SIMULATION OF INDIAN OCEAN CIRCULATION IMPACTS ON MH370 DEBRIS USING MULTI-OBJECTIVE EVOLUTIONARY ALGORITHM AND PARETO OPTIMAL SOLUTION

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Abstract. This study has used optimization techniques of Genetic algorithm to investigate the impact of ocean surface current on flight MH370 debris. The southern Indian Ocean during the months of March-April has dominated by anticlockwise large gyre moving with maximum velocity of 0.5 m/s and slowly drifts westward. It means that flight MH370 debris can potentially travel up to 50 km/day with large eddies of a width of 100 km wide. The study shows that flight MH370 debris could not move to Africa within 24 months and with less than 2 months it would sink before washed up on Réunion Island. However, it can be said that the turbulent flow due to large Southern Indian gyre would make the debris submerged in deep water more than 2000 m across the Southern Indian Ocean. In conclusion, multi-objectives genetic algorithm suggests that fake and uncertainties information had been delivered by satellite data. In conclusion, MH370 could be never fly and crash in offshore of Perth, Australia.

1. INTRODUCTION

Regardless of the superior area, marine, and communication technologies, the mystery of the Malaysia Airline flight MH370 cannot be explicated. Excluding twelve countries that allied for the search and rescue efforts of missing the flight MH370 on March 8th, 2014, it is very sophisticated to analyze the dramatic situation of the flight MH370 that non-existent from secondary microwave radar. MH370 routes of 5 nmi / 8–10 km wide are delineated conversely differed in breadth as 20 nmi / 35–40 km (Asia News 2014 and Excell , 2014; Zweck, 2014a; staff writer 2014).

Consequently, the Malaysian military microwave radar reported that MH370 cosmopolitan over the Straits of Malacca whereas the white circle indicates disappearing of flight from the radar screen. China therefore, fairly deployed 10 high-resolution satellites to scurry the South China Sea, digital globe opened its crowdsourcing platform Tomnod and airliner defence and area mobilized its 5 satellites to search out some leads (Marghany 2014; Grady 2014; Linlin, 2014; Zweck, 2014b). Under this fact, physical oceanography theories and models should extraordinarily be instigated to analyze the mystery of the flight MH370. The observation procedures that are tutored for the undergraduates of physical oceanography students does not add this case. Indeed, commonplace and changed models are needed to verify the knowledge of Inmarsat satellite. In fact, there are several of researchers who simply used the physical oceanography models and do not very perceive however the models are operated. The scientists enforced the drifter models to trace the trajectory model of MH370 trash.

Martini (2015) commented that a prediction model and therefore the temporal order could be a very little off since it is solely been 18 months since the crash. Martini (2015) further this pair presumably raised since the model was prospective loped with historical surface current information and false numerical rubble. Martini (2015), withal, raised up the subsequent question why has not any debris been found on Australian and Tasmanian beaches as foreseen by numerical debris model (Figure 3)? So, that model is not correct enough to trace the rubble of crashed flight MH370 that scattered within the search space. Additionally, there are several alternative dynamic ocean parameters extraordinarily suffering from the debris movements on the surface and thru the water column.

Notwithstanding the advanced remote sensing sensors and communication technologies, the flight MH370 debris cannot be found since March 8, 2014. There have been many satellite images that have been claimed to be objects happiness to the flight MH370. One amongst these satellite information may be a Thai satellite that has detected 300 floating objects within the ocean, regarding 200 kilometers from the international search space for the missing Malaysia Airlines MH 370 at 10am Perth time on the 24th of March. During this context, the THEOS satellite payload options each high resolution in panchromatic mode and wide field of read in multispectral mode and has been tailored to Thailand's specific desires with a worldwide imaging capability. Additionally, it contains 2-m resolution for black and white images and 15m resolution for panchromatic image. Nevertheless, the images claimed to belong to flight MH370 are dominated by cloud covers (Marghany, 2015).

The foremost enquiry would be raised up what applicable sensors are often accustomed monitor and discover flight MH370 debris? The high-resolution sensors either on board of satellite or airborne can discover and determine the flight MH370 debris. Even HF ground can detect any foreign objects occupancy the coastal zone. This is also needed the worth approaches of object automatic detection by exploitation high resolution microwave satellite information with 1 m as within the spot mode of each RADARSAT-2 SAR, TerraSAR-X satellite information. The RADARSAT-2 SAR satellite incorporates a synthetic aperture radar (SAR) with multiple polarization modes, as well as a completely polarimetric mode information are no inheritable. Its highest resolution is 1 m in Spotlight mode (3 m in Ultra-Fine mode) with 100 m positional accuracy demand. Additionally, RADARDSAT-2 SAR Scan narrow SCNB beam is its and a high return period of 7 days. Further, has nominal close to and much resolutions of 7 m. If the length of the flight is 24 m, means that it may clearly be detected in RADARDSAT-2 SAR Scan narrow. This implies that, as high cloud covers are dominated within the southern ocean, it is urged to use airborne SAR sensors like unpopulated aerial vehicle synthetic aperture radar (UAVSAR, by JPL, L-band) with a 22-km-wide ground swath at 22° to 65° (Marghany 2014 and Marghany et al., 2016).

The core objective is to develop a multi-objective optimisation via Pareto dominance to scale back the uncertainties for the debris automatic detection in satellite information like China satellite. Additionally, multi-objective optimisation supported genetic algorithmic rule is developed to forecast the debris flight movements from Perth, west of Australia i.e. the crashed claimed space.

2. SEARCH AREA

The bathymetry of the search area is simulated from a survey which was conducted from May to December 2014, collecting data over 200,000 square kilometres through the Joint Agency Coordination Centre (JACC) of geoscience Australia. The seabed is dominated around Broken Ridge, an extensive linear, mountainous sea floor structure that once formed the margin between two geological plates. These plates evolved and spread apart between 20 and 100 million years ago, under similar processes found today at spreading plate margins (such as the Mid-Atlantic Ridge) (Geoscience Australia, 2015). Figure 1 shows a discovered new seabed features which are: (i) seamounts (remnant submarine volcanoes), up to 1400 metres high and often forming a semi-linear chain; (ii) ridges (semi-parallel) up to 300 meters high, and (iii) depressions up to 1400 metres deep (compared to the surrounding seafloor depths) and often perpendicular to the smaller semi-parallel ridges (Smith and Marks 2014).

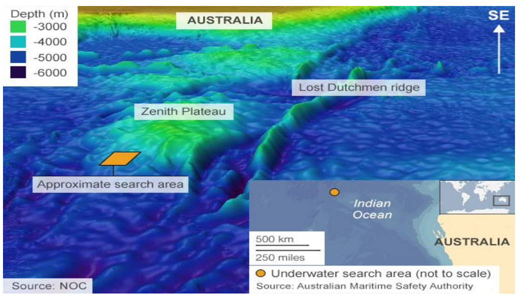

Figure 1. Bathymetry of MH370 search area.

The main question is how the searching operation failed to detect any wreckage with the topography under water? Side scan sonar delivers a two dimensional map of an area on either side of the sonar which cannot detect far enough due to the complicated water topography with outcrops, seamounts and various other changes in relief in many places throughout the deep Indian Ocean. This is concluded that it is very difficult to detect wreckage with complicated topography of the Indian Ocean.

3. MULTI-OBJECTIVE EVOLUTIONARY ALGORITHM

We assume that large parameter space $\mathbb{R}$ could be searched by the genetic algorithm (GA) to determine efficient solutions. With regard to this, the predictive algorithm involves the nonlinear approximation function which is based on historical time series information of sea surface current, sea level variation, wave height variation and the Indian Ocean floor features to forecast the current location of MH370 debris to any feature state (Anderson et al., 2003; Anderson 2013; Anderson 2014). Let $\{x_i\}$ be the observation made with generic function φ which can state as follows:

$$\bigcap_{m=1}^{\infty}\bigcup_{n=1}^{\infty}\left(x_n-\frac{1}{2^{n+m}},\,x_n+\frac{1}{2^{n+m}}\right) \qquad (1)$$

The sequence observations that itemize the rational numbers is represented by $\{x_n\}_{n=1}^{\infty}$. This means that generic function φ is satisfying

$$\{x_n\}_{n=1}^{\infty}=\sum_{n=1}^{\infty}\varphi(x_i) \qquad (2)$$

In the genome, for each member of the population, the population is initialized by random assignment of a 0 or 1 to each of the 32 bits. Subsequently, the first 20 and 12 bits are transcribed into an integer representing the *i,j* coordinates, respectively to evaluate the fitness. The locations of trajectory movement of debris thenceforth are simulated (Anderson et al., 2013; 2013Serafino,2015; Marghany et al., 2016). Let X be a compact set of feasible decisions in the Euclidean space with $\mathbb{R}^n$ *closed* unit interval [0, 1], and Y is the feasible set of criterion vectors in $\mathbb{R}^m$. Then Pareto front can be expressed as

$$P(Y)=\{y_1\in Y:\{y_2\in Y:y_2\succ y_1, y_2\neq y_1\}=0\} \qquad (3)$$

Let a hydrodynamic system of the southern Indian Ocean with m hydrodynamic parameters and n flight MH370 debris, and a utility function of each hydrodynamic parameters as

$$\psi=f(\vec{v}_i) \qquad (4)$$

where v_i is vector of the flight MH370 debris and $\vec{v}_i=(\vec{v}_1,\vec{v}_2,\ldots\ldots,\vec{v}_n)$. Then the feasibility constraint equals $\sum_{j=1}^{m}\vec{v}_j=b_j$ for j=(1,2,3,…….,n). Finally, the Euler–Lagrange equations are maximized to find the Pareto optimal allocation for the flight MH370 debris trajectory movements across the southern Indian Ocean.

$$L_i((x_j^k)_{k.j},(\lambda_k)_k,(\mu_j)_j)=f(\vec{v})+\sum_{k=2}^{m}\lambda_k(\psi_k-f^k(v^k))+\sum_{j=1}^{n}\mu_j(b_j-\sum_{k=1}^{m}\vec{v}_j) \qquad (4)$$

Whereby, L is Lagrangian with respect to each debris v^k for k=1,….,m and the vectors of multipliers are λ_k and $(\mu_j)_j$, respectively and $k \neq j$. The historical data of significant wave heights, sea surface current, sea level variations and wind speed March 2014 to March 2016 are collected from the Jason-2/Ocean Surface Topography Mission (OSTM), and QuikSCAT respectively to simulate the current and possible debris trajectory movements across the southern Indian Ocean.

4. RESULTS AND DISCUSSION

Figure 2 shows the comparison between Chinese satellite data, MH370 simulated using the multi-objective algorithmic. Figure 2b shows the simulated MH370 debris by mistreatment multi-objective algorithmic rule in 44° 57´S 90° 13´E within the southern Indian Ocean with the length of 24 m. In this understanding, the correlation between real warship and one simulated by multi-objective rule is 0.87 with commonplace errors of 0.002. Figure 2c, confirmed that the intense object that claimed by Chinese satellite as MH370 debris is belong to warship. This implies that the delivered data by remote sensing satellite are uncommon uncertainty.

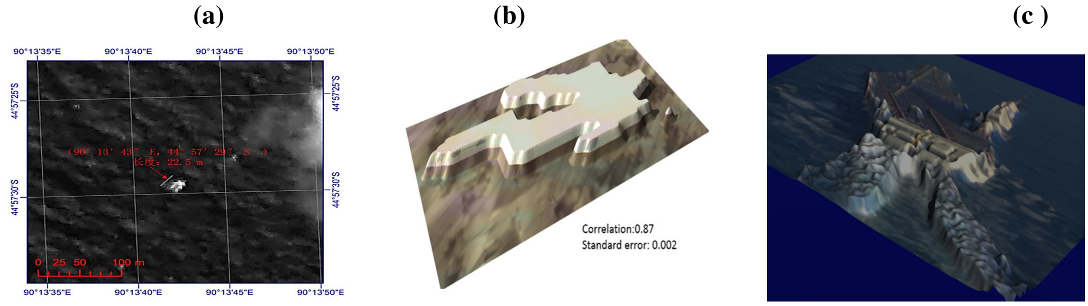

Figure 2. Flight MH370 debris in (a) China satellite, (b) GA segmentation results correlated to (c) aircraft carrier as example.

Figure 3 presents the simulated mechanical phenomenon movements of MH370 (white circles and blue rectangular) that supported multi-objectives of Indian Ocean circulation from Jason-2/Ocean Surface Topography Mission (OSTM), wind speed from QuikSCAT, debris, and bottom topography, severally. Figure 2 shows that debris should flow in anti-clockwise direction with root mean square error of current rate of 10 cm/sec that is coincided with the Southern Indian current movement. It is attention-grabbing to seek out that the MH370 debris underneath the present effects had unsuccessful in problem of Indian Ocean among the month of September and October 2014.

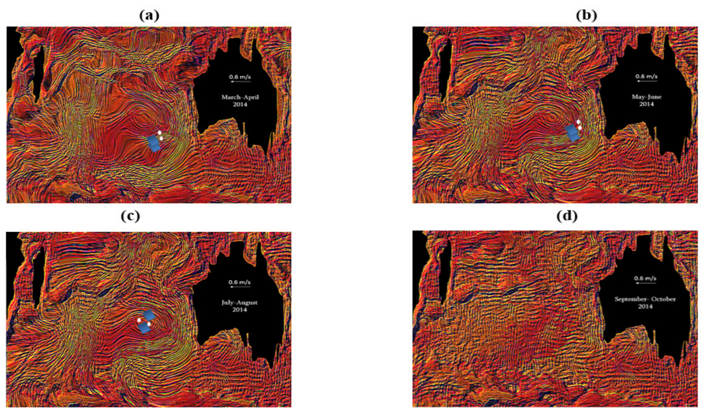

Figure 3. Multi-objective algorithm for suspected MH370 debris trajectory movements during (a)March-April 2014,(b)May-June, (c) July-August 2014, and (d) September-October 2014.

Nevertheless, the part of the detritus would not have floated for many months at the water's surface however would have drifted underwater thousand meters deep. In fact, the Antarctic Circumpolar Current (ACC) can cause instabilities for the detritus flight movements. During this concern, the MH370 detritus may transport westward and spin in a very giant scale counter-clockwise eddies rotation and drifted westward to the African east i.e. Mozambique and Madagascar coastal waters.

Finally Figure 4 of the Pareto optimization proved that within water depth of 3000 m the remain debris of 60% of total debris would sink down with highest cumulative percentage of 95%. As the debris would undergo the impacts of turbulent across the Southern Indian Ocean.

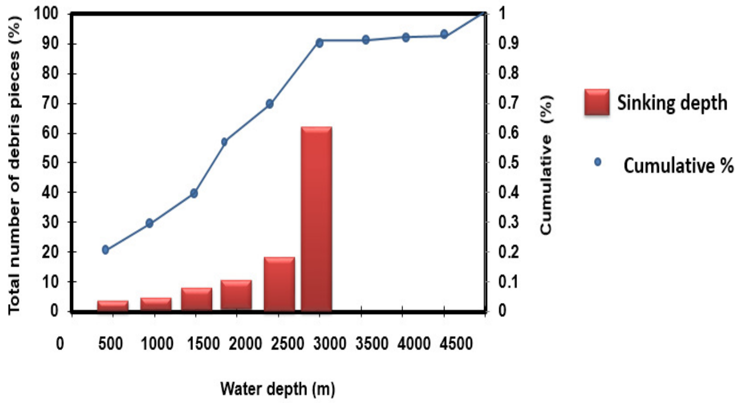

Figure 4. Pareto optimization for debris concentration in water depth.

Marghany (2015) stated that the dynamic instability, either detritus are additional buoyant than water, within which case they float, or they are less buoyant, within which case they sink. Hence, the turbulent movements with 50 km/ day of the massive southern Indian curl with dimension of 100 km would cause the detritus to submerged thorough of 3,000 m to 8,000 m across the Southern Indian Ocean.

The detritus has been found in Réunion Island do not seem to be belong to MH370. In fact, the detritus would sink below ocean surface of 3000 water depth at intervals less than few months as explained above. If there is no clue confirms the existence of debris either from remote sensing information or ground search across the Southern Indian Ocean, this implies the MH370 have landed vertically through the ocean surface and stony-broke right down to many items through the water column as a result of immense hydrostatic pressure of 29,430,000 Pa. This confirms the idea of subgenus Chen et al., (2015).

5. CONCLUSIONS

This study has used optimisation techniques of genetic algorithmic rule to analyze the impact of ocean surface circulation on flight MH370 detritus. The southern Indian Ocean throughout the months of March-April has dominated by anticlockwise massive whorl moving with most speed of 0.5 m/s and slowly drifts westward. It means flight MH370 detritus can doubtless travel up to 50 km/day with massive eddies of a dimension of 100 km wide.

The study shows that flight MH370 detritus could not move to Africa at intervals 24 months and with less than a pair of months it might sink before washed abreast of Réunion Island. However, it may be previously mentioned that the flow as a result of massive Southern Indian curl would build the detritus submerged in deep water over 3000 m across the Southern ocean. Lastly, intelligent system supported multi-objectives Genetic rule are often accustomed investigate uncertainties in information and data. Finally, it is tough to work out the MH370 detritus within the Southern ocean as a result of refined and turbulent current, that might drift the debris away to westward that needed large-scale search areas.

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