

School of Engineering and Design  
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Real-World Smartphone Sensing

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[Figure 2: Banana ripe stages as used for BananaCo classification, from left to right: unripe, ripe, overripe 3](file:///D:\Projects\Smartphone-Sensing-Framework\BananaCo_report\BananaCo_report.docx#_Toc4181396)

Abstract

<TODO: 1 page>

# Introduction

**Feedback Dio & Dimi:**

TODO1: Begründung warum kein “einfaches” Color-Filter verwendet; warum keine 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, damit der Leser dies mittels bereitgestellter App auch direct testen kann

TODO3: aus dem aktuellen Reifegrad Empfehlungen ableiten für:

1. die weitere geeignete Verwendung bzw. Verarbeitung (z.B. Verkochen, Drink / Mixer, direkter Verzehr) sowie
2. zur voraussichtlichen weiteren Haltbarkeit (i.S.v. „MHD“)

## Initial Problem

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

Target groups:

* industry
* retailer,
* end users,
* persons with disabilities (e.g. red-green deficiency) or sugar intolerances (e.g. diabetes)

## Proposed Solution

BananaCo – Banana colour: 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, predominantly in Africa and South America. While fruit-bananas are edible instantaneously, plantains require to be cooked initially to be palatable.

Opposed 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 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.

## Background

The maturity stage of fresh banana is important in marketing, for both, industry and dealers as well as 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 however 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

### General criteria

To detect and classify bananas, certain criteria need to be examined which will be provided subsequently. In theory, one can use several aspects to determine the maturity of fruits in general and bananas in particular, encompassing:

* size / shape,
* peel texture features,
* degree of hardness (e.g. hard or soft),
* starch / sugar proportion,
* smell,
* flavour (e.g. blunt, sweetish, sweet) and, of course the
* peel colour (e.g. green vs. yellow vs. 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 reached 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. Additionally, several sample locations are required to product representative results.

BananaCo on the contrary focuses onto automated visual, i.e. image recognition using smartphone cameras. Also, computer aided analysis techniques are 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 initially 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 is used later to manually categorise banana images acquired from the internet into three maturity stages (unripe, ripe, overripe, cf. figure 2), thus creating data sets. These images will then be labelled and fed into the computer vision / neural network, serving as training data.



unripe ripe overripe

Figure 2: Banana ripe stages as used for BananaCo classification

# Neural Network

## Introduction

My text…

## Methodology

My text…

## Operating Principle

My text…

# Graphical User Interface

## Mock-up

My text…

## BananaCo App UI

My text…

.

# Operating Principle

## Introduction

My text…

## Flowchart

My text…

# 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, 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.

Template:

* template: \_ws5\_listing
* Listing
* Figure

Number

1. template: \_ws5\_number
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], seven stages are recognised in the context of trading: 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)