

# **Trainable Analog Hardware Platform for Recurrent Neural Networks (RNN)**

Machine learning models currently require extensive computational resources and this demand is growing rapidly with new models and applications being introduced. Addressing this need, Stanford researchers at the Fan Group have developed a specialized analog computing hardware platform for machine learning models such as RNN. This is an entirely analog method, using wave physics in a material, to achieve the behavior of a neural network. Benefits of this approach include improved computational performance, compact size, and higher energy efficiency, which enable high-speed neural network processing for extraction of patterns from large datasets. This invention has broad applications including, optics, audio / acoustics, medicine, edge computing, IoT, biology, finance, and speech recognition. These findings pave the way for a new class of analog machine learning platforms, capable of fast and efficient processing of information in its native domain.



## **Stage of Development:**

- **Proof-of-Concept**
- Plans to build hardware for acoustic system this year

# Applications

- **Machine learning involving sequential data**, including time-series prediction and classification, natural language processing, machine translation, speech recognition, genetic sequence analysis
- **General approach can be applied to a wide range of fields**, including optics, audio / acoustics, medicine, biology, finance, and speech recognition

# Advantages

- **Ability to train hardware system** required for implementing machine learning models such as RNN
- **Higher accuracy** than current computational models
- **Higher speed and reduction in power consumption**
- **Compact size with smaller device footprint**
- **Analog hardware platform** - can be faster and more energy efficient than digital processors
- **Uses inverse design techniques** during numerical modeling to design the physical system
- **Applicable to all wave-based systems** - this hardware platform may be realized in optical, acoustic, hydraulic, or geophysical systems

# Publications

- Hughes, Tyler W., Ian AD Williamson, Momchil Minkov, and Shanhui Fan. ["Wave physics as an analog recurrent neural network."](#) *Science Advances* 5, no. 12 (2019): eaay6946.

# Innovators

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