

# Multilingual NMT Bibliography

Companion to COLING 2020 Tutorial

December 2020

## Tutorial Website

[https://github.com/anoopkunchukuttan/multinmt\\_tutorial\\_coling2020](https://github.com/anoopkunchukuttan/multinmt_tutorial_coling2020)

## References

- Armen Aghajanyan, Xia Song, and Saurabh Tiwary. 2019. Towards language agnostic universal representations. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, pages 4033–4041, Florence, Italy. Association for Computational Linguistics.
- Željko Agić and Ivan Vulić. 2019. JW300: A wide-coverage parallel corpus for low-resource languages. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, pages 3204–3210, Florence, Italy. Association for Computational Linguistics.
- Roei Aharoni, Melvin Johnson, and Orhan Firat. 2019a. Massively multilingual neural machine translation. In *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, pages 3874–3884, Minneapolis, Minnesota. Association for Computational Linguistics.
- Roei Aharoni, Melvin Johnson, and Orhan Firat. 2019b. Massively multilingual neural machine translation. In *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, pages 3874–3884, Minneapolis, Minnesota. Association for Computational Linguistics.
- Maruan Al-Shedivat and Ankur Parikh. 2019. Consistency by agreement in zero-shot neural machine translation. In *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, pages 1184–1197, Minneapolis, Minnesota. Association for Computational Linguistics.
- Chantal Amrhein and Rico Sennrich. 2020. On Romanization for Model Transfer Between Scripts in Neural Machine Translation. In *Findings of the Association for Computational Linguistics: EMNLP 2020*, pages 2461–2469, Online. Association for Computational Linguistics.
- Naveen Arivazhagan, Ankur Bapna, Orhan Firat, Roei Aharoni, Melvin Johnson, and Wolfgang Macherey. 2019a. The missing ingredient in zero-shot neural machine translation. *CoRR*, abs/1903.07091.
- Naveen Arivazhagan, Ankur Bapna, Orhan Firat, Dmitry Lepikhin, Melvin Johnson, Maxim Krikun, Mia Xu Chen, Yuan Cao, George Foster, Colin Cherry, Wolfgang Macherey, Zhifeng Chen, and Yonghui Wu. 2019b. Massively multilingual neural machine translation in the wild: Findings and challenges. *CoRR*, abs/1907.05019.
- Mikel Artetxe, Gorka Labaka, and Eneko Agirre. 2016. Learning principled bilingual mappings of word embeddings while preserving monolingual invariance. In *Proceedings of the 2016 Conference on Empirical Methods in Natural Language Processing*, pages 2289–2294, Austin, Texas. Association for Computational Linguistics.
- Mikel Artetxe, Gorka Labaka, Eneko Agirre, and Kyunghyun Cho. 2018. Unsupervised neural machine translation. In *Proceedings of International Conference on Learning Representations*, Vancouver, BC, Canada.
- Mikel Artetxe and Holger Schwenk. 2019. Massively multilingual sentence embeddings for zero-shot cross-lingual transfer and beyond. *Transactions of the Association for Computational Linguistics*, 7:597–610.

- Dzmitry Bahdanau, Kyunghyun Cho, and Yoshua Bengio. 2015. Neural machine translation by jointly learning to align and translate. In *3rd International Conference on Learning Representations, ICLR 2015, San Diego, CA, USA, May 7-9, 2015, Conference Track Proceedings*.
- Laura Banarescu, Claire Bonial, Shu Cai, Madalina Georgescu, Kira Griffitt, Ulf Hermjakob, Kevin Knight, Philipp Koehn, Martha Palmer, and Nathan Schneider. 2013. Abstract meaning representation for sembanking. In *Proceedings of the 7th Linguistic Annotation Workshop and Interoperability with Discourse*, pages 178–186, Sofia, Bulgaria. Association for Computational Linguistics.
- Tamali Banerjee, Anoop Kunchukuttan, and Pushpak Bhattacharya. 2018. Multilingual Indian language translation system at WAT 2018: Many-to-one phrase-based SMT. In *Proceedings of the 32nd Pacific Asia Conference on Language, Information and Computation: 5th Workshop on Asian Translation: 5th Workshop on Asian Translation*, Hong Kong. Association for Computational Linguistics.
- Ankur Bapna and Orhan Firat. 2019. Simple, scalable adaptation for neural machine translation. In *Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing and the 9th International Joint Conference on Natural Language Processing (EMNLP-IJCNLP)*, pages 1538–1548, Hong Kong, China. Association for Computational Linguistics.
- Emmanuel Bengio, Pierre-Luc Bacon, Joelle Pineau, and Doina Precup. 2016. Conditional computation in neural networks for faster models. In *ICLR Workshop Track*.
- N. Bertoldi, M. Barbaiani, M. Federico, and R. Cattoni. 2008. Phrase-based statistical machine translation with pivot languages. In *Proceedings of the International Workshop on Spoken Language Translation*, pages 143–149, Hawaii.
- Graeme Blackwood, Miguel Ballesteros, and Todd Ward. 2018. Multilingual neural machine translation with task-specific attention. In *Proceedings of the 27th International Conference on Computational Linguistics*, pages 3112–3122, Santa Fe, New Mexico, USA. Association for Computational Linguistics.
- Ondřej Bojar, Christian Federmann, Mark Fishel, Yvette Graham, Barry Haddow, Philipp Koehn, and Christof Monz. 2018. Findings of the 2018 conference on machine translation (WMT18). In *Proceedings of the Third Conference on Machine Translation: Shared Task Papers*, pages 272–303, Belgium, Brussels. Association for Computational Linguistics.
- Ondřej Bojar, Rajen Chatterjee, Christian Federmann, Yvette Graham, Barry Haddow, Shujian Huang, Matthias Huck, Philipp Koehn, Qun Liu, Varvara Logacheva, Christof Monz, Matteo Negri, Matt Post, Raphael Rubino, Lucia Specia, and Marco Turchi. 2017. Findings of the 2017 conference on machine translation (WMT17). In *Proceedings of the Second Conference on Machine Translation*, pages 169–214, Copenhagen, Denmark. Association for Computational Linguistics.
- Mauro Cettolo, Marcello Federico, Luisa Bentivogli, Jan Niehues, Sebastian Stüker, Katsuhito Sudoh, Koichiro Yoshino, and Christian Federmann. 2017. Overview of the IWSLT 2017 evaluation campaign. In *Proceedings of the 14th International Workshop on Spoken Language Translation*, pages 2–14, Tokyo, Japan.
- Sarath Chandar, Stanislas Lauly, Hugo Larochelle, Mitesh Khapra, Balaraman Ravindran, Vikas C Raykar, and Amrita Saha. 2014. An autoencoder approach to learning bilingual word representations. In *Proceedings of the Advances in Neural Information Processing Systems*, pages 1853–1861, Montréal, Canada.
- Rajen Chatterjee, M. Amin Farajian, Matteo Negri, Marco Turchi, Ankit Srivastava, and Santanu Pal. 2017. Multi-source neural automatic post-editing: Fbk’s participation in the WMT 2017 ape shared task. In *Proceedings of the Second Conference on Machine Translation*, pages 630–638, Copenhagen, Denmark. Association for Computational Linguistics.
- Aditi Chaudhary, Siddharth Dalmia, Junjie Hu, Xinjian Li, Austin Matthews, Aldrian Obaja Muis, Naoki Otani, Shruti Rijhwani, Zaid Sheikh, Nidhi Vyas, Xinyi Wang, Jiateng Xie, Ruochen Xu, Chunting Zhou, Peter J. Jansen, Yiming Yang, Lori Levin, Florian Metze, Teruko Mitamura, David R. Mortensen, Graham Neubig, Eduard Hovy, Alan W Black, Jaime Carbonell, Graham V. Horwood, Shabnam Tafreshi, Mona Diab, Efsun S. Kayi, Noura Farra, and Kathleen McKeown. 2019. The ARIEL-CMU Systems for LoReHLT18. *CoRR*, abs/1902.08899.

- Xilun Chen, Ahmed Hassan Awadallah, Hany Hassan, Wei Wang, and Claire Cardie. 2019. Multi-source cross-lingual model transfer: Learning what to share. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, pages 3098–3112, Florence, Italy. Association for Computational Linguistics.
- Yun Chen, Yang Liu, Yong Cheng, and Victor O.K. Li. 2017. A teacher-student framework for zero-resource neural machine translation. In *Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 1925–1935, Vancouver, Canada. Association for Computational Linguistics.
- Yun Chen, Yang Liu, and Victor O. K. Li. 2018. Zero-resource neural machine translation with multi-agent communication game. In *Proceedings of the Thirty-Second AAAI Conference on Artificial Intelligence*, pages 5086–5093. AAAI Press.
- Yong Cheng, Yang Liu, Qian Yang, Maosong Sun, and Wei Xu. 2016. Neural machine translation with pivot languages. *CoRR*, abs/1611.04928.
- Yong Cheng, Qian Yang, Yang Liu, Maosong Sun, and Wei Xu. 2017. Joint training for pivot-based neural machine translation. In *Proceedings of the Twenty-Sixth International Joint Conference on Artificial Intelligence, IJCAI-17*, pages 3974–3980, Melbourne.
- Kyunghyun Cho, Bart van Merriënboer, Dzmitry Bahdanau, and Yoshua Bengio. 2014a. On the properties of neural machine translation: Encoder–decoder approaches. In *Proceedings of SSST-8, Eighth Workshop on Syntax, Semantics and Structure in Statistical Translation*, pages 103–111, Doha, Qatar. Association for Computational Linguistics.
- Kyunghyun Cho, Bart van Merriënboer, Çağlar Gülçehre, Dzmitry Bahdanau, Fethi Bougares, Holger Schwenk, and Yoshua Bengio. 2014b. Learning phrase representations using rnn encoder–decoder for statistical machine translation. In *Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP)*, pages 1724–1734, Doha, Qatar. Association for Computational Linguistics.
- Gyu Hyeon Choi, Jong Hun Shin, and Young Kil Kim. 2018. Improving a multi-source neural machine translation model with corpus extension for low-resource languages. In *Proceedings of the Eleventh International Conference on Language Resources and Evaluation (LREC-2018)*, pages 900–904, Miyazaki, Japan. European Language Resource Association.
- Christos Christodouloupoulos and Mark Steedman. 2015. A massively parallel corpus: the Bible in 100 languages. *Language Resources and Evaluation*, 49:375–395.
- Chenhui Chu and Raj Dabre. 2018. Multilingual and multi-domain adaptation for neural machine translation. In *Proceedings of the 24th Annual Meeting of the Association for Natural Language Processing (NLP 2018)*, pages 909–912, Okayama, Japan.
- Chenhui Chu and Raj Dabre. 2019. Multilingual multi-domain adaptation approaches for neural machine translation. *CoRR*, abs/1906.07978.
- Chenhui Chu, Raj Dabre, and Sadao Kurohashi. 2017. An empirical comparison of domain adaptation methods for neural machine translation. In *Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics (Volume 2: Short Papers)*, pages 385–391, Vancouver, Canada. Association for Computational Linguistics.
- Chenhui Chu and Rui Wang. 2018. A survey of domain adaptation for neural machine translation. In *Proceedings of the 27th International Conference on Computational Linguistics*, pages 1304–1319, Santa Fe, New Mexico, USA. Association for Computational Linguistics.
- Hyung Won Chung, Dan Garrette, Kiat Chuan Tan, and Jason Riesa. 2020. Improving multilingual models with language-clustered vocabularies. In *Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing (EMNLP)*, pages 4536–4546, Online. Association for Computational Linguistics.
- Michael Collins, Philipp Koehn, and Ivona Kučerová. 2005a. Clause restructuring for statistical machine translation. In *Proceedings of the 43rd Annual Meeting of the Association for Computational Linguistics (ACL’05)*, pages 531–540, Ann Arbor, Michigan. Association for Computational Linguistics.

- Michael Collins, Philipp Koehn, and Ivona Kučerová. 2005b. Clause restructuring for statistical machine translation. In *Annual meeting on Association for Computational Linguistics*.
- Alexis CONNEAU and Guillaume Lample. 2019. Cross-lingual language model pretraining. In H. Wallach, H. Larochelle, A. Beygelzimer, F. d'Alché-Buc, E. Fox, and R. Garnett, editors, *Advances in Neural Information Processing Systems 32*, pages 7059–7069. Curran Associates, Inc.
- Alexis Conneau, Guillaume Lample, Marc'Aurelio Ranzato, Ludovic Denoyer, and Hervé Jégou. 2018a. Word translation without parallel data. In *Proceedings of the International Conference on Learning Representations*, Vancouver, BC, Canada. URL: <https://github.com/facebookresearch/MUSE>.
- Alexis Conneau, Rutu Rinott, Guillaume Lample, Adina Williams, Samuel Bowman, Holger Schwenk, and Veselin Stoyanov. 2018b. XNLI: Evaluating cross-lingual sentence representations. In *Proceedings of the 2018 Conference on Empirical Methods in Natural Language Processing*, pages 2475–2485, Brussels, Belgium. Association for Computational Linguistics.
- Marta R. Costa-Jussà, Noé Casas, Carlos Escolano, and José A. R. Fonollosa. 2019. Chinese-catalan: A neural machine translation approach based on pivoting and attention mechanisms. *ACM Trans. Asian Low-Resour. Lang. Inf. Process.*, 18(4):43:1–43:8.
- Anna Currey and Kenneth Heafield. 2019. Zero-resource neural machine translation with monolingual pivot data. In *Proceedings of the 3rd Workshop on Neural Generation and Translation*, pages 99–107, Hong Kong. Association for Computational Linguistics.
- Raj Dabre, Fabien Cromieres, and Sadao Kurohashi. 2017a. Enabling multi-source neural machine translation by concatenating source sentences in multiple languages. In *Proceedings of MT Summit XVI, vol.1: Research Track*, pages 96–106, Nagoya, Japan.
- Raj Dabre, Fabien Cromieres, Sadao Kurohashi, and Pushpak Bhattacharyya. 2015. Leveraging small multilingual corpora for SMT using many pivot languages. In *Proceedings of the 2015 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies*, pages 1192–1202, Denver, Colorado. Association for Computational Linguistics.
- Raj Dabre and Atsushi Fujita. 2019. Recurrent stacking of layers for compact neural machine translation models. *Proceedings of the AAAI Conference on Artificial Intelligence*, 33(01):6292–6299.
- Raj Dabre, Atsushi Fujita, and Chenhui Chu. 2019. Exploiting multilingualism through multistage fine-tuning for low-resource neural machine translation. In *Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing and the 9th International Joint Conference on Natural Language Processing (EMNLP-IJCNLP)*, pages 1410–1416, Hong Kong, China. Association for Computational Linguistics.
- Raj Dabre, Anoop Kunchukuttan, Atsushi Fujita, and Eiichiro Sumita. 2018. NICT's participation in WAT 2018: Approaches using multilingualism and recurrently stacked layers. In *Proceedings of the 5th Workshop on Asian Language Translation*, Hong Kong, China.
- Raj Dabre and Sadao Kurohashi. 2017. MMCR4NLP: Multilingual Multiway Corpora Repository for Natural Language Processing. *arXiv preprint arXiv:1710.01025*.
- Raj Dabre, Tetsuji Nakagawa, and Hideto Kazawa. 2017b. An empirical study of language relatedness for transfer learning in neural machine translation. In *Proceedings of the 31st Pacific Asia Conference on Language, Information and Computation*, pages 282–286. The National University (Philippines).
- Andrew M. Dai, Christopher Olah, and Quoc V. Le. 2014. Document embedding with paragraph vectors. In *NIPS Deep Learning Workshop*.
- Jacob Devlin, Ming-Wei Chang, Kenton Lee, and Kristina Toutanova. 2019. BERT: Pre-training of deep bidirectional transformers for language understanding. In *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, pages 4171–4186, Minneapolis, Minnesota. Association for Computational Linguistics.

- Mattia A. Di Gangi, Roldano Cattoni, Luisa Bentivogli, Matteo Negri, and Marco Turchi. 2019. MuST-C: a Multilingual Speech Translation Corpus. In *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, pages 2012–2017, Minneapolis, Minnesota. Association for Computational Linguistics.
- Daxiang Dong, Hua Wu, Wei He, Dianhai Yu, and Haifeng Wang. 2015. Multi-task learning for multiple language translation. 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 1723–1732, Beijing, China. Association for Computational Linguistics.
- Bonnie J. Dorr. 1987. UNITRAN: An Interlingua Approach to Machine Translation. In *Proceedings of the 6th Conference of the American Association of Artificial Intelligence*, Seattle.
- Kevin Duh, Graham Neubig, Katsuhito Sudoh, and Hajime Tsukada. 2013. Adaptation data selection using neural language models: Experiments in machine translation. In *Proceedings of the 51st Annual Meeting of the Association for Computational Linguistics (Volume 2: Short Papers)*, pages 678–683, Sofia, Bulgaria.
- Akiko Eriguchi, Melvin Johnson, Orhan Firat, Hideto Kazawa, and Wolfgang Macherey. 2018. Zero-shot cross-lingual classification using multilingual neural machine translation. *CoRR*, abs/1809.04686.
- Carlos Escolano, Marta R. Costa-jussà, and José A. R. Fonollosa. 2019. From bilingual to multilingual neural machine translation by incremental training. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*.
- Cristina España-Bonet, Ádám Csaba Varga, Alberto Barrón-Cedeño, and Josef van Genabith. 2017. An empirical analysis of nmt-derived interlingual embeddings and their use in parallel sentence identification. *IEEE Journal of Selected Topics in Signal Processing*, 11(8):1340–1350.
- Angela Fan, Shruti Bhosale, Holger Schwenk, Zhiyi Ma, Ahmed El-Kishky, Siddharth Goyal, Mandeep Baines, Onur Celebi, Guillaume Wenzek, Vishrav Chaudhary, Naman Goyal, Tom Birch, Vitaliy Liptchinsky, Sergey Edunov, Edouard Grave, Michael Auli, and Armand Joulin. 2020. Beyond English-Centric Multilingual Machine Translation. *arXiv preprint 2010.11125*.
- Chelsea Finn, Pieter Abbeel, and Sergey Levine. 2017. Model-agnostic meta-learning for fast adaptation of deep networks. In *Proceedings of the 34th International Conference on Machine Learning*, volume 70 of *Proceedings of Machine Learning Research*, pages 1126–1135, International Convention Centre, Sydney, Australia. PMLR.
- Orhan Firat, Kyunghyun Cho, and Yoshua Bengio. 2016a. Multi-way, multilingual neural machine translation with a shared attention mechanism. In *Proceedings of the 2016 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies*, pages 866–875, San Diego, California. Association for Computational Linguistics.
- Orhan Firat, Baskaran Sankaran, Yaser Al-Onaizan, Fatos T. Yarman Vural, and Kyunghyun Cho. 2016b. Zero-resource translation with multi-lingual neural machine translation. In *Proceedings of the 2016 Conference on Empirical Methods in Natural Language Processing*, pages 268–277, Austin, Texas. Association for Computational Linguistics.
- Markus Freitag and Orhan Firat. 2020. Complete Multilingual Neural Machine Translation. In *Conference on Machine Translation*.
- Yaroslav Ganin, Evgeniya Ustinova, Hana Ajakan, Pascal Germain, Hugo Larochelle, François Laviolette, Mario Marchand, and Victor Lempitsky. 2016. Domain-adversarial training of neural networks. *The Journal of Machine Learning Research*, 17(1):2096–2030.
- Luyu Gao, Xinyi Wang, and Graham Neubig. 2020. Improving target-side lexical transfer in multilingual neural machine translation. In *Findings of the Association for Computational Linguistics: EMNLP 2020*, pages 3560–3566, Online. Association for Computational Linguistics.
- Ekaterina Garmash and Christof Monz. 2016. Ensemble learning for multi-source neural machine translation. In *Proceedings of COLING 2016, the 26th International Conference on Computational Linguistics: Technical Papers*, pages 1409–1418, Osaka, Japan. The COLING 2016 Organizing Committee.

- Jonas Gehring, Michael Auli, David Grangier, Denis Yarats, and Yann N. Dauphin. 2017. Convolutional sequence to sequence learning. In *Proceedings of the 34th International Conference on Machine Learning*, volume 70 of *Proceedings of Machine Learning Research*, pages 1243–1252, International Convention Centre, Sydney, Australia. PMLR.
- Mozhdeh Gheini and Jonathan May. 2019. A Universal Parent Model for Low-Resource Neural Machine Translation Transfer. *CoRR*, abs/1909.06516.
- Adrià De Gispert and José B. Mariño. 2006. Catalan-English statistical machine translation without parallel corpus: bridging through Spanish. In *Proceedings of the 5th International Conference on Language Resources and Evaluation (LREC)*, pages 65–68, Genoa, Italy.
- Raymond G Gordon, Barbara F Grimes, et al. 2005. *Ethnologue: Languages of the world*, volume 15. SIL International Dallas, TX.
- Vikrant Goyal, Anoop Kunchukuttan, Rahul Kejriwal, Siddharth Jain, and Amit Bhagwat. 2020. Contact Relatedness can help improve multilingual NMT: Microsoft STCI-MT @ WMT20. In *Conference on Machine Translation*.
- Jiatao Gu, Hany Hassan, Jacob Devlin, and Victor O.K. Li. 2018a. Universal neural machine translation for extremely low resource languages. In *Proceedings of the 2018 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long Papers)*, pages 344–354, New Orleans, Louisiana. Association for Computational Linguistics.
- Jiatao Gu, Yong Wang, Yun Chen, Victor O. K. Li, and Kyunghyun Cho. 2018b. Meta-learning for low-resource neural machine translation. In *Proceedings of the 2018 Conference on Empirical Methods in Natural Language Processing*, pages 3622–3631, Brussels, Belgium. Association for Computational Linguistics.
- Jiatao Gu, Yong Wang, Kyunghyun Cho, and Victor O.K. Li. 2019. Improved zero-shot neural machine translation via ignoring spurious correlations. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, pages 1258–1268, Florence, Italy. Association for Computational Linguistics.
- Francisco Guzmán, Peng-Jen Chen, Myle Ott, Juan Pino, Guillaume Lample, Philipp Koehn, Vishrav Chaudhary, and Marc’Aurelio Ranzato. 2019. The FLORES evaluation datasets for low-resource machine translation: Nepali–English and Sinhala–English. In *Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing and the 9th International Joint Conference on Natural Language Processing (EMNLP-IJCNLP)*, pages 6098–6111, Hong Kong, China. Association for Computational Linguistics.
- Thanh-Le Ha, Jan Niehues, and Alexander H. Waibel. 2016. Toward multilingual neural machine translation with universal encoder and decoder. In *Proceedings of the 13th International Workshop on Spoken Language Translation*, pages 1–7, Seattle.
- Thanh-Le Ha, Jan Niehues, and Alexander H. Waibel. 2017. Effective strategies in zero-shot neural machine translation. In *Proceedings of the 14th International Workshop on Spoken Language Translation*, pages 105–112, Tokyo, Japan.
- Barry Haddow and Faheem Kirefu. 2020. PMIndia – A Collection of Parallel Corpora of Languages of India. *arxiv 2001.09907*.
- Di He, Yingce Xia, Tao Qin, Liwei Wang, Nenghai Yu, Tie-Yan Liu, and Wei-Ying Ma. 2016. Dual learning for machine translation. In *Proceedings of the 30th International Conference on Neural Information Processing Systems*, pages 1–9, Barcelona, Spain.
- Junxian He, Jiatao Gu, Jiajun Shen, and Marc’Aurelio Ranzato. 2020. Revisiting self-training for neural sequence generation. In *8th International Conference on Learning Representations, ICLR 2020, Addis Ababa, Ethiopia, April 26-30, 2020*. OpenReview.net.
- Carlos Henríquez, Marta R. Costa-jussá, Rafael E. Banchs, Lluís Formiga, and José B. Mariño. 2011. Pivot Strategies as an Alternative for Statistical Machine Translation Tasks Involving Iberian Languages. In *Proceedings of the Workshop on Iberian Cross-Language Natural Language Processing Tasks (ICL 2011)*, pages 22–27, Huelva, Spain.

- Geoffrey Hinton, Oriol Vinyals, and Jeff Dean. 2014. Distilling the knowledge in a neural network. In *NIPS 2014 Deep Learning Workshop*.
- Chris Hokamp, John Glover, and Demian Gholipour Ghalandari. 2019. Evaluating the supervised and zero-shot performance of multi-lingual translation models. In *Proceedings of the Fourth Conference on Machine Translation (Volume 2: Shared Task Papers, Day 1)*, pages 209–217, Florence, Italy. Association for Computational Linguistics.
- Yanping Huang, Yonglong Cheng, Dehao Chen, HyounJoong Lee, Jiquan Ngiam, Quoc V. Le, and Zhifeng Chen. 2019. Gpipe: Efficient training of giant neural networks using pipeline parallelism. In *NeurIPS*.
- Pratik Jawanpuria, Arjun Balgovind, Anoop Kunchukuttan, and Bamdev Mishra. 2019. Learning multilingual word embeddings in latent metric space: A geometric approach. *Transactions of the Association for Computational Linguistics*, 7:107–120.
- Sébastien Jean, Orhan Firat, and Melvin Johnson. 2019. Adaptive scheduling for multi-task learning. In *Continual Learning Workshop at NeurIPS 2018*.
- Girish Nath Jha. 2010. The TDIL program and the Indian language corpora initiative (ILCI). In *Proceedings of the Seventh conference on International Language Resources and Evaluation (LREC’10)*, Valletta, Malta. European Languages Resources Association (ELRA).
- Baijun Ji, Zhirui Zhang, Xiangyu Duan, Min Zhang, Boxing Chen, and Weihua Luo. 2020. Cross-lingual pre-training based transfer for zero-shot neural machine translation. In *Proceedings of the Thirty-Fourth AAAI Conference on Artificial Intelligence*.
- Melvin Johnson, Mike Schuster, Quoc V. Le, Maxim Krikun, Yonghui Wu, Zhifeng Chen, Nikhil Thorat, Fernanda Viégas, Martin Wattenberg, Greg Corrado, Macduff Hughes, and Jeffrey Dean. 2017. Google’s multilingual neural machine translation system: Enabling zero-shot translation. *Transactions of the Association for Computational Linguistics*, 5:339–351.
- Alina Karakanta, Jon Dehdari, and Josef van Genabith. 2018. Neural machine translation for low-resource languages without parallel corpora. *Machine Translation*, 32(1):167–189.
- Yoon Kim and Alexander M. Rush. 2016. Sequence-level knowledge distillation. In *Proceedings of the 2016 Conference on Empirical Methods in Natural Language Processing*, pages 1317–1327, Austin, Texas. Association for Computational Linguistics.
- Yunsu Kim, Yingbo Gao, and Hermann Ney. 2019a. Effective cross-lingual transfer of neural machine translation models without shared vocabularies. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*.
- Yunsu Kim, Petre Petrov, Pavel Petrushkov, Shahram Khadivi, and Hermann Ney. 2019b. Pivot-based transfer learning for neural machine translation between non-English languages. In *Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing and the 9th International Joint Conference on Natural Language Processing (EMNLP-IJCNLP)*, pages 866–876, Hong Kong, China. Association for Computational Linguistics.
- Eliyahu Kiperwasser and Miguel Ballesteros. 2018. Scheduled multi-task learning: From syntax to translation. *Transactions of the Association for Computational Linguistics*, 6:225–240.
- Ryan Kiros, Yukun Zhu, Ruslan R Salakhutdinov, Richard Zemel, Raquel Urtasun, Antonio Torralba, and Sanja Fidler. 2015. Skip-thought vectors. In *Proceedings of the Advances in neural information processing systems*, pages 3294–3302, Montréal, Canada.
- Alexandre Klementiev, Ivan Titov, and Binod Bhattarai. 2012. Inducing crosslingual distributed representations of words. In *Proceedings of COLING 2012*, pages 1459–1474, Mumbai, India. The COLING 2012 Organizing Committee.
- Tom Kocmi and Ondřej Bojar. 2018. Trivial transfer learning for low-resource neural machine translation. In *Proceedings of the Third Conference on Machine Translation, Volume 1: Research Papers*, pages 244–252, Belgium, Brussels. Association for Computational Linguistics.

- Philipp Koehn. 2005. Europarl: A Parallel Corpus for Statistical Machine Translation. In *Conference Proceedings: the tenth Machine Translation Summit*, pages 79–86, Phuket, Thailand. AAMT, AAMT.
- Philipp Koehn. 2017. Neural machine translation. *CoRR*, abs/1709.07809.
- Philipp Koehn, Hieu Hoang, Alexandra Birch, Chris Callison-Burch, Marcello Federico, Nicola Bertoldi, Brooke Cowan, Wade Shen, Christine Moran, Richard Zens, Chris Dyer, Ondrej Bojar, Alexandra Constantin, and Evan Herbst. 2007. Moses: Open source toolkit for statistical machine translation. In *Proceedings of the 45th Annual Meeting of the Association for Computational Linguistics Companion Volume Proceedings of the Demo and Poster Sessions*, pages 177–180, Prague, Czech Republic. Association for Computational Linguistics.
- Philipp Koehn and Rebecca Knowles. 2017. Six challenges for neural machine translation. In *Proceedings of the First Workshop on Neural Machine Translation*, pages 28–39, Vancouver. Association for Computational Linguistics.
- Philipp Koehn, Franz J. Och, and Daniel Marcu. 2003. Statistical phrase-based translation. In *Proceedings of the 2003 Human Language Technology Conference of the North American Chapter of the Association for Computational Linguistics*, pages 127–133.
- Taku Kudo and John Richardson. 2018. SentencePiece: A simple and language independent subword tokenizer and detokenizer for neural text processing. In *Proceedings of the 2018 Conference on Empirical Methods in Natural Language Processing: System Demonstrations*, pages 66–71, Brussels, Belgium. Association for Computational Linguistics.
- Sneha Kudugunta, Ankur Bapna, Isaac Caswell, and Orhan Firat. 2019. Investigating multilingual NMT representations at scale. In *Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing and the 9th International Joint Conference on Natural Language Processing (EMNLP-IJCNLP)*, pages 1565–1575, Hong Kong, China. Association for Computational Linguistics.
- Anoop Kunchukuttan. 2020a. IndoWordnet Parallel Corpus. [https://github.com/anoopkunchukuttan/indowordnet\\_parallel](https://github.com/anoopkunchukuttan/indowordnet_parallel).
- Anoop Kunchukuttan. 2020b. The IndicNLP Library. [https://github.com/anoopkunchukuttan/indic\\_nlp\\_library/blob/master/docs/indicnlp.pdf](https://github.com/anoopkunchukuttan/indic_nlp_library/blob/master/docs/indicnlp.pdf).
- Anoop Kunchukuttan and Pushpak Bhattacharyya. 2016. Orthographic syllable as basic unit for SMT between related languages. In *Proceedings of the 2016 Conference on Empirical Methods in Natural Language Processing*, pages 1912–1917, Austin, Texas. Association for Computational Linguistics.
- Anoop Kunchukuttan and Pushpak Bhattacharyya. 2017. Learning variable length units for SMT between related languages via byte pair encoding. In *Proceedings of the First Workshop on Subword and Character Level Models in NLP*, pages 14–24, Copenhagen, Denmark. Association for Computational Linguistics.
- Anoop Kunchukuttan and Pushpak Bhattacharyya. 2020. Utilizing Language Relatedness to improve Machine Translation: A Case Study on Languages of the Indian Subcontinent. *arXiv preprint arXiv:2003.08925*.
- Anoop Kunchukuttan, Abhijit Mishra, Rajen Chatterjee, Ritesh Shah, and Pushpak Bhattacharyya. 2014. Shatanuvadak: Tackling multiway translation of Indian languages. In *Proceedings of the Ninth International Conference on Language Resources and Evaluation (LREC’14)*, pages 1781–1787, Reykjavik, Iceland. European Language Resources Association (ELRA).
- Anoop Kunchukuttan, Maulik Shah, Pradyot Prakash, and Pushpak Bhattacharyya. 2017. Utilizing lexical similarity between related, low-resource languages for pivot-based smt. In *Proceedings of the Eighth International Joint Conference on Natural Language Processing (Volume 2: Short Papers)*, pages 283–289, Taipei, Taiwan. Asian Federation of Natural Language Processing.
- Surafel M. Lakew, Mattia A. Di Gangi, and Marcello Federico. 2017a. Multilingual neural machine translation for low resource languages. In *Proceedings of the 4th Italian Conference on Computational Linguistics (CLIC-IT)*, pages 1–6, Rome, Italy.
- Surafel Melaku Lakew, Mauro Cettolo, and Marcello Federico. 2018a. A comparison of transformer and recurrent neural networks on multilingual neural machine translation. In *Proceedings of the 27th International Conference on Computational Linguistics*, pages 641–652, Santa Fe, New Mexico, USA. Association for Computational Linguistics.



- Surafel Melaku Lakew, Aliia Erofeeva, and Marcello Federico. 2018b. Neural machine translation into language varieties. In *Proceedings of the Third Conference on Machine Translation: Research Papers*, pages 156–164, Belgium, Brussels. Association for Computational Linguistics.
- Surafel Melaku Lakew, Aliia Erofeeva, Matteo Negri, Marcello Federico, and Marco Turchi. 2018c. Transfer learning in multilingual neural machine translation with dynamic vocabulary. In *Proceedings of the 15th International Workshop on Spoken Language Translation (IWSLT)*, pages 54–61.
- Surafel Melaku Lakew, Quintino F. Lotito, Matteo Negri, Marco Turchi, and Marcello Federico. 2017b. Improving zero-shot translation of low-resource languages. In *Proceedings of the 14th International Workshop on Spoken Language Translation*, pages 113–119, Tokyo, Japan.
- Guillaume Lample, Alexis Conneau, Ludovic Denoyer, and Marc’Aurelio Ranzato. 2018. Unsupervised machine translation using monolingual corpora only. In *Proceedings of International Conference on Learning Representations*, Vancouver, BC, Canada.
- Quoc Le and Tomas Mikolov. 2014. Distributed representations of sentences and documents. In *Proceedings of the 31st International conference on machine learning*, pages 1188–1196, Beijing, China.
- Jason Lee, Kyunghyun Cho, and Thomas Hofmann. 2017. Fully character-level neural machine translation without explicit segmentation. *Transactions of the Association for Computational Linguistics*, 5:365–378.
- Yichong Leng, Xu Tan, Tao Qin, Xiang-Yang Li, and Tie-Yan Liu. 2019. Unsupervised pivot translation for distant languages. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, pages 175–183, Florence, Italy. Association for Computational Linguistics.
- Yinhan Liu, Jiatao Gu, Naman Goyal, Xian Li, Sergey Edunov, Marjan Ghazvininejad, Mike Lewis, and Luke Zettlemoyer. 2020. Multilingual denoising pre-training for neural machine translation. *arXiv preprint 2001.08210*.
- Yichao Lu, Phillip Keung, Faisal Ladhak, Vikas Bhardwaj, Shaonan Zhang, and Jason Sun. 2018. A neural interlingua for multilingual machine translation. In *Proceedings of the Third Conference on Machine Translation: Research Papers*, pages 84–92, Belgium, Brussels. Association for Computational Linguistics.
- Minh-Thang Luong, Quoc V. Le, Ilya Sutskever, Oriol Vinyals, and Lukasz Kaiser. 2016. Multi-task sequence to sequence learning. In *Proceedings of International Conference on Learning Representations*.
- Sungwon Lyu, Bokyung Son, Kichang Yang, and Jaekyoung Bae. 2020. Revisiting Modularized Multilingual NMT to Meet Industrial Demands. In *Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing (EMNLP)*, pages 5905–5918, Online. Association for Computational Linguistics.
- Mieradilijiang Maimaiti, Yang Liu, Huanbo Luan, and Maosong Sun. 2019. Multi-round transfer learning for low-resource nmt using multiple high-resource languages. *ACM Trans. Asian Low-Resour. Lang. Inf. Process.*, 18(4):38:1–38:26.
- Chaitanya Malaviya, Graham Neubig, and Patrick Littell. 2017. Learning language representations for typology prediction. In *Proceedings of the 2017 Conference on Empirical Methods in Natural Language Processing*, pages 2529–2535, Copenhagen, Denmark. Association for Computational Linguistics.
- Giulia Mattoni, Pat Nagle, Carlos Collantes, and Dimitar Shterionov. 2017. Zero-shot translation for indian languages with sparse data. In *Proceedings of MT Summit XVI, Vol.2: Users and Translators Track*, pages 1–10, Nagoya, Japan.
- Evgeny Matusov, Nicola Ueffing, and Hermann Ney. 2006. Computing consensus translation for multiple machine translation systems using enhanced hypothesis alignment. In *11th Conference of the European Chapter of the Association for Computational Linguistics*, pages 33–40.
- Cettolo Mauro, Girardi Christian, and Federico Marcello. 2012. Wit3: Web inventory of transcribed and translated talks. In *Proceedings of the 16th Conference of European Association for Machine Translation*, pages 261–268, Trento, Italy.
- Tomas Mikolov, Quoc V. Le, and Ilya Sutskever. 2013. Exploiting similarities among languages for machine translation. *CoRR*, abs/1309.4168.

- Rohit More, Anoop Kunchukuttan, Pushpak Bhattacharyya, and Raj Dabre. 2015. Augmenting pivot based SMT with word segmentation. In *Proceedings of the 12th International Conference on Natural Language Processing*, pages 303–307, Trivandrum, India. NLP Association of India.
- Rudra Murthy, Anoop Kunchukuttan, and Pushpak Bhattacharyya. 2019. Addressing word-order divergence in multilingual neural machine translation for extremely low resource languages. In *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, pages 3868–3873, Minneapolis, Minnesota. Association for Computational Linguistics.
- Toshiaki Nakazawa, Shohei Higashiyama, Chenchen Ding, Raj Dabre, Anoop Kunchukuttan, Win Pa Pa, Isao Goto, Hideya Mino, Katsuhito Sudoh, and Sadao Kurohashi. 2018. Overview of the 5th workshop on asian translation. In *Proceedings of the 5th Workshop on Asian Translation (WAT2018)*, pages 1–41, Hong Kong, China.
- Toshiaki Nakazawa, Shohei Higashiyama, Chenchen Ding, Hideya Mino, Isao Goto, Hideto Kazawa, Yusuke Oda, Graham Neubig, and Sadao Kurohashi. 2017. Overview of the 4th workshop on Asian translation. In *Proceedings of the 4th Workshop on Asian Translation (WAT2017)*, pages 1–54, Taipei, Taiwan. Asian Federation of Natural Language Processing.
- Preslav Nakov and Hwee Tou Ng. 2009. Improved statistical machine translation for resource-poor languages using related resource-rich languages. In *Proceedings of the 2009 Conference on Empirical Methods in Natural Language Processing*, pages 1358–1367, Singapore. Association for Computational Linguistics.
- Preslav Nakov and Jörg Tiedemann. 2012. Combining word-level and character-level models for machine translation between closely-related languages. In *Proceedings of the 50th Annual Meeting of the Association for Computational Linguistics (Volume 2: Short Papers)*, pages 301–305, Jeju Island, Korea. Association for Computational Linguistics.
- Graham Neubig. 2017. Neural machine translation and sequence-to-sequence models: A tutorial. *CoRR*, abs/1703.01619.
- Graham Neubig and Junjie Hu. 2018. Rapid adaptation of neural machine translation to new languages. In *Proceedings of the 2018 Conference on Empirical Methods in Natural Language Processing*, pages 875–880, Brussels, Belgium. Association for Computational Linguistics.
- Toan Q. Nguyen and David Chiang. 2017. Transfer learning across low-resource, related languages for neural machine translation. In *Proceedings of the Eighth International Joint Conference on Natural Language Processing (Volume 2: Short Papers)*, pages 296–301, Taipei, Taiwan. Asian Federation of Natural Language Processing.
- Yuta Nishimura, Katsuhito Sudoh, Graham Neubig, and Satoshi Nakamura. 2018a. Multi-source neural machine translation with data augmentation. In *Proceedings of the 15th International Workshop on Spoken Language Translation (IWSLT)*, pages 48–53, Brussels, Belgium.
- Yuta Nishimura, Katsuhito Sudoh, Graham Neubig, and Satoshi Nakamura. 2018b. Multi-source neural machine translation with missing data. In *Proceedings of the 2nd Workshop on Neural Machine Translation and Generation*, pages 92–99, Melbourne, Australia. Association for Computational Linguistics.
- Xing Niu, Michael Denkowski, and Marine Carpuat. 2018. Bi-directional neural machine translation with synthetic parallel data. In *Proceedings of the 2nd Workshop on Neural Machine Translation and Generation*, pages 84–91, Melbourne, Australia. Association for Computational Linguistics.
- Eric Nyberg, Teruko Mitamura, and Jaime Carbonell. 1997. The KANT Machine Translation System: From R&D to Initial Deployment. In *Proceedings of LISA Workshop on Integrating Advanced Translation Technology*, pages 1–7, Washington, D.C.
- Franz Josef Och and Hermann Ney. 2001. Statistical multi-source translation. In *Proceedings of MT Summit*, volume 8, pages 253–258.
- Arturo Oncevay, Barry Haddow, and Alexandra Birch. 2020. Bridging linguistic typology and multilingual machine translation with multi-view language representations. In *Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing (EMNLP)*, pages 2391–2406, Online. Association for Computational Linguistics.

- Robert Östling and Jörg Tiedemann. 2017. Continuous multilinguality with language vectors. In *Proceedings of the 15th Conference of the European Chapter of the Association for Computational Linguistics: Volume 2, Short Papers*, pages 644–649, Valencia, Spain. Association for Computational Linguistics.
- Sinno Jialin Pan and Qiang Yang. 2010. A survey on transfer learning. *IEEE Transactions on Knowledge and Data Engineering*, 22(10):1345–1359.
- Ngoc-Quan Pham, Jan Niehues, Thanh-Le Ha, and Alexander Waibel. 2019. Improving zero-shot translation with language-independent constraints. In *Proceedings of the Fourth Conference on Machine Translation (Volume 1: Research Papers)*, pages 13–23, Florence, Italy. Association for Computational Linguistics.
- Telmo Pires, Eva Schlinger, and Dan Garrette. 2019. How multilingual is multilingual BERT? In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, pages 4996–5001, Florence, Italy. Association for Computational Linguistics.
- Emmanouil Antonios Platanios, Mrinmaya Sachan, Graham Neubig, and Tom Mitchell. 2018. Contextual parameter generation for universal neural machine translation. In *Proceedings of the 2018 Conference on Empirical Methods in Natural Language Processing*, pages 425–435, Brussels, Belgium. Association for Computational Linguistics.
- Matt Post, Chris Callison-Burch, and Miles Osborne. 2012. Constructing parallel corpora for six indian languages via crowdsourcing. In *Proceedings of the Seventh Workshop on Statistical Machine Translation*, pages 401–409. Association for Computational Linguistics.
- Raj Noel Dabre Prasanna. 2018. *Exploiting Multilingualism and Transfer Learning for Low Resource Machine Translation*. Ph.D. thesis, Kyoto University.
- Maithra Raghu, Justin Gilmer, Jason Yosinski, and Jascha Sohl-Dickstein. 2017. Svcca: Singular vector canonical correlation analysis for deep learning dynamics and interpretability. In I. Guyon, U. V. Luxburg, S. Bengio, H. Wallach, R. Fergus, S. Vishwanathan, and R. Garnett, editors, *Advances in Neural Information Processing Systems 30*, pages 6076–6085. Curran Associates, Inc.
- Prajit Ramachandran, Peter Liu, and Quoc Le. 2017. Unsupervised pretraining for sequence to sequence learning. In *Proceedings of the 2017 Conference on Empirical Methods in Natural Language Processing*, pages 383–391, Copenhagen, Denmark. Association for Computational Linguistics.
- Ananthakrishnan Ramanathan, Jayprasad Hegde, Ritesh Shah, Pushpak Bhattacharyya, and M. Sasikumar. 2008. Simple Syntactic and Morphological Processing Can Help English-Hindi Statistical Machine Translation. In *International Joint Conference on Natural Language Processing*.
- Shuo Ren, Wenhui Chen, Shujie Liu, Mu Li, Ming Zhou, and Shuai Ma. 2018. Triangular architecture for rare language translation. In *Proceedings of the 56th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 56–65, Melbourne, Australia. Association for Computational Linguistics.
- Matīss Rikters, Mārcis Pinnis, and Rihards Krišlauks. 2018. Training and Adapting Multilingual NMT for Less-resourced and Morphologically Rich Languages. In *Proceedings of the Eleventh International Conference on Language Resources and Evaluation (LREC 2018)*, pages 3766–3773, Miyazaki, Japan. European Language Resources Association (ELRA).
- Annette Rios, Mathias Müller, and Rico Sennrich. 2020. Subword Segmentation and a Single Bridge Language Affect Zero-Shot Neural Machine Translation. In *Conference on Machine Translation*.
- Roberts Rozis and Raivis Skadiņš. 2017. Tilde MODEL - multilingual open data for EU languages. In *Proceedings of the 21st Nordic Conference on Computational Linguistics*, pages 263–265, Gothenburg, Sweden. Association for Computational Linguistics.
- Sebastian Ruder. 2016. An overview of gradient descent optimization algorithms. *CoRR*, abs/1609.04747.
- Sebastian Ruder, Ivan Vulić, and Anders Søgaard. 2017. A survey of cross-lingual embedding models. *Journal of Artificial Intelligence Research*.
- Devendra Sachan and Graham Neubig. 2018. Parameter sharing methods for multilingual self-attentional translation models. In *Proceedings of the Third Conference on Machine Translation: Research Papers*, pages 261–271, Belgium, Brussels. Association for Computational Linguistics.

- Amrita Saha, Mitesh M. Khapra, Sarath Chandar, Janarthanan Rajendran, and Kyunghyun Cho. 2016a. A correlational encoder decoder architecture for pivot based sequence generation. In *Proceedings of COLING 2016, the 26th International Conference on Computational Linguistics: Technical Papers*, pages 109–118, Osaka, Japan. The COLING 2016 Organizing Committee.
- Amrita Saha, Mitesh M. Khapra, Sarath Chandar, Janarthanan Rajendran, and Kyunghyun Cho. 2016b. A correlational encoder decoder architecture for pivot based sequence generation. In *COLING 2016, 26th International Conference on Computational Linguistics, Proceedings of the Conference: Technical Papers, December 11-16, 2016, Osaka, Japan*, pages 109–118.
- Peter H Schönemann. 1966. A generalized solution of the orthogonal procrustes problem. *Psychometrika*, 31(1):1–10.
- Josh Schroeder, Trevor Cohn, and Philipp Koehn. 2009. Word lattices for multi-source translation. In *Proceedings of the 12th Conference of the European Chapter of the ACL (EACL 2009)*, pages 719–727, Athens, Greece. Association for Computational Linguistics.
- Mike Schuster and Kaisuke Nakajima. 2012. Japanese and korean voice search. In *ICASSP*, pages 5149–5152. IEEE.
- Holger Schwenk, Vishrav Chaudhary, Shuo Sun, Hongyu Gong, and Francisco Guzmán. 2019. Wikimatrix: Mining 135m parallel sentences in 1620 language pairs from wikipedia. *CoRR*, abs/1907.05791.
- Sukanta Sen, Kamal Kumar Gupta, Asif Ekbal, and Pushpak Bhattacharyya. 2019. Multilingual unsupervised nmt using shared encoder and language-specific decoders. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*.
- Rico Sennrich, Barry Haddow, and Alexandra Birch. 2016a. Improving neural machine translation models with monolingual data. In *Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 86–96, Berlin, Germany. Association for Computational Linguistics.
- Rico Sennrich, Barry Haddow, and Alexandra Birch. 2016b. Neural machine translation of rare words with subword units. In *Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 1715–1725, Berlin, Germany. Association for Computational Linguistics.
- Lierni Sestorain, Massimiliano Ciaramita, Christian Buck, and Thomas Hofmann. 2018. Zero-shot dual machine translation. *CoRR*, abs/1805.10338.
- Petr Sgall and Jarmila Panevová. 1987. Machine translation, linguistics, and interlingua. In *Proceedings of the Third Conference on European Chapter of the Association for Computational Linguistics*, EACL ’87, pages 99–103, Copenhagen, Denmark. Association for Computational Linguistics.
- Itamar Shatz. 2016. Native language influence during second language acquisition: A large-scale learner corpus analysis. In *Proceedings of the Pacific Second Language Research Forum (PacSLRF 2016)*, pages 175–180.
- Noam Shazeer and Mitchell Stern. 2018. Adafactor: Adaptive learning rates with sublinear memory cost. In *Proceedings of the 35th International Conference on Machine Learning, ICML 2018, Stockholmsmässan, Stockholm, Sweden, July 10-15, 2018*, volume 80 of *Proceedings of Machine Learning Research*, pages 4603–4611. PMLR.
- Aditya Siddhant, Melvin Johnson, Henry Tsai, Naveen Arivazhagan, Jason Riesa, Ankur Bapna, Orhan Firat, and Karthik Raman. 2020. Evaluating the cross-lingual effectiveness of massively multilingual neural machine translation. In *AAAI*.
- Shashank Siripragada, Jerin Philip, Vinay P. Namboodiri, and C V Jawahar. 2020. A multilingual parallel corpora collection effort for Indian languages. In *Proceedings of The 12th Language Resources and Evaluation Conference*, pages 3743–3751, Marseille, France. European Language Resources Association.
- Samuel L. Smith, David H. P. Turban, Steven Hamblin, and Nils Y. Hammerla. 2017. Offline bilingual word vectors, orthogonal transformations and the inverted softmax. In *ICLR*.
- Anders Søgaard, Sebastian Ruder, and Ivan Vulić. 2018. On the limitations of unsupervised bilingual dictionary induction. In *Proceedings of the 56th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 778–788, Melbourne, Australia. Association for Computational Linguistics.

- Bokyoung Son and Sungwon Lyu. 2020. Sparse and decorrelated representations for stable zero-shot NMT. In *Findings of the Association for Computational Linguistics: EMNLP 2020*, pages 2260–2266, Online. Association for Computational Linguistics.
- Kai Song, Yue Zhang, Heng Yu, Weihua Luo, Kun Wang, and Min Zhang. 2019. Code-switching for enhancing NMT with pre-specified translation. In *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, pages 449–459, Minneapolis, Minnesota. Association for Computational Linguistics.
- Ralf Steinberger, Mohamed Ebrahim, Alexandros Poulis, Manuel Carrasco-Benitez, Patrick Schlüter, Marek Przybylski, and Signe Gilbro. 2014. An overview of the European Union’s highly multilingual parallel corpora. *Language Resources and Evaluation*, 48(4):679–707.
- Ralf Steinberger, Andreas Eisele, Szymon Kloczek, Spyridon Pilos, and Patrick Schlüter. 2012. DGT-TM: A freely available translation memory in 22 languages. In *Proceedings of the Eighth International Conference on Language Resources and Evaluation (LREC-2012)*, pages 454–459, Istanbul, Turkey. European Language Resources Association (ELRA).
- Ilya Sutskever, Oriol Vinyals, and Quoc V. Le. 2014. Sequence to sequence learning with neural networks. In *Proceedings of the 27th International Conference on Neural Information Processing Systems, NIPS’14*, pages 3104–3112, Montreal, Canada. MIT Press.
- Xu Tan, Jiale Chen, Di He, Yingce Xia, Tao Qin, and Tie-Yan Liu. 2019a. Multilingual neural machine translation with language clustering. In *Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing and the 9th International Joint Conference on Natural Language Processing (EMNLP-IJCNLP)*, pages 963–973, Hong Kong, China. Association for Computational Linguistics.
- Xu Tan, Yichong Leng, Jiale Chen, Yi Ren, Tao Qin, and Tie-Yan Liu. 2019b. A study of multilingual neural machine translation. *CoRR*, abs/1912.11625.
- Xu Tan, Yi Ren, Di He, Tao Qin, and Tie-Yan Liu. 2019c. Multilingual neural machine translation with knowledge distillation. In *International Conference on Learning Representations (ICLR)*, New Orleans, LA, USA.
- Brian Thompson, Jeremy Gwinnup, Huda Khayrallah, Kevin Duh, and Philipp Koehn. 2019. Overcoming catastrophic forgetting during domain adaptation of neural machine translation. In *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, pages 2062–2068, Minneapolis, Minnesota. Association for Computational Linguistics.
- Ye Kyaw Thu, Win Pa Pa, Masao Utiyama, Andrew M Finch, and Eiichiro Sumita. 2016. Introducing the asian language treebank (ALT). In *Proceedings of the Tenth International Conference on Language Resources and Evaluation (LREC 2016)*, pages 1574–1578, Portorož, Slovenia. European Language Resources Association (ELRA).
- Jörg Tiedemann. 2012a. Character-based pivot translation for under-resourced languages and domains. In *Proceedings of the 13th Conference of the European Chapter of the Association for Computational Linguistics*, pages 141–151, Avignon, France. Association for Computational Linguistics.
- Jörg Tiedemann. 2012b. Parallel data, tools and interfaces in OPUS. In *Proceedings of the Eighth International Conference on Language Resources and Evaluation (LREC’12)*, pages 2214–2218, Istanbul, Turkey. European Language Resources Association (ELRA).
- Nikolai Trubetzkoy. 1928. Proposition 16. In *Actes du premier congrès international des linguistes à La Haye*.
- Hiroshi Uchida. 1996. UNL: Universal Networking Language – An Electronic Language for Communication, Understanding, and Collaboration. In *UNU/IAS/UNL Center*.
- Masao Utiyama and Hitoshi Isahara. 2007. A comparison of pivot methods for phrase-based statistical machine translation. In *Human Language Technologies 2007: The Conference of the North American Chapter of the Association for Computational Linguistics; Proceedings of the Main Conference*, pages 484–491, Rochester, New York. Association for Computational Linguistics.

- Ashish Vaswani, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N Gomez, Łukasz Kaiser, and Illia Polosukhin. 2017. Attention is all you need. In I. Guyon, U. V. Luxburg, S. Bengio, H. Wallach, R. Fergus, S. Vishwanathan, and R. Garnett, editors, *Proceedings of the Advances in Neural Information Processing Systems 30*, pages 5998–6008. Curran Associates, Inc.
- Raúl Vázquez, Alessandro Raganato, Mathias Creutz, and Jörg Tiedemann. 2020. A systematic study of inner-attention-based sentence representations in multilingual neural machine translation. *Comput. Linguist.*, 46(2):387–424.
- Raúl Vázquez, Alessandro Raganato, Jörg Tiedemann, and Mathias Creutz. 2018. Multilingual NMT with a language-independent attention bridge. *CoRR*, abs/1811.00498.
- David Vilar, Jan-Thorsten Peter, and Hermann Ney. 2007. Can we translate letters? In *Proceedings of the Second Workshop on Statistical Machine Translation*, pages 33–39, Prague, Czech Republic. Association for Computational Linguistics.
- Karthik Visweswariah, Rajakrishnan Rajkumar, Ankur Gandhe, Ananthakrishnan Ramanathan, and Jiri Navratil. 2011. A word reordering model for improved machine translation. In *Proceedings of the 2011 Conference on Empirical Methods in Natural Language Processing*, pages 486–496, Edinburgh, Scotland, UK. Association for Computational Linguistics.
- Rui Wang, Andrew Finch, Masao Utiyama, and Eiichiro Sumita. 2017a. Sentence embedding for neural machine translation domain adaptation. In *Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics (Volume 2: Short Papers)*, pages 560–566, Vancouver, Canada. Association for Computational Linguistics.
- Rui Wang, Masao Utiyama, Lemao Liu, Kehai Chen, and Eiichiro Sumita. 2017b. Instance weighting for neural machine translation domain adaptation. In *Proceedings of the 2017 Conference on Empirical Methods in Natural Language Processing*, pages 1482–1488, Copenhagen, Denmark. Association for Computational Linguistics.
- Rui Wang, Masao Utiyama, Lemao Liu, Kehai Chen, and Eiichiro Sumita. 2017c. Instance weighting for neural machine translation domain adaptation. In *Proceedings of the 2017 Conference on Empirical Methods in Natural Language Processing*, pages 1482–1488, Copenhagen, Denmark. Association for Computational Linguistics.
- Xinyi Wang and Graham Neubig. 2019. Target conditioned sampling: Optimizing data selection for multilingual neural machine translation. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, pages 5823–5828, Florence, Italy. Association for Computational Linguistics.
- Xinyi Wang, Hieu Pham, Philip Arthur, and Graham Neubig. 2019a. Multilingual neural machine translation with soft decoupled encoding. In *International Conference on Learning Representations (ICLR)*, New Orleans, LA, USA.
- Yining Wang, Jiajun Zhang, Feifei Zhai, Jingfang Xu, and Chengqing Zong. 2018. Three strategies to improve one-to-many multilingual translation. In *Proceedings of the 2018 Conference on Empirical Methods in Natural Language Processing*, pages 2955–2960, Brussels, Belgium. Association for Computational Linguistics.
- Yining Wang, Long Zhou, Jiajun Zhang, Feifei Zhai, Jingfang Xu, and Chengqing Zong. 2019b. A compact and language-sensitive multilingual translation method. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics*, pages 1213–1223, Florence, Italy. Association for Computational Linguistics.
- Toon Witkam. 2006. History and Heritage of the DLT (Distributed Language Translation) project. In *Utrecht, The Netherlands: private publication*, pages 1–11.
- Hua Wu and Haifeng Wang. 2007. Pivot language approach for phrase-based statistical machine translation. *Machine Translation*, 21(3):165–181.
- Hua Wu and Haifeng Wang. 2009. Revisiting pivot language approach for machine translation. In *Proceedings of the Joint Conference of the 47th Annual Meeting of the ACL and the 4th International Joint Conference on Natural Language Processing of the AFNLP*, pages 154–162, Suntec, Singapore. Association for Computational Linguistics.

- Yonghui Wu, Mike Schuster, Zhifeng Chen, Quoc V. Le, Mohammad Norouzi, Wolfgang Macherey, Maxim Krikun, Yuan Cao, Qin Gao, Klaus Macherey, Jeff Klingner, Apurva Shah, Melvin Johnson, Xiaobing Liu, Lukasz Kaiser, Stephan Gouws, Yoshikiyo Kato, Taku Kudo, Hideto Kazawa, Keith Stevens, George Kurian, Nishant Patil, Wei Wang, Cliff Young, Jason Smith, Jason Riesa, Alex Rudnick, Oriol Vinyals, Greg Corrado, Macduff Hughes, and Jeffrey Dean. 2016. Google’s neural machine translation system: Bridging the gap between human and machine translation. *CoRR*, abs/1609.08144.
- Fei Xia and Michael McCord. 2004. Improving a statistical MT system with automatically learned rewrite patterns. In *COLING 2004: Proceedings of the 20th International Conference on Computational Linguistics*, pages 508–514, Geneva, Switzerland. COLING.
- Chang Xu, Tao Qin, Gang Wang, and Tie-Yan Liu. 2019. Polygon-net: A general framework for jointly boosting multiple unsupervised neural machine translation models. In *Proceedings of the Twenty-Eighth International Joint Conference on Artificial Intelligence, IJCAI-19*, pages 5320–5326. International Joint Conferences on Artificial Intelligence Organization.
- Zhen Yang, Wei Chen, Feng Wang, and Bo Xu. 2018. Unsupervised neural machine translation with weight sharing. In *Proceedings of the 56th Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, pages 46–55, Melbourne, Australia. Association for Computational Linguistics.
- Poorya Zareemoodi, Wray Buntine, and Gholamreza Haffari. 2018. Adaptive knowledge sharing in multi-task learning: Improving low-resource neural machine translation. In *Proceedings of the 56th Annual Meeting of the Association for Computational Linguistics (Volume 2: Short Papers)*, pages 656–661, Melbourne, Australia. Association for Computational Linguistics.
- Biao Zhang, Philip Williams, Ivan Titov, and Rico Sennrich. 2020. Improving massively multilingual neural machine translation and zero-shot translation. In *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics*, pages 1628–1639, Online. Association for Computational Linguistics.
- Yang Zhao, Jiajun Zhang, and Chengqing Zong. 2018. Exploiting pre-ordering for neural machine translation. In *Proceedings of the Eleventh International Conference on Language Resources and Evaluation (LREC 2018)*, Miyazaki, Japan. European Language Resources Association (ELRA).
- Long Zhou, Wenpeng Hu, Jiajun Zhang, and Chengqing Zong. 2017. Neural system combination for machine translation. In *Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics (Volume 2: Short Papers)*, pages 378–384, Vancouver, Canada. Association for Computational Linguistics.
- Zhong Zhou, Matthias Sperber, and Alex Waibel. 2019. Paraphrases as foreign languages in multilingual neural machine translation. In *Proceedings of the 57th Annual Meeting of the Association for Computational Linguistics: Student Research Workshop*.
- Changfeng Zhu, Heng Yu, Shanbo Cheng, and Weihua Luo. 2020. Language-aware interlingua for multilingual neural machine translation. In *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics*, pages 1650–1655, Online. Association for Computational Linguistics.
- Michał Ziemski, Marcin Junczys-Dowmunt, and Bruno Pouliquen. 2016. The United Nations Parallel Corpus v1.0. In *Proceedings of the Tenth International Conference on Language Resources and Evaluation (LREC 2016)*, pages 3530–3534, Portorož, Slovenia. European Language Resources Association (ELRA).
- Barret Zoph and Kevin Knight. 2016. Multi-source neural translation. In *Proceedings of the 2016 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies*, pages 30–34, San Diego, California. Association for Computational Linguistics.
- Barret Zoph and Quoc V. Le. 2017. Neural architecture search with reinforcement learning. In *5th International Conference on Learning Representations, ICLR 2017, Toulon, France, April 24-26, 2017, Conference Track Proceedings*. OpenReview.net.
- Barret Zoph, Deniz Yuret, Jonathan May, and Kevin Knight. 2016. Transfer learning for low-resource neural machine translation. In *Proceedings of the 2016 Conference on Empirical Methods in Natural Language Processing*, pages 1568–1575, Austin, Texas. Association for Computational Linguistics.