SUCCESS STORY

Artificial Intelligence in Medicine, Brain Connectivity

Mapping Brain Connectivity Using AI

Machine learning and AI are helping visualize brain connectivity more effectively in cases of neurological diseases.

"One challenge to proper diagnosis is the fact that there are many other disorders that can cause changes in behavior and be confused with epilepsy. Understanding what happens during a seizure is one of the most important pieces of information to develop a proper diagnosis."[1]

- Nathan Minnich, Director, Global Marketing of Neuromodulation and Cardiac Rhythm Management, LivaNova

Challenge

Medical understanding of certain neurological conditions, such as epilepsy and Alzheimer's disease, has been an ongoing challenge, both in terms of the diagnosis and treatment of these conditions. Better tools are needed to unlock the mysteries of brain connectivity and provide a more comprehensive understanding of diseases of the brain.

Solution

Machine learning and artificial intelligence (AI) unlock opportunities to gain a more complete picture of brain connectivity by classifying characteristics in cases of epilepsy and Alzheimer's. Techniques being developed by Panuwat Janwattanapong, using neural network inferences and natural language processing, are showing promising results that could have significant medical benefits.

Background and History

Panuwat Janwattanapong, an Intel® Student Ambassador of the Intel® AI Developer Program, had an early passion for AI and machine learning. Enrolled in the PhD program at Florida International University, engaged in electrical and computer engineering studies, Panuwat currently works in the Center of Advanced Technology and Education (CATE Lab) with a focus on improving the diagnostic methods and treatment techniques through new technologies. His coursework has steadily directed him toward the study of neurological disorders, including epilepsy and Alzheimer's disease, and the methods by which AI and machine learning can contribute to a better understanding of brain connectivity. His projects have already begun to yield insights, including one novel method for determining brain connectivity that is taking place during epileptic seizures.

Panuwat offered this description of his brain connectivity project: "This research aims to take full advantage of connectivity analysis, where the method can be used to reveal and extract the hidden features presented in neurological disorders. The study would improve the fundamental understanding of the disease and enhance the diagnosis significantly. Functional connectivity extracted from epileptic patients will be explored in different frequency bands and compared with the control population to generate distinct patterns that can be used as key parameters of classification algorithms. The comparison of connectivity patterns for different stages of seizure will be investigated as well."

Prior work in the CATE Lab included analyzing images of PET scan and MRI results, as well as analyzing time-series bioinformatics. Ongoing work is taking advantage of subject data primarily collected from regional hospitals collaborating on the project, including patient data for Alzheimer's disease and epilepsy. Inputs from this data are used for the classifiers. "For example," Panuwat said, "if the main

data consists of MRI images, we can extract the volume of different parts of the cortex or the thickness of regions. It becomes more complex when we are figuring a way to extract meaningful features from time series data." In this case, Panuwat explained, he transforms the time series data into the spatial features, representing the brain connectivity.

"Brain connectivity provides the details on how the neurons in our brain interact over a set period of time. I compared the features across different groups of subjects, such as the control versus the epileptic group, applying statistical analysis initially. After identifying any significant differences, I combine the features with the demographics of the subjects and construct a classifier."

The classifiers used include simple machine learning classifiers, such as Support Vector Machine (SVM) and Random Forrest. Neural network optimization techniques are performed when necessary, including ten-fold cross validation and algorithms for weights initialization, momentum, and so on.

More recently, the lab has been exploring the use of machine learning and AI to achieve more effective research results. Panuwat has several interrelated projects underway. "I have been working on these topics for more than three years now," he said. "I have multiple goals for these projects and currently most of them are completed. However, I believe there is still a long way to go to completely integrate the approaches and use them to replace the current standard medical procedures."

Figure 1 illustrates brain connectivity mapping used to find patterns in the different stages of a seizure.

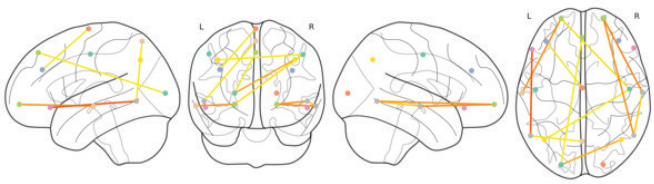

Figure 1. Example of brain connectivity mapping.

Notable Career Milestones

Working as a student ambassador in the Intel AI Developer Program, Panuwat has:

- Presented machine learning and AI concepts to various audiences in tech conferences
- Successfully applied machine learning and AI to features extracted from bioinformatics
- Explored the fields of machine learning and AI through applications run on Intel® hardware platforms
- Integrated machine learning tools to perform brain connectivity analysis

As a research assistant in the CATE Lab at Florida International University, he has:

- Conducted analysis of functional connectivity of brain with epileptic patients using coherence and statistical data analysis
- Performed data analysis of bioinformatics data and in the process created visualizations that aid doctors in diagnosing illnesses
- Implemented a machine learning algorithm for classifying and predicting seizures with high precision

Enabling Technologies

Panuwat took advantage of a number of resources from Intel during the work on his project. "Currently," he said, "I am using Intel® Distribution for Python*. This increases the performance of the overall program and reduces the time that it takes to train the models. Changing to this version of Python is a very easy process, resulting in a significant improvement in performance."

Online training resources and tutorials, such as those included through the Intel AI Developer Program, also helped accelerate project development and circumvent obstacles to completion.

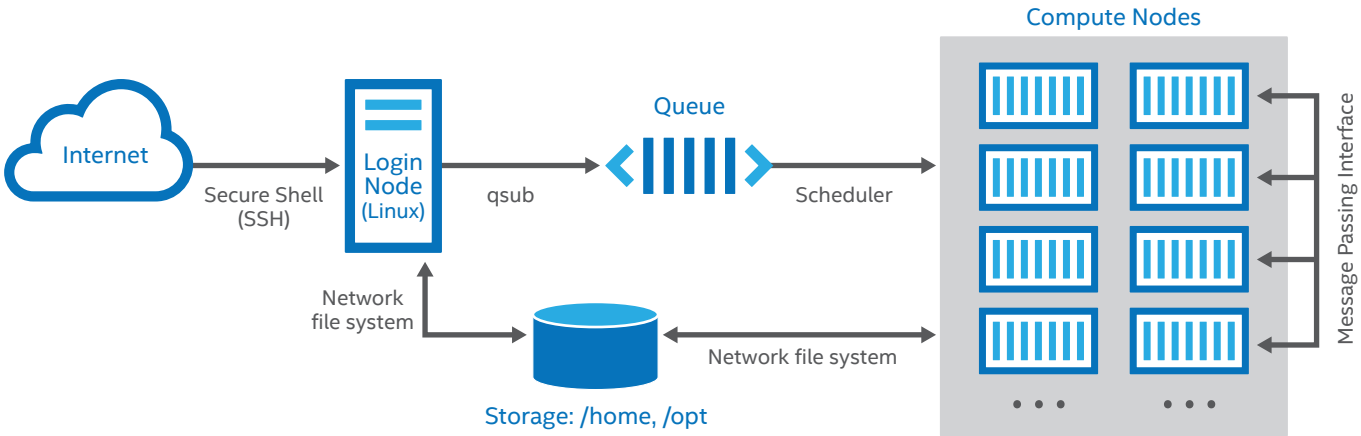

Figure 2. Cluster configuration for improving the deep learning model.

Offering advice to other developers embarking on a similar type of project, Panuwat said, "The most important part about this project (and something I think can be applied to any project) is documentation. Keep track of every decision you make and record the results to track the progression of the project. This also helps when you have multiple teams working on sub problems."

Looking back at the project stages, he thinks it would have been smarter to break down large problems into sub problems and develop a way to use repeated approaches.

"I would go back and write more efficient, well-documented APIs that are generalized enough to be reused. I don't consider myself a software developer or a programmer, but it makes sense to focus more on the optimization of the code and use version control, such as GIT*. That makes tracking of your code progress much easier."

The large volumes of data required to improve the accuracy of the model by extracting functional connectivity, a goal for the next stage of the project, calls for additional compute capabilities. Panuwat's plan is to transform the functional connectivity into an Eigen system domain and use a deep learning model to enhance the training precision. Figure 2 shows the configuration envisioned to accomplish this. "I am in the process of collecting more data," Panuwat said, "and I plan on using Intel® Xeon® Scalable processors to deliver more computational power when the dataset becomes large enough."

Currently, the Intel® AI DevCloud, offering free cloud compute to Intel AI Developer Program members, is powered by Intel Xeon Scalable processors.

Ongoing AI research and development in the medical sector is showing positive results in both diagnostic and treatment methods for patients. Data-driven AI is providing insights into disease that are increasingly being shared among hospitals and healthcare facilities. Anthony Philippakis, a cardiologist and chief data officer at the Broad Institute of MIT and Harvard, noted, "Data is the key. It's the fuel of precision medicine, making all the parts of the complex engine work together to find the right course of treatment."[2]

"Resources provided from Intel create more ideas and creative approaches to complex problems. Also, Intel's engineering team is considered one of the best and having an opportunity to consult with them is very helpful."

– Panuwat Janwattanapong, Intel® Student Ambassador of the Intel® AI Developer Program

AI is Expanding the Boundaries of Science

Through the design and development of specialized chips, sponsored research, educational outreach, and industry partnerships, Intel is firmly committed to advancing the state of AI to solve difficult challenges in medicine, manufacturing, agriculture, scientific research, and other industry sectors. Intel works closely with government organizations, educational institutions, and corporations to uncover and advance solutions that address major challenges in the sciences.

For example, **a collaborative AI project between Princeton University neuroscientists and Intel Labs computer scientists** is providing deeper understanding of how the brain reacts to different stimuli, mapping the brain activity in real time. The software jointly developed through this project decodes neural data and links brain activity to learning, memory, and other cognitive functions.

The Intel® AI portfolio includes:

Intel Xeon Scalable processors: Tackle AI challenges with a compute architecture optimized for a broad range of AI workloads, including deep learning.

Intel® Movidius™ Myriad™ Vision Processing Unit (VPU): Create and deploy on-device neural networks and computer vision applications.

Framework Optimization: Achieve faster training of deep neural networks on a robust scalable infrastructure.

For more information, visit this portfolio page: **https://ai.intel.com/technology**

"We are only at the beginning of solving these problems [healthcare challenges]. We are continuing to push forward and work with industry-leading entities to solve even more."[3]

– Arjun Bansal, VP Artificial Intelligence Products Group and GM of Artificial Intelligence Labs and Software at Intel Corporation

RESOURCES

Intel® AI Developer Program:
software.intel.com/ai

Next-Level Computing Powered by Intel® AI:
ai.intel.com/

Brain Connectivity Project in Intel® Developer Mesh:
devmesh.intel.com/projects/brain-connectivity-analysis-with-classification

AI in Neuroscience: Understanding the Brain:
www.intel.com/content/www/us/en/analytics/artificial-intelligence/ai-in-neuroscience-video.html

Mapping the Mind with Artificial Intelligence:
iq.intel.com/mapping-mind-artificial-intelligence/

Build an Image Classifier in 5 steps on the Intel® Movidius™ Neural Compute Stick:
software.intel.com/ai/build-image-classifier

Intel® AI DevCloud:
software.intel.com/ai/devcloud

Getting the Most out of AI with Caffe* Deep Learning Framework:
software.intel.com/caffe/deep-learning

Intel® Distribution for Caffe*:
software.intel.com/frameworks/caffe/

Accelerated Characterization of the Neural Circuits:
software.intel.com/ai/neural-circuits

"The brain is arguably the most complex device in the universe and so tracking activity within it remains a large unmet challenge."[4]

– Jonathan Cohen, Co-Director, Princeton Neuroscience Institute

[1] "Understanding the Challenges of Epilepsy." Media Planet. 2017. http://www.futureofpersonalhealth.com/education-and-research/understanding-the-challenges-of-epilepsy

[2] Slater, Derek. "Will Data-Driven Healthcare Bring Precision Medicine to All?" IQ by Intel. 2017. https://iq.intel.com/data-driven-healthcare-can-heal-one/

[3] "Kyoto University Chooses Intel Machine and Deep Learning Tech to Tackle Drug Discovery, Medicine and Healthcare Challenges." Intel(R) Newsroom 2018 https://newsroom.intel.com/news/kyoto-university-chooses-intel-machine-deep-learning-tech-tackle-drug-discovery-medicine-healthcare-challenges/

[4] "AI in Neuroscience – Understanding the Brain. Intel video. 2017. https://www.intel.com/content/www/us/en/analytics/artificial-intelligence/ai-in-neuroscience-video.html