform for text generation models. arXiv preprint arXiv:1802.01886, 2018.
- [78] David H Ackley, Geoffrey E Hinton, and Terrence J Sejnowski. Connectionist models and their implications: Readings from cognitive science. chapter a learning algorithm for boltzmann machines, 1988.
- [79] Alessandro Sordoni, Michel Galley, Michael Auli, Chris Brockett, Yangfeng Ji, Margaret Mitchell, Jian-Yun Nie, Jianfeng Gao, and Bill Dolan. A neural network approach to context-sensitive generation of conversational responses. arXiv preprint arXiv:1506.06714, 2015.
- [80] Lifeng Shang, Zhengdong Lu, and Hang Li. Neural responding machine for short-text conversation. arXiv preprint arXiv:1503.02364, 2015.
- [81] Tsung-Hsien Wen, Milica Gasic, Nikola Mrksic, Pei-Hao Su, David Vandyke, and Steve Young. Semantically conditioned lstm-based natural language generation for spoken dialogue systems. arXiv preprint arXiv:1508.01745, 2015.
- [82] Kaisheng Yao, Geoffrey Zweig, and Baolin Peng. Attention with intention for a neural network conversation model. arXiv preprint arXiv:1510.08565, 2015.
- [83] Yi Luan, Yangfeng Ji, and Mari Ostendorf. Lstm based conversation models. arXiv preprint arXiv:1603.09457, 2016.

- [84] Tsung-Hsien Wen, David Vandyke, Nikola Mrksic, Milica Gasic, Lina M Rojas-Barahona, Pei-Hao Su, Stefan Ultes, and Steve Young. A networkbased end-to-end trainable task-oriented dialogue system. arXiv preprint arXiv:1604.04562, 2016.
- [85] Tsung-Yi Lin, Michael Maire, Serge Belongie, James Hays, Pietro Perona, Deva Ramanan, Piotr Dollár, and C Lawrence Zitnick. Microsoft coco: Common objects in context. In *European conference on computer vision*, pages 740–755. Springer, 2014.