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6. AUTHOR(S)

Dr. Michael R. Feldman

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

University of North Carolina at Charlotte
Electrical Engineering Department,
Hwy 49N, Charlotte, NC 28223

8. PERFORMING ORGANIZATION REPORT NUMBER

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The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

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13. ABSTRACT *(Maximum 200 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.

14. SUBJECT TERMS

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Final Report

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Performing Organization:	University of North Carolina at Charlotte (UNCC)
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Contract Number:	DAAL03-91-G-0091
Author of Report:	Dr. Michael R. Feldman
Personnel Supported:	Jared Stack, Graduate student
	Nianglamching Hangzo, Graduate student
	Hudson Welch, Graduate student
	Michael Feldman, Assistant Professor
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 ration 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 Sparcstation. 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

1. J. D. Stack and M. R. Feldman, "Recursive mean-squared-error algorithm for iterative discrete on-axis encoded holograms," Applied Optics 31, 4839-4846, 1992.

2. W. H. Welch, J. E. Morris and M. R. Feldman, "Iterative Discrete On-axis Encoding of radially symmetric computer generated holograms," Submitted for publication to JOSA-A, 1992.

3. Jared D. Stack and Michael R. Feldman, "Iterative Discrete On-axis Encoding Of Computer Generated Holograms, Optimized for Generation of Large Spot Arrays," OSA Annual Meeting, 1991.

4. W. Hudson Welch, James E. Morris and Michael R. Feldman, "Design and Fabrication of Radially Symmetric Computer Generated Holograms," OSA Annual Meeting, 1991.

5. J. D. Stack and M. R. Feldman, "Iterative Discrete On-axis Endoding for generating Spot arrays," to be submitted to Appl. Opt.

F. Degrees Awarded to Supported Personnel

Hudson Welch M.S. Electrical Engineering

Jared Stack M.S. Electrical Engineering

Nianglamching Hangzo M.S. Electrical Engineering

Bibliography

1. W. H. Welch, J. E. Morris and M. R. Feldman, "Iterative Discrete On-axis Encoding of radially symmetric computer generated holograms," Submitted for publication to JOSA-A, 1992.
2. J. R. Leger, M. L. Scott, P. Bundman and M. P. Griswold, "Astigmatic wavefront correction of a gain-guided laser diode array using anamorphic diffractive microlenses," Computer Generated Holography II, Proc. SPIE, vol. 884, pp. 82-89, 1988.
3. Michael R. Feldman and C. C. Guest, "Iterative Encoding of High Efficiency Holograms for Generation of Spot Arrays", Optics Letters, vol. 14, pp. 479-481,1989.
4. J. D. Stack and M. R. Feldman, "Recursive mean-squared-error algorithm for iterative discrete on-axis encoded holograms," Applied Optics, vol. 31, 4839-4846, 1992.
5. S. J. Walker and J. Jahns, "Array Generation with Multilevel Phase Gratings," JOSA-A, vol. 7, pp. 1509-1513, 1990.
6. F. B. McCormick, "Generation of large spot arrays from a single laser beam by multiple imaging with binary phase gratings," Optical Engineering, vol. 28, pp. 299-304, 1989.