MaNIAC-UAV - a methodology for automatic pavement defects detection using images obtained by Unmanned Aerial Vehicles

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Abstract. Intelligent Transportation Systems - ITS is a set of integrated technologies (Remote Sensing, Image Processing, Communications Systems and others) that aim to offer services and advanced traffic management for the several transportation modes (road, air and rail). Collect data on the characteristics and conditions of the road surface and keep them update is an important and difficult task that needs to be currently managed in order to reduce accidents and vehicle maintenance costs. Nowadays several roads and highways are paved, but usually there is insufficient updated data about current condition and status. There are different types of pavement defects on the roads and to keep them in good condition they should be constantly monitored and maintained according to pavement management strategy. This paper presents a methodology to obtain, automatically, information about the conditions of the highway asphalt pavement. Data collection was done through remote sensing using an UAV (Unmanned Aerial Vehicle) and the image processing and pattern recognition techniques through Geographic Information System.

1. Introduction

The highways preservation and monitoring are something of great importance especially when we are talking about countries witch a large geographical area, like Brazil. Roads are increasingly presenting emergency maintenance situations, especially in areas of difficult access and in remote locations.

From the user point of view, the state of the pavement surface is the most important because the defects or irregularities are perceived as affecting both the comfort as raises the related operating costs to vehicle maintenance parts, the fuel consumption, tires and others. Furthermore, the precarious highway conditions may result in accidents, thus endangering the human beings lives.

The use of traditional techniques for fieldwork, or even ground vehicles for detecting the quality of the roads is something that is very time consuming and costly. Thus, the use of modern technologies that allow monitoring the conditions of these roads and act more effectively in the recovery of these highways is an important task.

Starting from this current reality we aim with this research provide a more efficient and cost-effective method for the highways preservation using Unmanned Aerial Vehicles (UAVs).


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In this paper we present MaNIAC-UAV (Methodology for Asphalt Automatic Characterization – using Unmanned Aerial Vehicles) a low cost and automatic methodology for the detection of defects in the asphalt surface using UAVs to support the Pavement Management Systems.

2. Related Work

In this regard, some works are highlighted. Through the development of algorithms, [1] extracted points of interest on various scales of hyperspectral images obtained by UAVs. In [2], the author presents georeferencing video accurately and in near real time in a small UAV developed for fire monitoring. In [3], determines the best ways of measuring textures associated with the scale of analysis obtained by UAV images that present the highest spatial resolution in pursuance of monitoring vegetation.

The study presented in [4] discusses the use of spectrometry combined to hyperspectral remote sensing to explore the potential road network conditions. The pavements aging and degradation are represented by distinct spectral characteristics. This study used image indices and the spatial variance measures relate to the remote sensing signal to the pavement condition index. Similarly, the same authors continue the study presented in [5-7]. In these studies the authors point out that the drones are an emerging technology in the context of transport. In this way, MaNIAC-UAV uses UAVs and provides an automatic pavement defects detection.

3. MaNIAC-UAV definition

The first step to use a set of high-resolution images to assist in automatic detection of defects in pavements is the definition of well-defined steps. Thus, we propose MaNIAC-UAV (Methodology for Asphalt Automatic Characterization – using Unmanned Aerial Vehicles) that is illustrated in Figure 1a.

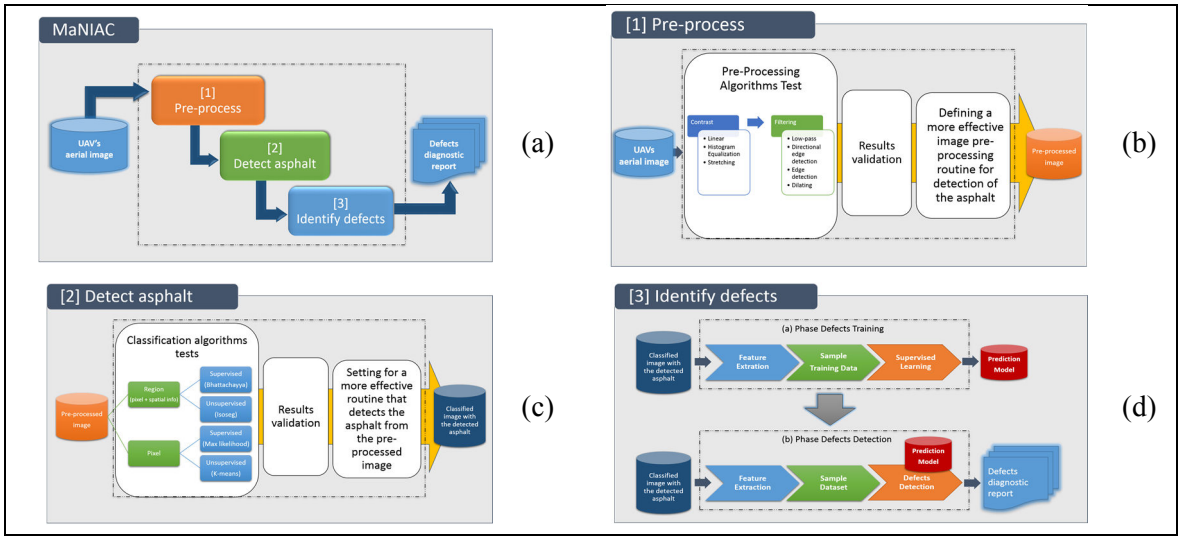


Figure 1. (a) MaNIAC - UAV. (b) Pre-process detail. (c) Detect Asphalt detail. (d) Identify Defects

The methodology is divided into three processes: Pre-Process, Detect Asphalt and Identify Defects. As input we have the high spatial resolution images, like 4cm/px, obtained by UAVs and as outputs the defects reports found under the Standard DNIT 005/2003 - B [8].

Initially, the Pre-Process (Figure 1b) refers to the initial processing of the raw data that allows the radiometric calibration image, correction of geometrical distortions and noise removal. The objective is to improve image quality, allowing objects in the image are differentiated.

The second process, Detect Asphalt (Figure 1c), aims to the classification of the images obtained and is made by SPRING (Sistema de PRocessamento de INformações Georeferenciadas) [9], a GIS (Geographic Information System) open-source software with image processing features.

The output result of this process is the classified images. These images are divided to be automatically identified using Machine Learning for the defects identification. Thus, Identify Defects (Figure 1d) makes use of two data sets: one is used as a training set, and the results obtained from other images as sample dataset. From then obtained the report with the defects identified in the reported images.

4. Results and Discussions

The images were obtained in São Carlos in Area II of the USP Campus and its surroundings. The camera resolution was 16 megapixel while the flight altitude was 130m with a spatial resolution of 4.0cm/pixel.

The flight adjustments are made directly on the UAV software. The missions were planned by polygons to delimit the areas to be imaged. The flight altitude and the images overlap that will be obtained were defined during the programming of the mission.

It is possible see that in areas with higher population density the pavement identification presents a challenge when compared to areas with lower density. This is because of the presence not only of vegetation but also constructs.

The first step was performed Pre-Process. The Histogram Equalization, the Dilation and the Edges Detection methods were used, illustrated in Figure 2a, 2b and 2c respectively.

For the second step, the Detect Asphalt two-classification process was used: a pixel supervised and unsupervised. In the unsupervised the image was loaded as monochromatic and the classification obtained using linear operation. In a supervised were extracted samples of the pavement surface and the MAXVER (Maximum Likelihood), that analysis each class based in its value. Figures 3a and 3b, shows a comparison of supervised and unsupervised process.

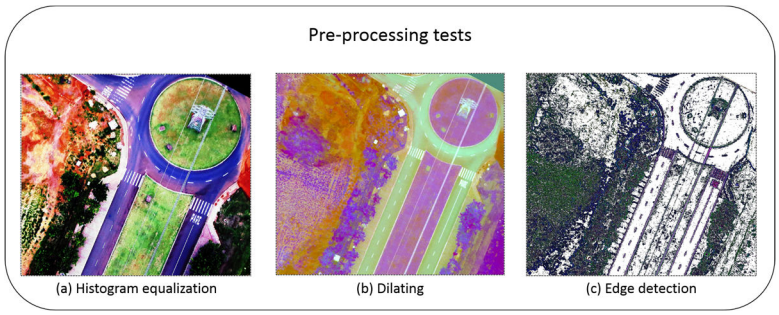


Figure 2. Pre-Process – selection areas. (a) Histogram Equalization; (b) Morphologic Dilatation; (c) Edge Detection.

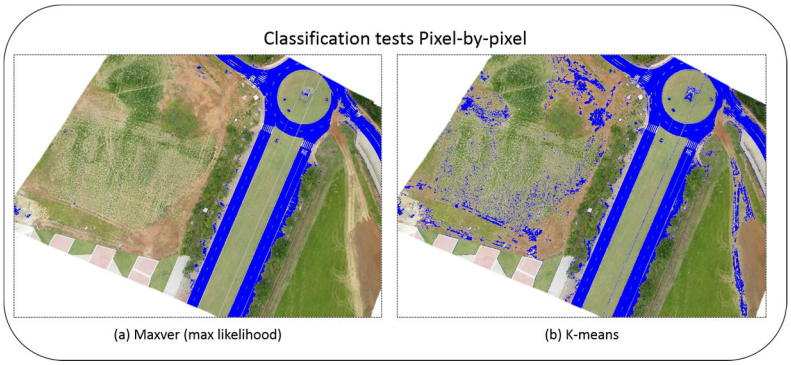


Figure 3. Classification process comparison – (a) Maximum Likelihood – (b) k-means

The last step was Identify Defects. The last step was obtained in this fist moment using a specific algorithm to detect one class of defect that is illustrated in Figure 4.

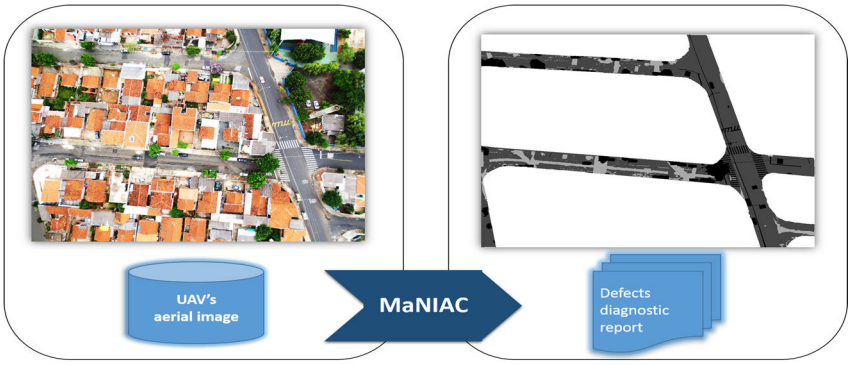


Figure 4. Asphalt defect characterized.

5. Conclusion

The main objective of this paper was present MaNIAC-UAV a methodology to automatic pavement defects detection. The MaNIAC-UAV was presented and some stages were validated by images taken, pre-processed and classified.

The results obtained from the use of image processing and geographic information systems allowed the proof of concept needed to thereafter perform the classification of defects types. These defects will be presented in a future work that will use Machine Learning to provide an automatic detection of different asphalt defects classes.

6. References

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