DETECTION AND TRACKING OF CLOUDS USING GROUND-BASED CAMERA SYSTEMS

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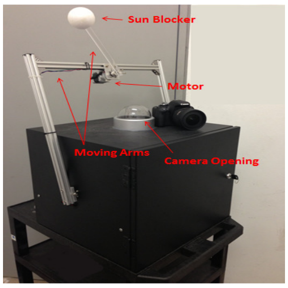
Abstract

- High-frequency ground-to-air (e.g. satellite) communication links may be greatly affected by cloud coverage
- Using ground-based cameras, the project aims to detect clouds, cloud type, cloud cover, cloud bottom altitude, cloud motion and other parameters
- Corroborate image analysis findings with satellite, radar, and weather data

Whole Sky Imager (WSI)

We designed a custom WSI:

- Cheap compared to commercially available WSIs
- Control based on Arduino microcontroller
- Featuring high resolution DSLR camera (Canon EOS 600D) with special fish-eye lens (180 degrees field of view)



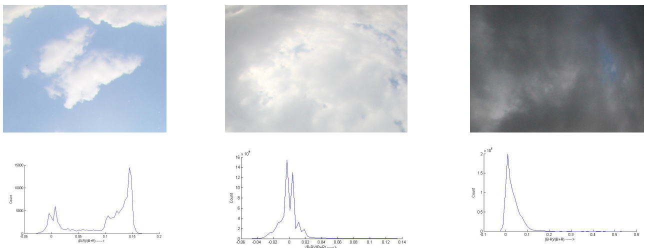
Initial Approaches and Results

Detection and tracking of clouds consists of the following sub-problems.

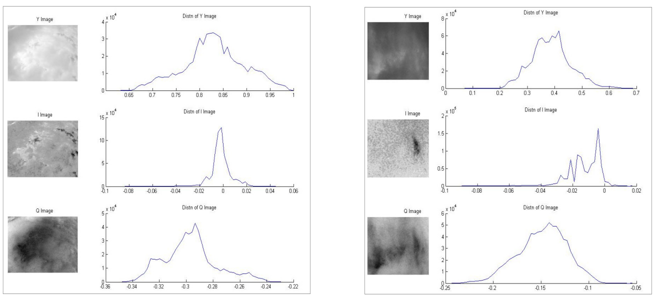
- Cloud segmentation: Traditional image segmentation techniques are not suitable for the detection of clouds, as the shape, size and color of clouds are not well defined.
- Cloud Tracking involves the detection of a homogeneous cloud mass and the specification of feature points on the boundary of an extracted cloud segment.

Color space considerations

Three cloud-sky images of varied types are taken into consideration. In order to distinguish cloud and sky from an image, the BR-Ratio= (B-R)/(B+R) is computed for all the pixels of the image; and their histogram distribution plotted.

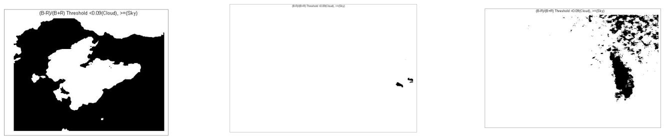


The in-phase component of YIQ color model seems to efficiently detect clear sky in case of the images whose majority of the pixels are covered with cloud.



No single color model (viz. RGB, HIS, YIQ etc.) can effectively distinguish all variants of sky-cloud images (clear sky or cloudy sky) under a particular set of settings of shutter speed and focal length of the camera and the lighting conditions of the sky.

Image segmentation using fixed threshold



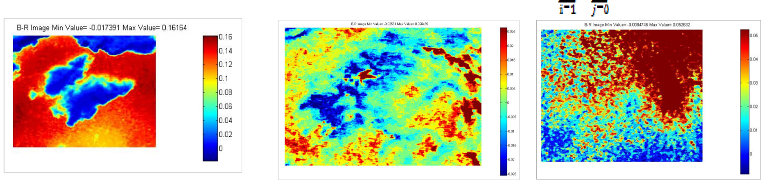
A fixed threshold does not work well under many conditions.
A probabilistic model (assigning a probability for a pixel to be classified as cloud) is now employed to reap the benefits of soft thresholding.

Image segmentation using fuzzy approach

Approach 1

Each pixel of the image is replaced by its corresponding (B-R)/(B+R) value; and fuzzy c means clustering is applied with the following objective function

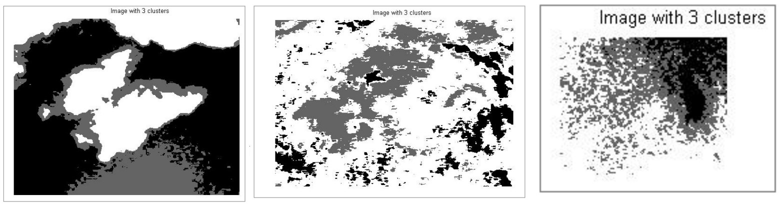
$$J=\sum_{i=1}^{2}\sum_{j=0}^{L-1} h_j * \mu_i(j)^r * d(j,v_i)^2$$



Approach 2

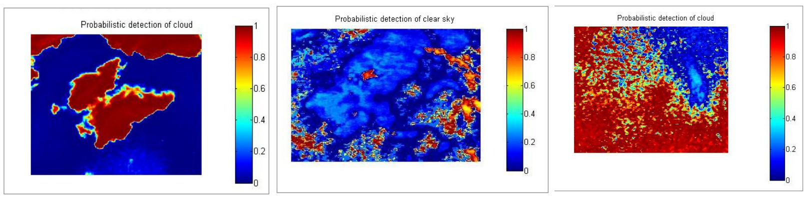
Each pixel of the image is classified into three fuzzy clusters. The objective function is given as:
Cluster 1: Clear Sky; Cluster 2: Full cloudy sky; Cluster 3: Partial cloudy sky

$$J=\sum_{i=1}^{3}\sum_{j=0}^{L-1} h_j * \mu_i(j)^r * d(j,v_i)^2$$



Approach 3

In this approach, we tried to replace the Euclidean distance d in the Fuzzy objective function with a new distance d'; where d'=alpha*d1+beta*d2 ; all with usual conventions



Future Work

- Compare segmentation of cloud images with hand-marked segmentation database
- Perform consistent analysis of complex fluid flows through computationally fluid dynamics techniques.
- Track motion of non-rigid objects (viz. clouds), e.g. using snake models. It is challenging because the Object Of Interest (OOI) after the initial segmentation changes its shape in successive image frames