

# A Survey of Optical Neural Networks Applications and Technology

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The aim of this work is to summarize some selected contributions appeared in the scientific literature during the last 15 years about the branch of optical computing relying on optical neural networks.

Over recent years, there has been a great interest in artificial neural networks (ANNs), since ANNs are capable of performing various engineering tasks such as pattern recognition, classification, blind signal processing and optimization.

A possible hardware implementation of neural networks is made through optics<sup>1-12</sup>: This implementation uses light (typically provided by a laser) to process information in the form of signals and images. The inherent parallelism and interconnection capability of optics make it a good candidate for the implementation of the artificial neural network interconnections, as well as the optical non-linear phenomena may be advantageously exploited for the realization of non-linear processing elements.

The goal of the work in optical neural networks is to exploit this enormous capability to design practical neural network devices that solve real-world problems.

There are three research mainstreams in this area: The fabrication of optoelectronic devices for the implementation of the nonlinear activation function of the neurons, the development of holographic materials and techniques for the implementation of the artificial synapses, and the application of these ideas to image-processing problems.

The aim of the present work is to briefly illustrate some selected topics in optical neural network theory and technology, drawn from the relevant literature. In particular, the following topics are considered within the extended paper: The capabilities and limitations of using fixed planar holographic interconnections in a neural network system; the quantum neural networks; the artificial optical sensor for neural network application based on *Bacteriorhodopsin*; the coherent optical neural networks; the technology of off-axis holograms with high space-BW product; an associative Hopfield model; optical neuro-fuzzy models; the optical activation function implementation and the intensity-subtraction question, and the optical neural networks with binary weights and inputs.

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