Automatic Geo-referencing of Multi and Hyper Spectral images

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Abstract:
Geo-referencing is the process of referencing spatial data to one common datum and projection system. Without proper Geo-referencing, the use of geographic data will be significantly reduced. This paper proposes an automatic method to Geo-referencing satellite images by utilizing multiple methods from vision and image processing technique therby building a pipeline for the same.

Keywords: Geo-Referencing, Hyper spectral Images, Feature extraction from satellite images

Introduction:
GCP manual selection is extensively used in practical applications. However, obtaining a reliable number of GCPs is a very tedious and labor-intensive work. Moreover, it is subject to inconsistency problems, limited accuracy, and, in many instances, lack of availability of GCPs due to partial or total occlusions. Thus, there is a critical need to develop automated techniques requiring little or no operator intervention to georeferencing multitemporal and/or multisensor images when higher accuracy is desired. This project proposes two new feature-based approaches to automatic georeferencing remotely sensed images

Previous work in area:
There are numerous research papers published in this area [1],[2],[3],[4], each proposing their own method. A few of them have been mentioned here. This projects borrows few ideas from them, but builds a complete new and different pipeline from the existing ones. This propsed method works well on the test dataset. Though there are numerous papers on this topic for multispectral data, there are almost no papers pusblished for hyperspectral data

Objective:
Our objective is to achieve a good RMSE value for both Hyper and Multi spectral data. Though our implementation in this project was limited to multi-spectral data, due to unavailability of data for the latter. The propsed technique could be extended to hypersectral images as well.

Study area:
The test study area for this project was Washington DC, USA. This was selected as a random choice as well as for having prominent landmarks and water-bodies. The dataset was obtained from USGS website. We take two different time periods of data one of them having partial cloud cover for testing the robustness of our algorithm.

Materials Used:
The hyperspectral data was obtained from Proba-CHRIS, it has 62 spectral bands, with a spatial resolution of 18m. The multispectral data was obtained from Landsat-7 (ETM+). It has 7 bands and has a spatial resolution of 30m.

Method:

The proposed technique has the following pipeline:
In this method we have two images, rectified image (rec_img) and raw satellite image (raw_img). Rectified image has the UTM or Lat-Long values, we need to map these values on to the raw image.

Step 1) We perform image segmentation. The idea behind segmentation is that, since the satellite images have high spatial information, we want to minimize this info as much as possible for efficient computation. Hence we use a clustering algorithm called K-means which clusters all the pixels into groups. We use k=5 in our method.

Step 2) In this step we perform extract water bodies, since they have good outlines and are prominent across the image which is helpful in feature matching. To achieve this we use thresholding. Here the user needs to give an upper and lower bound of the color of the water bodies in the image.

Step 3) The thresholded image will most probably contain noise. To remove the noise we use morphological techinques called erosion and dilation. The parameters to these are tested and tuned accordigly. Here we use a square kernel of size 15x15.

Step 4) We then find SIFT features on the obtained image from previous step. We then apply RANSAC to remove the outliers. This gives us the best possible homography.

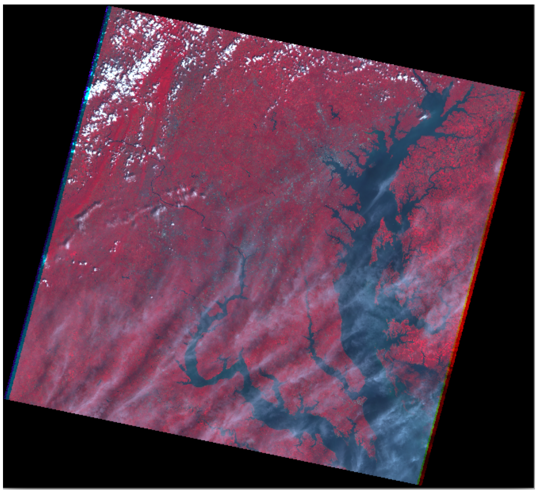
Step 5) We repeat step-4 on multiple levels of an image pyramid. We then compute RSME and select the best homography.

Step 6) We use the homography to transform the coordinates of rec_img to raw_img

Results:

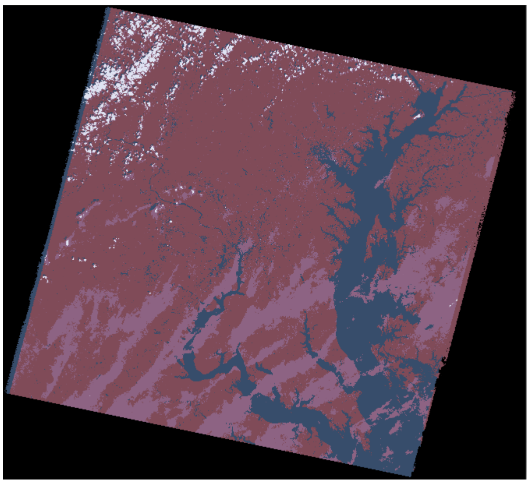
The following are the screenshots of the intermediate steps in the pipeline.

Step 0



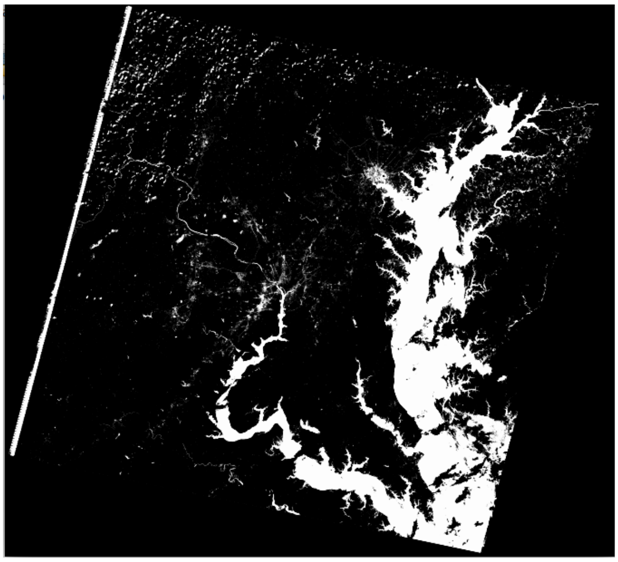
Multi Spectral Image from Landsat-7

Step 1



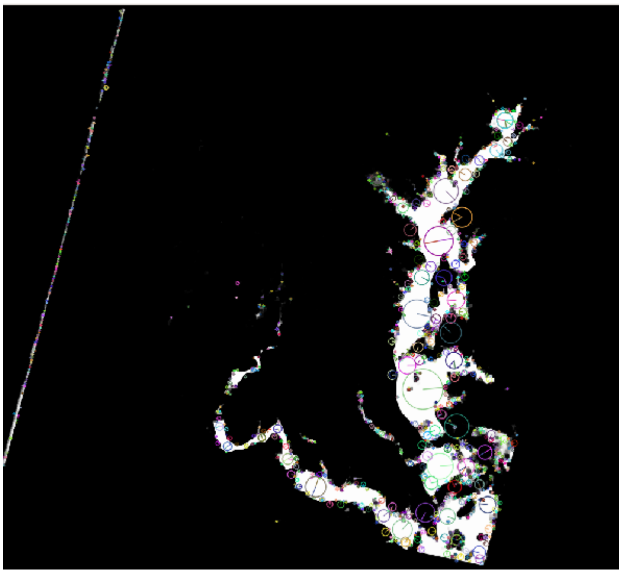
Segmentation (K=5)

Step 2



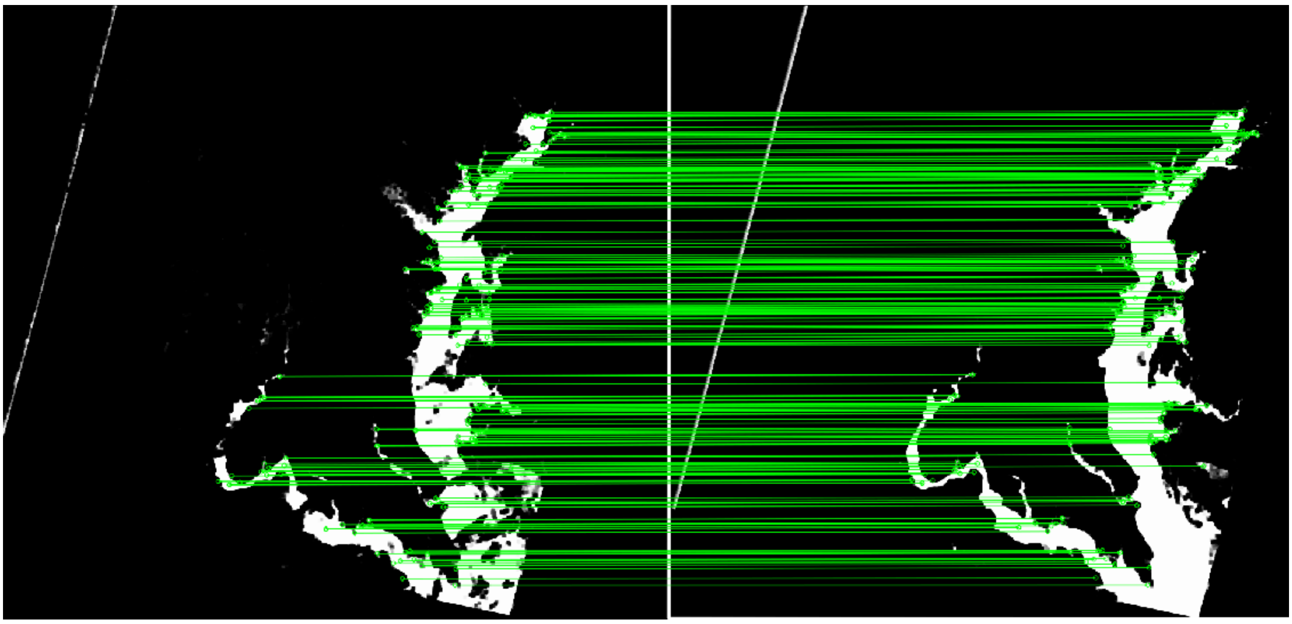
Thresholding of water bodies

Step 3 & 4



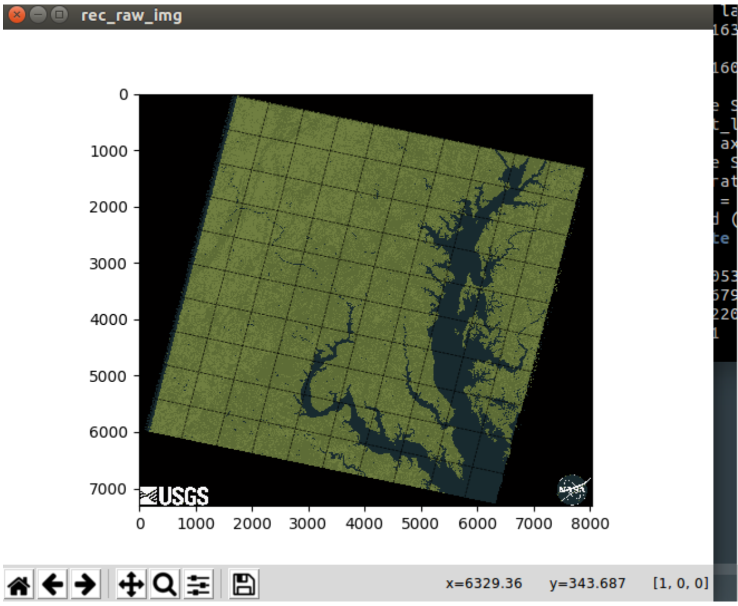
Morphing + SIFT detection

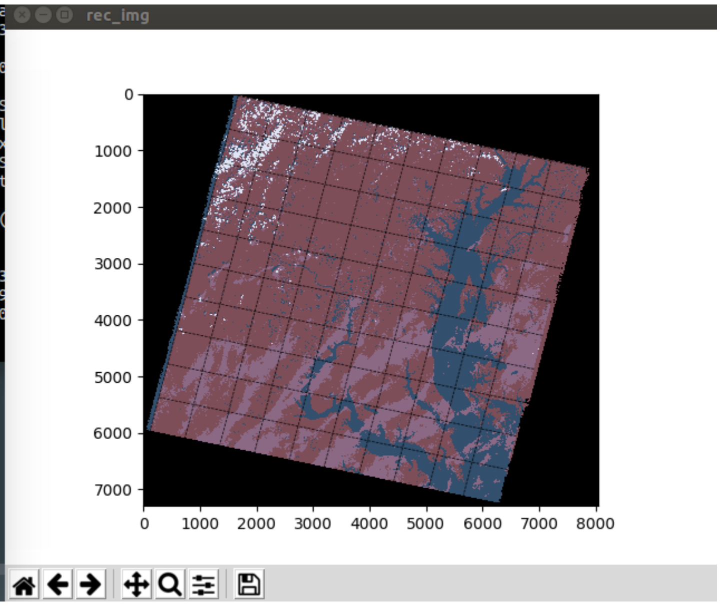
Step 5



RANSAC + Feature Matching

Step 6





Rectified Raw Image

Rectified Image

Though we were not able to apply the proposed algorithm on hyperspectral data due to lack of enough data. We can extend this algorithm by apply the step 6 on multiple layers of CHRIS images.

Discussion:

Comparision with the exisiting methods was not possible as their test dataset is not publicly available.

Source Code:

https://github.com/bhattagoutham/automatic_georeferencing_of_satellite_images

Acknowledgment:

Earth Explorer, USGS
https://earthexplorer.usgs.gov/

CHRIS data format
https://earth.esa.int/c/document_library/get_file?folderId=23844&name=DLFE-592.pdf

OpenCV library
https://opencv.org/

HDF5 for python
https://www.h5py.org/

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[5] Automatic georeferencing of satellite images in Arcgis
https://www.youtube.com/watch?v=8PK7QgEF2Wc

[6] Automatic georeferencing of images acquired from UAV
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