

ECE 601 - Project 1

Photonic Chips for Machine Learning

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Problem Statement

- “Deep” machine learning: multiple layers in a neural network
- Moore’s Law (number of transistors per integrated circuit doubles each year) losing relevance
- Digital computing requires high energy cost and resources
- Photonic Chips improve processing speeds, require lower energy consumption
- This is not the first time optical analog computing has been used, but new manufacturing has made it a more feasible option

Importance

Electrons shuffling around inside the computers move pretty fast, the top speed in silicon is up to 100,000 m/s.

We use photon for communication: fiber optic cable.

Process the data: convert light to electrons and run them to transistors. Conversion uses energy and electrons are comparatively are slow.

Transistors can be seen as nano switches, its output can act as the input for the next transistor

At least two transistors for logic signals to propagate.

Besides, preserving the signal quality to keep errors minimum is important.

The reason that optical switches don't work as a replacement for silicon transistors the output signal is different wavelength than input, making controlling the next switch in line difficult, or the switch is too big in micron scale instead of the nanoscale.

Mechanics

Scientists at MIT built a chip that uses beams of light sent through channels of silicon to mimic neural network.

The beam split and combine and travel at different speed as the silicon is heated and cooled. Different brightness represent different numbers.(split combine interfere)

They have applied the photonic chip to train a neural network to understand vowel sound and have had modest success.

Before we can see an all light chip will probably see hybrid optical electronic systems that take advantage of lights ability to transmit data quickly.

Application

- Optical neural networks perform linear algebra calculations (matrix multiplication)
- Lightmatter company (based in Cambridge)
 - Uses Mach-Zender interferometers
- Shortfalls: accuracy, noise, ability to train neural networks
- neuromorphic photonic systems.
- Image Processing
- pattern recognition
- Target Tracking
- real-time video processing
- file security
- light switch
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Development and Controversy

With the development of technology, high-speed processing speed and small size enable photonic chips to be upgraded. The development of these technologies has met people's expectations for the speed of information processing. In several experimental products, the processing speed of the photonic chip has performed well.

Usefulness:

autopilot

Development and Controversy

High Price

The practicality is relatively low, and these photonic chips are used in experimental products. If a technology cannot be used in daily life, it is difficult for people to judge whether it is an excellent product technology. In addition, the high production price is also a disadvantage of photonic chips.

However, as the technology matures, the fabrication of photonic chips becomes less complex and the price decreases accordingly.

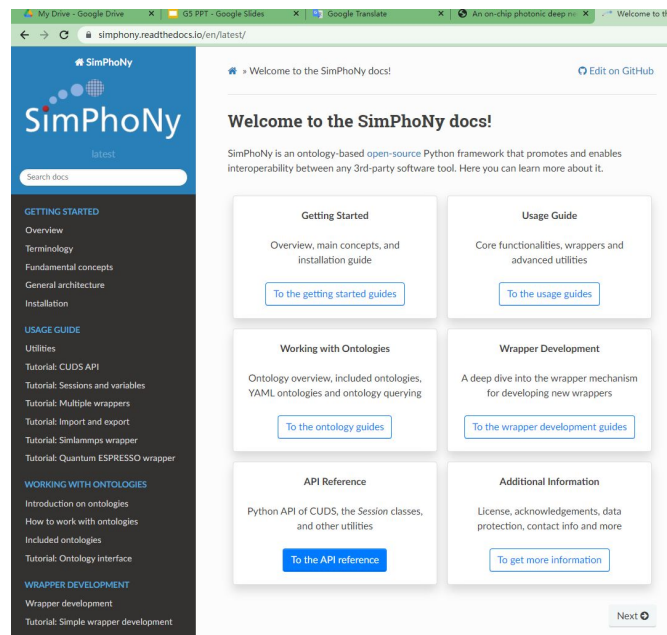
Conclusion

Photonic chip is a promising information processing technology. People expect to process information faster. Although this technology still faces high price and practicality test, better products are always worth looking forward to.

Achievement

1. Shannon found an open source API

<https://github.com/simphony/docs>



Achievement

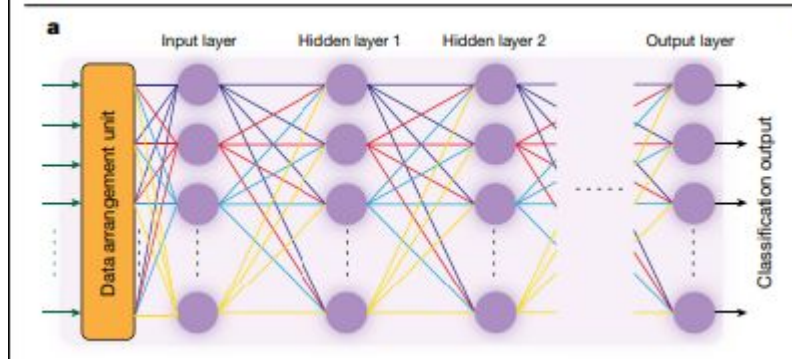
2. Get the suggestions from Professor Milos and Professor Osama.

The academic suggestions are very helpful when we want to make a decision on which direction to take on our project.

When meeting with Pro. Milos, he introduced a lot of basic information about photonic chips to us. And suggests us to attend his lab to use some physical devices.

The python code simulator

Until now, we are still working to do the simulator by coding.



We want to use python to organize the chip's structure which shows on the picture.

It can help pc to recognize the image faster and more clear.

The next step

Complete the coding, make it simulator work.

Try to find a comparison function that can compare the improvement of photonic chips for image recognition.

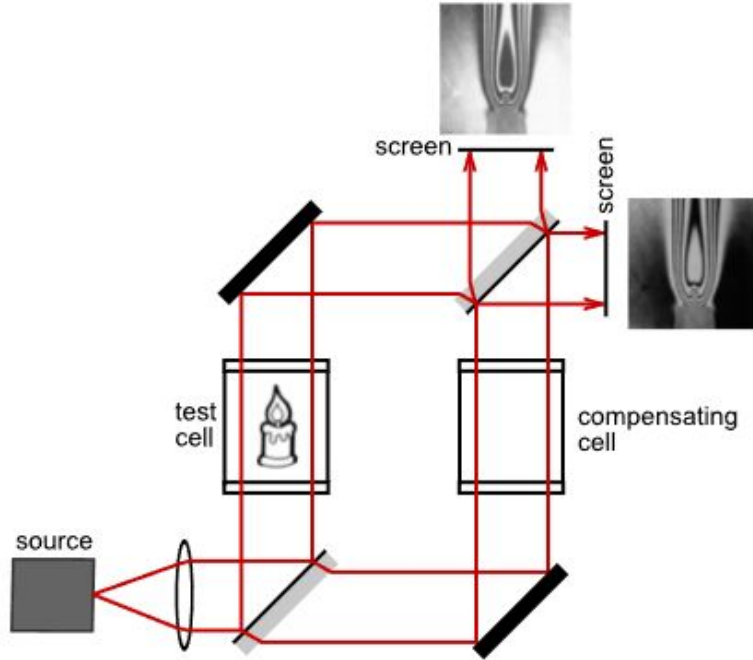
Consider about the physical device, it might help us learn deeper about photonic chips.

Sprint 3

The Achievement this stage:

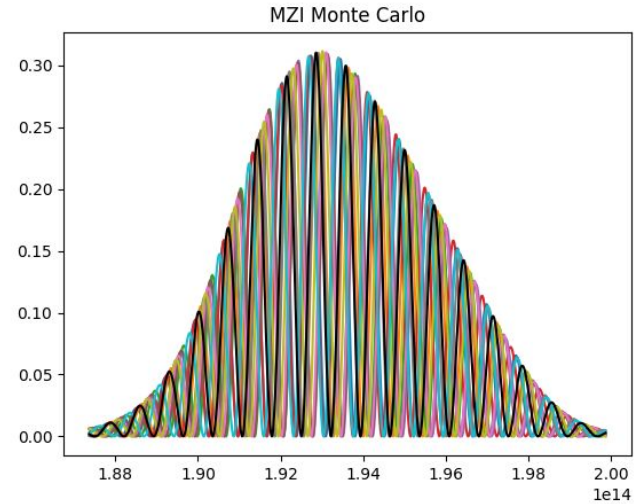
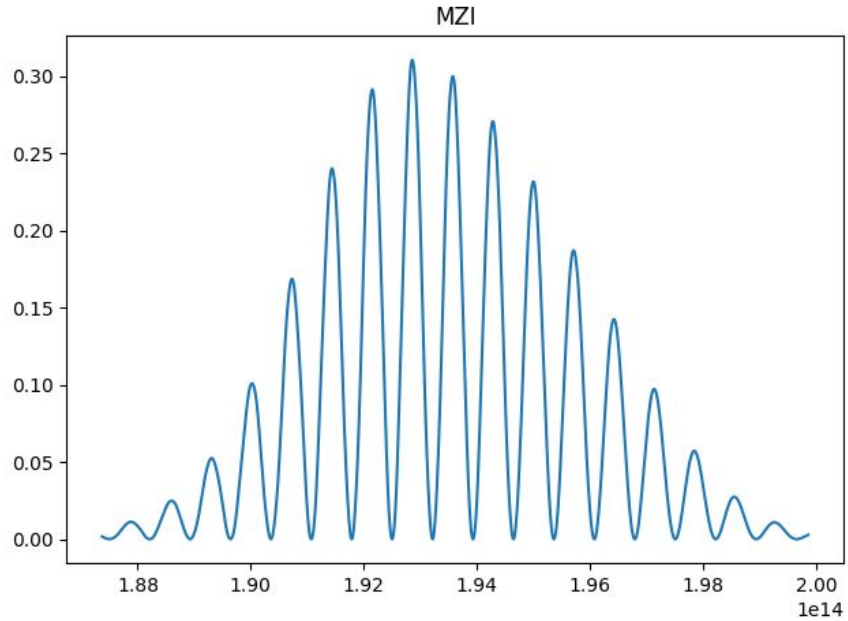
1. open source simulator function on Python
2. test codes' results

The Theory Mach-Zehnder interferometer



Through the interference of the semi-mirror, the candlelight is projected into two output images(one candle light is white, one candle light is black)

Monte-Carlo Simulation



Next stage purpose

1. Design the circuits by simulator to get the completed images
2. Continue to complete the phonnotic chip's code
3. Thin about using the hardware to design the experiment.