FOUR-DIMENSIONAL OF TSUNAMI COASTAL DAMAGES USING COMPUTER GENERATING INCOHERENT HOLOGRAPHIC INTERFEROMETRY

Maged Marghany
Geoinformation Global Space Technology
130B, Jalan Burhanuddin Helmi,
Taman Tun Dr. Ismail,
60000 Kuala Lumpur
Email:magedupm@hotmail.com

KEY WORDS: Tsunami, Quickbird satellite, RapidEye, Incoherent hologram interferometric, 4-D phase unwrapping, n-dimensional.

ABSTRACT: Recently, N-dimensional, is curious topic between mathematicians and physicians. This work aims at using incoherent hologram interferometric with 4-D phase unwrapping to reconstruct fourth-dimensional of tsunami impacts on coastline. The data are used that involved Quickbird and Rapid Eye images with implementation of 4-D phase unwrapping. The results show that the incoherent hologram Interferometric an excellent tool for reconstructing tsunami chaotic influences on land uses from Quickbird and Rapid Eye satellite data. The study shows coastline of is flooded by tsunami run-up of 6 m which totally damaged road network and urban structures. Incoherent Hologram interferometry can be used to reconstruct 4-D of coastal water turbulent flows. In conclusion, In conclusions, incoherent hologram interferometry hold a great promise for 4-D tsunami inundation using Quickbird and Rapid Eye satellite data. .

1. INTRODUCTION

Yet superior remote sensing science does not enforce N-dimensional and simply constrained to three-dimensional. Though, n-dimensional recently, is curious subject matter between mathematicians and physicians. Although, the geometry of four-dimensional (4-D) axis is plentiful greater convoluted than that of third-dimensional space, because of the reality of the rather degree of freedom. Consequently, 4-D entails 4-polytopes which can be two formulated of polyhedral. Further, 4-D in addition consists of 6 convex regular 4-polytopes, which are the analogues of the Platonic solids. Consequently, as 3-D beings it cannot switch freely in time, however in 4-D it has to be possible. In this context, 4-D can distinguish 3-D and it cannot be conveyed to Euclidean space which indicates that fourth- measurement is spatial. Consequently, 4-D can be generated algebraically, through using the regulations of vectors and coordinate geometry to a vicinity in 4-D (Marghany 2014b and Marghany and Mansor 2016).

Therefore, Marghany (2015) stated that 4-D can be constructed by understanding the string theory, M-theory, and Supergravity theories. In this understanding, String theory, consequently, proposed that the universe is shaped in multiple dimensions: (i) height, (ii) width, and (iii) length compose three-dimensional space; and (iv) time contributes an entirety of four observable dimensions. String theories, nonetheless, continued the probability of ten dimensions – the remaining six of which human capability cannot depiction precisely (Ray 1992;Alday et al., 2010 and Marghany 2015).

Marghany (2003 and 2011) carried the hologram from labs to remote sensing technology to simulate shoreline change. At present, Marghany (2015) invented 4-D shape based on the remote sensing data of both synthetic aperture radar (SAR) and optical satellite data. However, these studies do no longer explained truly the mathematical components used to reconstruct 4-D. In fact, 4-D is required to formulate mathematical protocols to be carried out in countless functions (Marghany 2014b and Marghany 2015).

Hologram and four –dimensional (4-D), therefore, are required theoretical thoughtful prior digital implementations in four-dimensional tsunami reconstruction from optical satellite data. With this regard, hologram techniques can be used to collect third-dimensional (3-D) which is encoded in two-dimensional (2-D) object. Therefore, the foremost query which is raised up how 4-D is encoded in 3-D? Besides, how hologram interferometry can be derived from incoherent satellite optical information such as QuickBird data? In fact, QuickBird data are imagined due to reflection of solar radiation which is recorded by means of sensor. Under this circumstance, the information are recorded in optical satellite data is simply amplitude of electromagnetic wave reflection. On contrast, synthetic aperture interferometric radar (InSAR) is generated based on the existence of phase information in pair of complex SAR data(Pepe,2012). Though, it is impossible to retrieve the hologram fringes from QuickBird data or other optical remote sensing due to an absent of phase information. Therefore, it may additionally be probabilities to enforce the hologram interferometry (Marghany and Mansor 2016) from optical satellite data with the aid of considering the techniques of incoherent hologram.

The principal query is how to reconstruct four-D from 3-D? This finds out about postulates that 4-D can be implied from 3-D phase unwrapping of optical hologram interferometry. As a count of truth, optical interferometry is a powerful approach to degree shifts of the steadiness of electromagnetic wavelength spectra. One extensive limitation of commonplace interferometric techniques is they require specular reflectors. This impediment may be removed by the use of holography, permitting very small motions of arbitrary, diffusely reflecting, devices to be detected. The foremost novelty of this have a seem to be at is to derive a producer of new method for 4-D hologram interferometry part unwrapping Hybrid Genetic algorithm (HGA). The fundamental aim is to reconstruct fourth-dimensional container-day Tsunami 2004 and 2011 Japan 's tsunami affects from Quickbird and Rapid Eye satellite data, respectively with the aid of optimization of 4-D hologram interferometry (Marghany 2014a).

2. FOURTH-DIMENSIONAL USING INCOHERENT HOLOGRAM INTERFEROMETRY

Computer generated holograms do not compel particular pursuits to produce the hologram which is imparting information of the light scattered or diffracted off the object. With this regard, mathematical approaches can be concerned to present these incoherent hologram procedures. Under these circumstances, the light transmission and reflection properties of the object are no longer a hassle considering the perfect object wave can be computed mathematically. Consequently, a laptop created holographic image can be simulated by means of numerically primarily based on the physical phenomena of light diffraction and interference (Takeda et al., 1982;Schwarz 2004; De la Torre-Ibarra, et al., 2010;Marghany 2014b)

Following Marghany (2015), assume that I_1 and I_2 are the different acquisition times of two optical satellite data for instance, QuickBird . Consequently, $I_1 \in E_1$ and $I_2 \in E_2$ where $E_1 \notin E_2$ or $E_1 \neq E_2$ as E is electromagnetic spectra which presents in two QuickBird satellite data. Then, the phase ϕ derived from the image intensity information by using phase demodulation procedures (Saxby 1987). Then phase map can determine mathematically from equations 1 and 2 as follows:

$$\phi_I = \tan^{-1}\left[\frac{I_{fs}(i,j)}{I_{fc}(i,j)}\right] \tag{1.0}$$

$$\phi_H = \tan^{-1}\left[\frac{H_s(i,j)}{H_c(i,j)}\right] \tag{2.0}$$

where ϕ_I can be used to extend the non-ambiguity range of ϕ_H . Therefore, ϕ_H indicates higher sensitivity than ϕ_I against height (z) variations.

The 4-D wrapped phase is generated by following equation

$$\Psi_w(x,y,z,t) = \mathrm{mod}\left[\eta \sin\left(\frac{(x+y+z+t)2\pi}{\lambda}\right) + G(\sigma)\right] \tag{3.0}$$

where x,y,z,t are the 4-D coordinate space of estimated wrapped phase Φ_w, mod the modulo operator wrapping the data within the range of $0 \le \Psi_w \le 2\pi$ and $G(\sigma)$ is an additive Gaussian noise function with standard deviation σ .

The accurate 4-D phase unwrapping can be obtained by phase matching algorithm which is suggested by Schwarz (2004) and Hussein et al., (2005). Consistent with Schwarz (2004), phase matching algorithm is matched the phase of wrapped phase with unwrapped phase by the given equation

$$\psi_{i,j,k,p} = \Delta\phi_{i,j,k,p} + 2\pi\rho\left[\frac{1}{2\pi}\left(\Delta\hat{\phi}_{i,j,k,p} - \Delta\phi_{i,j,k,p}\right)\right] \quad (4.0)$$

where $\psi_{i,j,k,p}$ is the phase matched unwrapped phase, *i,j,*and *k* are the pixel positions in the quality phase map, $\Delta\phi_{i,j,k,p}$ is the given wrapped phase, $\Delta\hat{\phi}_{i,j,k,p}$ is the approximated unwrapped phase, $\rho[.]$ is a rounding function which is defined by $\rho[t] = \lfloor t + 1/2 \rfloor$ for $t \geq 0$ and $\rho[t] = \lfloor t - 1/2 \rfloor$ for $t < 0$ and are *i,j, k* and *p* the pixel positions in *x* and *y,z,w* directions, respectively (Schwarz 2004; Smith, 2010;Pepe, A., 2012; Marghany 2015).

The phase unwrapping problem can be solved by L^2 norm second differences reliability criterion. Consequently, L^2 can be extend to 4D as

$$\mathrm{Re}(O) = \sum_{n=1}^{40} \sqrt{(O - n_+)^2 + (O - n_-)^2} \quad (5.0)$$

where $\mathrm{Re}(O)$ the reliability of the pixel O, n_+ a neighbour on the 4D hypercube of neighbors to O, n_- the opposite neighbour. In four dimensions each voxel has 80 neighbours, resulting in a reliability criterion that is the sum of 40 measurements.

3. RESULTS AND DISCUSSION

The comparison between 2-D phase unwrapping; 3-D phase unwrapping; and 4-D phase unwrapping is shown in Figure 1. The hologram interferometry fringes pattern are more vibrant by using 4-D phase unwrapping as compared to other phase unwrapping dimensions i.e. 2-D and 3-D. Particularly, the complete cycle of hologram interferometry fringe patterns are certain with 4-D phase unwrapping algorithm. With this regard, 4-D holographic interferometry fringes produced by using Hybrid Genetic Algorithm based on Pareto Optimal Solutions. It is interesting to find that the proposed algorithm has produced clear features detection of infrastructures. In fact, the proposed algorithm has minimized the error in interferogram cycle due the low coherence in water and vegetation zones and along the coastline due to tsunami impact. This confirms the study of Marghany (2015). This can be improvement of such preceding work of Hussein et al. (2005); Karout(2007);Marghany (2015).

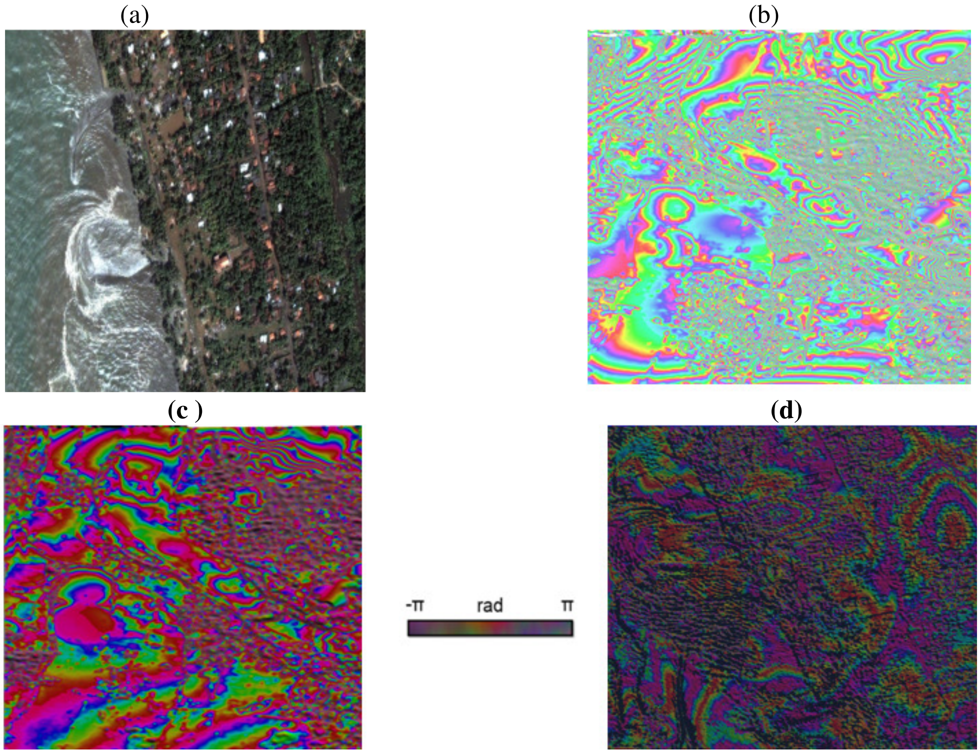

Figure 1. Phase unwrapping (a) orginal data;(b)2-D;(c)3-D; and (d) 4-D.

Figure 2 show 4-D hologram interferometry which is generated by HGA for Quickbird satellite data along Aceh coastal waters. It is interesting to find the complete cycle of fringe pattern. This leads to full scenario of coastal deformation and run-up tsunami wave height along Aceh. The maximum run-up wave height is 7 m which is caused coastal erosion of -60 m / month and coastal deposition of 10 m/month. Figure 3 shows the 4-D damages occurred due to 2011 Japan's tsunami. It is dominant damages scenario which have been occurred within previous tsunami and it will occur with future tsunami.

(a) **(b)**

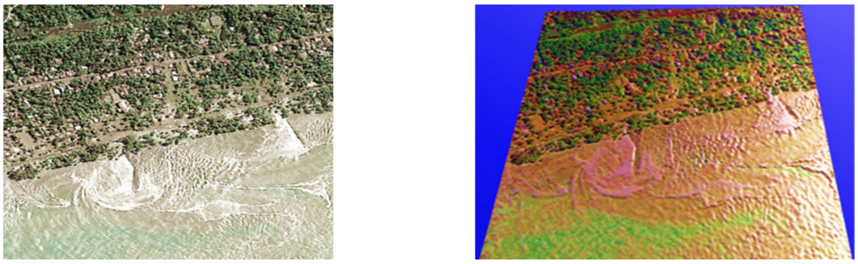

Figure 2. Visualization produced (a) 2-D original data(b) 4-D hologram interferometry for Quickbird data.

(a) **(b)**

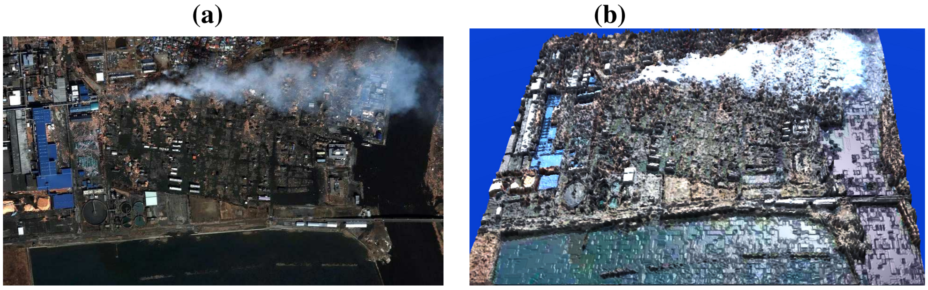

Figure 3. Visualization produced (a) 2-D original data(b) 4-D hologram interferometry for Rapid Eye data.

Clearly, the 4-D visualization discriminates between infrastructures and buildings. Roads, structures and infrastructures are absolutely displayed in both QuickBird and Rapid Eye satellite data facts though the damages have been induced by using tsunami. This is due to the fact that the hologram interferometry, is regarded as a deterministic algorithm, which is described right here to optimize a triangulation solely locally between two different points. This corresponds to the characteristic of deterministic techniques of finding solely sub-optimal options usually. The visualization of the infrastructures is sharp by means of 4-D segment unwrapping primarily based HGA. This learns about is displaying awesome promising for 4-D visualization that is derived from hologram interferometry. This finds out about is enhancing the work completed through Marghany (2014a and 2014c)). In addition, the including fourth coordinate p in mathematical components of 3-D HI produced excellent 4-D view. This confirms the studies of Consistent with Karout (2007) and Saravana et al., (2003).

4-D is showing excellent promises than 3-D object reconstruction which can be generated by InSAR techniques. In fact, InSAR is one of the precise remote sensing method for 3-D visualization. Yet, the performance of interferometric phase estimation suffers significantly from poor image coregistration. Interferogram filtering algorithms such as adaptive contoured window, pivoting imply filtering, pivoting median filtering, and adaptive section noise filtering are the most important methods for the conventional InSAR interferometric phase estimation (Marghany 2012; Pepe et al., 2012; Marghany 2014b).

6. CONCLUSIONS

This study has demonstrated a new approach to generate a phase unwrapping of incoherent optical satellite data by using phase demodulation procedures. This was issued by using the technique of Computer generated holograms. The 4-D phase unwrapping techniques outlined are relevant to reconstruct 4-D visualization of tsunami consequences the use of QuickBird and Rapid Eye satellite data. The involving of Hybrid genetic algorithm to optimize change components of two hologram interferometry can allow the QuickBird and Rapid Eye satellite data to be coded into 4-D. The results suggests that the types of 2-D objects in QuickBird and Rapid Eye images can be visualized in 4-D. The quality strictures of roads, urban, constructions and infrastructures are well visualized in

4-D. In conclusion, the change and optimization of hologram interferometry formula hold notable promise for 4-D object visualization in such incoherent optical satellite data of QuickBird and Rapid Eye data.

References

Alday, L., Gaiotto, D., & Tachikawa, Y., 2010, "Liouville correlation functions from four-dimensional gauge theories", Letters in Mathematical Physics, 91 (2),pp. 167–197.

Anne, D., W., 2013, “Moral Authority, Men of Science, and the Victorian Novel”. Cambridge University Press

De la Torre-Ibarra, M. H., Santoyo, F. M., & Moreno, I., 2010, “Digital holographic interferometer using Simultaneously three lasers and a single monochrome sensor for 3D displacement measurements”, Optics express,18(19),pp. 19867-19875.

Hussein, S. A., Gdeist M, Burton D, & Lalor M., 2005, “Fast three-dimensional phase unwrapping algorithm based on sorting by reliability following a non-continuous path”, Proc. SPIE, 5856,pp. 40.

Karout, S., 2007, “Two-Dimensional Phase Unwrapping”, Ph.D Theses, Liverpool John Moores University.

Marghany, M., 2012, “Simulation of 3-D Coastal Spit Geomorphology Using Differential Synthetic Aperture Interferometry (DInSAR)”.,In I. Padron.,(ed.) Recent Interferometry Applications in Topography and Astronomy, Croatia: InTech – Open Access Publisher, pp. 83-94.

Marghany, M., 2013, “DInSAR technique for three-dimensional coastal spit simulation from radarsat-1 fine mode data”, Acta Geophysica, 61,2, pp.478-493.

Marghany, M., 2014a, “Simulation of three-dimensional of coastal erosion using differential interferometric synthetic aperture radar”, Global NEST Journal, 16, 1, pp 80-86.

Marghany, M. 2014b, “Hybrid Genetic Algorithm of Interferometric Synthetic Aperture Radar For Three-Dimensional Coastal Deformation”, *Frontiers in artificial intelligence and applications: new trends in software methodologies, tools and technique*, *265*, pp.116-31.

Marghany, M. 2011, “Modelling shoreline rate of changes using holographic interferometry”, *Int. J. of Phys. Sci*, *6*, pp. 7694-7698.

Marghany, M.,2003, “Polarised AIRSAR along track interferometry for shoreline change modeling”, In *Geoscience and Remote Sensing Symposium, 2003. IGARSS'03. Proceedings. 2003 IEEE International* ,Vol. 2, pp. 945-947.

Marghany M.,2014c,”Hologram interferometric SAR and optical data for fourth-dimensional urban slum reconstruction”, CD of 35th Asian Conference on Remote Sensing (ACRS 2014), Nay Pyi Taw, Myanmar 27- 31, October 2014,http://www. a-a-r-s.org/acrs/administrator/components/com.../OS-303%20.pdf.[Access on August 2 2016].

Marghany M., 2015, Fourth dimensional optical hologram interferometry of RapidEye for Japan ‘s tsunami effects” CD of 36th Asian Conference on Remote Sensing (ACRS 2015), Manila, Philippines, 24-28 October 2015, http://www.a-a-r-s.org/acrs/index.php/acrs/acrs-overview/proceedings-1?view=publication&task=show&id=1691, Access on August 2 2016.

Maged M. and Mansor,S., (2016). Four-Dimensional Of Sri Lanka Coastal Damages During 2004 Tsunami Using Hologram Interferometry Of Quickbird Satellite Data. CD of 37th Asian Conference on Remote Sensing (ACRS), 37th ACRS from 17th - 21st October 2016, Galadari Hotel, Colombo,Sri Lanka,pp.1-6. http://www.a-a-r-s.org/acrs/index.php/acrs/acrs-overview/proceedings-1?view=publication&task=show&id=2106, Access on September 8 2017.

Pepe, A., 2012, “Advanced Multitemporal Phase Unwrapping Techniques for DInSAR Analyses”, In Padron I. (ed.) "Recent interferometry applications in topography and astronomy". InTech - Open Access Publisher, University Campus STeP Ri, Croatia, pp.57-82.

Smith, J., 2010, “Optimizing remote sensing for disaster monitoring, retrieved May 13, 2005, from http://www.remotesening.net/index.htm.

Saravana, S.S., Ponnanbalam, S.G., & Rajendran, C. A. 2003, "Multiobjective genetic algorithm for scheduling a flexible manufacturing system", International Journal of Advanced Manufacturing Technology, 22, pp. 229-236.

Ray, I., 1992, Introducing Einstein's Relativity,Clarendon Press, chp. 22.8 *Geometry of 3-spaces of constant curvature*, p.319ff, ISBN 0-19-859653-7.

Schwarz O. 2004. Hybrid phase unwrapping in laser speckle interferometry with overlapping windows, Shaker Verlag.

Saxby G., 1987: "Practical Holography", Prentice Hall,NJ.

Takeda, M., Ina, H., & Kobayashi, S.,1982, "Fourier-transform method of fringe-pattern analysis for computer-based topography and interferometry", *JosA*, *72*(1), pp.156-160.