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NEUROMORPHIC COMPUTING HELPS DRIVE AI AT THE EDGE

VIDEO TRANSCRIPT

Alex Kass:
Accenture's purpose is to deliver on the promise of technology and human ingenuity. Accenture Labs joined the Intel neuromorphic research community as one of the first enterprise partners because we see tremendous promise in using neuromorphic technologies to deliver responsive, adaptive, energy efficient AI at the Edge. This could enable our clients to create smart products and environments that are more autonomous and easier to interact with. Our most important role in the neuromorphic research community is to help shape experimentation at the application level. We do that by having conversations with our clients about their path to change and the role that Edge AI can play in that journey. Many of our clients have yet to hear of neuromorphic computing. But when we look closely, we often find that they are seeking the type of Edge AI capability that neuromorphic technology can provide

Alex Kass:
We also collaborate closely with neuromorphic researchers at universities around the world. We participate in projects that build and pilot prototypes that prove out neuromorphic's ability to help address the needs of our clients and their customers. When selecting neuromorphic R&D projects to invest in, we focus on problems where Edge AI is needed to compliment cloud-based capabilities. We look for problems that are difficult to solve with the CPUs or GPUs that are common today. And we most prefer to focus on capabilities that can be applied across many business contexts.

Alex Kass:
This is certainly the case with the three exciting projects that we'll highlight in this session. These projects illustrate the use of neuromorphic processing for voice command recognition, full-body gesture, classification, and adaptive control for mobile robots. Let me now turn it over to our first demo. Tim Shea, a research scientist at Accenture Labs, has been working with an automotive client on prototyping the use of neuromorphic computing to help people interact with smart vehicles.

Tim Shea:
Consumer demand for AI driven experiences is increasing rapidly. Especially in the automotive industry. Customers expect responsive voice gesture and contextual intelligence from their vehicles. But current AI hardware is too power hungry, which can impact vehicle performance and limit the possible applications. Smart vehicles need more efficient Edge AI devices to meet the demand. Using Edge AI devices to compliment cloud-based AI could also increase responsiveness and improve reliability when connectivity is poor. So we've built a proof of concept system with one of our major automotive partners to demonstrate that

neuromorphic computing can make cars smarter, without draining the batteries. We're using Intel's Kapoho Bay to recognize voice commands that an owner would give to their vehicle. The Kapoho Bay is a portable and extremely efficient neuromorphic research device for AI at the Edge. We're comparing that proof of concept system against a standard approach, using a GPU. To build the system, we train spiking neural networks to differentiate between command phrases.

Tim Shea:
Then we ran the trained networks on the Kapoho Bay. We connected the Kapoho Bay to a microphone and a controller similar to the electronic control units that operate various functions of a smart vehicle. We're targeting commands that reflect features that can be accessed from outside a smart vehicle, such as park here or unlocked passenger door. These functions also need to be energy efficient. So the vehicle can remain responsive, even when parked for long stretches of time. As a first step, we trained the system to recognize simple commands, such as lights on and lights off, open door, closed door, or start engine. Using a combination of open-source voice recordings and a smaller sample of specific commands, we can approximate the kinds of voice processing needed for smart vehicles. We tested this approach by comparing our trained spiking neural networks, running on Intel's neuromorphic research cloud, against a convolutional neural network, running on a GPU.

Tim Shea:
Both systems achieved acceptable accuracy recognizing our voice commands, but we found that the neuromorphic system was up to a thousand times more efficient than the standard AI system with a GPU. This is extremely impressive and it's consistent with the results from other labs. As Intel will show further in their session on benchmarking the Intel Loihi. The neuromorphic system also responded up to 200 milliseconds faster than the GPU. This dramatic improvement in energy efficiency for our task comes from the fact that computation in Loihi is extremely sparse.

While the GPU performance billions of computations per second, every second, the neuromorphic chip only processes changes in the audio signal and neuron cores inside Loihi communicate efficiently with spikes. This project demonstrates that neuromorphic systems can prove more efficient and more responsive than conventional solutions for AI in smart vehicles. This research is helping our partners in the automotive industry understand how Intel's neuromorphic systems might impact their next-generation products, and it helps us develop a roadmap for future neuromorphic applications.

Alex Kass:
Thanks, Tim. Making it feasible to provide vehicles with robust, responsive voice command recognition is a really good example of using neuromorphic computing to make products easier and more natural to interact with. Another type of interaction we're focused on is gesture. People use gestures to communicate with each other all the time. With the pandemic at the forefront of everyone's mind, there's been a renewed push for touchless interfaces. So for example, instead of having to touch kiosks at the store, at the mall, at the movie theater, what if you could use natural gestures to browse through pages, scroll or make selections. This summer we hosted Kenneth Stewart, a graduate student in [Emery Nefshee's 00:07:01] lab from UC Irvine, to work with Andreea Danielescu, a researcher at Accenture Labs. Kenneth and Andreea will now highlight work. They're doing using neuromorphic computing, paired with a neuromorphic camera, to create a robust gesture recognition capability.

Kenneth:
Everyone uses gestures and body language when talking to each other. So what if we could interact with technology as easily as you interact with other people? To select the movie you want to see at the theater or in your home, or to find out how to get to your favorite store in the mall. We believe that neuromorphic computing can play an important role in making this kind of interaction common place and are working on developing new algorithms to achieve this.

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Automatic recognition of full body gestures, like waves, has been challenging because people can make the same gesture many different ways. And people have no problem recognizing these different gestures as having the same meaning because our brains adapt to the subtle differences in these gestures. To conventional AI, these gestures are completely different. Using neuromorphic computing, we can create AI models that, like our brains, can adapt to the subtle differences in people's gestures using synaptic plasticity.

Kenneth:
This feature of the Loihi research processor enables continuous on-chip learning and doesn't require the large amount of data the other AI approaches require. Our approach combines the best of both conventional and neuromorphic hardware. State-of-the-art gesture recognition algorithms use deep convolutional neural networks on GPUs. So we at first train a model using a deep spiking convolutional neural network and Loihi simulator on a GPU. Then we transfer the model to the Intel Loihi and retrain the last layer of the network using local learning rules that can learn from new input data in real time, as seen here. We also leverage an event based camera, which is, effectively, a silicon retina that mimics how human retina see what's around us. The silicon retina can detect changes up to 30,000 times faster than an RGB camera, with virtually no motion blur. Making it ideal for seeing dynamic movements, such as gestures.

Kenneth:
Here's an example. First I teach Loihi how I wave. Then I try waving in a different way with a larger, faster motion. After seeing only one example of both types of waves, Loihi can recognize both as waving gestures. We can use the same concept to easily recognize different people's waves and compare the similarity of those waves using variational autoencoders, or VAEs. VAEs can be used to learn relationships between data points in complex data, such as gestures.

The data can be encoded into a latent space representation that can be used to analyze relationships between data points. The representation captures relationships, such as nearby pixels being organized into objects, such as right hand versus left hand. By calculating the latent space representation of our gesture set, we can compare similarities between people's gestures.

Kenneth:
Here we use a hybrid spiking neural network and artificial neural network VAE. The spiking network encodes gestures, and the artificial neural network decodes the latent space representation into an image from visualization. Because VAEs are an unsupervised learning method, we could learn from any new data that is provided after we train our model, without needing a label.

Kenneth:
This allows us to do online, self-supervised learning of new people's gestures by comparing the latent space representation of the new gestures to existing gesture data, and applying a label automatically for learning. With this new approach, using neuromorphic computing, people will be able to naturally interact with technology through gestures to watch TV, or use the directory at the local mall, and much more.

Alex Kass:
Thank you, Andreea and Kenneth. These first two demos highlight the ways that neuromorphic computing can enable more natural forms of interaction. Our final project for this session focuses on something a bit different. Using neuromorphic computing to provide the onboard intelligence needed to control a wheelchair mounted robot arm. This Accenture sponsored work is being led by one of our university partners, professor Elishai Ezra-Tsur. He directs the Interdisciplinary Neuro-Biomorphic Engineering Lab at The Open University of Israel. Lazar Supic, a research scientist in our labs at Accenture, is working with Elishai's team. He will describe this inspiring application and illustrate why neuromorphic computing could play a crucial role in making it feasible.

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Lazar Supic:
For individuals with severe mobility impairments, activities such as eating and drinking, shopping, and simply arranging items in their surroundings can become very difficult. Significantly reducing independence and quality of life. Studies suggest that assisted robotics can increase disabled user's sense of independence and reduce time needed from a caregiver. A wheelchair-mounted robot arm could be used to grab and move objects, helping some users with mobility impairments do everyday tasks. However, it has been challenging to develop a wheelchair-mounted robot arm that is functional and affordable for the real-world users. Accenture Labs is working with Intel Labs, The Open University of Israel, and ALYN hospital to overcome the challenges confronting existing solutions. Our innovations uses Intel's neuromorphic computing hardware and then adaptive control algorithm, developed by Applied Brain Research.

Lazar Supic:
Moving a robot arm accurately to an object you want to pick up is both mechanically and computationally complex. It involves precise position estimation and 3D motion planning. When the arm is carrying something where the weight can shift around, like a bottle of water, that makes accurate movement even more difficult. You can see that the added weight causes the arm to unintentionally run into the table. When the arm is mounted on a moving wheelchair or is reaching towards a moving target, like a user's mouth, that requires the control algorithm to be continuously adjusted with very little delay.

Lazar Supic:
And for a wheelchair-mounted device, the chip that controls the robot needs to be energy efficient to avoid draining the battery. So even with the best robotic hardware position estimation and motion planning are never perfect in the real world. But the most precise, state-of-the-art robot arms are very expensive. Pricing out many people who need them.

To help provide the population of users with the movement impairments, if you want to use more cost-effective robotic arm. But that will mean a robot arm that is less mechanically precise.

Lazar Supic:
To address these challenges, Open University of Israel designed a lower-cost robot arm, and the project team is developing a prototype solution that uses adaptive control algorithms powered by Intel Loihi to enable the low-cost arm to move precisely. Loihi's on-chip learning, low-power consumption, and the ability to drive streaming real-time AI can control a robot time that performs everyday tasks more effectively, and without draining the onboard batteries too quickly. With adaptive control powered by neuromorphic computing, the robot arm learns as it moves. It adapts to overcome movement errors with lifting heavy objects. In the simulation, the robot arm learns during the course of just a few movements to accurately reach a target position. Our collaborators are benchmarking this approach against an adaptive control algorithm running on a GPU and against the traditional method of controlling a robot arm with a PID controller.

Lazar Supic:
So far, these results suggest that neuromorphic proof of concept system can provide a better experience to the user with better accuracy, longer battery life and more responsive movements. The neuromorphic system could also learn efficiently over time to continuously improve the system. This project illustrates the potential for Intel's neuromorphic devices to enable accurate and flexible robotics with lower-cost hardware. We can see that being extremely important in the future for our clients that are increasingly relying on the robots in the world. And it is extremely exciting to see how we might apply this technology to improve the quality of life for people with disabilities and use cutting Edge AI for social good.

Alex Kass:
Thanks, Lazar. The three projects we've highlighted today illustrate key benefits of neuromorphic computing for solving some real-world problems. It can operate with less data, less power, and better real-time learning than existing AI solutions. All at the Edge. We see this as a key enabler of the world we envision, populated with many smart products and environments that are more autonomous and easier to use than what we have today. We expect neuromorphic powered Edge AI will have an important role in the enterprise computing environment. As our clients expand their footprint in the cloud, neuromorphic Edge devices will enable seamless integration with sensors and systems everywhere.