

Kisuk Lee

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RESEARCH INTERESTS	Artificial & Biological Neural Networks Deep Learning & Artificial Intelligence Connectomics & Computational Neuroscience Crowdsourcing	
EDUCATION	Massachusetts Institute of Technology <i>Ph.D. candidate in Computation</i> Department of Brain & Cognitive Sciences Advisor: Prof. H. Sebastian Seung	SEP. 2012 – PRESENT
	Princeton University <i>Ivy-Plus Exchange Scholar</i> Princeton Neuroscience Institute	AUG. 2015 – PRESENT
	Deep Learning Summer School 2015 Université de Montréal	AUG. 2015
	Seoul National University, Seoul, South Korea <i>B.S. in Computer Science and Engineering</i> <i>B.S. in Biological Sciences</i> <i>Summa Cum Laude</i>	MAR. 2004 – AUG. 2012
HONORS AND AWARDS	Samsung Scholarship <i>Samsung Foundation of Culture</i> Formerly known as the <i>Samsung Lee Kun Hee Scholarship Foundation (SLSF)</i>	NOV. 2011 – PRESENT
	National Scholarship for Science and Engineering <i>Korea Student Aid Foundation (KSAF)</i> A full tuition undergraduate scholarship for eight semesters	2004 – 2007
	Scholarship for Outstanding College Freshman <i>College of Engineering, Seoul National University</i>	MAR. 2005
SELECTED PUBLICATIONS	ZNN - Fast 3D Sliding-Window ConvNets for Multi-Core Shared Memory Machines Zlateski, A., Lee, K. and Seung, H.S., 2015. (Manuscript in preparation)	
	Recursive Training of 2D-3D Convolutional Networks for Neuronal Boundary Detection Lee, K., Zlateski, A., Vishwanathan, A. and Seung, H.S., In <i>NIPS</i> , 2015.	
	Space-Time Wiring Specificity Supports Direction Selectivity in the Retina Kim, J.S., Greene, M.J., Zlateski, A., Lee, K., Richardson, M., Turaga, S.C., Purcaro, M., Balkam, M., Robinson, A., Behabadi, B.F., Campos, M., Denk, W., Seung, H.S. and the EyeWriters, <i>Nature</i> , 509 :331-336, 2014.	
	Cooking Action Recognition via Spatio-temporal Feature Learning based on ISA Lee, K., Kim, E.-S., Amaro, K.R., Beetz, M. and Zhang, B.-T., <i>Journal of the Korean Institute of Information Science Society: Computing Practices and Letters</i> , 19 (8):434-438, 2013. (in Korean)	

- **Recursive Training of 2D-3D Convolutional Networks for Neuronal Boundary Detection**¹

Although it has been shown that 3D convolutional networks (ConvNets) can be trained to automatically analyze electron microscopic (EM) images of neural tissue with isotropic resolution in x, y, and z-directions [1], it has never been shown that the same framework can be applied to analyzing EM images of conventionally-stained neural tissue with anisotropic resolution, such as one obtained by ATUM-SEM technique [2]. In this project, we develop a novel hybrid 2D-3D ConvNet architecture for successfully analyzing anisotropic EM dataset, along with a novel recursive approach for efficiently training 2D-3D ConvNets. Automated analysis of anisotropic EM images is a technical advance crucial in connectomics, which demonstrates that connectomics approach can be extended to the cortex of the brain.

- **ZNN - Fast 3D Sliding-Window ConvNets for Multi-Core Shared Memory Machines**

Our lab has recently released ZNN [3], a new ConvNet implementation optimized for 3D ConvNets, and also specialized for 3D volume data such as serial EM images. The most striking feature of ZNN is that it exploits multi-core CPU to parallelize its computation, which is in stark contrast to the mainstream GPU-based implementations that have rapidly dominated the field of deep learning in recent years. ZNN also makes use of FFT-based convolution using either `fftw` library [4] or Intel MKL libraries. To the best of our knowledge, ZNN is the first deep learning implementation that is fully scalable with respect to the number of CPU cores on a single shared-memory machine.

- **Crowd Intelligence in EyeWire**²

EyeWire [5], the world's first game to map the brain, is designed to speed up the process of analyzing EM images of neural tissue by combining machine and crowd intelligence. In this project, we try to develop a probabilistic model for an optimal integration of the results from multiple players in EyeWire. As a preliminary step, we developed a weighted voting scheme by parameterizing each player's expertise, approximating the full probabilistic model with a simple logistic regression in which the parameters are estimated by the stochastic gradient descent (SGD) method.

Rotation Student (Supervisor: Prof. Michale S. Fee)

Nov. 2012 – Dec. 2012

*Fee Lab., Department of Brain & Cognitive Sciences,
Massachusetts Institute of Technology, Cambridge, MA*

- **Automatic Conversion from 3D Reconstruction to Skeleton for Compartmental Modeling**

In this one-month period lab rotation project, I wrote Matlab codes that automatically convert the detailed 3D reconstruction of a medium spiny neuron (MSN) in a basal ganglia (BG) nucleus Area X of the songbird into a 3D skeletal model for more precise compartmental modeling.

Rotation Student (Supervisor: Prof. Mriganka Sur)

OCT. 2012 – Nov. 2012

*Sur Lab., Department of Brain & Cognitive Sciences,
Massachusetts Institute of Technology, Cambridge, MA*

- **Spiking Neural Networks for Simulating Surround Suppression**³

In this one-month period lab rotation project, I constructed a model spiking neural network composed of conductance-based leaky integrate-and-fire neurons to simulate cortical surround suppression generated by interaction between three different cortical neuron types, i.e., excitatory pyramidal neurons, inhibitory somatostatin-expressing (SOM⁺) interneurons, and inhibitory parvalbumin-expressing (PV⁺) interneurons. Simulation results demonstrate that a simple distance-dependent connectivity rule for SOM⁺ interneurons is sufficient to fully reproduce the characteristic size-tuning curves [6] for each of the neuron types in the model network.

¹<http://arxiv.org/abs/1508.04843>

²http://kisuklee.wdfiles.com/local--files/research/crowdintelligence_EyeWire.pdf

³http://kisuklee.wdfiles.com/local--files/projects/surround_suppression.pdf

Research Intern (Supervisor: Prof. Byoung-Tak Zhang)
*Biointelligence Lab., Department of Computer Science and Engineering,
Seoul National University, Seoul, South Korea*

FEB. 2011 – JUL. 2012

- **Convolutional Stacked ISA for Action Recognition**

In this project, we adopted a convolutional stacked independent subspace analysis (ISA) algorithm [7] to learn spatio-temporal features for human cooking action recognition. Programmed in Matlab. This work was presented at the Korea Computing Congress (**KCC 2012**) in November 2012, and selected as one of the best oral presentation papers, leading to an invited publication in the Journal of the Korean Institute of Information Science Society: Computing Practices and Letters.

- **EEG Signal Pattern Detection using Hypernetwork**

In the spring of 2011, I worked on a research project analyzing spatio-temporal patterns in EEG signals with Hypernetwork [8], a random hypergraph structure representing higher-order probabilistic relations of data by an evolutionary self-organizing process based on molecular self-assembly. Specifically, I developed a novel Hypernetwork architecture incorporating the temporal dimension to detect dominant spatio-temporal patterns in EEG signals. Programmed in C++.⁴ This work was presented at the Korea Computing Congress (**KCC 2011**) in June 2011.

Summer Research Intern (Supervisor: Prof. Marcus Kaiser)
*Kaiser Neuroinformatics Lab., School of Computing Science,
Newcastle University, Newcastle Upon Tyne, United Kingdom*

AUG. 2011 – SEP. 2011

- **Neuroinformatics System based on Amazon Web Services**

I worked on developing a neuroinformatics system with cloud-computing environment provided by Amazon Web Services (AWS). Specifically, I prototyped a system on AWS, scaling-up complex network analysis routines in LONI neuroimaging pipelines. Programmed in AWS API and PHP.

- **Synchronizing Remote Neuroimaging Servers with XNAT [9]**

I worked on synchronizing remote neuroimaging servers with the XNAT imaging informatics platform. Specifically, I installed the XNAT platform on two remote servers, located in the U.K. and South Korea, and prototyped a system synchronizing both servers on a regular basis. Programmed in Python.

WORK
EXPERIENCE

Electronic Arts Korea, Seoul, South Korea
Software Engineer

MAR. 2009 – OCT. 2010

I worked as a software engineer at the Seoul branch of Electronic Arts, one of the largest game companies in the world.

- **EA SPORTS™ FIFA Online 2**

I developed a game server and client for FIFA Online 2, the online version of world's most famous football game, which is an officially licensed product of FIFA. Specifically, I participated in a large-scale upgrade of the core game engine, optimizing 3D resource processing and real-time rendering pipelines.

Gamevil Inc., Seoul, South Korea
Software Engineer

DEC. 2007 – FEB. 2009

I worked as a software engineer at Gamevil Inc., the number one mobile game company in South Korea.

- **Hybrid**

I developed a game titled "Hybrid", which was released onto the market in South Korea in early 2009. As the main programmer, I developed all aspects of the game, including the game system, networking, graphical rendering, user interface, etc. Programmed in C++.

- **Golf Superstars 2008**

I developed a game titled "Golf Superstars 2008", which was released onto the US market through AT&T in the spring of 2008. As the main programmer, I ported the game from WIPI (former standard mobile platform in South Korea) to J2ME platform. Programmed in Java.

⁴<https://github.com/torms3/hypernetwork>

TEACHING
EXPERIENCE

- Teaching Assistant for MIT 9.00 “Introduction to Psychological Science” taught by Prof. John Gabrieli (2014)
- Teaching Assistant for MIT 9.073 “Statistics for Neuroscience Research” taught by Prof. Emery E. Brown (2015)

SKILLS &
CERTIFICATION

Technical Skills

- C++ (C++11 and Boost), C, Julia, Matlab, Python (NumPy/SciPy)
- PHP, Linux shell scripting, \LaTeX , SQL, Java
- Linux, Mac OS X, Unix, MS Windows

Language Skills

- Korean and English

EXTRA-CURRICULAR
ACTIVITIES

STEM Membership

MAR. 2011 – AUG. 2012

Seoul National University Tomorrow’s Edge Membership
The 1st official Honor Society of Seoul National University

Winner, Members Squash Competition

AUG. 2010

POSCO Sports Center, Seoul National University, Seoul, South Korea

- As a member of the SNU/POSCO sports center, I participated in the 2010 members squash competition, and I won first place at the intermediate level.

BIBLIOGRAPHY

- [1] S.C. Turaga et al., “Convolutional Networks Can Learn to Generate Affinity Graphs for Image Segmentation”, *Neural Comput.* **22**, 511-538 (2010).
- [2] <http://cbs.fas.harvard.edu/science/connectome-project/atlum>
- [3] <https://github.com/seung-lab/znn-release>
- [4] <http://www.fftw.org/>
- [5] <http://eyewire.org/>
- [6] H. Adesnik, W. Bruns, W. Taniguchi, H. Huang, and M. Scanziani, “A Neural Circuit for Spatial Summation in Visual Cortex”, *Nature* **490**, 226-231 (2012).
- [7] Q. V. Le, W. Y. Zou, S. Y. Yeung, and A. Y. Ng, “Learning Hierarchical invariant spatio-temporal features for action recognition with independent subspace analysis”, *CPVR* (2011).
- [8] B.-T. Zhang, “Hypernetworks: A molecular evolutionary architecture for cognitive learning and memory”, *IEEE Computational Intelligence Magazine* **3(3)**, 49-63 (2008).
- [9] D. S. Marcus, T. Olsen, M. Ramaratnam, and R. L. Buckner, “The Extensible Neuroimaging Archive Toolkit (XNAT): An informatics platform for managing, exploring, and sharing neuroimaging data”, *Neuroinformatics*, **5(1)**: 11-34, 2007.