Visual Detection and Species Classification of Orchid Flowers

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Introduction

Goal of the research
- Given a limited set of orchid flower training data
- Detect (see section 1) and classify (see section 2) any given orchid flower cultivar

Nature of the orchid flowers
- Make it very hard to apply classic segmentation based techniques
- Ideal test case for object categorization techniques
- Lots of variation in shape, color, size and orientation
- Known scene constraints like setup, background, lighting
- Prove the theorem provided by [1]

Detection specific goals
- Close to zero false positive detections
- Still maintain several flower detections for a single plant
- Both conditions important for successful classification

Classification specific goals
- Only artificial training set available for the moment
- Obtain a good classification of in-field test data
- Divide cultivars in visual texture based classes + color description

Application Specific Challenges

Academic versus industrial application
- Academic research focusses on very challenging situations like pedestrian or car detection, which require large training sets and complex training
- However these cases are not representative for the industry
- Industrial cases
  - Usually very small sets of training data available
  - Well known scene and application specific constraints

Challenges for this application
- Existence of over 100,000 different Phalaenopsis orchid flower cultivars
- Very small dataset, but the need of high accuracy detector
- Color descriptions for cultivars are not unique
- But combined with a texture based classification they are!

1. Orchid flower detection

Training the object model

Techniques explored
- HOG + SVM
  - Need a balanced positive and negative training set, which is not the case
  - HOG features do not generalize well over small data sets
- Viola&Jones – cascade classification + adaBoost [2]
  - No need for balanced training set
  - HAAR & LBP features generalize well over small data sets
- Used OpenCV based implementation

Training set used
- 250 orchid flower images grabbed from industrial pipeline and used as positive training samples
- Negative sampling from orchid plant images with flowers removed
- 2000 negative training samples used for each stage of weak classifiers

Resulting model
- Model size 48x56 pixels = smallest possible object that can be detected
- 16 stages with a total of 57 weak classifiers, trained as binary single layer decision trees, max FA rate 0.95, min hit rate 0.5
- Very specific to the setup, by carefully selecting samples
- Will not work in setup with different backgrounds and other lighting conditions

Actual object detection

Multi scale detection
- Using image pyramid to apply multi scale detections with single scale model
- Reduced by the known setup and camera position, adding scale reducing borders
- Combined with efficient background segmentation due to known lighting

Apply high score threshold
- Ensure that we have very small amount of false positive detections
- Ensure that we have at least several flower detections on a single plant

Detection specific results

On the complete validation set of 360 images, not a single false positive detection was obtained, by carefully fine tuning the parameters. We ensured that for each plant at least 3 flowers are retrieved by the detector. (→ See Figure 1)

2. Orchid flower classification

Selected visual classes

Selection of 5 texture based visual classes
- (A) Uniformly colored
- (B) Lip colored
- (C) Striped pattern
- (D) Spotted pattern
- (E) Speckled pattern

Visual characteristics and feature selection

Feature selection based on visual properties of the flower (see Figure 2)
1. Segment flower from detection removing branches, background and buds
2. Apply conversion to La*b* color space
3. Apply K-means clustering with K=2 on a*b* pixels, assign each cluster the average color of that cluster, obtaining a foreground and a background cluster
4. Calculate the relative y-position of the center of gravity of foreground
5. Connected component analysis → ratio foreground/background blobs
6. Radial unwarping of image → define radial dominant edges

Figure 2: Orchid flower feature calculation + feature space visualization

Binary support vector machine tree

Classification using binary SVM tree
- Each SVM trained with all available features
- Used a linear kernel due to limited training data
- Usage of in between classes, like coarse pattern

Classification results

Classification can be difficult
- Even experts can sometimes wrong define flower
- But decent results for validation set

Combined pipeline

Flowers grabbed and segmented from detection pipeline
- Even after training with artificial data this still works well
- Using flower majority voting to get 100% correct plant based classification

Acknowledgments
This work is supported by the Institute for the Promotion of Innovation through Science and Technology in Flanders (IWT) via the IWT-TETRA project TOSCA1: Industrial Applications of Object Categorization Techniques. We would also like to thank Anti BV, the company that provided the orchid flower datasets.

Reference:

KATHOLIEKE UNIVERSITEIT LEUVEN
EAVISE Research & Education Centre for Electrical Engineering