4 Solution 5

In order to cartoonize the image (which was a color image), was converted to a grayscale image. The grayscale image was then denoised using a median filter using kernel size of 5. Next, Adaptive threshold was used to determine the threshold locally. This derives different thresholds for different regions thus adjusting for the illumination variation. "ADAPTIVE THRESH MEAN C" method was used to apply threshold and find edges in a region of 13x13. This edge array is stored separately. Using the original image, bilateral filter was applied four times iteratively, with a kernel size of "9x9", sigmaColor = 50 and sigmaSpace=10. Finally bitwise "and" operation was performed between stored edge image and the output of iterative bilateral filter to get the cartoon image.

5 Solution 6

As per the given problem, IITK is planning to use drones for spraying insecticide over vegetation. Drones should spray insecticide accurately over desired area. Considering the fact that drone imaging is usually done in nadir direction by taking color images obtained during daylight. In this scenario, distant places (horizon image with respect to drone camera) in any image will have different light reflectance as compare to areas in nadir direction.

The process of vegetation identification from a color image consists of following processes:

1. Denoising using Median filter
2. Vegetation Detection
   (a) Chromaticity transformation
   (b) Normalized Difference Vegetation Index (NDVI) determination
3. Thresholding
4. Binary Intensity Transformation
5. Denoising using Median filter.

The above mentioned processes are described in detail below:

Denoising using Median filter - Median filtering is a nonlinear denoising process which helps to remove impulsive, or salt-and-pepper noise. This method helps in preserving edges while reducing noise. Here, a median filter of kernel size 7 is exploited to denoise the "iitk.jpg" image.

Figure 15: This shows the output of Denoising using Median filter with kernel size = 7

Vegetation Detection - In order to detect vegetation, literature review was done and several method like NDVI, Transformed NDVI, K-T Transformation (Greenness component) were explored. Most of these method utilise spectrum outside visible region (NIR, MIR, SWIR) and hence they are difficult to incorporate in a RGB image. The popular and effective Normalized Difference Vegetation Index (NDVI) was considered in our method to detect vegetation. (KD19) explored the capability of application of RGB images from digital cameras for detection of vegetation. (KD19) performed chromatic transformation before extracting NDVI from the RGB image.

Chromaticity transformation - Average chromaticity for RGB channels can be computed as follows:

$$\bar{R} = \sum_i \sum_j \frac{R(i,j)}{N, M} \tag{1}$$

$$\bar{G} = \sum_i \sum_j \frac{G(i,j)}{N, M} \tag{2}$$

$$\bar{B} = \sum_i \sum_j \frac{B(i,j)}{N, M} \tag{3}$$

where i and j are pixel index, $R(i,j)$, $G(i,j)$ and $B(i,j)$ are pixel intensity value for the three channels for $(i,j)^{th}$ pixel, N and M are number of pixels in height and width. Next, The value of grey colour is calculated using the following formula:

$$Grey = \frac{w1.\bar{R} + w2.\bar{G} + w3.\bar{B}}{3} \tag{4}$$

where $w1$, $w2$ and $w3$ are empirical coefficients having values $w1 = 0.213$, $w2 = 0.715$ and $w3 = 0.072$ for chromaticity analysis (KD19).

The chromaticity transformation for each of the channel will be then be evaluated as:

$$R_n(i,j) = \frac{R(i,j).Grey}{\bar{R}} \tag{5}$$

$$G_n(i,j) = \frac{G(i,j).Grey}{\bar{G}} \tag{6}$$

$$B_n(i,j) = \frac{B(i,j).Grey}{\bar{B}} \tag{7}$$

Figure 16: This shows the output of Chromaticity corrected process

Normalized Difference Vegetation Index (NDVI) determination - Although NDVI originally was developed utilising Green and Near Infra red channel, whereas the red channel includes the maximum of spectral reflectance of vegetation only partially. Nevertheless, the vegetation index NDVI (for each pixel) may be calculated on the basis of the digital camera data (KD19):

$$N\bar{D}VI(i,j) = \frac{G_n(i,j) - R_n(i,j)}{G_n(i,j) + R_n(i,j)} \tag{8}$$

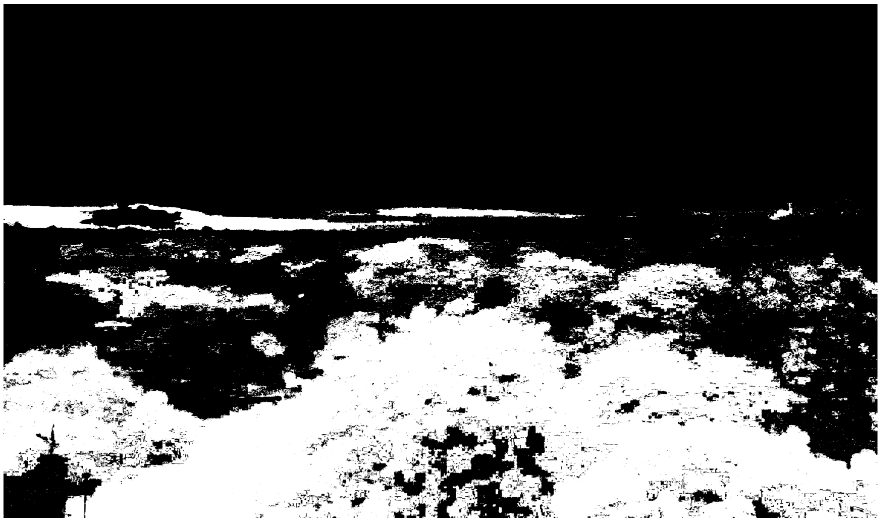

Figure 17: This shows the output of NDVI determination step

Thresholding - The previous process outputs a single channel NDVI image for which each pixel lies between [-1, 1]. According to (RT13) NDVI value -0.1 and below indicates soil or barren areas of rock, sand, or urban built-up. NDVI of zero indicates the water cover. Moderate values between 0.1 and 0.3 represent low density vegetation whereas values ranging higher than 0.6 indicate thick canopy vegetation. Hence a threshold of 0.1 was considered such that pixel values only above the threshold were classified as vegetation area.

Binary Intensity Transformation This step simply assigns "255" to vegetation area and "0" to non vegetation areas.

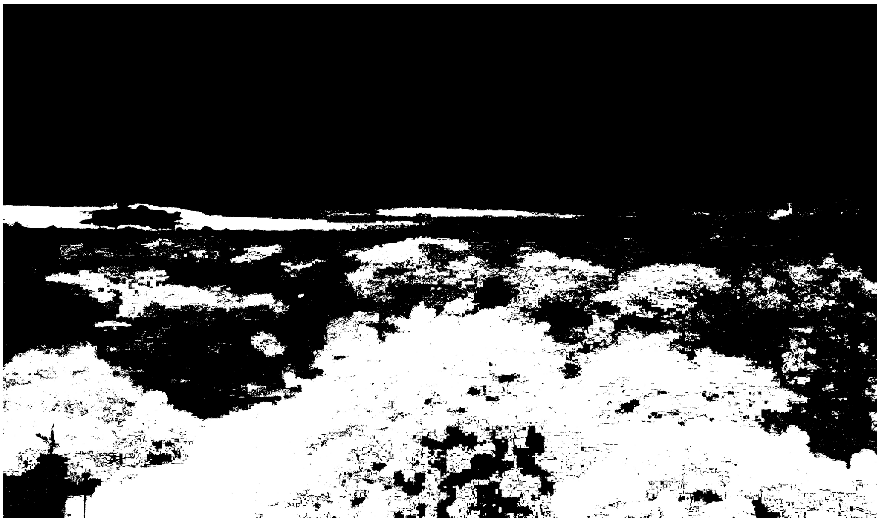

Figure 18: This shows the output after thresholding and binarization of NDVI image

Denoising using Median filter Finally, denoising with median filter with a kernel size of 19 was done to fill up the small gaps and irregularities in the classification. This generates the image ("fordrone.jpg") that can be used by the drone for spraying insecticide over vegetation.

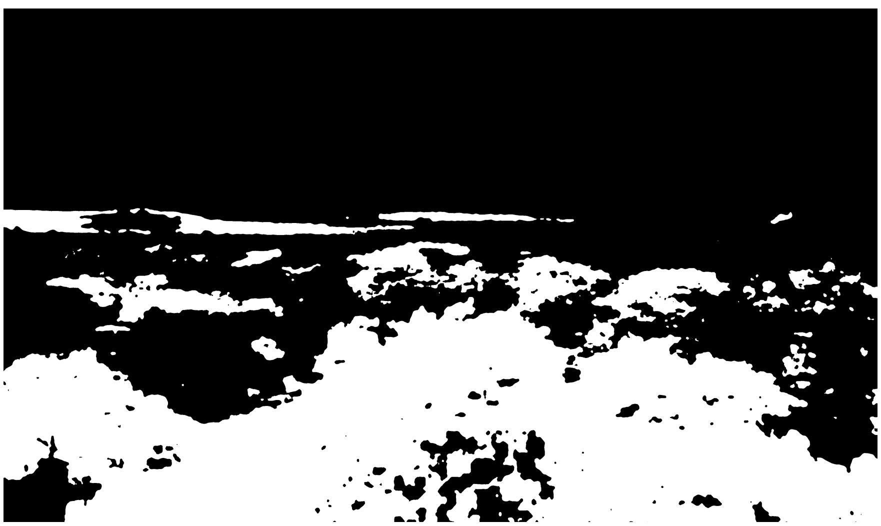

Figure 19: This shows the output "fordrone.jpg" after final denoising

References

[KD19] Michael Yu. Kataev and Maria M. Dadonova. Method of vegetation detection using rgb images made by unmanned aerial vehicles on the basis of colour and texture analysis. *Light Engineering*, 27(5):55 – 62, 2019.

[RT13] Aithal B. H. Ramachandra T.V. Sprawl in the tier ii city: Metrics, dynamics and modelling using spatio-temporal data. *International Journal of Remote Sensing Applications*, 3(3):65–74, June 2013.

[YTA09] Qingxiong Yang, Kar-Han Tan, and Narendra Ahuja. Real-time o(1) bilateral filtering. In *2009 IEEE Conference on Computer Vision and Pattern Recognition*, pages 557–564, 2009.