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A vision-based hybrid approach for identification of Anthurium flower cultivars

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Highlights

- Flowers cultivar identification is a key step for subsequent classification tasks.
- Anthurium flowers could be identified based on their spadix.
- The Viola-Jones algorithm was used to detect the spadix of Anthurium flower.
- Computation time is a constraint especially for matching with a lot of templates.
- Application of the Viola-Jones algorithm decreased computation time significantly.

Abstract

A hybrid approach was developed for highly accurate and effective identification of Anthurium flower cultivars in a computer vision-based sorting machine. Anthurium flowers have a small spike-shaped inflorescence called spadix. These flowers are distinguishable according to the color scheme of the spadix region. In the developed cultivar classification algorithm, the spadix region of test images was detected using the Viola-Jones object detection algorithm. The Viola-Jones detector was trained by positive images prepared from different cultivars of Anthurium flower, and the Oxford Flowers 17 dataset was used as negative images. Then, the detected region as Region of Interest (ROI) matched with images of various cultivars at different sizes and angles of rotation templates as a multi-template matching approach, in which each image was representative of a specified cultivar. The experiment results indicate that the proposed technique has acceptable performance in detecting the spadix region and inspiring performance in classifying the flower cultivars. At different conditions of the templates used for classification, the computation time as a critical criterion for real-time classification was less than 0.5 s, with the classification accuracy of more than 99%. In an automatic grading machine for flowers, cultivar classification of flowers is an important step for subsequent grading tasks.

Introduction

Cut flower production has a significant role in the diversification of tropical agriculture (Dufour and Guérin, 2005). Anthurium is a popular cut-flower and pot-plant ornamental due to its attractive long-lasting inflorescences, colorful, cylindrical spadix subtended in a large heart-shaped spathe and unusually attractive foliage (Tadashi Higaki, 1995, Teixeira da Silva et al., 2015). In the global market, the Anthurium sales are second in the world among tropical cut flowers (Rikken, 2010). Fifteen cultivars of Anthurium flower with beautiful color schemes at three shape categories are shown in Fig. 1.

Application of flower classification can be found useful in automation of floriculture operations such as flower trade, nursery and potted plants, seed and bulb production, micro propagation and extraction of essential oil from flowers, as well as flower searching for patent analysis. Developing a system for classification of flowers is a difficult task because of considerable similarities among different classes and also due to a large intra-class variation (Guru et al., 2010). It becomes more difficult when the classification of cultivars of a special

flower considered. On the other hand, the postharvest operations in greenhouses or fields, such as bunching, packing and grading are important to maintain quality and lifetime of cut flowers and foliage (Celikel and Karacali, 1995). So, developing automatic systems to implement the postharvest operations is a need for all ornamental cultivars. Automatic systems caused the postharvest operations performed independently without labor intervention, and at the highest rate and efficiency. Among instrumental-oriented classification approaches, computer vision systems do not imply contact with the object and could be effectively used. The performance and efficiency of these systems are extremely dependent on the robustness of applied image processing algorithms and machine learning techniques (Soleimani Pour et al., 2018).
Classification of flowers according to visual features and imperfections has been studied by many researchers. Application of artificial vision systems and machine learning methods for horticultural crops include detection, classification, and quality monitoring (Agrawal et al., 2012, Aquino et al., 2015, Belhumeur et al., 2008, Bhardwaj and Kaur, 2013, Garbez et al., 2016, Guyer et al., 1993, Handa and Agarwal, 2015, Hsiao et al., 2015, Kohsel, 2001, Kumar et al., 2012, Lee and Hong, 2017, Liu et al., 2018, Mg et al., 2017, Morel et al., 2009, Moriondo et al., 2016, Nilsback and Zisserman, 2008, Nilsback and Zisserman, 2006, Parsons et al., 2009, Rao et al., 2007, Soleimani Pour et al., 2018, Timmermans, 1998, Timmermans and Hulzebosch, 1996, Yang et al., 2000, Zhang et al., 2014, Zhenjiang et al., 2006).

Most of the publications related to application of computer vision and machine learning in the classification of flowers discussed on differences among various flower types and did not concern about a single flower species. However, there are some exceptions (Pandolfi et al., 2009). A flower, like Anthurium may have dozens of commercial species with clear differences even for an expert person. Cultivars of Anthurium flower are different in color, size, and shape. The color of this flower is very diverse and varies from pastel pink and greens to vibrant red and green combinations. The size of different cultivars of Anthurium flower varies from less than an inch to almost one foot in length. Also, this flower was categorized into three main shapes of Cupped, Obake, and Standard.

Hong et al. (2004) used a color histogram segmentation method and then used with the centroid contour distance and angle code histograms to form a classifier. They concluded that outline shape is an important character to consider for flower species identification purposes, especially in combination with other features. Zhenjiang et al. (2006) presented a rose analysis and recognition system. They have discussed mathematical description methods for

features such as shape, size, and color of the flower, petal, leaf, etc., and the object-oriented pattern recognition (OOPR) approach which mathematically deals with how to comprehensively use all different rose features rationally in the recognition scheme. Their results demonstrate the efficiency of the mathematical description methods and the OOPR approach in their variety recognition system. Nilsback and Zisserman (Nilsback and Zisserman, 2010) combined a generic shape model of petals and flowers with a color-based segmentation algorithm. Yanikoglu et al. (2014) presented a plant identification system for automatically identifying the plant in a given image using a variety of shape, texture and color features.

Template matching is a common method for detecting and recognizing objects in digital image processing. This technique was recently used in some agricultural researches. A template matching method was used by Johansson et al. (2015) to recognize board images under realistic conditions. To speed up the matching step, they downsampled the flower images to low pixel density. They concluded that the proposed recognition method could be used in industrial practices. Bao et al. (2016) used the multi-template matching method to identify cucumber in the field from its branches and leaves. A multi-template matching library derived from a standard image was constructed through the transformation of scale and angle, which contained 65 cucumber images. Their approach recognized cucumbers from 100 image frames using the multi-template matching method, with a quite acceptable accuracy of 98%.

Viola-jones algorithm is an object detector that used for detection of the human face, facial features, cars, and etc. in images (Alionte and Lazar, 2015, Cuevas et al., 2017, El Kaddouhi et al., 2017, Lobban and Jones, 2008, Murphy et al., 2017, Nguyen et al., 2013, Schneiderman and Kanade, 2000, Sharma et al., 2009, Viola and Jones, 2004). Recently, the Viola-Jones algorithm was used for detection of orchid flowers by (Puttemans and Goedeme, 2015). They used a Viola and Jones based approach with LBP features and AdaBoost learning, where the classification part was solved by training a binary tree of linear SVM classifiers on a limited set of training data. They concluded that the proposed approach was a robust orchid flower detection and classification pipeline according to the desired classification accuracy. Juman et al. (2016) developed a tree trunk detection algorithm using the Viola-Jones detector along with a pre-processing method, combined with tree trunk detection via depth information. It is concluded that the Viola-Jones detector outperformed both the Neural Network and SVM based detectors in detecting oil palm tree trunks in a plantation. In General, searching for a

target object in a wide-scene image to classify it, would be time-consuming and sometimes cause improper results. So, combining an object detection method with classification approaches will lead to better results.

Recently, Soleimani Pour et al. (2018) developed an approach for cultivar classification of Anthurium flowers based on image processing, B-spline curves, mathematical calculations, and machine learning classifiers. Curvature amount and variation at various boundary points of a flower was used to detect its cultivar. Indeed, they only feed the signature of Anthurium flower cultivars as a sequential set of data-points to machine learning algorithms; and other features of the flower instances, such as color and/or size-related features were neglected. Among various machine learning methods, the SVM had the highest classification accuracy. In this research, we have developed a hybrid approach composed of the Viola-Jones and multi-template matching algorithms to solve the flower cultivar classification issue. The nature and process of the approach proposed in this article are completely novel. In contrary to the above-mentioned paper, the developed method does not apply processing techniques to select or extract the boundary curvature feature of the samples. In fact, the overall shape of the flower specified by its boundary has no effect on the cultivar recognition process. Instead, the developed method uses the chroma features of a special section of Anthurium flower, i.e. spadix, to identify its cultivar. The objective of the proposed method is described in the following.
The overall objective of the present research is to design an automated grading system for Anthurium flowers based on computer vision and machine learning techniques. To achieve this objective, it is necessary to develop an algorithm to identify the cultivar of query flower image in order to grade it according to given grading criteria. So, in this paper, we have presented a novel cultivar classification system based on the Viola-Jones object detection algorithm and multi-template matching. Spadix region of Anthurium flowers was firstly detected using the Viola-Jones detector. Then, this region matched with different templates prepared from 15 various cultivars. The best one with highest matching accuracy, based on the normalized cross-correlation (NCC) algorithm, is selected as identified cultivar.

Section 2.1 presents the datasets used for training and testing, and the computer vision setup used for imaging. Section 2.2 describes the vision-based hybrid approach, the image preprocessing pipeline required to provide different image datasets for evaluation of the developed algorithm, and the basic principles of the Viola-Jones and multi-template matching methods. Also, this section presents the steps required to obtain the chromatic features data

of the templates images and query images, and convert them from spatial to the frequency domain, which is used to evaluate template matching by NCC standard similarity criteria. Section 3.1 presents the results of the application of the proposed approach for identification of Anthurium flower cultivars. In Section 3.2 the results and the proposed algorithm are compared with similar works, while the paper closes with some concluding remarks and directions for real-time applications and future research towards the deployment of the proposed approach.

Section snippets

Database and query images

The cultivars of Anthurium flower are classified into three main shape categories: Cupped, Obake, and Standard. In this study, 15 commercial cultivars of Anthurium flower are selected to train the Viola-Jones detector and prepare multiple matching templates, as well as for testing the proposed recognition approach (Fig. 1). The selected cultivars which were classified into three categories include; Cupped shape: 'Marea', 'Facetto', 'Peruzzi', 'Previa' and 'Azadi'; Obake shape: 'Baron', 'Simba', …

Results

The proposed cultivar identification approach was evaluated based on the identification accuracy and computation time. It is worth to note that the experiments were carried out on a Laptop with Intel B960 2.20GHz processor and 4.00GB of RAM running under the Microsoft Windows 7 operating system. The algorithm was entirely developed on MATLAB 2015a (The Mathworks©) computer program. In order to truly evaluation of the computation time, all of other programs were stopped before running the…

Conclusions

Cultivars of Anthurium flower were successfully identified using a hybrid of the Viola-Jones detector and multi-template matching. The spadix section of the flower in query images detected via a cascade object detector and the specified section was used to identify cultivar of the query flower based on the normalized cross-correlation (NCC) algorithm. The proposed hybrid approach was evaluated using 300 query images of the flower at different pixel densities. Also, six multi-template libraries…

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