Iterative Encoding methods for Computer Generated Holograms

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11. SUPPLEMENTARY NOTES
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12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. ABSTRACT (Maximum 400 words)
Iterative encoding methods capable of greatly increasing the performance of CGH's were investigated. An F/1 holographic lens, designed with an iterative encoding method was measured to have a diffraction efficiency of 87%. This is the highest reported efficiency for an F/1 element. A recursive Mean Squared Error Algorithm was developed to reduce the computation time. A hologram was fabricated to generate a 32x32 spot array. The experimental measurements indicated a diffraction efficiency of 72% and uniformity of ±1%. This is the highest reported diffraction efficiency for such large sized spot arrays.
Final Report

Contract title: Iterative Encoding Methods for Computer Generated Holograms
Performing Organization: University of North Carolina at Charlotte (UNC)
ARO Proposal Number: 28416-PH
Contract Number: DAAL03-91-G-0091
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Report of Inventions: None

Enclosure (1)
Statement of Problem Studied

Iterative encoding methods capable of greatly increasing the performance of CGH's were investigated. The goal was to develop new methods and/or modify previous methods to improve the performance of CGH's for specific applications. Several applications were to be identified near the beginning of the project. Performance was to be measured in terms of diffraction efficiency and signal-to-noise ratio while limited to specific practical constraints. Such practical constraints included: computation time and fabrication limitations (minimum feature size and positioning resolution).

Significant Results

The first prototype CGH encoded with the recently developed Radially Symmetric Iterative Discrete On-axis (RSIDO) encoding method was measured experimentally. This hologram was fabricated in silicon by a deposition lift-off process and was coated with an anti-reflection layer on both sides. It was a holographic lens with an F-number of 1. The experimentally measured diffraction efficiency was 87% [1]. This is the highest reported efficiency of an F/1 element. The previously highest reported diffraction efficiency of an F/1 element was 52% [2].

A modified version of the Iterative Discrete On-axis (IDO) encoding method [3] was developed to decrease the computation time. This was achieved through the use of a Recursive Mean Squared Error (RMSE) algorithm. Results showed that if the hologram was limited by fabrication requirements the modified IDO algorithm can reduce the computation time at a cost of less diffraction efficiency. (For example for a 32x32 spot array can be generated with a 128x128 cell CGH in about 1/5 the computation time needed for the original IDO method and with about 6% lower diffraction efficiency). On the other hand, if the CGH design process is limited by computation time, then the RMSE algorithm can provide higher performance. For example, a 32x32 spot array can be generated with a 256x256 cell CGH with a diffraction efficiency of ~76% and with ~86 hours of CPU time on a SUN Sparestation. Comparing this to a 128x128 CGH encoded with the original IDO method, this corresponds to a savings of 50 hours in CPU time, an increase of ~5% in diffraction efficiency, and a large increase in signal spot power uniformity [4].

Experimental CGH's were fabricated to verify the efficiency of the above encoding method. A 32 x 32 spot array was fabricated with a uniformity within ±1% of a central value and a diffraction efficiency of 72%. We believe this is the highest efficiency reported for large size spot arrays. (Previously reported diffraction efficiencies and array sizes include: 72% for a 3x3 [3], 62% for a 5x5 [5] and 25% for an 81x81 spot array [6]).

Extensive theoretical comparisons between the IDO method and other encoding methods were performed to find conditions under which IDO achieves higher performance.
List of Publications/Reports/Presentations


F. Degrees Awarded to Supported Personnel

Hudson Welch M.S. Electrical Engineering
Jared Stack M.S. Electrical Engineering
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Bibliography


