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PARA	**Dr. Alfonso Padilla Vivanco** Secretario Académico de la UPT
DE	**Dr. José Humberto Arroyo Núñez** Director de Investigación y Posgrado
ASUNTO	**Conclusión de Proyecto**
FECHA	23 febrero 2022

Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

" Characterizations and Use of Recycled Optical Components for Polarizing Phase-Shifting Interferometry Applications"

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

Se anexa al presente documento la evidencia de la publicación.

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ATENTAMENTE

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Article

Characterizations and Use of Recycled Optical Components for Polarizing Phase-Shifting Interferometry Applications †

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† This paper is dedicated to the memory of our marvelous colleague, Doctor Gustavo Rodríguez Zurita. "That person who helps others simply because it should or must be done and because it is the right thing to do, is genuine without a doubt, a real superhero (SL)".

Abstract: In this research, we report using optical components such as cubic beam splitters, lenses, diffraction gratings, and mirrors from broken, obsolete, or disused electronic devices to implement a simultaneous polarization-based phase-shifting interferometric system. The system is composed of a polarized Mach–Zehnder interferometer (PMZI) which generates a sample pattern coupled to a 4f imaging system with a diffraction grating placed on its Fourier plane. Such a diffractive element replicates the pattern generated by the PMZI, and each replica is centered and modulated by each diffraction order generated by the grating. The corresponding individual phase shifts are controlled by placing linear polarizers with known angles in front of each replica. Experimental results are presented using several phase samples such as an oil drop, a pseudoscorpion claw, a microarthropod, and red blood cells. In addition, a comparison of the retrieved phase was conducted by employing two different phase demodulation algorithms.

Keywords: interferometry; phase shifting; polarization

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1. Introduction

In the last few decades, the so-called brown economic model caused the depletion of natural resources, degradation, and widespread loss of ecosystems. As a response, an alternative economic model emerged called the green economy. An essential part of the green economy model is the circular economy practice of reducing, reusing, and recycling (3R scheme) [1,2]. Following this 3R scheme, we implemented a polarization-based phase-shifting interferometric system using recovered optics from electronic waste [3].

Today, throwing away CD/DVD reading devices and broken or obsolete projectors is prevalent. However, those devices are sources of good-quality optical components such as lenses, mirrors, diffraction gratings, cubic beam splitters, polarizer sheets, and Fresnel lenses, among others that can be used in the implementation of interferometric systems. Currently, several industrial sectors and academic fields incorporate optical and photonic technologies for quality inspection metrics [4–7]; therefore, it is important to develop interferometric techniques and devices capable of contactless high-precision measurements applied to phase objects [4–10].

There are a wide variety of techniques to perform these measurements, mainly based on the recovery of the optical phase. Several methods are applied in this field, with Fourier

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ASUNTO	**Conclusión de Proyecto**
FECHA	10 abril 2022

Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

" Improvement of Retinal Images Affected by Cataracts"

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

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Article

Improvement of Retinal Images Affected by Cataracts

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Abstract: Eye fundus images are used in clinical diagnosis for the detection and assessment of retinal disorders. When retinal images are degraded by scattering due to opacities of the eye tissues, the precise detection of abnormalities is complicated depending on the grading of the opacity. This paper presents a concept proof study on the use of the contrast limited adaptive histogram equalization (CLAHE) technique for better visualization of eye fundus images for different levels of blurring due to different stages of cataracts. Processing is performed in three different color spaces: RGB, CIELAB and HSV, with the aim of finding which one better enhances the missed diagnostic features due to blur. The experimental results show that some fundus features not observable by naked eye can be detected in some of the space color processed with the proposed method. In this work, we also develop and provide an online image process, which allows clinicians to tune the default parameters of the algorithm for a better visualization of the characteristics of fundus images. It also allows the choice of a region of interest (ROI) within the images that provide better visualization of some features than those enhanced by the processing of the full picture.

Keywords: retinal images; eye opacities; cataracts; CLAHE; RGB; CIELAB; HSV

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1. Introduction

Cataract is a common eye condition which cause vision loss due to opacity of the crystalline lens. Its development is related with genetics, aging, systemic or ocular pathologies, or injuries [1]. The loss of vision is manifested by a reduction in contrast due to scattering at the tissues. This pathology not only limits vision to patients, but also can impede visualization of the eye fundus, confusing or complicating the diagnosis of ocular pathologies such as age-related macular degeneration or Stargardt disease [2], retinal detachment, diabetic retinopathy [3], or visceral leishmaniasis [4]. Systemic illness, such as diabetes, not only affects the eye fundus, inducing retinal hemorrhages and venous tortuosity, but also causes cataract development [3]. A crystalline lens might present different stages of cataracts, which cause a shift in the color temperature of retinal images to warmer temperatures and a reduction of the contrast due to intraocular scattering.

Detecting the finer details of the fundus images is very important for eye doctors to provide an accurate diagnosis. Improvement of blurred eye fundus images has been

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Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

" Optical cavitation in non-absorbent solutions using a continuous-wave laser via optical fiber"

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

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Optical cavitation in non-absorbent solutions using a continuous-wave laser via optical fiber

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ABSTRACT

Optical cavitation can be induced by short pulse lasers focused into a solution with a low absorption coefficient or using a continuous-wave laser focused into highly absorbent solutions. In this work, we report the generation of cavitation bubbles in ethanol using a continuous-wave fiber optic laser with emission at 450 nm wavelength. Silver and copper nitrate nanoparticles were immobilized on the flat end-face of a multimode optical fiber tip using the photodeposition technique and then immersed into the solution. Laser light transmitted through the optical fiber is strongly absorbed by both nanoparticles causing an abrupt increase in temperature around the tip of the optical fiber, reaching the spinodal limit of ethanol (~187 °C). At this temperature, an explosive phase transition (liquid–gas) occurs causing the generation of a microbubble, which grows until reaches its maximum radius (~1072 μm in 132 μs) and subsequently collapses, emitting a shock wave. The dynamic behavior of the gas bubble was studied as a function of the laser power using a high-speed video camera, and the shock wave emitted immediately after the bubbles collapse was detected by a microphone. The pressure of the shock wave was analyzed photodepositing different thin films of silver nanoparticles at the tip of the optical fiber, causing optical attenuations of 1, 3, 5, and 7 dB. The experimental results obtained showed that when a thin film of copper nitrate nanoparticles was photodeposited on a film of silver nanoparticles (5 dB), the pressure of the shock wave increases up to ~ 13-fold, in comparison, if we use only one film of silver nanoparticles. Energetic shock waves have potential applications in a variety of areas such as medicine, biological sciences, material processing, liquid microjets generation, among others.

1. Introduction

The phenomenon of optical cavitation has attracted attention because bubble collapse has many interesting applications in science and engineering, such as: sonoluminescence [1], cavitation damage [2], surface cleaning [3], shock wave generation [4], among others. Optical cavitation is normally produced by short laser pulses focused inside a cuvette with a solution with low absorption coefficient, commonly water. In this case, the light intensity at the focus is so high that the nonlinear absorption or avalanche ionization leads to plasma formation, which can be rapidly heated up by the laser leading to water explosive vaporization, producing a vapor bubble [5,6]. The use of pulsed lasers is not the only method to produce optical cavitation bubbles; it can be produced by a continuous-wave (CW) laser; however, it must be focused into a highly absorbent solution, which is generally a mixture of water with some dye [7]. Here, the photon flux is strongly absorbed by a small volume of the solution heated up until the critical limit of water (~300 °C), around this temperature the small volume of superheated water is converted to vapor producing a fast-expanding bubble, which is known as thermocavitation bubble [7].

On the other hand, in 2004 Taylor et al. reported the generation of vapor bubbles at the output end of an optical fiber, which was covered with platinum nanoparticles and immersed in water. In that work, the bubbles were formed due to heat transfer from the nanoparticles to water [8]. Eight years later, Pimentel-Rodriguez et al. reported the generation of microbubbles using fiber optic tips coated with carbon nanoparticles and metallic powders; furthermore, they provide details about the hydrodynamic effects induced around the vicinity of the fiber

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