Problem Statement:

The topic is covering how photonic chip applications are used for machine learning. To learn about this project, here is some background research about what a photonic chip is and how it is different from a normal chip. Traditionally the chip is powered by electricity, it contains resistors, inductors, transistors, etc. But the photonic chip is based on a photonic integrated circuit, it can also be called an optical processing unit, instead of having electron flux, there are only photons that pass through optical components like lasers, waveguides, phase shifters, etc. [1]

The photonic chip injects light, as the communication medium to drive its components, it consumes less power than the classic chip, which also means less heat is generated. But it could perform more efficiently to transmit massive data.

As a result, it can be applied to a wide variety of applications, besides machine learning, it also has great performance in computer vision, computes time series, neural networks, image processing, identifies objects, Autonomous vehicles, and more.

As the computational demand keeps increasing, more data processing and computing ability are required. Since the photonic chips can process more data with less power consumption, it becomes possible to speed up the computing environment. The disadvantages of the photonic chip are compared to the electrical chips, it will be much more costly, and also the chip will only be compatible with photonic systems, which means the user may need to replace the entire system, it will be too expensive. Also, the optical system will rely on bulky optical components, it has limitations when dealing with small neural networks.

In this project, I am going to focus on how photonic chips are related to machine learning. The major reason is that photonic chips can process and diagnose massive data more efficiently than electrical chips. As an

application, MIT researchers have developed a compact photonic accelerator, theoretically it consumes less energy and reduces chip area. Simulations suggest that this photonic accelerator can process neural networks more than 10 million times below the energy-consumption limit of traditional electrical-based accelerators and about 1,000 times below the limit of photonic accelerators. The researchers are now working on a prototype chip to experimentally prove the results.[2] One of the problems they are trying to solve is finding the balance point between accuracy and efficiency. More light fed into the chip means greater accuracy but inefficient, less light input will boost the efficiency but weaker the performance. Based on this research, indicates that using photonics chips for machine learning will significantly improve the data processing speed with less energy consumption. Since the cost of the photonics chip is typically expensive, one way to control the budget is to combine photonics and transistors in the chip. It will impact the performance but will be more budget-friendly.

From the industrial perspective, there is a company called Lightmatter that is producing silicon photonics processors for computing purposes, their chip is called Envise, under the same power footprint, the optical processor performs five times faster and seven times more efficient than Nvidia A100. [3] They believe that the photonics chip with the new algorithms will be the next-generation computing platform for artificial intelligence.

The conclusion is that machine learning and artificial intelligence have had an important influence on our society. Developing photonics processors and algorithms related to it will significantly increase efficiency. The goal of developing the photonic processor should be set as an alternative way to compute the applications that require lower energy consumption, lower latency, and higher bandwidth. It could speed up the learning process

Reference:

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