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Current Position

KAIST, Republic of Korea, *March 2020 - Present*
Assistant Professor, Graduate School of AI

Current Research Topic

Representation learning on Electronic Health Records (EHR) data using deep learning algorithms. Recent works focus on interpretable prediction models, attention-based models and learning representations of medical concepts such as diagnosis codes or patients.

Research interest: Machine Learning, Health Analytics, Natural Language Processing

Education

Georgia Institute of Technology, USA, August 2014 - August 2018

Ph.D. in Computer Science (Advisor: Jimeng Sun)

Thesis: *Doctor AI: Interpretable Deep Learning for Modeling Electronic Health Records*

Korea Advanced Institute of Science & Technology, South Korea, August 2007 - August 2009

M.S. in Computer Science (Advisor: Jong C. Park)

Thesis: *Extracting Melody from Piano Music using Structural Information*

Seoul National University, South Korea, March 2002 - August 2007

B.S. in Computer Science & Engineering (minor in Applied Biochemistry)

Professional Experience

Research and development at Google, Palo Alto, California, September 2018 - February 2020

As a part of Google Health, I led the project "Graph Convolutional Transformer", which aimed to capture the hidden graphical structure of electronic health records (EHR) to gain better prediction performance. This work was presented at AAAI 2020. I also participated in a project to analyze how the model uncertainty affects the neural network prediction models for EHR data, which was presented in the Conference on Health, Inference, and Learning (CHIL) 2020.

Research Internship at Google, Mountain View, California, May 2017 - August 2017

I participated in the project named MorphNet. The objective was to automatically learn the structure of neural networks given some resource constraint (e.g. number of parameters, number of FLOPs), using various regularization methods. My specific task was related to NLP applications and I modified well-known variable selection algorithms such as Smoothly Clipped Absolute Deviation (SCAD) to activate/deactivate groups of parameters. MorphNet was accepted at CVPR 2018.

Research Internship at DeepMind, London, U.K., February 2017 - May 2017

My first project was to train an embodied agent to find out the heaviest object in a virtual environment. This was an extended work of “Which is heavier?” experiment from “Learning to Perform Physics Experiments via Deep Reinforcement Learning” (Denil et al. ICLR 2017). The agent was equipped with a hammer to probe the objects, and a positive reward was given when the hammer was in contact with the heaviest object. The agent successfully learned to interact with the objects and stick to the heaviest one, the video of which was demonstrated at ICLR 2017.

My second project was training neural agents to develop compositional language purely from raw pixels by playing an image description game. By employing a communication strategy named Observer, which is motivated by the theory of mind, we confirmed that two neural agents could develop a highly structured/patterned communication protocol. This work was presented at ICLR 2018.

Internship at Research, Development and Dissemination (RD&D), Sutter Health, Walnut Creek, California, May 2016 - August 2016

In my second internship at Sutter Health, I focused on developing interpretable deep learning models for predictive healthcare. Specifically, using the neural attention mechanism combined with RNN and MLP, I was able to design a sequence prediction model “RETAIN” that demonstrated similar AUROC as RNN but completely interpretable; the model allowed precise calculation of how much each diagnosis/medication/procedure in the past visits contributed to the final prediction. This work was presented at NIPS 2016.

Internship at Research, Development and Dissemination (RD&D), Sutter Health, Walnut Creek, California, May 2015 - August 2015

I explored the potential of applying deep learning methods to healthcare problems, specifically predicting the future heart failure diagnosis. Applying stacked de-noising auto encoders to heart failure prediction enabled sophisticated analysis of the relation between patient features and heart failure diagnosis. Through the combination of the word embedding technique and recurrent neural networks, I was able to improve the heart failure prediction performance from 0.81 AUROC to 0.86 AUROC. This work was published in JAMIA.

Research and development at Knowledge Mining Research Team, Electronics & Telecommunications Research Institute (ETRI), Daejeon, South Korea, February 2010 - April 2014**Performed the following tasks:**

February 2010 - February 2013: I was in charge of setting up and developing a Hadoop system for processing large text data. I implemented various MapReduce applications to analyze news, blogs, and Tweets using the in-house text analysis engine in a distributed fashion. Later I introduced HBase to the system to store the analysis results and implemented APIs to support communication between C++ applications and HBase.

February 2012 - April 2014: I was responsible for implementing and improving the named entity recognition module and the event extraction module. Both were components of the text analysis engine in a social event monitoring platform.

February 2012 - April 2014: I was in charge of developing various solvers for machine learning algorithms including binary SVM, multiclass structural SVM, HMM structural SVM, one-class SVM and ranking SVM.

Participated in the following projects:

Development of Web QA (Question Answering) Technology, *February 2010 - February 2011*

Development of Social Web Issue Detection-Monitoring & Prediction Technology for Big Data Analytic Listening Platform of Web Intelligence, *March 2011 - February 2013*

Development of Knowledge Evolutionary WiseQA Platform Technology for Human Knowledge Augmented Services, *May 2013 - April 2014*

Honors and Awards

Travel award, ICLR 2018
 Moon-Jung Chung Scholarship, KOCSEA 2017
 Travel award, SIGKDD 2017
 Travel award, NIPS 2016
 Travel award, SIGKDD 2016
 Top-7 finalist in Student Design Challenge, AMIA 2015
 Samsung Scholarship (for Ph.D. study), 2014-2018
 Best Paper, The 24th Annual Conference on Human & Cognitive Language Technology 2012
 Best Paper, Korea Computer Congress 2009
 Geumgang Scholarship (for undergraduate study), 2003-2004

Academic Activities

Session lead at Machine Learning for Health (ML4H) Unconference 2019
 Plenary lecture at Korean Society of Artificial Intelligence in Medicine (KOSAIM) 2019
 Program Committee for Machine Learning for Health (ML4H) workshop at NIPS (2017, 2018, 2019)
 Program Committee for Machine Learning for Healthcare (MLHC) (2018, 2019)
 Tutorial at KDD 2018: Deep Learning for Computational Healthcare
 Tutorial at AAAI 2018: Deep Learning Models for Healthcare, Challenges and Solutions
 Teaching assistant for CSE8803 Big Data for Health (Spring 2016, Spring 2018), Georgia Tech
 Teaching assistant for CS521 Natural Language Processing (Fall 2008), KAIST

Publications

Conference & Journals

Edward Choi, Zhen Xu, Yujia Li, Michael W. Dusenberry, Gerardo Flores, Emily Xue, Andrew M. Dai, 2020, Learning the Graphical Structure of Electronic Health Records with Graph Convolutional Transformer, In *Proc. of Association for the Advancement of Artificial Intelligence (AAAI) 2020*.

Chayakrit Krittanawong, Albert J. Rogers, Mehmet Aydar, **Edward Choi**, Kipp W. Johnson, Zhen Wang, Sanjiv M. Narayan, 2019, Integrating blockchain technology with artificial intelligence for cardiovascular medicine, *Nature Reviews Cardiology*, doi:10.1038/s41569-019-0294-y.

Edward Choi, Cao Xiao, Walter F. Stewart, Jimeng Sun, 2018, MiME: Multilevel medical embedding of electronic health records for predictive healthcare, In *Proc. of Neural Information Processing Systems (NIPS) 2018*, pp.4552-4562.

Bum Chul Kwon, Min-Je Choi, Joanne Taery Kim, **Edward Choi**, Young Bin Kim, Soonwook Kwon, Jimeng Sun, Jaegul Choo, 2018, RetainVis: Visual analytics with interpretable and interactive recurrent neural networks on electronic medical records, *Proc. of IEEE Visualization Conference (VIS) 2018*, pp.299-309.

Cao Xiao, **Edward Choi**, Jimeng Sun, 2018, Opportunities and challenges in developing deep learning models using electronic health records data: a systematic review, *Journal of the American Medical Informatics Association (JAMIA)*, doi:10.1093/jamia/ocy068.

Ariel Gordon, Elad Eban, Ofir Nachum, Bo Chen, Hao Wu, Tien-Ju Yang, **Edward Choi**, 2018, MorphNet: Fast & simple resource-constrained structure learning of deep networks, *Proc. of Conference on Computer Vision and Pattern Recognition (CVPR) 2018*, pp.1586-1595.

Edward Choi, Angeliki Lazaridou, Nando de Freitas, 2018, Compositional obverter communication learning from raw visual input, *Proc. of International Conference on Learning Representations (ICLR) 2018*.

Edward Choi, Siddharth Biswal, Bradley Malin, Jon Duke, Walter F. Stewart, Jimeng Sun, 2017, Generating multi-label discrete patient records using generative adversarial networks, In *Proc. of Machine Learning in Health Care (MLHC) 2017*, pp.286-305.

Edward Choi, Mohammad Taha Bahadori, Le Song, Walter F. Stewart, Jimeng Sun, 2017, GRAM: Graph-based attention model for healthcare representation learning, In *Proc. of Knowledge Discovery and Data Mining (KDD) 2017*, pp.787-795.

Edward Choi, Mohammad Taha Bahadori, Andy Schuetz, Walter F. Stewart, Jimeng Sun, 2016, RE-TAIN: Interpretable predictive model in healthcare using reverse time attention mechanism, In *Proc. of Neural Information Processing Systems (NIPS) 2016*, pp.3504-3512.

Edward Choi, Mohammad Taha Bahadori, Andy Schuetz, Walter F. Stewart, Jimeng Sun, 2016, Doctor AI: Predicting clinical events via recurrent neural networks, In *Proc. of Machine Learning in Health Care (MLHC) 2016*, pp.301-308.

Edward Choi, Andy Schuetz, Walter F. Stewart, Jimeng Sun, 2016, Using recurrent neural network models for early detection of heart failure onset, *Journal of the American Medical Informatics Association (JAMIA)*, doi:10.1093/jamia/ocw112

Edward Choi, Mohammad Taha Bahadori, Elizabeth Searles, Catherine Coffey, Michael Thompson, James Bost, Javier Tejedor-Sojo, Jimeng Sun, 2016, Multi-layer representation learning for medical concepts, In *Proc. of Knowledge Discovery and Data Mining (KDD) 2016*, pp.1495-1504.

Edward Choi, Nan Du, Robert Chen, Le Song, Jimeng Sun, 2015, Constructing disease network and temporal progression model via context-sensitive Hawkes process, In *Proc. of International Conference of Data Mining (ICDM) 2015*, pp.721-726.

Edward Choi, Hyunki Kim, Changki Lee, 2014, Balanced Korean word spacing with structural SVM, In *Proc. of Empirical Methods in Natural Language Processing (EMNLP) 2014*, pp.875-879.

Jeong Heo, Pum-Mo Ryu, **Yoonjae Choi**, Hyunki Kim, Cheol Young Ock, 2013, An Issue event search system based on big data for decision supporting: Social Wisdom, *Journal of Korean Institute of Information Scientists and Engineers (KIISE): Software and Applications*, vol.40, no.7, pp.381-394.

Yoonjae Choi, Pum-Mo Ryu, Hyunki Kim, Changki Lee, 2013, Extracting events from web documents for social media monitoring using structured SVM, *The Institute of Electronics, Information and Communication Engineers(IEICE) Transactions on Information and Systems*, vol.E96-D, no.6, pp.1410-1414.

Jeong Heo, Pum-Mo Ryu, **Yoonjae Choi**, Hyunki Kim, 2012, Event template extraction for the decision support based on social media, In *Proc. of the 24th Annual Conference on Human & Cognitive Language Technology (HCLT) 2012*, pp.53-57. (Best paper)

Yoonjae Choi, Jong C. Park, 2009, Extracting melodies from piano solo music based on its characteristics, *Journal of Korean Institute of Information Scientists and Engineers (KIISE): Computing Practices and Letters*, vol.15, no.12, pp.923-927.

Yoonjae Choi, Jong C. Park, 2009, Extracting melodies from piano solo music based on characteristics of music, In *Proc. of Korea Computer Congress (KCC) 2009*, pp.124-125. (Best paper)