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
- Existance 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

Figure 1: Orchid flower detections without false positives

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

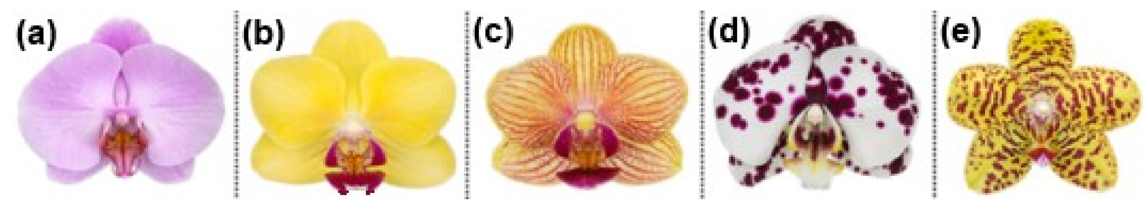
Detection specific results

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**

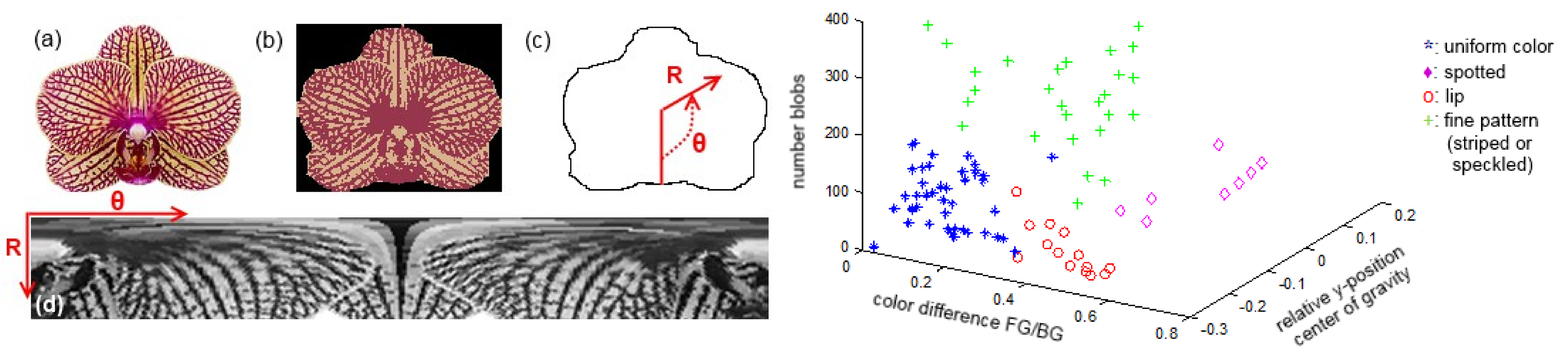
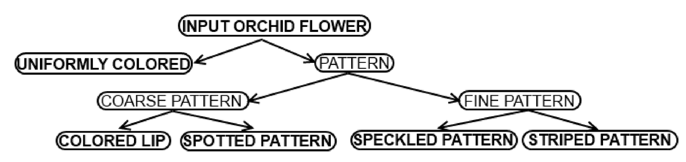


Figure 2: Orchid flower feature calculation + feature space visualization

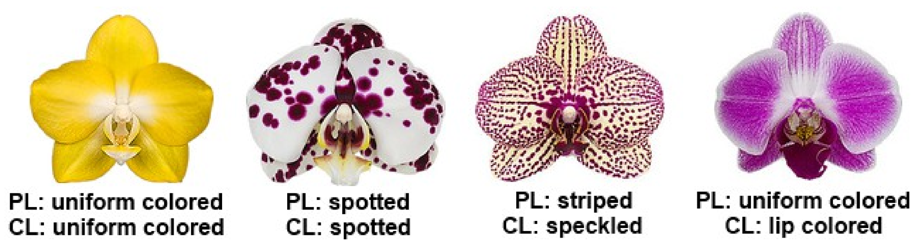
Binary support vector machine tree

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

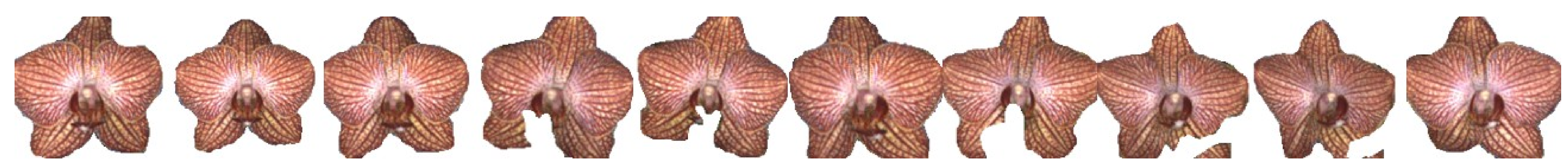
Classification can be difficult
- Even experts can sometimes wrong define flower
- But decent results for validation set



Class	Amount	Correct
Uniformly Colored	51	94.23%
Colored Lip	16	93.75%
Spotted Pattern	10	100%
Speckled Pattern	16	100%
Striped Pattern	23	78.26%

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



Orchid	Manual	#Flowers	Uniform	Lip	Spottted	Speckled	Striped	Majority
1	Striped	10	1	0	0	0	9	Striped
2	Uniform	11	11	0	0	0	0	Uniform
3	Speckled	16	1	0	5	3	7	Speckled

[1] S. Puttemans and T. Goedeme. How to exploit scene constraints to improve object categorization algorithms for industrial applications? In VISAPP, volume 1, pages 827-830, 2013.

[2] P. Viola and M. Jones. Rapid object detection using a boosted cascade of simple features. In CVPR, pages I-511, 2001.

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