DEMONSTRATION ON ENVIRONMENTAL NOISE REMOVAL TECHNIQUES FOR RASTER DATA VIA USER-FRIENDLY SOFTWARE INTERFACES

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ABSTRACT

Environmental noise in the form of influences from cloud cover and/or smoke is often a critical problem faced when deploying analyses using remotely sensed information. Such 'noise' will impact on the quality of the analysis. Hence, it becomes necessary to remove such 'noise' in the pre-processing stages of the GIS~remote sensing analysis. Whilst various noise-removal methods have been developed by the purist image processing community, a common problem faced by general practitioners in environmental science is that these methods are complex and very hard to comprehend and apply off-the-hand. Considering these difficulties, a simple yet comprehensive methodology is presented in this paper, where a tutorial spatial model using MS Excel is applied to explain the principle(s) behind spatial noise removal. Using digitized data based on Landsat images for the Vavuniya district, the paper provides a detailed step-by-step discussion on how environmental noise could be removed using Boolean logic operators in the MS Excel platform. Further, a detailed description of how this 'noise removal concept' can be transferred into the ERDAS Imagine software platform for remotely sensed analysis is also given using the (original) Landsat image (ry) for Vavuniya district as an example. Whilst this prototyping method is established as an excellent venue for validation, refinement and improvement of the analytical procedure, it is also stressed that future research in-these regards should focus on developing software interfaces in advanced mathematical programming languages for enabling development of efficient and user-friendly tools for environmental noise removal.

Key words: Environmental noise, GIS, Noise removal, Prototype, Remote sensing, Spatial model

INTRODUCTION

Usually noise (or non-data related material that critically reduces data quality) is ubiquitous in any downloadable raster based image data set (i.e. satellite images or aerial photographs). Therefore, these data need to be smoothened before being used in environmental science research. Such 'environmental noise' occurs due to influence of cloud cover, water (vapor), snow, shadow, fumes and etc. Concurrently, this results in critical problems when deploying analyses using remotely sensed information gathered by satellite borne sensors. Influences of such 'noise' will impact on the quality of the analysis. If there is a problem due to noise elements like cloud-cover, then definitely - there should be the shadow of the particular cloud which also will need to be removed from the image data set. As such, it becomes necessary to remove such 'noise' in the pre-processing stages of image processing. Whilst various methods have been developed by the purist image processing community to deal with noise factors in the spatial domain, a common problem faced by general practitioners in environmental science is that these methods due to their inherent theoretical (and technical) complexities are very hard to comprehend and apply off-the-hand. This paper, considering the previous statement, strives to provide with a user friendly and easy (prototype) method for visualizing the impacts of environmental noise in raster image datasets – that can be easily comprehended by non-mathematically oriented environmental scientists. This prototyping method can then be used to implement the appropriate strategy to process the environmental noise pollution effects on raster image data.

DATA AND MATERIALS

For this study, Landsat TM (Thematic Mapper) image/raster data for 1994 was used as a primary data source. This image was obtained from the public domain (downloading using FTP methods). MS Excel was used as the software platform to develop the prototype model. In addition, ERDAS v8.9 software was also used as the remote sensing software to perform the main part of the research work.

METHODOLOGY

Initially, a MS Excel based prototype model was used to understand the basic idea behind the cloud cover removal for implementation on the actual analytical software platform i.e. ERDAS v8.9. This, to a certain extent - reduces the unnecessary time consumption and makes it easy for having clear cut ideas of the whole (research) work - at the same time ensuring the reliability of the basic principle applied. For the prototype, an individual cell[1] in a spreadsheet was considered as a single pixel in a raster data layer; and the (respective) spread sheet/s - to resemble various raster layers generated by satellite image or aerial photographs of the real world. As such, the boundary of Vavuniya district was developed in a 50×50 square grid of the spreadsheet consisting of a grid/cluster of 626 cells.(where the peripheries of the digital image obtained from Landsat were digitized on the Excel platform enabling the development of the corresponding raster cell matrix). Then, within that boundary, by giving the value as 7 to the pixels, the forest cover layer of the district was developed. Afterwards, by using **conditional formatting**, the assigned forest cover was coded as green in color. In the same way, by giving 20 as the (numerical) value to pixels randomly within the forest cover in the boundary of the district (loosely based on the satellite image used for digitizing and generating the raster outline for the Excel representation), the hypothetical cloud cover over the Vavuniya district was created as a raster layer and coded as black in color (Figure 01)

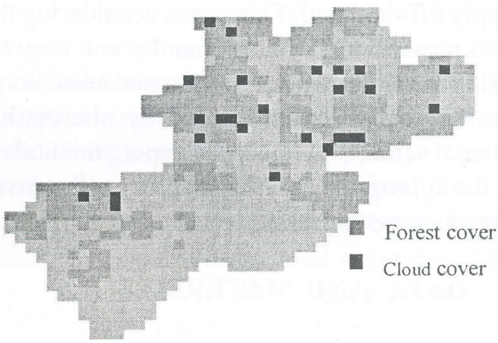


Figure 01: Prototype illustration of Forest cover of Vavuniya District with cloud cover

Then the entire particular land cover class layer was selected ('highlight' option in Excel), and then the **focal sum** command was used as part of the analytical/modeling function to remove the cloud cover from the forest cover land cover class layer. The following Equation 01 shows the logical function of the focal sum as per Excel algorithm.

```
=IF(clou_fore_boun_94!B2=20,SUM(clou_fore_boun_94!A1+clou_fore_
boun_94!B1+clou_fore_boun_94!C1+clou_fore_boun_94!C2+clou_fore_
boun_94!C3+clou_fore_boun_94!B3+clou_fore_boun_94!A3+clou_fore_
boun_94!A2)/8, clou_fore_boun_94!B2) → Equation 01
```

The **focal sum integrated approach** focuses on **identifying** the problem pixel polluted with environmental noise (i.e. in the prototype, the hypothetical MS Excel cell with the assigned numerical value of 20), and, then evaluating the values of the cells surrounding it, summing the values of the surrounding cells and, deriving the average value – thereafter, the command enables the average value be assigned to the problem cell. As such, the problem cell's value is then transformed to reflect the general (i.e. average or mean) nature of the pixels representing the terrain surrounding it. In this approach, there is a possibility that if the problem pixel (with influence from environmental noise) lies in a transient zone, for example between paddy land (A) and forest cover (B); then – the possibility of having a better description of the polluted cell is evident. However, this could not be the case if the polluted cell is actually land cover type A and not B, the focal sum integrated processing will enable the polluted cell to be regarded as (A+B)/2 = ½ AB! This could not be an exact representation of the terrain that the polluted cell ought to indicate (accurately). Figure 02 shows the prototype output simulation of the forest cover in the Vavuniya district after the removal of hypothetical cloud cover.

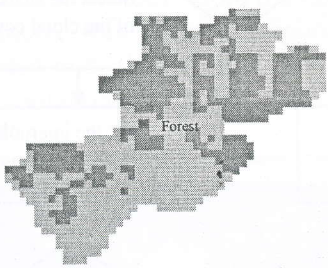


Figure 02: Prototype illustration of forest cover of Vavuniya district after the cloud cover removal.

The logic (and modeling philosophy) behind the **focal sum integrated approach** was then transferred into the ERDAS software platform and the consequent preprocessing was performed to remove the influence of environmental noise created by cloud cover in the image data. Figure 03 describes the logic and sequence of the said methodology in the ERDAS platform. In that, not only the noise by the cloud-cover but also the influences by the shadow of the cloud cover also can be removed.

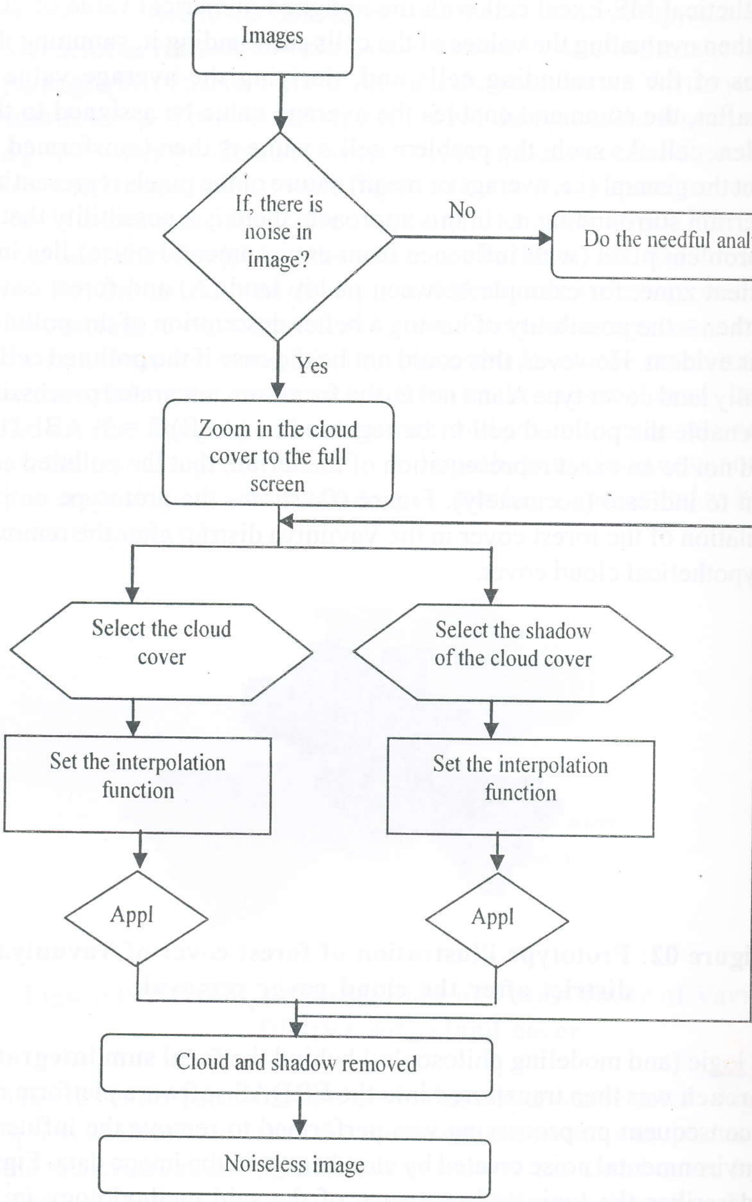
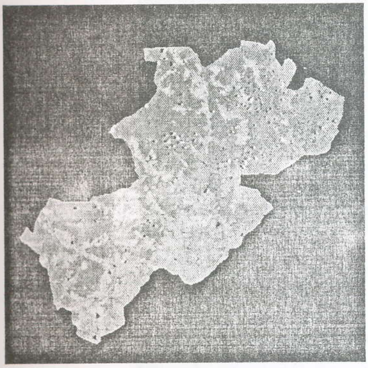
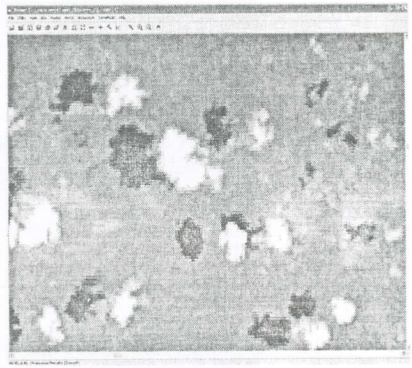


Figure 03: Flow chart of the analytical routine for cloud removal in ERDAS

Firstly, in order to remove the cloud cover from the image, the image with cloud was opened in viewer (Figure 04 (a) and (b)).



(a)



(b)

Figure 04: The Vavuniya District's image with cloud cover (a) and part of it as a zoom in image (b).

Then, the 'local surface interpolation tool was selected from the 'raster tools' which is in raster menu of the viewer. Then by using the 'create polygon AOI (area of interest) tool' from the raster toolbox the cloud covered area in the image was selected, (Figure: 05) after the cloud cover area was selected with the help of above mentioned AOI tool, then moved to the interpolation dialogue box (which was opened already) (Figure: 06).

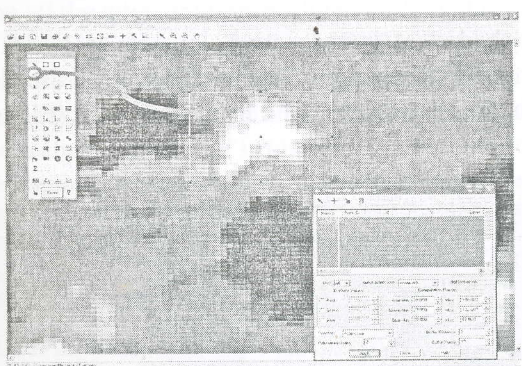


Figure 05: Selected cloud cover (AOI) area by using the AOI tool.

In this dialogue box, **distance weight function** was selected as the **interpolate function** and clicked on for application. Now the selected cloud cover (by using the above mentioned AOI tool) can be removed (Figure: 07).

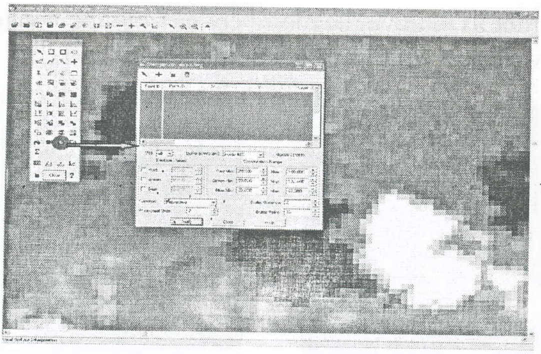


Figure 06: Showing to get interpolation dialogue box

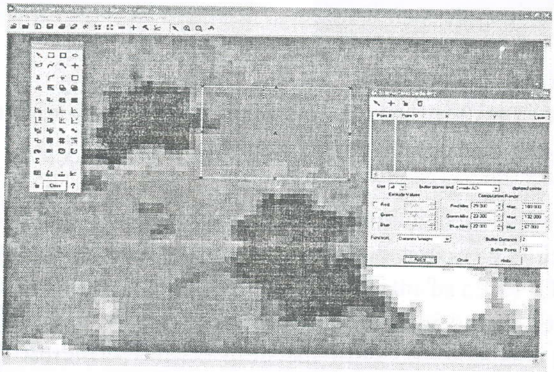


Figure 07: Removed AOI of cloud cover

Likewise the shadow of the respective cloud cover (which was removed) was also removed via the same way. In this way all the clouds and their respective shadows were removed from the image (Figure 08).

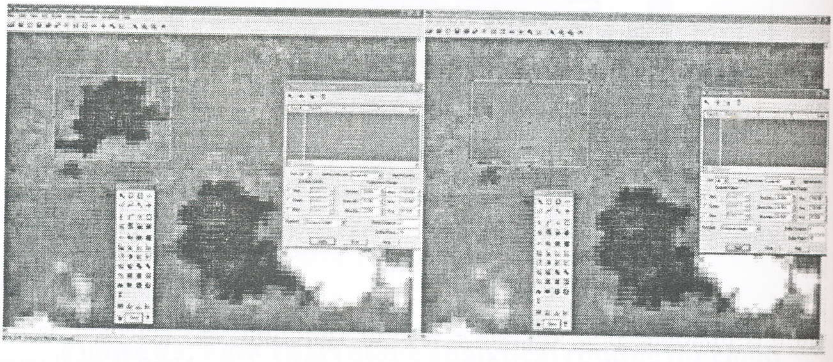


Figure 08: (a) Selected AOI (shadow of cloud) to be removed, (b) removed area of cloud's shadow

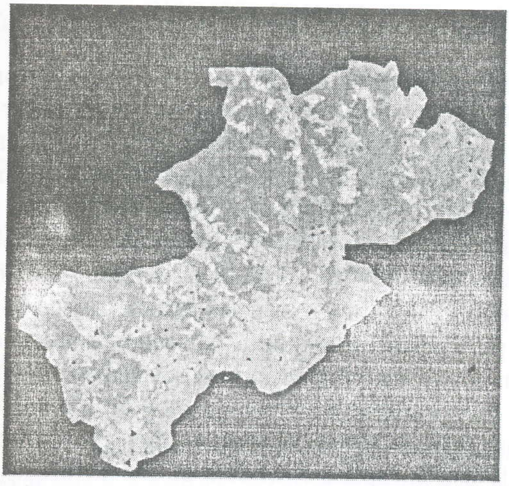


Figure 09: Cloud cover removed image of the Vavuniya district.

DISCUSSION AND CRITICAL ANALYSIS

The simple arithmetic functions (e.g. focal sum) and 'if' conditions (as per Boolean Logic principles) had been used in the MS Excel based prototype analysis. This method which incorporates the focal sum function and if condition (referred to as the 'focal sum integrated method) sees that if the polluted cell's numerical value is that of the cloud cover; and, then adds the all the adjacent non-polluted cells' values and obtains the average of that aggregated value – thereafter, it replaces the cloud value by the output of this operation, or if the cell is not polluted it will leave the value as it is. In the remotely sensed data analysis, we use/d the **distance weight method of interpolation** technique: which allows for seeing the surrounding features of the pixels dominated by the clouds or shadow and then interpolates it according to the values of the surrounding features. This is of the same logic as in the prototype. For example if there are forests, water bodies and paddy land, this method will be interpolating each of the adjacent features to the selected noise area. Suppose if there is a fairly large cloud cover area, then, when interpolating both the cloud cover area and the shadow of the cloud cover, by using the same technique, in middle part of the this noise covered area may be valued somewhat in an unfair way. Therefore, this prescribed technique will not be accurately correct under these conditions, and then, since this is a modeling approach we normally take the assumption as the method is fairly correct – considering the principle functionality of the purpose of noise removal.

CONCLUSIONS

This prescribed prototype approach in the Excel platform to remove cloud cover induced environmental noise from raster images, is a simplified approach to validate the feasibility of the research work and also easily understandable by non-mathematicians. More or less, the same basic principle (i.e. logic and philosophy) behind the technique explained using the prototype was used in the analysis using remote sensing software to remove the influence by cloud cover and shadows of the cloud cover. Even though, this approach cannot be considered as an inherently pure scientific method, this can be used as means to tutor researchers on noise-removal principles when dealing with raster data. To overcome this problem developing good Graphical User Interface (GUI) software will be more offering to the environmental scientists who frequently use the space born data of the earth.

Whilst on the other hand, this prototyping method in the Excel platform can be regarded as an excellent venue for validation, refinement and improvement of the analytical procedure; it is also stressed that future research in-these regards should focus on developing software interfaces in mathematical programming languages for enabling development of efficient and user-friendly tools for environmental noise removal. Of particular mention in these regards is the exploration of neural network models as add-ons to the Excel platform that could enable further refinements to the method prescribed, as such allowing for a much more realistic representation of the pixel/cell of concern (to that of the real world feature it reflects) once it is noise removed.

ACKNOWLEDGEMENTS

We wish to express our gratitude to the Environmental Information Systems Laboratory (EISL) at the Department of Biological Science, Faculty of Applied Science, Vavuniya Campus of the University of Jaffna - for offering the opportunity and platform to bring out our work.

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