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Photonics Chips for Machine Learning

With the development of technology, many electronic products appear and become an integral part of our lives. Electronic chips have become the most important component in electronic devices as a symbol of human's brain. While in recent years, a new type of chip, photonics chips, has become the focus of research because of its superior performance in signal transmission and processing. "The chip could be used to process massive neural networks millions of times more efficiently than today's classical computers do." [1] As mentioned, photonics chips could make a huge contribution to the study of neural networks and machine learning. And because of those advantages, photonics chips will bring greater convenience to machine learning than electronic chips. Thus, to make machine learning more efficient, we need photonics chips.

Although photonics chips are not fully developed, there are some great applications based on them. One of them is a photonics sensor with embedded computing [2]. This product will calculate signals from input light spots and then output the light position information, which means it does not need an external controller to compute processing. Without the external controller, the sensor can be designed in a smaller size and less cost. Moreover, since its high-speed readout and auto light tracking, the sensor can be used in a wide range of automatic equipment. Besides sensors, the most significant application of photonics chips for machine learning is optical computing, such as optical computers and self-driving cars. Optical computers are computers using photon beams instead of electric current. When people need to transmit data or signal for long distances, optical computers will let people know how powerful they are. Except for a faster speed, optical computers can hold more data on a smaller size than electric computers because beams and light do not interact when they pass through each other. [3] And self-driving cars can also use optical computing to estimate the motion of objects on the road instead of using classical computer vision. [4] However, using optical computing brings huge challenges because we still do not know how to prevent the optical networks from attacks. Once optical computing can be used in self-driving cars, we will get a higher speed detection of objects that would affect the car motion. Based on previous research, having lower price and smaller size, large capability, and preventing interaction between magnetics and electronics will be the societal significance of photonics chips.

After having researched online, photonics neural networks is a part that I am really interested in. There is a company called LightOn located in France. They have an amazing solution for machine learning, OPU (optical processing units). [5] To implement

the features of OPU, they have an open source library for the public to try with a simulated OPU. In order to build OPUs, a background research should be done, which is direct feedback alignment. They let the direct feedback alignment work like a back propagation(BP), and they did even better than BP. After dividing different types of data from a normal training signal, they finally can do things with neural networks that are similar to dealing with signals because neural networks are like a web of signals.[6] Except LightOn, a research talks about neural networks enabled by nanophotonics also give me a basic understanding how it works. The article discusses two types of artificial neural networks(ANNs), direct and indirect.[7] For indirect ANNs, they build four basic types to separate billions of neurons, and they divide them by weight. In order to deal with billions of data, photonics would be one of the best choices. "Optical signals can be multiplexed in time, space, polarisation, angular momentum and wavelength, domains, and optical technologies may overcome the problems inherent to electronics. "[8] Because of those benefits, using photonics technology will highly improve the function of ANNs. For direct ANNs, it is a good idea to build ANNs on the neurons to solve problems like drug screening and targeting, and recreation computational units based on living cells[9]. Though the research has not been accomplished, I get some interesting thoughts from it, and I want to get a chance to solve it in the future.

In the end, the research of photonics chips for machine learning is still limited, but industries and researchers are doing their best in this area. More and more ideas come out and are accomplished already. Once photonics chips mature, it will make a huge difference to the world.

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