CONTAGEM DE EUCALIPTOS UTILIZANDO VANT E PROCESSAMENTO DIGITAL DE IMAGENS

COUNTING EUCALYPTUS TREES USING UAV AND DIGITAL IMAGE PROCESSING

Data de entrega dos originais à redação em 26/02/2016, e recebido para diagramação em: 30/11/2016.

Arthur Avelar Chaves[1]
Rodrigo Antônio La Scalea[2]
Célia Leiko Ogawa Kawabata[3]
Kalinka Regina Lucas Jaquie Castelo Branco[4]

Novas tecnologias estão sendo empregadas na agricultura de precisão, sendo uma delas a utilização de VANT na aquisição de imagens aéreas de alta resolução espacial e temporal, as quais permitem um melhor monitoramento da cultura. Neste sentido este estudo visa identificar e quantificar árvores de eucaliptos em imagens aéreas obtidas por um VANT. Para isto foram implementados algoritmos de processamento de imagens existentes na biblioteca OpenCV. O método proposto identificou com sucesso 342 árvores de eucaliptos em uma área de 2025 m² mostrando-se satisfatório, uma vez que a estimativa realizada em áreas de "cerca viva" é condizente e o mesmo não apresentou omissões.

Palavras-chave: contagem, eucalipto, VANT, processamento de imagens digitais, OpenCV.

New technologies are being used in precision agriculture, like the use of UAV for acquiring images with high spatial and temporal resolution, which allow for a better monitoring of the crop. In this study, we aim to identify and quantify Eucalyptus trees in aerial images obtained with a UAV. To do so, we implemented digital image processing algorithms with the OpenCV library. The proposed method successfully identified 342 trees in an area of 2025 m², showing to be satisfactory, since that it did not miss any well-defined tree and the estimative for dense groups of trees is fairly accurate.

Keywords: counting, Eucalyptus, UAV, digital image processing, OpenCV.

[1]Mestrando em Ciências da Computação e Matemática Computacional - ICMC/USP
[2]Graduando em Análise e Desenvolvimento de Sistemas – IFSP São Carlos
[3]Professora Doutora – IFSP São Carlos
[4]Professora Doutora – ICMC/USP

1 INTRODUCTION

In Brazil, the production of *Eucalyptus* stands out. According to ABRAF (2013), the country held 6.664.812 ha of planted forests, of which 76.6% were *Eucalyptus*, while most of the crops are found in the South and Southeast regions of the country.

According to Jorge and Inamasu (2014), one technology that is gaining momentum in precision agriculture, are Unmanned Aerial Vehicles (UAV) because they can obtain images with high spatial and temporal resolution, which are ideal for monitoring crops. We can cite some examples of studies that use UAVs specifically for monitoring *Eucalyptus* cultures (ARAÚJO, CHAVIER E DOMINGOS; 2006; PONTES, FREITAS; 2015).

With the aging and growth of trees, it is common to appear, in aerial images, regions where trees are visually blended, making it more difficult for counting algorithms to perform with good precision and making the counting only possible with ground observations, which is, unviable in most cases. Since identify and count trees is a fundamental task to help producers have better knowledge about their own property and production, it is necessary to develop better methods and technologies to count trees in large properties.

Therefore, this study aims to use digital image processing techniques to properly identify and count *Eucalyptus* trees in high spatial resolution images taken with cameras aboard UAV.

2 MATERIALS AND METHODS

Materials used in this study are Near-Infrared (NIR) image with 9 cm spatial resolution and 8 bits radiometric resolution obtained with an eBee UAV, produced by Sensefly (www.sensefly.com). The algorithms presented were developed using C++ and the OpenCV library for digital image processing.

The proposed method can be divided in two stages. The first one aims to count well defined trees, with good spacing between them. The second one aims to estimate the amount of individuals in regions where the spacing is too small and the trees are visually mixed, making it difficult to directly count them.

In the first stage, we start with histogram equalization in order to highlight trees; then we apply an adaptive threshold to segment trees from soil and grass; then, in order to separate trees, we calculate a distance transform, apply a binary threshold and finish with an opening morphology operation. Figure 1 shows a flowchart with each of these steps and the resulting image of each one.

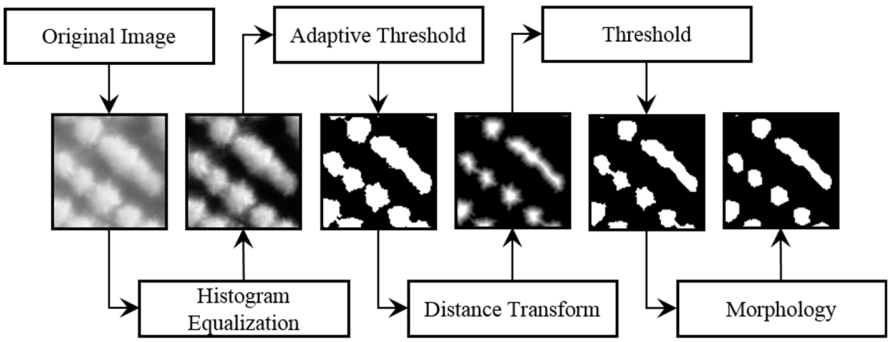

Figure 1 – Flowchart showing the first stage of the proposed method, detailing the resulted image in each step.

We can also see in Figure 1, in the upper right corner of each example, a larger area that represents a "hedge", that is, a group of trees that are visually mixed, making the algorithm count the whole "hedge" as a single tree.

Since the direct identification and counting in "hedge" areas is unfeasible, we developed the second stage of our method based on the size of trees to estimate the amount of individuals in a region of interest. In this stage, we used the OpenCV functions "findContours" and "rotatedRect" to find the "hedge" areas and draw bounding boxes around them. Then, along each rectangle, we trace a line in which will be estimated the positions of each tree.

Figure 2 presents the algorithm used to solve the "hedge" problem by estimating the amount of trees in that region.

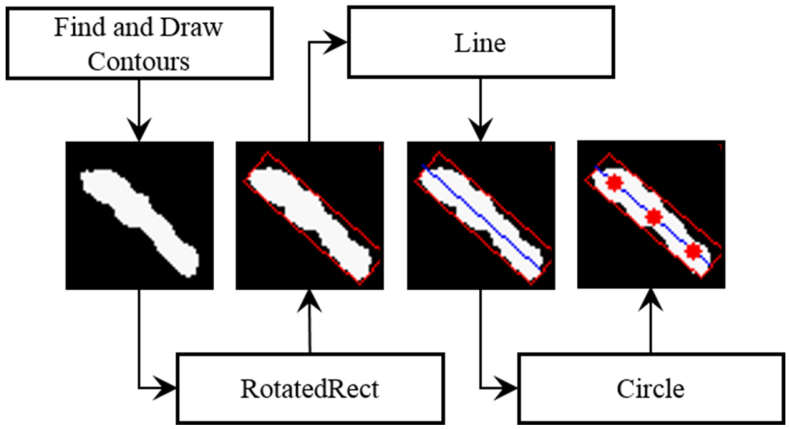

Figure 2 – Flowchart showing the first stage of the proposed method, detailing the resulted image in each step.

Finally, the trees found in the second stage are integrated with the result of the first staged so that they may be counted in the whole image.

3 RESULTS AND DISCUSSION

In Figure 3 (a) we can see the total area used in this study. In this image, it is possible to see that the area is mainly composed of well-defined and spaced trees. However, there is also the presence of many large "hedges". In Figure 3 (b) we can see the result of the identification of the 342 trees found by our method. While in Figure 3 (c) we can see the marked trees overlapped with the original image.

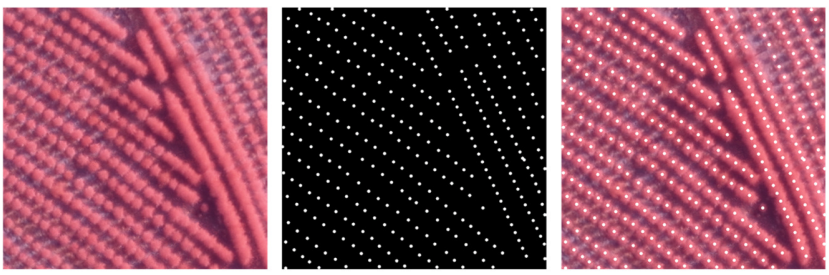

Figure 3 - (a) original image containing red, green and NIR channels; (b) Trees marked by our method; (c) Marked trees of (b) drawn in (a).

In order to validate, we can use the information about *Eucalyptus* cultures presented by Wilcken (2008). He states that in an area of 1 ha (10000 m²), 1667 trees are planted with a spacing of 3 m x 2 m. The total area considered in this study is of 2025 m², that is, it is estimated that there are 337 individuals in this area. Whereas our method counted 342 trees, we can say that it is a satisfactory result.

4 CONCLUSIONS

In view of the results obtained in this study, we can say that the proposed method showed to be efficient in the identification and counting of *Eucalyptus* trees, since it counted all the well-defined trees and the estimative for "hedge" areas showed to be consistent.

Since high spatial and temporal resolution images obtained with UAVs are continuously gaining notice for environmental and agricultural monitoring, the correct identification and counting of individuals in large crops is fundamental in approaches that analyze areas affected by diseases, plagues or crop failures.

ACKNOWLEDGEMENT

The authors would like to thank the support of CNPq and FAPESP.

REFERENCES

ABRAF. **Associação Brasileira Florestal dos Produtores de Florestas Plantadas.** Disponível em: < http://www.abraflor.org.br/estatisticas/abraf13/abraf13_br.pdf >. Acesso em: 29 de agosto de 2015.

ARAÚJO, M. A.; CHAVIER, F.; DOMINGOS, J. L. **Avaliação do Potencial de Produtos Derivados de Aeronaves Não Tripuladas na Atividade Florestal**. Ambiência, Guarapuava, PR, v. 2. p. 69-82, 2006.

JORGE, L. A. C.; INAMASU, R. Y. **Uso de veículos aéreos não tripulados (VANT) em Agricultura de Precisão.** In: BERNARDI, A. C. C. et al., editores técnicos. Agricultura de precisão: Resultados de um novo olhar. Brasília, DF: Embrapa, 2014. 596 p.

OPENCV. **Documentation**. Disponivel em: < http://docs.opencv.org/index.html >. Acesso em: 01 de agosto de 2014.

PONTES, G. R.; FREITAS, T. U. **Monitoramento de plantios de eucalipto utilizando técnicas de sensoriamento remoto aplicadas em imagens obtidas por VANT**. In: SIMPÓSIO BRASILEIRO DE SENSORIAMENTO REMOTO - SBSR**,** XVII, 2015, João Pessoa-PB. Anais... João Pessoa-PB: INPE, 2015. Disponível em: < http://www.dsr.inpe.br/sbsr2015/files/p0801.pdf >. Acesso em: 29 de agosto de 2015.

WILCKEN, C. F. et al. **Guia Prático de Manejo de Plantações de Eucalipto**. Botucatu: FEPAF, 2008. 25 p.