

School of Engineering and Design  
Electronic and Computer Engineering  
M.Sc. Course in Distributed Computer Systems Engineering

Workshop 7  
Embedded Systems Engineering  
Real-World Smartphone Sensing

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Date: 23rd April, 2019  
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Deadline: 23rd April, 2019

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# Introduction

TODO1: Begründung warum kein “einfaches” Color-Filter verwendet; warum kein vorgeschobene Bilderkennung via computer vision => Grund: Zusammenführung von Shape / Size und Farberkennung in einem Model / einer App

TODO2: Farbe-Reifegrad / Zuckergehalt Korrelation darstellen und z.B. Farbabstufungen auf Papier ausdrucken für Testzwecke

## Initial Problem

In real-world, detection of ripeness / maturity of banana-fruits in real-time

Target groups:

* industry
* retailer,
* end users,
* people with disability

## Idea / Proposed Solution

Detect objects or rather bananas via image recognition and output result, so that users get a definite statement on the ripeness.

# Bananas

## Introduction

In general, a distinction must be made between *plantains* and *fruit-bananas*. In the context of *BananaCo* project, only the latter is taken into consideration. Both originate from tropical regions in Africa and South America. While fruit-bananas are edible immediately, plantains require to be cooked initially to be palatable.

In opposite to fruit-bananas, plantains are rather angular and thicker. In addition, plantains are coloured pale-yellow, grey or cream; once ripe they are characterised by a violet or black peel.

Banana fruit peel colour is to be considered as the first quality parameter evaluated by consumers. In fact, the external condition correlates well with its internal, physical and chemical changes during the ripening process of bananas.

## Background / Literature review

Maturity stage of fresh banana is important for marketing, for both, dealers and end consumers. In early ripening stages, banana fruits synthesize compounds such as alkaloids and tannins, making the fruit taste bitter and astringent. In progressing stages of growth, the fruit incorporates water, sugars, starches, acids and vitamins.

In the meantime, banana fruit turns from green to yellow, then from yellow into yellow with brown spots. Finally, starch and acid contents decrease, while sugar increases; alkaloids and tannins disappear, aromas develop. The calorie content remains the same, independent of the degree of maturity.

“To ensure the productivity, competitivity, quality standards, and reliability of banana fruit products, automatic image processing tools based upon intelligent techniques are paramount over visual features methods.” [Mazen2019]

## Maturity assessment

To detect and classify bananas, certain criteria need to be examined which will be provided subsequently.

### General criteria

In theory, one can use several aspects to determine the maturity of fruits in general and banana in particular, encompassing:

* size / shape,
* peel texture features,
* degree of hardness (hard / soft),
* starch / sugar proportion,
* smell,
* flavour (blunt / sweetish / sweet) and, of course the
* peel colour (green / yellow / brown).

### Visual criteria

In literature, a lot of methods developed for ripeness classification involve *colour moments* and *colour histogram*. Also, the variance of RGB (Red Green Blue) or HSV (Hue, Saturation, Value) colour spaces of the banana fruit have been utilised for analysis. According to [Mazen2019], the classification of banana fruits as under-mature, mature and over-mature may reach an accuracy of 99.1 %.

Visual inspection by humans may underlie subjection and is tedious as well as time-consuming and labour-intensive. Utilising instruments such as colorimeters provide the advantage of accurate and reproducible measurements, but require quite unique surface colours; also several sample locations are required to product representative results.

BananaCo on the contrary focuses onto visual, i.e. image recognition using the smartphone camera. Also, computer aided analysis techniques will be utilised, offering objective measurement and mitigating deficiencies of manual visual and instrumental techniques. Suitable aspects for visual detection include:

* size / shape,
* peel colour,
* development / mottle of brown spots and
* analysis of peel texture features.

## Classification and Feature Selection

Regarding literature, one encounters most approaches in classifying the maturity level of fruit-bananas to be based on at least five, more frequent seven[[1]](#footnote-1) or even 15 stages. In the scope of BananaCo project, the smartphone camera is used to scan fruits and determine their maturity based on visuals. To limit the complexity within the boundaries of the project, the granularity is limited to subsequent three ripening stages with according feature aspects (table 1):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Class** | **Peel colour** | **Maturity stage** | **Feature Aspects** | | |
|  |  |  | *Stern* | *Fruiting body* | *Tip* |
| 1 | green | unripe | green | green | green |
| 2 | yellow | ripe | yellow | yellow | brown |
| 3 | brown | overripe | brown | brown, at least 50 % of peel surface | brown |

Table 1: Maturity categories

## Methodology

The criteria listed before are used afterwards to manually categorise banana images acquired from the internet into three maturity stages (unripe, ripe, overripe, cf. figure 2). The images will then be labelled and fed into the computer vision / neural network, serving as training data.



Figure 2: Banana ripe stages as used for BananaCo classification, from left to right: unripe, ripe, overripe

# Conclusion

* Expected results vs. actual
* Prediction accuracy
* Chosen methodology
* Computer vision vs. manual / instrumental
* Possible extensions / improvements
* outlook

Appendix

List of abbreviations

|  |  |
| --- | --- |
| **Abbreviation** | **Explanation** |
| BananaCo | “Banana colour”, the title of the project related to the undertaking of recognising the ripeness of fruit-bananas with the help of computer vision … |
| HSV | Hue Saturation Value colour model |
| RGB | Red Green Blue colour model |
|  |  |

References

[Mazen2019] *Mazen, Fatma M. A., Nashat, Ahmed A. (2019)*, Ripeness Classification of Bananas Using an Artificial Neural Network. Arabian Journal for Science and Engineering 04/2019, 1-10.

[Mendoza2005] *Mendoza, F., Aguilera, J. M., Dejmek, P. (2005)*, Predicting Ripening Stages of Bananas (Musa cavendish) by Computer Vision. Acta horticulturae 682, 1363-1370.

[Prabha2013] *Surya Prabha, D., Satheesh Kumar, J. (2013)*. Assessment of banana fruit maturity by image processing technique. Journal of food science and technology 52(3), 1316-27.

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* Figure

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2. number a
3. number b[[2]](#footnote-2)
4. number c[[3]](#footnote-3)

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Figure 1: Sample Figure

1. According to [Mendoza2005] in the context of trading, seven stages are recognised: stage 1: green; stage 2: green, traces of yellow; stage 3: more green than yellow; stage 4: more yellow than green; stage 5: green tip and yellow; stage 6: all yellow and stage 7: yellow, flecked with brown. [↑](#footnote-ref-1)
2. [footnote 1] [↑](#footnote-ref-2)
3. [footnote 2] [↑](#footnote-ref-3)