On hue and saturation of natural and non-natural materials

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***Abstract* – In this paper, the measurement results of hue and saturation of artificial and natural materials for long distance images are presented. Distances ranging from 10 up to 200 meters were considered. It has been shown that hue and saturation can efficiently be used for image segmentation and recognition of artificial materials in natural environment. Also, a short overview of method for recognition of humans from environmental images based on hue and saturation is given.**

I. INTRODUCTION

Search and rescue missions of humans are, unfortunately, almost everyday reality. Large areas of generally unfamiliar terrain are needed to be covered in order to find the lost, hurt or persons that are in some kind of danger. Such missions are demanding large and diverse task forces.

Different kinds of sensors such as shape, color, motion, IR signals, temperature, voice signals, CO_2 emissions sensors etc. [1] are used for detection of humans. But, almost exclusively, scientific research articles are dealing with the on-ground search of the humans and their focus is mainly on various image processing and computer vision methods needed for detection of human parts, robot localization methods and sensor fusion [2][3].

Number of available sensors and the resolution is significantly lower for the long distance, primarily aerial surveillance, and it makes the above mentioned approach generally inapplicable. The modern human (and general target) long distance detection is dependent upon several types of images data including photographic (optical) data, infrared data and radar data. Aerial surveillance systems that are using infrared cameras have some significant gains over conventional photographic methods [4] but they also have some limitations. While it has the advantage for the night surveillance, problems occur during the day because of the temperature raise and inability to distinguish humans from other warm objects. Radar images are used mainly for military application for target detection (mostly moving objects such as thanks, vehicles, etc.).

As a necessary component of the efficient and complete search and rescue system, a system that could perform successful surveillance and human detection based on real-time optical image processing of the aerial (long distance) day-images is needed. At this moment searches for humans are usually conducted by naked eye. Sometimes helicopters or UAV are used for searching. But, combination of flying height and speed results in relatively low probability of detections. In some rarely occasions, pictures are taken using helicopters or UAV in order to be examined later by humans. This approach is extremely demanding in term of man hours needed and can not be done in real time.

There are no many articles or systems dealing with human detection from long-distance images. Long distance images (including satellite images) are usually used for soil type detection, road and building detection [5]. Manolakis et al presented a tutorial review of the state of the art in target detection algorithms for hyperspectral imaging applications [6], while an image processing system for the detection of the rescue target (boats) in the marine accidents is presented by Sumimoto and Kuramoto [7].

We have developed a system [10],[11] for recognition of humans (and generally, non-natural materials) which is based on the fact that hue and saturation of natural and non-natural materials are usually significantly different.

In this paper, an analysis of distance impact on hue and saturation of images, for artificial and natural materials. Main target is to investigate magnitude of hue and saturation difference for natural and non-natural materials. Possible application of this difference for image segmentation and non-natural materials recognition is also examined. Also, we have investigated if hue and saturation are depending on distance. Distances that have been considered are ranging from 10 up to 200 meters.

Rest of the paper is organized as follows. Section II presents proposed method. Results are presented in section III. Section IV gives conclusion and some ideas regarding future work.

II. PROPOSED METHOD FOR RECOGNITION OF HUMANS

Our method consists of three main modules: preprocessing, segmentation and recognition module (Fig.1.).

Fig.1. Main modules of the method

Preprocessing module has two steps: 1. Translating of the image color format to the HSV model; 2. Filtering of the color components with median filter. Hue (H) and saturation (S) components were filtered with median filter. Filtered H and S components are then used as the input to the segmentation module.

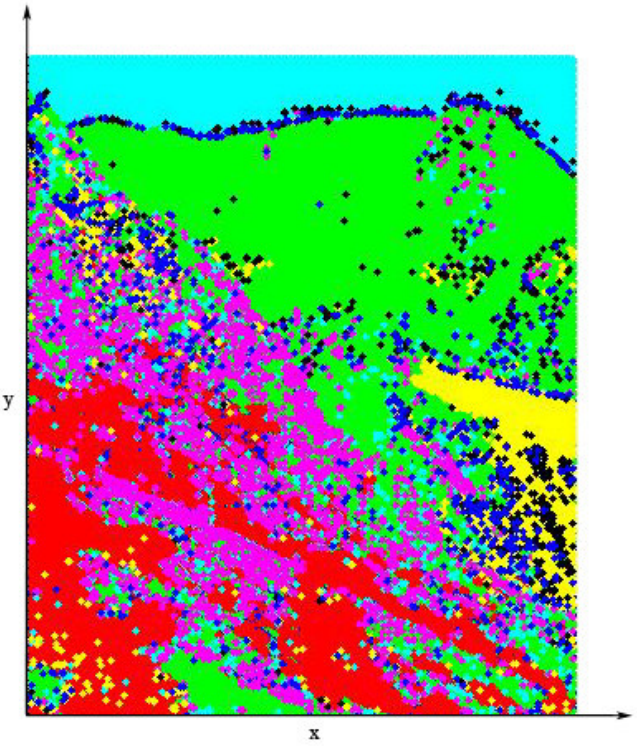


Fig.2. Typical output after segmentation. 18 clusters are found in the input image (Fig. 4) after mean shift segmentation using hue and saturation.

For segmentation the mean shift method has been chosen [9]. The mean shift algorithm is a nonparametric clustering technique which does not require prior knowledge of the number of clusters, and does not constrain the shape of the clusters.

Segmentation module provides certain number of clusters that have to be processed by the last, recognition module. Typical output after segmentation is shown in Fig 2.

Recognition module has six phases (Fig. 3). Phases 1 to 4 reject all the regions that are not likely to present humans.

All the remaining regions that were not eliminated by the previous four phases are forwarded to the next two phases that are optional. The fifth phase assigns scores to the remaining region in the image according to the available data and situation knowledge. Possible information for the region scoring can be colors of the missing person clothing, usual terrain colors, etc. It reduces the number of wrongly detected regions.

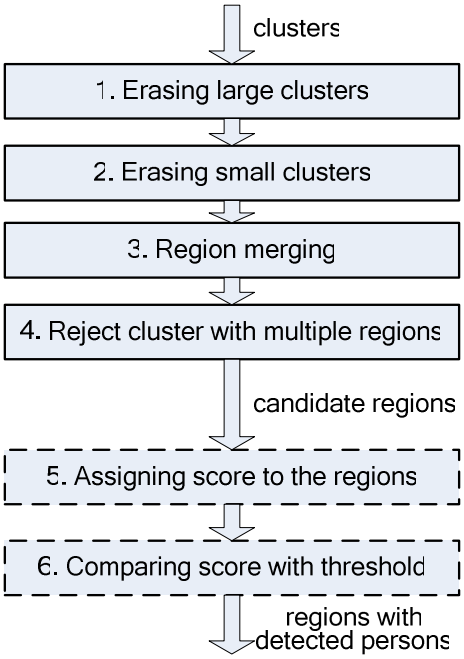


Fig.3. Recognition module

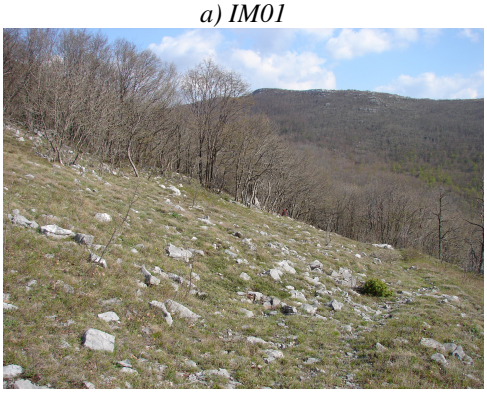
In Fig. 4, an example of successful recognition of two persons (clothes) is shown. More detailed description of the method as well as the results are given in [10],[11].

Fig 4. Correct detection example (2/2 persons)

III. RESULTS

As it can be seen from the previous section, the key assumption for the proposed recognition method is the significant difference of hue and saturation values between natural and artificial materials. If there is no difference, or the difference is too small, recognition would be unsuccessful. Thus, we have conducted a series of measurements in order to determine difference of hue and saturation values between natural and non-natural materials and also to determine if these values depend on distance between observer (camera) and the objects.

a) IM01



b) IM02

c) IM03

Fig 5. Test images (distance: 35m)

Measurement has been conducted on three series of images taken in surroundings of Ravni Dabar, Velebit. Images from each series have a human in the centre of the image (in typical mountaineer's clothes, artificial material), while the photographer moves away and measures the distance using the GPS. Object-camera distances were 10m, 20m, 35m, 50m, 75m, 100m, 150m and, where possible, 200m.

Three test images for 35m distance are shown in Fig.5 (a. IM01 – person with sky as background, b. IM02 – person partially occluded with braches, c. IM03 – person and dog sitting in a mixture of stones and grass).

Matlab software package is used for the analysis of the results. For the RGB to HSV colour model conversion, function rgb2hsv which is part of Image Processing Toolbox, has been used.

For each measurement, saturation and hue values (average value for all pixels) have been calculated for whole image. Also, hue and saturation values for segment representing person (clothes-artificial material) have been calculated. The results for the first image series (IM01) are shown in Fig.6. Similarly, results for the image series IM02 and IM03 are given in Fig.7 and 8.

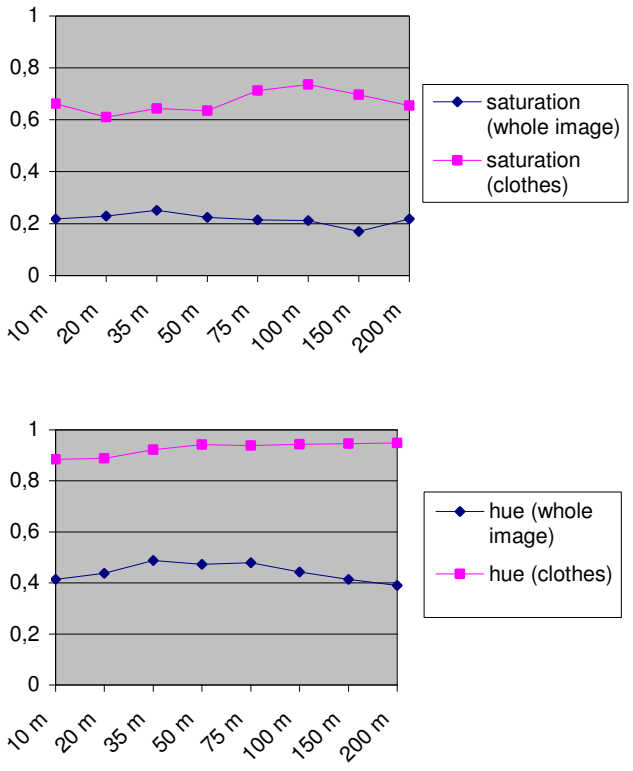


Fig 6. Measurement results for image series IM01

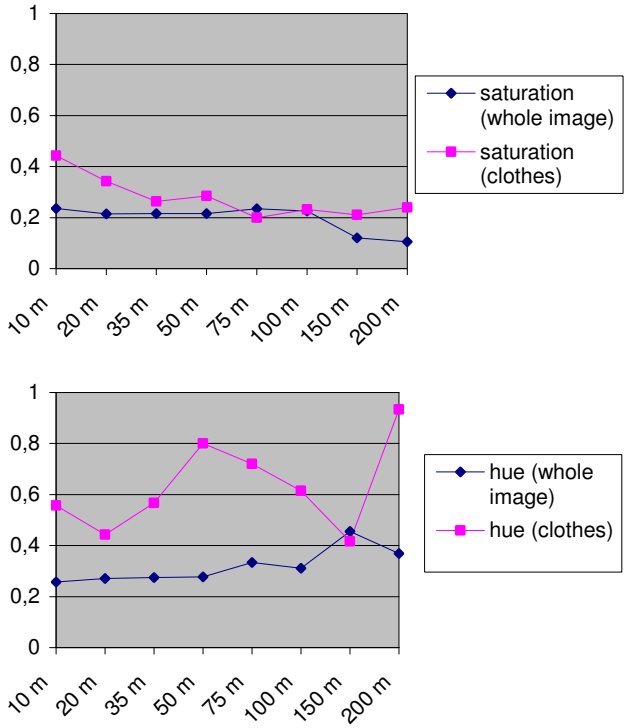


Fig 7. Measurement results for image series IM02

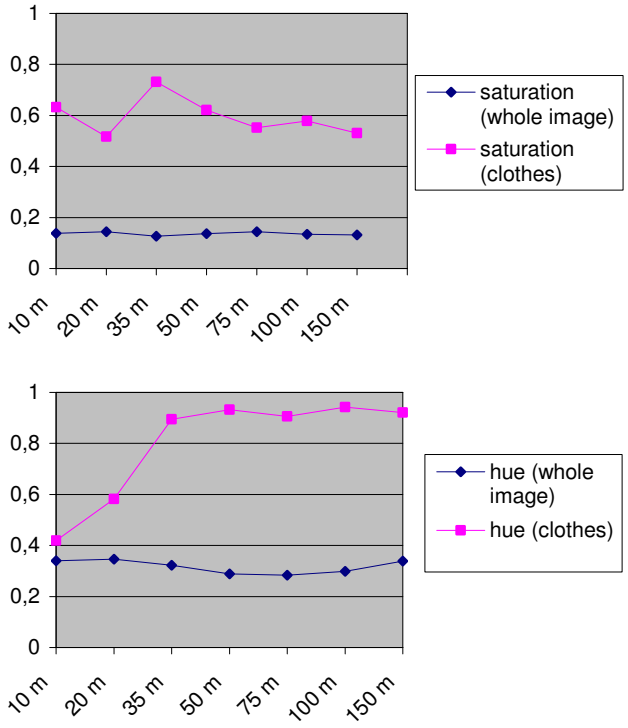


Fig 8. Measurement results for image series IM03

Measurement results shows that distance does not significantly change hue and saturation values. We can conclude that, for the distances up to 200m, hue and saturation does not depend on distance between object and camera.

	Saturation (whole image)	Saturation (clothes)	hue (whole image)	hue (clothes)
IM01	0.218	0.669	0.443	0.927
IM02	0.196	0.277	0.319	0.631
IM03	0.136	0.595	0.317	0.799
average	0.183	0.514	0.360	0.786

Table 1. Average saturation and hue

Average hue and saturation values for all distances are given in Table 1. Measurement results shows that hue and saturation differences between natural materials (whole image) and non-natural materials (clothes) are, in average, significant.

The only exception is saturation in image series IM02 where the difference is relatively small. It has been expected because that series contains person with partially occluded clothes.

IV. COLUSION AND FUTURE WORK

In this paper, the results of the hue and saturation value measurements for artificial (mountaineers clothes) and natural materials are given. Measurement was conducted on three typical image series for distances from 10 up to 200 meters.

It is shown that the difference of hue and saturation values for natural and non-natural objects can be used for the successful recognition. Therefore, average saturation on a whole image for all distances and all image series is 0.183 while the average saturation for the segment with artificial material is 0.514. Similarly, average hue in all images is 0.360 while the average hue of the segment with clothes is 0.786.

Also, it is shown that, for the measured distances, hue and saturation values are not significantly dependant of distance. The paper also provides a short description of the method for recognition of humans in long distance images based on the difference of hue and saturation values for natural and non-natural images. The primarily intention of the proposed

method is for the search and rescue missions in the non-urban terrain.

Future work considering the presented issues would be focused on hue and saturation analysis of various artificial materials such as everyday clothing and military clothing and also, their relation to natural materials.

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