The capabilities of photorefractive crystals as media for holographic interconnections in neural networks are examined. Limitations on the density of interconnections and the number of holographic associations which can be stored in photorefractive crystals are derived. Optical architectures for implementing various neural schemes are described. Experimental results are presented for one of these architectures.

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Abstract

Analysis of weighted fan-out/fan-in volume holographic optical interconnections
Praveen Asthana, Gregory P. Nordin, Armand R. Tanguay, and B. Keith Jenkins

Multilayer optical learning networks
Kelvin Wagner and Demetri Psaltis

Cascaded-grating holography for artificial neural networks
Neural networks based on adaptive resonance theory (ART) offer a number of implementation challenges, the greatest of these being the resent mechanism, the massive interconnectivity requirements, and the requirement that these interconnections be adaptive. Previous research on holographic associative memory has inspired us to create a related device capable of learning and of normalizing memories.

In our optical ART implementation the crystal is photorefractive barium titanate (BaTiO₃), which is capable of recording multiple holograms in real time. It acts as part of a resonant cavity designed to converge on the correct images so that it behaves as an ART unit. Contrast this use of a crystal with Fig. 3, in which a fixed hologram is used. The main problems with photorefractive crystals, as far as a potential user is concerned, are (i) they are not very light sensitive, (ii) they are physically small (not always a disadvantage) and (iii) they are expensive, particularly if good optical quality is required (typical in coherent light applications).

This book summarizes the principles and applications of photorefractive crystals and reminds us that, when a suitable material is found, there is a rich variety of really impressive uses of this effect. The authors are experts who have themselves spent much of their scientific lives on this...