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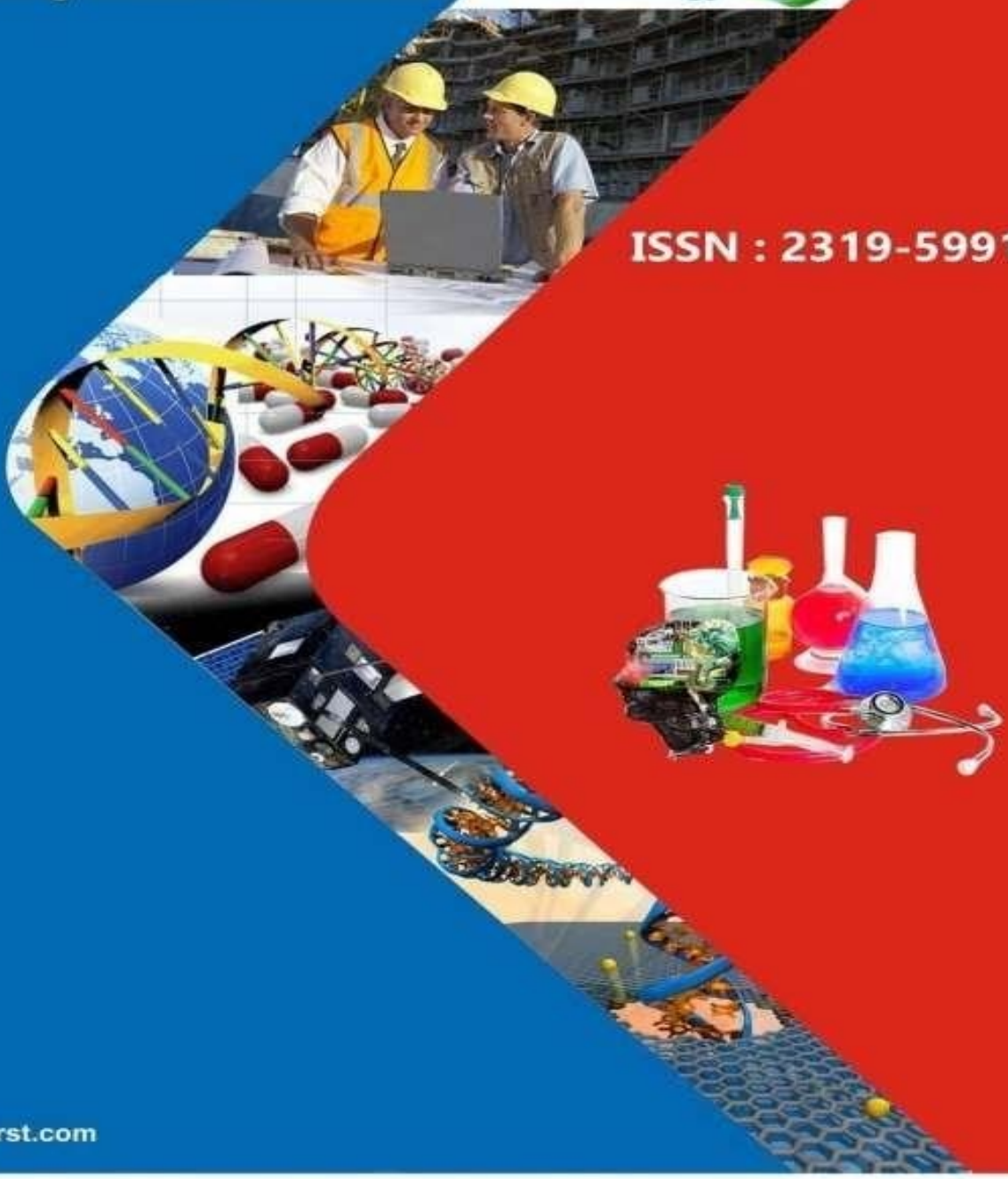

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Holographic Encryption Applications Using Multichannel Bessel Beam

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Abstract—

For microwave encryption, holography offers a way to reconstitute both the intensity distribution and the phase distribution. This study presents a holographic encryption method that uses a multichannel Bessel beam as the encryption key and uses the phase distribution of special characters carrying information as the output. The two quasi-optical mirrors that make up the bulk of the system are optimized for deformation using a tweaked version of the Katsenelenbaum-Semenov algorithm. Using commercial software, we can simulate a system and get its output field for various inputs. together with high levels of security are confirmed by simulation.

Keywords—holographic encryption, multichannel Bessel beam, quasi-optical mirror.

INTRODUCTION

Holography, which has been used with X-rays, electron beams, and an optical beam, offers a crucial method for reconstructing intensity and phase information [1]. Various physical aspects of microwaves, including as polarization, wavelength, and time, have been used to transmit separate data channels for holographic systems with huge capacities. Additionally, there has been a lot of focus on orbital angular momentum (OAM) as it is a crucial physical feature of microwaves. As a whole, OAM Image 1. A holographic encryption system schematic. Part A: Interchannel The Bessel beam The Helmholtz equation governs the propagation of scale fields in a homogeneous medium, as is well known [3]. The equation that describes the Helmholtz phenomenon is (∇2- 1 v2 ∂2 ∂t2). φ(r⃗,t)=0 (1) The variables φ, r⃗, v, and t represent the scale field, position vector, phase velocity, and time, respectively, of the wave. Among the several answers to (1), non-diffracting waves or beams—also known as localized waves—proceed without divergence and have their energy spatially confined. denoted by exp(ilθ), where l is the helical mode index and θ is the azimuthal angle of a helical wavefront, is equivalent to a helical phase factor. Unfortunately, traditional digital holograms do not show OAM selectivity, thus we miss out on this degree of freedom's potential information carrying capabilities [2]. It is essential to maintain the OAM property and exhibit OAM selectivity while reconstructing the related holographic pictures in order to realize OAM holography, where the helical phase may be used as the data carrier. The authors of this work simulated holographic encryption using a multichannel Bessel beam. With the use of multimode OAM, the Katsenelenbanum-Semenov (K-S) technique is used to retrieve the target image's mirrors. Findings from the simulations prove that electromagnetic encryption using a holographic encryption scheme is feasible. Clear reconstruction of the target picture is possible for certain multichannel Bessel beams; otherwise, fuzzy reconstruction is possible. Part Two: The Basics and the Design Process The procedure for generating the target field's phase using the Bessel beam as an input is shown in Figure 1. The target area may be illuminated with a field with a specific phase distribution that carries the desired information when the predicted Bessel beam shines on the mirrors. On the other side, a distorted and unidentifiable phase distribution of the target field results from using the incorrect beam of light to illuminate the mirrors.

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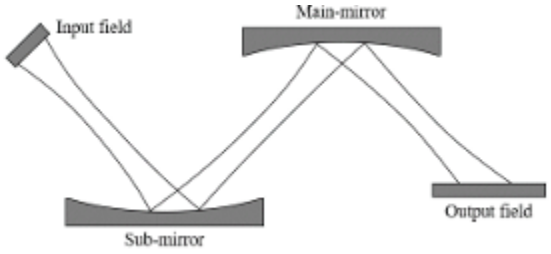

Fig. 1. Schematic diagram of holographic encryption system.

Chapter One: Multichannel Bessel Beam The Helmholtz equation governs the propagation of scale fields in a homogeneous medium, as is well known [3]. Here is the Helmholtz equation:

$$(\nabla^2-\frac{1}{v^2}\frac{\partial^2}{\partial t^2})\psi(\vec{r},t)=0 \qquad (1)$$

The variables φ, r⃗, v, and t represent the scale field, position vector, phase velocity, and time, respectively, of the wave. Among the several answers to (1), non-diffracting waves or beams—also known as localized waves—proceed without divergence and have their energy spatially confined.
In cylindrical coordinates, the Bessel beam provides a solution to (1) and is a kind of confined wave. The amplitude A0, the radial and longitudinal components of the wave vector (□), the angular frequency ϋ, the polar coordinates ρ and φ, and the Bessel function of the first type of order n are all components of a monochromatic wave's solution. Two things connect β and kρ:

$$\beta^2+k_\rho^2=(\frac{\omega}{c})^2=k_0^2 \qquad (3)$$

ıere the angle between them is axicon angle, δ, given by:

$$\delta=\arctan(\frac{k_\rho}{\beta}) \qquad (4)$$

A cone with an opening angle of 2δ, as provided by (4), is described by equation (3). Holographic Encryption System Design (B) The holographic encryption system's uneven mirror is its design key. As shown in Figure 1 [4], when the input and output fields are known, the modified K-S method is a useful tool for optimizing the quasi-optical mirrors. Consequently, the holographic encryption system is designed using the K-S algorithm in this research. The relative location of the source field, as seen in Figure 2,

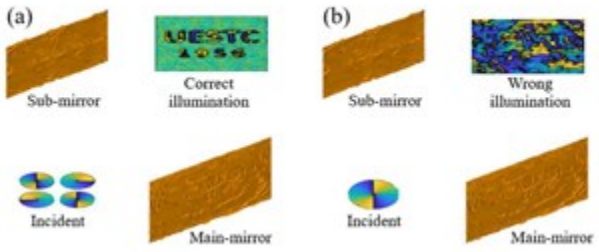

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Fig. 2. The process of phase generation of target field with the Bessel beam as input.

This is the necessary data. (b) Incorrect data entry. The geometric optical approach determines the target field and mirrors prior to iteration. Here is a brief overview of the algorithm's iterative process: The field on the Main-mirror may be determined using the inverse scalar diffraction formula when the target field is adjusted to the "UESTC 1956" phase distribution. First, optimize the Main-mirror field, which will have an effect on the Sub-mirror. Then, compare this field to the input field of the multichannel Bessel beam. from 280 to 300 4. Determine the field that extends from the Sub-mirror to the Main-mirror, compare it to the target field, and thereafter optimize the Main-mirror. Look at the target field that was set and the output field side by side. Stop iterating if vector purity is met; otherwise, keep going as before.

DESIGN AND RESULTS

The final product and the steps used to create the mirrors are shown in Figure 3. The source field and encryption key in this configuration are four Bessel beams of various modes but same intensity. Splitting the target picture into four sections, each stimulated by a Bessel beam, allows for simple identification following iteration and a clear target image overall. Thus, in order to acquire the phase information of the relevant section, the preset Bessel beam must be utilized as an input. A+, -1, +1, and -2 are the four predefined Bessel beam modes.

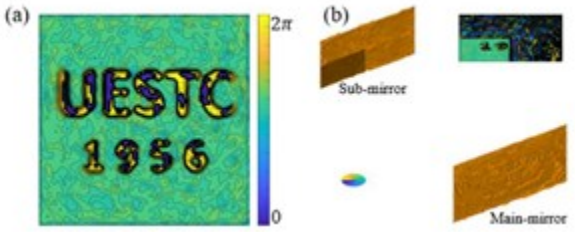

Fig. 3. (a) The target image(b)

The procedure for creating mirrors. The sub-mirrors for each component are then obtained by feeding the preset Bessel beam independently. Figure 3(b) shows an example of how to generate a partly clear phase picture by transferring Mode +1 from the shaded portion of the Sub-mirror to the Main-mirror. The same procedure also yields the other three Sub-mirror components. Finally, the Main-mirror's deformation is determined after an additional iteration, with four beams employed concurrently as inputs. Table I displays the parameters of the primary components.

	Size(mm)	*Theta(degree)*	*Center position(mm)*
Source plane	140×140	0	(0,0,0)
Sub-mirror	200×200	157.5	(0,0,280)
Main-mirror	240×240	157.5	(280,0,0)
Observation plane	200×200	0	(280,0,300)

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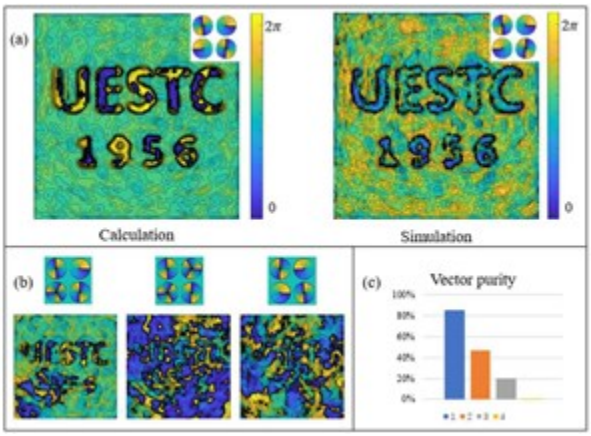

Fig. 4. Analysis of target image under different inputs.

The output of the computation and the simulation when given the right parameters. (b) The incorrectly inputted output. (c) The target field's vector purity in four different scenarios. As seen in Figure 4, a crystal clear "UESTC 1956" and a vector purity of 85.3% may be achieved with the appropriate multichannel Bessel beam illumination. A commercial software simulation was used to produce the desired picture, and the results were in agreement with the calculations. The result is examined under three distinct inputs to confirm the security. First, the target image's overall resolution changes and the vector purity drops to 46.7% when the third input is switched from +1 mode to +3 mode. Furthermore, the vector purity drops to 20.5% when the second and third inputs are altered. You can't make out the desired phase distribution when you switch the directions of the four input modes' rotation. The results of the simulation demonstrate that the system is somewhat secure.

CONCLUSION

This work presents the entire design procedure for a multichannel Bessel beam illuminated mirror holographic encryption system. Holography is used to identify the precise deformation of the mirrors once the target picture and source field information have been pre-designed. The security of the encryption system is ensured by simulations of various input situations, which allow for the decoding of the target picture using the appropriate Bessel beam illumination.

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