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TARJETA INFORMATIVA

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	10 de mayo de 2019

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

"An Intelligent Compensation Through B-Spline Neural Network for a Delta Parallel Robot"

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

Se anexa al presente documento la evidencia de la publicación.

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UNIVERSIDAD POLITÉCNICA TULANCINGO HIDALGO
DIRECCIÓN DE INVESTIGACIÓN Y ESTUDIOS DE POSGRADO

ATENTAMENTE

RECIBI ORIGINAL
HECTOR MENDOZA.
8 JUL 2019

An Intelligent Compensation Through B-Spline Neural Network for a Delta Parallel Robot

Jonatan Martín Escorcia-Hernández, Hipolito Aguilar-Sierra, Omar Aguilar-Mejía, Ahmed Chemori, José Arroyo-Núñez

TARJETA INFORMATIVA

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	21 de junio de 2019

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

"Simulación de la Fluorescencia de Objetos Turbios como medio Biológico mediante Opticstudio (ZEMAX)"

El resultado del trabajo, ha sido publicado en formato de cartel en el **X congreso Nacional de Tecnología Aplicada a Ciencias de la Salud**, llevado a cabo en la Universidad Iberoamericana de Puebla. Con el cual se obtuvo el 3° lugar, en la Categoría de Cartel de posgrado.

Se anexa al presente documento la evidencia de la publicación del Cartel.

Trabajo registrado bajo con el número MYT2019-180

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ATENTAMENTE

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013

20 de mayo de 2019

Estimado(a) ALEJANDRA CÁRDENAS ROSALES

PRESENTE

El Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE); la UNAM, a través del ICAT; el Centro de Investigaciones en Óptica (CIO), la Benemérita Universidad Autónoma de Puebla (BUAP), la Universidad Autónoma de Nuevo León, a través de la Facultad de Medicina y la Universidad Iberoamericana, le agradecen haber seleccionado participar en **X Congreso Nacional de Tecnología Aplicada a Ciencias de la Salud**, a efectuarse los días jueves 13, viernes 14 y sábado 15 de Junio del presente año en las instalaciones de la Universidad Iberoamericana, en la ciudad de Puebla.

Al respecto, le comentamos que su trabajo con el código de registro **FI1892019**:

SIMULACIÓN DE LA FLUORESCENCIA DE OBJETOS TURBIOS COMO EL MEDIO BIOLÓGICO MEDIANTE OPTICSTUDIO (ZEMAX)®

ALEJANDRA CÁRDENAS ROSALES JOSÉ ALBERTO DELGADO ATENCIO MARGARITA CUNILL RODRÍGUEZ

ha sido aceptado para su presentación.

Comentarios:

Cumple con la temática del congreso

Le informamos que el trabajo quedó registrado con el número **MYT2019-180** y está programado para presentarse en las sesiones de cartel los días 13 y 14 de junio de las 15:00 a las 17:00 horas.

El cartel deberá estar colocado el día jueves a las 11:00 horas; debiendo estar presente al menos uno de los autores durante las sesiones y podrá ser retirado el viernes 14 después de las 19:00 horas. Le recordamos que el formato del cartel será de 90 cm. de ancho por 120 cm. de alto.

Existe la posibilidad de incluir una versión en extenso de su trabajo en las memorias electrónicas del congreso. Para ello le pedimos nos haga llegar el texto en 3 páginas como mínimo y no más de ocho páginas incluyendo gráficas y figuras, utilizando el formato de Word que le haremos llegar en breve, o una copia de su cartel en formato pdf, al correo electrónico ssolis@inaoep.mx. La fecha límite de recepción es el 10 de Junio.

Agradecemos nuevamente su participación y quedamos a sus órdenes para cualquier aclaración.

Atentamente

Por el Comité organizador

Lic. Silvia Hernández Solis

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TARJETA INFORMATIVA

PARA	**Dr. Alfonso Padilla Vivanco** Secretario Académico de la UPT
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ASUNTO	**Conclusión de Proyecto**
FECHA	02 de Septiembre de 2019

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

"Normalized difference indices in Landsat 5 TM satellite data"

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

Se anexa al presente documento la evidencia de la publicación.

- https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11104/111040W/Normalized-difference-indices-in-Landsat-5-TM-satellite-data/10.1117/12.2532322.short?SSO=1

- https://doi.org/10.1117/12.2532322

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ATENTAMENTE

UNIVERSIDAD POLITÉCNICA DE TULANCINGO HIDALGO
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PROCEEDINGS OF SPIE

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Normalized difference indices in Landsat 5 TM satellite data

M. Delgadillo-Herrera, M. Arreola-Esquivel, C. Toxqui-Quitl, A. Padilla-Vivanco

M. Delgadillo-Herrera, M. Arreola-Esquivel, C. Toxqui-Quitl, A. Padilla-Vivanco, "Normalized difference indices in Landsat 5 TM satellite data," Proc. SPIE 11104, Current Developments in Lens Design and Optical Engineering XX, 111040W (30 August 2019); doi: 10.1117/12.2532322

SPIE. Event: SPIE Optical Engineering + Applications, 2019, San Diego, California, United States

Normalized difference indices in Landsat 5 TM satellite data

M. Delgadillo-Herrera, M. Arreola-Esquivel, C. Toxqui-Quitl, and A. Padilla-Vivanco

Computer Vision Laboratory, Universidad Politécnica de Tulancingo, Hgo. 43629, México

ABSTRACT

Urban growth, deforestation, water resources and thawing of the poles due to globe worming are topics of interest in the research community. Normalize difference indices are utilized in remote sensing to analyzed and classify surface cover types. In this paper research, a multispectral satellite data from Landsat 5 TM is preprocessing, in order to addresses and evaluates accuracy of Normalized difference Built-up Index (NDBI), Normalized Difference Vegetation Index (NDVI), Automated Water Extraction Index (AWEI) and Normalized Difference Snow Index (NDSI) at different time scenes. A quantitative statistical pixel percentages of build-up, vegetation cover, snow/ice and water body is given in this study for different periods of time.

Keywords: Landsat 5 TM, Remote sensing, radiometric correction, NDVI, AWEI, NDBI, NDSI

1. INTRODUCTION

The sustainability of natural resources is an important issue for the development of future generations and social welfare throughout the world. The scientific community dedicates time and effort to understand, measure and quantitatively predict the ecological effects due to deforestation, thawing of the poles, the lack of fresh water, the urban population, among others [1, 2]. Long-term Landsat data allows remote sensing of the earth-environmental change over time. Since Landsat 5 TM was launched in March 1984 by the National Aeronautics and Space Administration (NASA) and decommissioned in January 2013, it is an invaluable resource for the temporal and spatial analysis of vegetation, water, snow and build-up areas [3]. Several multi-band index approaches have been introduced in the literature to delimit these areas in which advantages and disadvantages of discriminating certain materials from others stand out. In this research paper we analyze the multi-band index basic principles (spectral signature in significant units) that were taken into account to increase the intensity contrast of the Region Of Interest (ROI) and the background. The Normalized difference Built-up Index (NDBI), Normalized Difference Vegetation Index (NDVI), Automated Water Extraction Index (AWEI) and Normalized Difference Snow Index (NDSI) are compute at different date and time using Landsat 5 TM multispectral images. In Table 1 is shown the wavelength bands and spatial resolution.

Table 1. Band specifications of Landsat 5 TM [4].

BANDS	Landsat 5 TM	
	Wavelength (μm)	Spatial resolution (m)
Band 1 (Blue)	0.45 - 0.52	30
Band 2 (Green)	0.52 - 0.60	30
Band 3 (Red)	0.63 - 0.69	30
Band 4 (NIR)	0.76 - 0.90	30
Band 5 (SWIR-1)	1.55 - 1.75	30
Band 7 (SWIR-2)	2.08 - 2.35	30

Before performing any ecological analysis or earth-surface mapping, the multi-temporal Landsat 5 TM imagery must be preprocessed. Multispectral image-distortion is a common effect in multi-temporal satellite data due to the difference in solar angle, sensor degradation, scattering and atmospheric absorption. The preprocessing steps allow to obtain similar atmospheric conditions in multi-temporal spectral images to deliver high quality data results [5]. The workflow of this document is as follows: In Section 2, the mathematical methods for normalized difference indices and spectral profiles are shown. In Section 3, outlines the indices extraction results. Finally in Section 4, a main conclusion is given.

Current Developments in Lens Design and Optical Engineering XX, edited by R. Barry Johnson, Virendra N. Mahajan, Simon Thibault, Proc. of SPIE Vol. 11104, 111040W · © 2019 SPIE · CCC code: 0277-786X/19/$21 · doi: 10.1117/12.2532322

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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	02 de Septiembre de 2019

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

"Fractal analysis for classification of breast lesions L."

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

Se anexa al presente documento la evidencia de la publicación.

- https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11104/111040U/Fractal-analysis-for-classification-of-breast-lesions/10.1117/12.2531201.short

- https://doi.org/10.1117/12.2531201

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Fractal analysis for classification of breast lesions

L. B. Alvarado-Cruz, M. Delgadillo-Herrera, C. Toxqui-Quitl, A. Padilla-Vivanco, R. Castro-Ortega, et al.

L. B. Alvarado-Cruz, M. Delgadillo-Herrera, C. Toxqui-Quitl, A. Padilla-Vivanco, R. Castro-Ortega, M. Arreola-Esquivel, "Fractal analysis for classification of breast lesions," Proc. SPIE 11104, Current Developments in Lens Design and Optical Engineering XX, 111040U (30 August 2019); doi: 10.1117/12.2531201

Event: SPIE Optical Engineering + Applications, 2019, San Diego, California, United States

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Fractal analysis for classification of breast lesions

L. B. Alvarado-Cruz [a], M. Delgadillo-Herrera[a], C. Toxqui-Quitl[a], A. Padilla-Vivanco[a], R. Castro-Ortega [a], and M. Arreola-Esquivel[a]

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ABSTRACT

Nowadays, breast lesions are a common health problem among women. Breast thermograms are images recorded by digital-optical systems with high resolution that use infrared technology in order to show vascular and temperature changes. In the present work, we study benign and malignant breast lesions shape by means of fractal analysis. The Fractal Dimension (FD) is calculated with the Box Counting method and the Hurst exponent is obtained using the Wavelet coefficients and the Detrending Moving Average algorithm. These algorithms was applied to synthetic images and breast thermograms. The Fractal Dimension value is used for patient classification with or without breast injury. The proposed methodology was applied to the Database For Mastology Research (DMR) in order to classify thermographic images. The FD of ROIs for breast thermograms was calculated. Results shows that the FD BCM values ranges from [0.45,0.81] in 4 healthy cases and from [0.92,1.33] in 4 unhealthy cases.

Keywords: Fractal analysis, breast thermograms, breast lesions.

1. INTRODUCTION

In recent years, breast cancer has been a relevant health problem that shows growing trend in both incidence and early diagnosis[1]. The main characteristic of this condition is the rapid and disorganized growing trend of abnormal cells. This process causes an exponential increase of the temperature in tissue[2]. Thermal symmetry and asymmetry caused by normal and abnormal cells can be analyzed through the use of infrared images,[3,4]. Moreover metabolic activity and vascular circulation can be also studied through of this kind of images[5]. Abnormal cells show a chaotic and poorly regulated growth. They also show an irregular morphology that can not be measured by classic Euclidean geometry based on shapes such as lines or spheres[6]. Computer-Aided Detection (CAD) systems based on the analysis of breast thermograms can be used to help us in order to identify abnormal thermal patterns related with possible breast cancer[7].

Several studies have shown that by fractal geometry, an irregular shape, can be useful to quantitatively describe the morphology of tumors[6]. James W. et al., describes mathematical models known as statistical growth processes and the application fractals to cancer as morphometric tools for diagnostic and prognostic purposes.[8]. Acording to Katharina Klein et al., they use fractal analysis to identify malignant cells in microscopic images by reflection interference contrast of individual living cells[9]. On the other hand, Maryam Arab Zade et al., indicate that the Fractal Dimension (FD) allows to differentiate malignant or benign tumors in the breast in a quantitative way[10]. Anindita et al., research the efficacy of fractal characteristics for the discrimination of abnormal and normal breast images in mammography and breast thermography[11]. In this work, we calculate the Fractal Dimension and the Hurst exponent of the maximum temperature regions in breast thermograms. The paper is organized as follows. In Section 2 we describe the mathematical methods to calculate the Fractal Dimension and Hurst exponent. Section 3 presents the numerical analysis using synthetic images. The fractal analysis of the breast thermograms are given in Section 4. Finally, in Section 5 the conclusions are sumarized.

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UNIVERSIDAD POLITÉCNICA · TULANCINGO

TARJETA INFORMATIVA

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	03 de Septiembre de 2019

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

"Wavefront coding with Jacobi-Fourier phase masks"

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

Se anexa al presente documento la evidencia de la publicación.

- https://www.spiedigitallibrary.org/conference-proceedings-of spie/11104/1110405/Wavefront-coding-with-Jacobi-Fourier-phase-masks/10.1117/12.2523611.short
- https://doi.org/10.1117/12.2523611

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ATENTAMENTE

UNIVERSIDAD POLITÉCNICA TULANCINGO HIDALGO
DIRECCIÓN DE INVESTIGACIÓN Y ESTUDIOS DE POSGRADO

PROCEEDINGS OF SPIE

Wavefront coding with Jacobi-Fourier phase masks

E. González-Amador, A. Padilla-Vivanco, C. Toxqui-Quitl, M. Olvera-Angeles, J. Arines, et al.

E. González-Amador, A. Padilla-Vivanco, C. Toxqui-Quitl, M. Olvera-Angeles, J. Arines, E. Acosta, "Wavefront coding with Jacobi-Fourier phase masks," Proc. SPIE 11104, Current Developments in Lens Design and Optical Engineering XX, 1110405 (30 August 2019); doi: 10.1117/12.2523611

Event: SPIE Optical Engineering + Applications, 2019, San Diego, California, United States

SPIE.

Wavefront coding with Jacobi-Fourier phase masks

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ABSTRACT

Wavefront coding is a hybrid optical-computational technique that makes use of a phase modulating element in conjunction with a deconvolution algorithm to extend the depth of focus of imaging systems. The phase mask codes the wave-front in such a way that the point-spread function do not change appreciably as a function of defocus. In this work, the modulation is introduced by phase masks in the shape of a subset of Jacobi-Fourier polynomials. We will show, by both numerical simulations and experiments that the Jacobi-Fourier polynomial phase masks are good candidates for high-resolution images under noise presence.

Keywords: Wavefront coding, Jacobi-Fourier, phase mask, trefoil phase mask, depth of focus, Gaussian noise, convolution-deconvolution.

1. INTRODUCTION

Wavefront coding (WFC) is a hybrid optical-computational technique that makes use of a phase modulating element in conjunction with a deconvolution algorithm to extend the depth of field or depth of focus (DOF) of a digital imaging system [1-2]. The trivial method for increasing DOF is to reduce the aperture of the instrument, in this way, the system presents less aberration, which results in better image quality. Nevertheless, a smaller aperture: 1) in-creases the role of diffraction, which limits the resolving power of optical instruments, and 2) reduces the amount of light that can be gathered by the system [3]. The other approach is to deconvolve the defocused images in order to deblur the out of focus regions. This approach has to main problems:

a) the response to the system (PSF) is not invariant under focus shifts and is therefore not known in most of the cases and,

b) deconvolution is an ill posed problem due to the loss of information for those special frequencies where the MTF is close or equal to zero. [4-5].

The technique known as WFC developed by Dowski and Cathey [1] proposes the simple placement of a phase mask (PM) at the exit pupil of the optical system that generates a controlled amount of third order aberrations. The aim of WFC is to modify the point spread function (PSF) in such a way that it becomes invariant over a range of distances around the image plane and MTF does not show zeroes. The coded images (intermediate images) look blurred and must be digitally filtered and an image close to diffraction-limited quality can be obtained [3].

From Dowski's proposal many shapes deriving from the original cubic phase mask solution have been proposed among them we can cite root square [4], trefoil [6], sinusoidal [7], free-form [8], among others. Recently, we have proposed a novel shape for the phase masks based on the Jacobi-Fourier polynomials [9]. These masks shape can be expressed as $r^{(p+1)/2}cos(3\theta)$, where r denotes the radial coordinate, and the azimuthal dependence goes with $cos(3\theta)$ same as trefoil mask. By changing the p value we obtain different shapes. We have shown by numerical simulations that the proper choice of the p value is a trade-off among signal to noise ratio, desired depth of focus and presence of artifacts. In this study, we study the performance of the masks by numerical and experimental analysis and compare with those for trefoil one which has been proven to perform better than cubic masks (less artifacts) [5,6].

This work is organized as follows: In section 2 we describe the Jacobi-Fourier phase masks (JFPM). In section 3 we analyze the optical properties of WFC system. Section 4 is devoted to show, analyze and discuss the numerical and experimental results. Lastly, in section 5 we present the conclusions.

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TARJETA INFORMATIVA

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	06 de Septiembre de 2019

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

"Deconvolution process with GPU in a wavefront coding microscopy system"

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

Se anexa al presente documento la evidencia de la publicación.

- https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11104/111040C/Deconvolution-process-with-GPU-in-a-wavefront-coding-microscopy-system/10.1117/12.2531457.short
- https://doi.org/10.1117/12.2531457

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ATENTAMENTE

UNIVERSIDAD POLITÉCNICA DE TULANCINGO HIDALGO
DIRECCIÓN DE INVESTIGACIÓN Y ESTUDIOS DE POSGRADO

PROCEEDINGS OF SPIE

Deconvolution process with GPU in a wavefront coding microscopy system

K. Ortega-Sánchez, C. Toxqui-Quitl, A. Padilla-Vivanco

K. Ortega-Sánchez, C. Toxqui-Quitl, A. Padilla-Vivanco, "Deconvolution process with GPU in a wavefront coding microscopy system," Proc. SPIE 11104, Current Developments in Lens Design and Optical Engineering XX, 111040C (30 August 2019); doi: 10.1117/12.2531457

SPIE.

Event: SPIE Optical Engineering + Applications, 2019, San Diego, California, United States

DECONVOLUTION PROCESS WITH GPU IN A WAVEFRONT CODING MICROSCOPY SYSTEM

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Universidad Politécnica de Tulancingo, Ingenierías 100, 43629, Hidalgo, México.

ABSTRACT

A Wavefront Coding microscopy system is implemented in order to extend the depth of field of an optical system. An $LC-SLM$ is used to display the profile of a phase mask. A set of optically coded images is recorded in an axial range $[-1, 1.5]$ mm. To accelerate the deconvolution process, a routine developed directly on a GPU is implemented. Using this GPU based approach, the deconvolution time is reduced by providing an additional speed up to the visualization. Digital images are acquired using an experimental setup and results are presented.

Keywords: Wavefront Coding, GPU, Microscopy system, Spatial Light Modulator.

1. INTRODUCTION

Increasing the depth of field (DoF) and maintaining a high resolution have been the classical aim in an optical system. It is well known, that the microscopy systems have a limited DoF. When the biological sample is analyzed under a microscope, commonly the sample is thicker than the DoF. A typical microscopy system produces blurry images in the portion of the object that lies outside of the DoF. To attain images with an extended DoF with high resolutions implies the use of high numerical aperture (NA). However, this leads to a reduction of the DoF.

Wavefront Coding (WFC) technique [1] is an effective way to extend DoF of a microscopy system compared to classical microscopy systems. WFC modulated the wavefront by inserting a properly designed phase mask (PM) in the exit pupil of an imaging system. Point spread function (PSF) can be highly invariant to defocus in an axial range. The images thus obtained are blurred. In addition, a deconvolution process is applied in order to get a final clear image and recover the frequency content of the coded image. Using liquid crystal spatial light modulator ($LC-SLM$) is possible to display any profile to PM. The implemented WFC microscopy system with the use of $LC-SLM$ has led to the desirability of a flexible system. Several PMs have recently proposed, a novel phase mask based on the Jacobi-Fourier polynomials was used [2].

In general, the computational time to perform the deconvolution process is according to the size of the image to be reconstructed. Applied in microscopy, it is required to obtain a quick result for the corresponding analysis. Recent methodologies such as Field-Programmable Gate Array ($FPGA$) [3] or Graphic Processing Unit (GPU) [4] work as hardware accelerators have been used for alternative accessories with better performance in digital processing. The $FPGA$ has been used to perform a reprogrammable implementation.

To accelerate the processing time, an algorithm that uses GPU technology is implemented. GPUs were developed as coprocessors dedicated to graphic functions on a computer [5]. It is auxiliary hardware that allows parallel process to accelerate algorithms that contain operations that can be carried out automatically, while another part of the code is executed in the CPU as shown in Fig. 1. *NVIDIA® GPUs* are graphical card used in image processing. They have different levels of internal memory that they use to store the data, each one has different speed and bandwidth. It offers the advantage of being able to program GPU in high-level language.

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UNIVERSIDAD POLITÉCNICA DE TULANCINGO

TARJETA INFORMATIVA

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	08 de Septiembre de 2019

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

"Index-based methods for water body extraction in satellite data"

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

Se anexa al presente documento la evidencia de la publicación.

- https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11137/111372N/Index-based-methods-for-water-body-extraction-in-satellite-data/10.1117/12.2529756.short
- https://doi.org/10.1117/12.2529756

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ATENTAMENTE

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DIRECCIÓN DE INVESTIGACIÓN Y ESTUDIOS DE POSGRADO

PROCEEDINGS OF SPIE

Index-based methods for water body extraction in satellite data

M. Arreola-Esquivel, M. Delgadillo-Herrera, C. Toxqui-Quitl, A. Padilla-Vivanco

M. Arreola-Esquivel, M. Delgadillo-Herrera, C. Toxqui-Quitl, A. Padilla-Vivanco, "Index-based methods for water body extraction in satellite data," Proc. SPIE 11137, Applications of Digital Image Processing XLII, 111372N (6 September 2019); doi: 10.1117/12.2529756

Event: SPIE Optical Engineering + Applications, 2019, San Diego, California, United States

SPIE.

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Index-based methods for water body extraction in satellite data

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ABSTRACT

Several water index-based methods have been proposed in the literature, which, combine satellite multispectral bands in an algebraic expression. The objective of these water index-based methods is to increase the intensity contrast between water-pixels (surface water-body) and non-water pixels (built-up, soil, vegetation, etc.). The present investigation evaluates the Modified Normalized Difference Water Index (MNDWI) and the Automated Water Extraction Index (AWEI) using the Satellite data from Landsat 5 TM, Landsat 8 and Sentinel 2A at different time scenes. Based on visual inspection of the Lake Metztitlan water body mapping results, a high performance of AWEI approached via the OLI and the MSI sensors is observed. In the selected study area of [9210±9380]m, a statistical water pixel percentage of 30.703616% is observed in a flooding season and 9.884537% for a dry season of the year.

Keywords: Water index-based methods, Landsat data, Sentinel imagery.

1. INTRODUCTION

Water body change detection is an excellent indicator of environmental alteration [1, 2]. The shortage of natural resources due to climate change, urban grow, deforestation, among others has great impact on society. These environmental changes can be evaluated by spectral information registered with a satellite sensor[3]. The long-term Landsat and Sentinel satellite imagery has proved to be an invaluable data resource for environmental water change and ecological analysis. Landsat missions has been operated by the US Geological Survey (USGS) since 1990 [4] and Sentinel 2A was launched by ESA on 2015 [5]. Since, Landsat and Sentinel data became a free download through Internet portals (i.e. Earth Explorer, USGS), it has become an object of study in remote sensing of the Earth surface. The USGS registers 50-fold annually increase in downloads of satellite images [6]. The spatial and spectral resolution in satellite imagery may differ according to the satellite sensor. A comparison of the wavelength bands and spatial resolution among sensors are shown in Table 1.

Table 1. Band specifications of TM, OLI and MSI satellite sensors [7].

BANDS	Landsat 5 TM		Landsat 8 OLI		Sentinel-2 MSI	
	Wavelength (μm)	Spatial resolution (m)	Wavelength (μm)	Spatial resolution (m)	Wavelength (μm)	Spatial resolution (m)
Blue	0.45 - 0.52	30	0.45-0.51	30	0.46-0.52	10
Green	0.52 - 0.60	30	0.53-0.59	30	0.55-0.58	10
Red	0.63 - 0.69	30	0.64-0.67	30	0.64-0.67	10
NIR	0.76 - 0.90	30	0.85-0.88	30	0.78-0.90	10
SWIR-1	1.55 - 1.75	30	1.57-1.65	30	1.57-1.65	20
SWIR-2	2.08 - 2.35	30	2.11-2.29	30	2.10-2.28	20

Based on algebraic expression and bands combination [8, 9], several methods have been developed for surface water extraction [10]. Among the highly threshold-number methods proposed in the literature are the Modified Normalized Difference Water Index (MNDWI) [11], and the Automated Water Extraction Index $AWEI_{nsh}$ no shadows [12].

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