Development of the web app which detects fruit ripeness using Python

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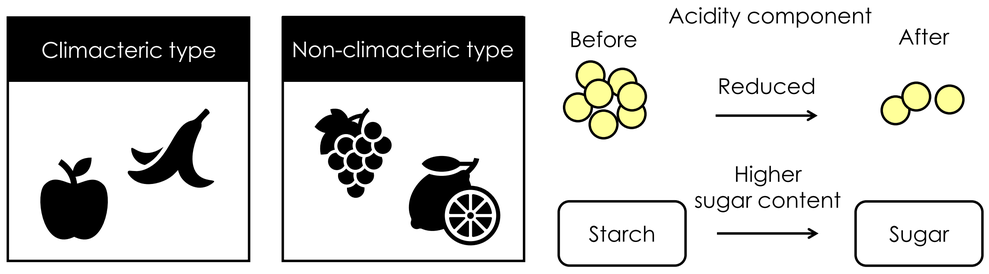
Problem

Some fruits ripen while others do not. Fruits that ripen are called climacteric fruits, while those that do not ripen are called non-climacteric fruits. When ripened, the acidity component is reduced and the starch is converted to sugar, resulting in a higher sugar content. Therefore, by measuring the sugar content, the best time to eat can be determined.



However, there were the following problems in measuring sugar content.
- Refraction-type sugar meters would waste fruit when it measures
- Non-destructive sugar meters would not waste fruit but are more expensive
- The use of those meters are impractical

Example of refraction-type sugar meter

How can we measure ripeness without destroy fruit and inexpensively?

Use image taken with a smartphone

These are benefits of using smartphone as sugar meters.
- Smartphones are expensive, but most people have them these days, and their use is not limited like that of a sugar meter.
- The method of taking pictures and measuring is simple and can be done at home.

Able to measure sugar content

Finally, by implementing it as a web application, we propose an easy way to measure the degree of ripeness.

Framework

Study

Examine previous research and study topics related to this research
e.g. Banana, Fruit ripeness, web app, image recognition, programming language

Select the fruit which to be used
The reason why we choose banana this time is because banana would change color, and it appears what we called sugar spot when it ripen therefore it is possible to recognize ripeness by image.

Back-end

Create a program in Python to determine banana ripeness using OpenCV library
It determine the degree of ripeness from both the average hue of the banana and the percentage of the banana's area occupied.

Using a sugar meter, compare the actual value with the value calculated by the program
Ripeness is determined by calculating the average hue (H values: 36–70). Sugar spots are identified by the number of brown pixels relative to the total banana pixels. This will also improve the accuracy of the program.

Modify the program and run it again
Repeat this procedure.

Front-end

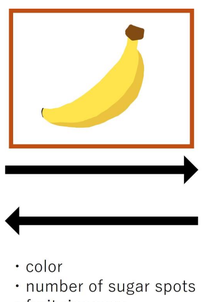
Implement as a web application using HTML, CSS, and JavaScript
Flask, a python web application development framework, was used as the framework.

Coordinate front-end and back-end
Verify that the image you want to determine the degree of ripeness is properly processed and that the results are displayed.

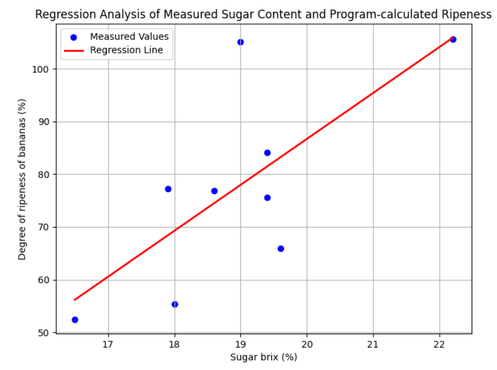
Web application completed and published on GitHub

GitHub, used to publish app

Deta flaw map
The data flow and structure of the web application is shown in the figure above.


・color
・number of sugar spots
・fruit ripeness

Finding



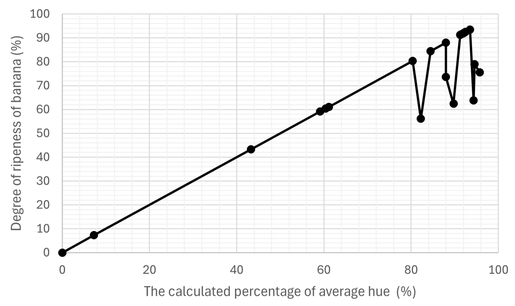
Relation between sugar brix and degree of ripeness

Regression Analysis of Programs

Regression equation:
$$y = 8.72x - 87.74$$

The coefficient of determination:
$$R^2 = 1 - \frac{\Sigma(y_i - \hat{y}_i)^2}{\Sigma(y_i - \bar{y}_i)^2} = 0.521$$

Root mean squared error:
$$MSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2} = 12.308$$

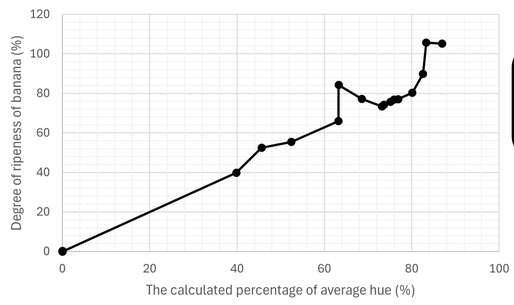


Relation between hue and ripeness (before)

Although we were able to obtain a value for the degree of ripeness that followed the sugar content, there are still problems with accuracy.

Equation Before
$$Ripeness = (Hue \times 0.6 + Brown\ area \times 0.4) \times 100$$

Change calculation method



Relation between hue and ripeness (after)

Equation After
$$Ripeness = Hue + Brown\ area \times 0.4$$

Program changes:
- Changed to add the percentage of brown area to the percentage of hue
- Narrowed hue range

→Allows more detailed evaluation of ripeness

Still being improved…


Original image of sample banana


Adjusted image of sample banana


Detected brown area

To solve the problem of shadows being recognized as brown areas, the cv2.convertScaleAbs function in the OpenCV library was used to reduce contrast and increase brightness. Following equation shows how to adjust the image.
$$x' = \alpha x + \beta$$
(x': adjusted pixel value, α: contrast, β: brightness)
As images above shows, the brown areas in the shadow areas were detected correctly, but the brown areas in the originally bright areas were not detected. This time, we did not apply this process but improvements have been made to improve the recognition accuracy of brown areas.

Interpretation and Conclusion

In conclusion, the development of this application has made it possible to determine the degree of banana ripeness from the color and sugar spot from the image, and to evaluate it numerically while relating it to the actual sugar content.

Evaluation of the completed program showed that accuracy was still problematic, with an average error of 12.308% occurring. In the future, we would like to solve this problem by unifying banana varieties, measuring sugar content more accurately, and increasing the number of samples.

Furthermore, we prepared an image with a white background and detected bananas, but we would like to solve the problem of banana shadows being recognized as sugar spots (brown areas), which can be on any background.

Reference

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