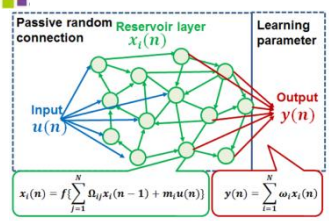
# 06 Optics makes machine learning much faster

## - Photonic reservoir computing for high-speed machine learning -

## Abstract

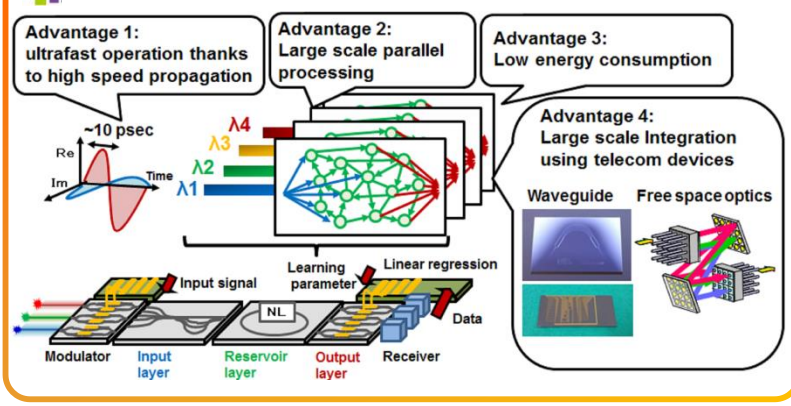
We demonstrate a novel implementation of an artificial neural network (ANN) using integrated photonics technology, which was developed for telecom applications. The photonic ANN has a potential to make machine learning much faster as light can emulate a large-scale neuro response with ultrafast propagation speed owing to its parallelism. Among ANN concepts, we focus on reservoir computing (RC), a neuromorphic system that mimics the human cerebellum, because it is highly suitable for photonic implementation. Here we present the first prototype of the photonic RC. The device successfully emulates neuro responses with ultrafast processing speed (subnano seconds), which is 3 or 4 digits faster than CPU processing. In addition, since the light has complex-valued amplitude, it processes the two dimensional inputs in the same optics. By upgrading the parallel nature of light using wavelength and space division multiplexing, the performance will exceed that of state-of-the-art exa-scale computers in future.

### Reservoir Computing



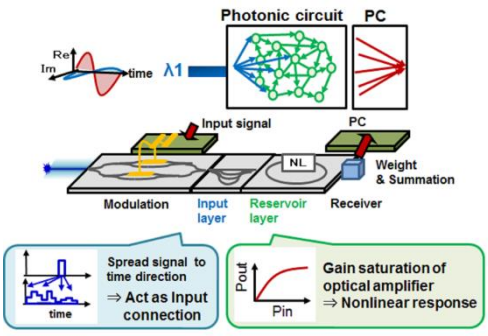

- Passive random connection of input & reservoir layer
- Few learning parameter
- Applicable to time-series processing image processing, and so on.

### Advantage of Photonic Reservoir Computing



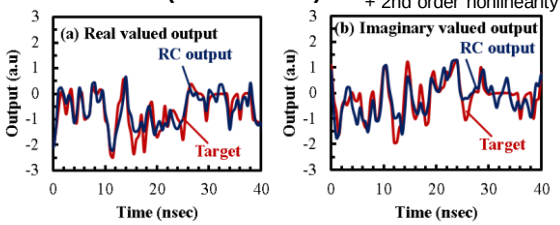

### Prototype Implementation

**Outlook of prototype**




**First demonstration using benchmark task (NARMA10※1)**

※1 NARMA10: Expectation task of 10th-order delay + 2nd order nonlinearity




Implement minimal architecture of photonic RC, and found
(i) Sub-nanosecond-order signal processing
⇒ 3-4 digits faster processing speed than that of CPU
(ii) Successful parallel processing using nature of light
⇒ Complex-valued reservoir computing is possible

**Future work**
- Much larger scale parallelize using wavelength, polarization, and space division multiplexing
- Real time processing using optoelectric implementation

## References

[1] M. Nakajima, M. Inubushi, T. Goh, T. Hashimoto, "Coherently Driven Ultrafast Complex-Valued Photonic Reservoir Computing," *CLEO 2018*, SM1C.4

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