Available online at www.sciencedirect.com

ScienceDirect

IFAC-PapersOnLine 49-16 (2016) 016–021

Precision Forestry: Trees Counting in Urban Areas Using Visible Imagery based on an Unmanned Aerial Vehicle

Omair Hassaan, Ahmad Kamal Nasir, Hubert Roth*, M.Fakhir Khan

Lahore University of Management Sciences , Pakistan (e-mail: (14030008, ahmad.kamal, fakhir.khan)@lums.edu.pk).
**Lehrstuhl fr Regelungs- und Steuerungstechnik (RST), Department Elektrotechnik und Informatik, Fakultt IV, Universitt Siegen, 57068, Siegen Germany (e-mail: hubert.roth@uni-siegen.de*

Abstract: This research work describes an approach to count trees in an urban environment. Furthermore it addresses the problems involved in detection of trees in aerial imagery. This work can be used to solve the problem of forest degradation and deforestation. Right now forest man labor isn't efficient enough to detect or prevent this problem. A multi-rotor UAV equipped with high resolution RGB camera was used to acquire aerial images and to count number of trees in surveyed area. Various issues involved in the robust implementation of proposed algorithm are discussed. The result of successful implementation of the proposed algorithm on multiple scenarios are also presented and we show that our naive approach is able to achieve ≈ 0.72 accuracy within reasonable amount of time.

Keywords: Precision Forestry, Robotics, Vision, UAV.

1. INTRODUCTION

In underdeveloped countries, lack of resources causes the major trouble for forest department to monitor a countrys forest area. Expensive sensor networks dont allow teams to get real time data to monitor forest degradation and man labor is expensive and really slow. In recent years, the use of Unmanned Aerial Vehicles (UAVs) has increased rapidly, mostly being adopted for many civilian applications. Inexpensiveness of UAV systems has enabled them to be used for various research applications e.g. agriculture, mapping and survey. Recently people have used UAV images for vegetation monitoring,Pollock (1996), and car counting, Moranduzzo et al. (2014) Daigavane and Bajaj (2010). In fact, UAVs allow mapping and monitoring small areas at extremely fine scales, quick survey of target area and multi-temporal acquisitions over the same area at predefined times.

In this research work, we have implemented a technique to count trees using UAV and computer vision algorithms. In developing countries millions of people depend on forests fao (2015), directly or indirectly, for their livelihood due to which a notable amount of forest is destroyed every year in tropics either in the form of forest degradation or deforestation. Deforestation and degradation has socio-economic impact on small communities. These communities use forests as their living hood. Forests provide major environmental benefit by reducing global warming. But excessive degradation of forests can damage atmosphere and release greenhouse gases in air which leads to global warming. Which eventually leads to climate change. In most of the cases, people clear tropical forest to cultivate land.

Object detection and counting has been widely used in computer vision community over the past decades. People have worked on automatic car counting, Moranduzzo et al. (2014), and people counting methods, Velipasalar et al. (2006). Research into automatic tree detection and delineation from digital imagery was started back in mid-1980. Since then a number of detection algorithms have been proposed. Pinz (1991) proposed a *Vision Expert System* using aerial imagery. He was able to locate the center of trees crown and estimate its radius using local brightness maxima. Valley following and rule based algorithm was presented by Gougeon (1995), in mid-1990s in which he follows the valleys of shadows between tree crowns using ground sampled distance digital aerial imagery. Machine learning has also been used to detect individual trees. Pollock (1996) used model-based template matching techniques to recognize individual trees.

We have preferred UAV's high resolution images over satellite images because satellite images are readily affected by cloudy environments. Also, freely available satellite images are of low resolution as compared to UAV images.

The rest of the paper is organized as follows, in section II we have presented some related work by use of satellite and UAV imagery. In section III we present our methodology and discuss an approach we have used to count trees from aerial imagery. Section IV presents results of our implemented algorithm and Section V discusses some conclusion and future work.

2. RELATED WORK

Vibha et al. (2009), produced promising results using a robust technique for counting of trees from remotely sensed

Peer review under responsibility of International Federation of Automatic Control.
10.1016/j.ifacol.2016.10.004

data. They have used high resolution satellite imagery and pre-processed the data using median filter and intensity based processing. For vegetation they used feature extraction and template generation techniques where a masking function is generated and scanned from bottom over the whole image. This algorithm has its limitations due to the use of satellite imagery, since high resolution images are not freely available, and specifically targets only the species of palm trees which are structurally different from the rest of tree species.

Kattenborn et al. (2014), proposed a technique of automatic single palm tree detection using photogrammetric point clouds. Single camera images were processed with a structure from motion tool chain using Visual SFM. Each image was classified into 3 classes, i) palm ii) shrubs/trees iii) ground. For classification, a multi-scale dimensionality criterion was used in which the classifier is trained on different scale factors for train and test dataset. Local dimensionality characteristics of point cloud are used to classify palm trees and ground soil. Training a classifier for dataset posts limitations for such algorithms. Since training classifier is time consuming and requires more computational power. For each type of tree species one has to train the classifier before detecting trees.

Bazi et al. (2014), used Scale Invariant Feature Transform (SIFT) to extract key points and used a pre-trained classifier based on Extreme Learning Machine (ELM) to classify the extracted key points. As output the ELM classifier marked each detected palm tree as key points. In order to capture the shape, the extracted key points are merged using active contour based method based on Level-Set (LS). Since some green plants can be confused with palm trees so to classify palm and non-palm regions texture analysis is performed. Kernel based learning machines pose a limitation of high training cost which includes time and computational power. This also restricts the detection/classification approach to single species, in case, if trees from different species are required to be detected, ELM has to be pre-trained before using.

Hung et al. (2006) proposed vision based shadow aided tree crown tree detection and classification algorithm using imagery from UAV. Algorithm comprises of 2 parts i) detection ii) classification. The algorithm uses color and texture information to segment regions of interest (tree crown existence). A model object matching step is done which uses the shape, scale and context information for classification to differentiate the tree crown species. Image segmentation step is done using Support Vector Machines (SVM). Although SVMs have good generalization performance, they can by really slow in test phase. SVMs depend on the choice of kernel and have high algorithmic complexity along with extensive memory requirements in large-scale tasks.

The use of Ground control points for UAV data acquisition and spatial filtering is also being used for forest tree counting. Mansur et al. (2014) used UAV to collect data. They have used the concept of crown geometry and vegetation response to radiation. The detection of tree crown can be possible by applying spatial convolution processing technique such low pass filter to enhanced image. After spatial filter, Morphological analysis is applied on the dataset to

Fig. 1. DJI Phantom 2.0

perform object extraction, image filtering operations and image segmentation operations.

Making the assumption that tree crowns are located at the center or close to the center of tree top, Brandtberg and Walter (1998) detected trees using local maxima values. In this algorithm, image is first smoothed to reduce the noise effect and then tree crowns are filtered using local maximum values. Trees crown and background is delimited using edge detection methods. This method is simple and produces promising results in very less time, but light variations and un-wanted background objects in image badly affects the results.

Wang and Gong (2004) further improved the work of Brandtberg and Walter (1998) by first detecting boundaries of tree crowns using edge detection methods and then intersected the results of local non-maximum suppression on gray-level image & local maximum values of morphological transformed distance between pixels. Intersecting both methods give a good estimate of the tree tops which are then counted using contour based methods. This algorithm also suffers the presence of background objects, for example, buildings and roads.

3. METHODOLOGY

In this research work we implement a technique of image segmentation. To interpret an image, it is usually necessary to extract objects from background or separate image into several meaningful regions. Generally image segmentation clusters pixels of an image based on a given rule or criteria. Color textures along with correlation among color bands form a good feature extraction.

We have used a quad-copter equipped with 14.4 Mega pixel camera pha (2014). Aerial imagery is acquired by first surveying the target area. Afterward we created a mosaic using acquired images so that we can easily detect and count trees using our algorithm.

3.1 Preprocessing

Data Acquisition The data acquisition for this thesis problem was done using quadrotor DJI-Phantom 2. This quadrotor is equipped with 14.4 Megapixel camera and has a flight time of almost 15-20 minutes. Figure 1 shows quadrotor. Aerial imagery is acquired by first surveying the target area and then those images are used for further processing. Different data sets were taken at different sites and at different heights.

LUMS dataset: Dataset at Lahore University of Management Sciences Pakistan was taken at a height of 100 meters from ground. GPS co-ordinates were given as input to the quad-rotor for trajectory to follow. A total of 150 images covering 610 meters of ground area were taken.