BYEONG TAK LEE

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SUMMARY

- Machine learning researcher specializing in the medical domain, passionate about leveraging AI to drive advancements in biology and medicine.
- Experienced in developing AI solutions for real-world healthcare applications and automated ML system.
- Investigated various techniques to enhance machine learning model in medicine, with a focus on domain generalization, noisy label, and inductive bias.

EDUCATION

Seoul National University   Seoul, Republic of Korea
M.S., Bioengineering   Aug. 2015 – Aug. 2017
- Thesis: Real-time estimation of left ventricular volume from echocardiogram during cardiopulmonary resuscitation using convolutional neural network
- Advisor: Jung Chan Lee

Pusan National University   Busan, Republic of Korea
B.S., Mechanical Engineering   Mar. 2011 – Aug. 2015
- Minor: Electrical Engineering
- Magna Cum Laude

PUBLICATIONS   (*equal contributions)

PEER-REVIEWED JOURNALS & PROCEEDINGS

- Kyung Geun Kim*, **Byeong Tak Lee***. Graph Structure Based Data Augmentation Method. 2024. Biomedical Engineering Letters.
- Kyung Geun Kim*, **Byeong Tak Lee***. Self Attention with Temporal Prior: Can We Learn More from Arrow of Time?. 2024. Frontiers in Artificial Intelligence.
- **Byeong Tak Lee***, Joom-myoung Kwon*, Jinwoo Cho, Woong Bae, Hyunho Park, Won-Woo Seo, Iksung Cho, Yeha Lee, Jinsik Park, Byung-Hee Oh, Ki-Hyun Jeon. Usefulness of Deep Learning Algorithm for Detecting Acute Myocardial Infarction Using Electrocardiogram Alone in Patients With Chest Pain at Emergency Department: DAMI-ECG Study. 2023. Journal of Cardiovascular Intervention.
- **Byeong Tak Lee***, Yong-Yeon Jo*, Seon-Yu Lim, Youngjae Song, Joon-myoung Kwon. Efficient Data Augmentation Policy for Electrocardiograms. 2022. Proceedings of the 31st ACM International Conference on Information & Knowledge Management.
- **Byeong Tak Lee**, Yong-Yeon Jo, Joon-myoung Kwon. On the Inductive Bias Transfer with Knowledge Distillation for Real World Data. 2022. Workshop on Applied Machine Learning Methods for Time Series forecasting.
- Changho Han, Youngjae Song, Hong-Seok Lim, Yunwon Tae, Jong-Hwan Jang, **Byeong Tak Lee**, Yeha Lee, Woong Bae, Dukyong Yoon. Automated Detection of Acute Myocardial Infarction Using Asynchronous Electrocardiogram Signals—Preview of Implementing Artificial Intelligence With Multichannel Electrocardiographs Obtained from Smartwatches: Retrospective Study. 2021. Journal of Medical Internet Research.
- Jinwoo Cho*, **Byeong Tak Lee***, Joon-myoung Kwon, Yeha Lee, Hyunho Park, Byung-Hee Oh, Ki-Hyun Jeon, Jinsik Park, Kyung-Hee Kim. Artificial intelligence algorithm for screening heart failure with reduced ejection fraction using electrocardiography. 2021. ASAIO Journal.
- **Byeong Tak Lee***, Seo Taek Kong*, Youngaje Song, Yeha Lee. Self-Supervised Learning with Electrocardiogram Delineation for Arrhythmia Detection. 2021. Annual International Conference of the IEEE Engineering in Medicine & Biology Society.
- **Byeong Tak Lee***, O-Yeon Kwon*, Hyungho Park, Kyung-Jae Cho, Joon-myoung Kwon, Yeha Lee. Graph Convolutional Networks-Based Noisy Data Imputation in Electronic Health Record. 2020. Critical Care Medicine.
- Yoon Sun Jung*, Woo Sang Cho*, Gil Joon Suh, Jung Chan Lee, Woon Yong Kwon, Kyung Su Kim, So Mi Shin, Min Woo Kang, Min Sung Lee, **Byeong Tak Lee**. Pulse Oximeter Plethysmograph Variation During Hemorrhage in Beta Blocker–Treated Swine. 2020. Journal of Surgical Research.
- **Byeong Tak Lee**, Kyung-Jae Cho, O-Yeon Kwon, Yeha Lee. Improving the Performance of a Neural Network for Early Prediction of Sepsis. 2019. Computing in Cardiology.

MANUSCRIPTS UNDER REVIEW, SUBMITTED & IN PREPARATION

- **Byeong Tak Lee**, Yong-Yeon Jo, Joon-myoung Kwon. Revisiting Neural Network Scale for ECG Classification. (under review)

- **Byeong Tak Lee**, Joon-myoung Kwon, Yong-Yeon Jo. TADA: Temporal Adversarial Data Augmentation for Time Series Data. (under review)
- Junho Song, Jong-Hwan Jang, **Byeong Tak Lee**, DongGyun Hong, Joon-myoung Kwon, Yong-Yeon Jo. Foundation Models for Electrocardiograms. (under review)
- Yong-Yeon Jo*, **Byeong Tak Lee***, Beom Joon Kim, Jeong-Ho Hong, Hak Seung Lee, Joon-myoung Kwon. New Test-Time Paradigm for Real-World Biosignal: Concept and Its Approach. (under review)
- **Byeong Tak Lee**, Joon-myoung Kwon, Yong-Yeon Jo. Optimizing Inductive Bias in Networks with a Generalized Self-Attention Layer. (in preparation)

PATENTS

- **Byeong Tak Lee**, Youngjae Song, Woong Bae, O-yeon Kwon. Deep neural network pre-training method for classifying electrocardiogram (ecg) data. US20220084679A1, KR102390326B1
- **Byeong Tak Lee**, Woong Bae, O-yeon Kwon. Disease judgment method. US20220076835A1, KR1020200113261
- Gil Joon Suh, Woon Yong Kwon, Kyung Su Kim, Sang Hoon Nam Jaeheung Park, Jung Chan Lee, Yoon Sun Jung, Kyoung Min You, Min Ji Park, TaeGyun Kim, Jung-In Ko, Jeeseop Kim, Jaesug Jung, Sanghyun Kim, Byeong Wook Yoo, **Byeong Tak Lee**, Woo Sang Cho, Jin Woo Choi. Automatic cardiopulmonary resuscitation device and control method therefor. US11071686B2, KR101956776B1

RESEARCH & WORK EXPERIENCE

Medical AI Co. Ltd.,   Seoul, Republic of Korea
Senior Research Scientist.   Apr. 2021 – Present
Research on improving ML model for real-world healthcare applications
- Developed a temporal adversarial data augmentation to address distribution shifts in the real-world time series data, achieving up to 40% performance improvement on a specific external dataset.
- Proposed a personalized blood pressure (BP) estimation model using ECG and PPG in medical scenario, incorporating test-time training, which achieved up to a 30% improvement in regression performance.
- Developed noisy data filtering and noisy label filtering algorithm for BP estimation in intensive care unit settings.
- Investigated the inductive bias of convolutional networks to enhance transformers performance and developed a method integrating self-attention and convolution, enabling hyperparameter-based control of inductive bias.
- Studied self-supervised learning method for electrocardiograms and proposed an effective learning strategy.
- Led empirical research to evaluate the network scalability, demonstrating that training neural network for ECG requires distinct hyperparameter setups compared to other domains, due to the cyclic nature of ECG data.
- Conducted empirical studies for data augmentation methods for ECG classifications, providing insights to guide efficient hyperparameter tuning for data augmentations.

Development of an Automated ML system
- Led the development of an automated ML experiment system built on large-scale distributed parallel framework (Ray), enabling medical professionals without ML expertise to conduct diverse experiments with medical data.

Development of products for screening cardiovascular disease from ECG
- Developed products for screening various cardiovascular diseases, including left ventricular systolic dysfunction, myocardial infactrion, and aeortic stenosis, which are officially approved as medical devices by the Korea FDA. One of the product (Aitia-LVSD) was recognized as an innovative medical device by the Korea FDA and won UNIST-UCLA Digital Healthcare Challenge.

VUNO Inc.   Seoul, Republic of Korea
Research Scientist.   Aug. 2017 – Apr. 2021
Research on improving ML model for real-world healthcare applications
- Developed a data augmentation technique for bio-signals that leverages the inherent graph structures of multi-channel ECG data, effectively addressing distribution shifts caused by variations of the heart position.
- Developed a regularization method for transformers that incorporates temporal correlation inductive bias into the self-attention matrix.
- Developed a self-supervised learning method for ECG using clinical knowledge-based pretext tasks, achieving superior performance compared to contrastive-based self-supervised learning for ECG data.
- Developed a missing value imputation method in electronic hospital records (EHR) by leveraging graphical structure of relationships between clinical variables.

Development of the cardiovascular disease diagnosis model from ECG
- Led the development of a neural network model and designed a medical study demonstrating its superiority over experienced cardiologists.
- Led one of the first studies demonstrating effectiveness of machine learning-based screening model for heart failure.
- Proposed myocardial infarction detection model capable of addressing versatile combination of ECG leads as input.

Development of a sepsis early detection model from EHR
- Evaluated the efficacy of regularization and dataset preprocessing techniques for for sepsis prediction from EHR, proposing an optimal combination that enhanced neural network performance by 5%.
- Developed a prediction model for predicting sepsis, severe sepsis and septic shock using various continuous waveform data from the intensive care unit.

Medical Biomechanics & Design Lab.   Seoul, Republic of Korea
Graduate Student Researcher (Advisor: Jung Chan Lee)   Aug. 2015 – Jul. 2017
Development of a robot cardiopulmonary resuscitation system
- Contributed to cardiac output estimation based on end-tidal carbon dioxide and echocardiography to identify the optimal position for cardiopulmonary resuscitation (CPR).
- Developed a left ventricular segmentation method for echocardiography and a left ventricular volume estimation algorithm for left ventricle during CPR, utilizing two-dimensional video of the left ventricle.

Others
- Implemented a signal collection and analysis system to estimate stroke volume based on pulse pressure variation in swine hemorrhage experiments.
- Contributed to the development of sensors for a low-cost extracorporeal membrane oxygenation system.

EXTRACURRICULAR ACTIVITIES
- An academic club on solving everyday problems from a multidisciplinary perspective.   Sep. 2016 – Aug. 2017
- Teaching Korean to foreigners living in Busan (9 students for 3 semesters).   Mar. 2014 – Jul. 2015
- Tutored mathematics to a local underprivileged high school student.   Mar. 2014 – Aug. 2014
- An academic club for international business strategy research.   Mar. 2012 – Feb. 2013
- A volunteer club that aid local welfare centers and children's care center.   Mar. 2011 – Aug. 2011

SKILLS
- Programming: Python, C/C++, MATLAB
- Frameworks & Tools: Pytorch, TensorFlow, scikit-learn, Ray, Git
- Languages: Korean (Native), English (Proficient)

RELEVANT COURSES
- Machine Learning and mathematics: Pattern recognition, Estimation theory, Signals and system, System modeling and control, Differential equation, Calculus, Linear algebra, Statistics, Complex analysis, Discrete mathematics
- Biology and medicine: Molecular Biology, Biomedical system simulation, Protein engineering, Cell biology, Human Biology, Biomedical engineering, PK/PD Modeling, Medical instrumentation