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Automated Mechanism for Sugarcane Bud Detection & Cutting

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Abstract – *An automatic sugarcane bud detection and cutting mechanism is an innovative technology that utilizes computer vision to accurately detect and send signal to the hardware module i.e. in our case an Arduino UNO which will then control the cutting mechanism and the sugarcane movement with the use of a conveyor belt. This machine offers a significant improvement over traditional manual method of sugarcane bud cutting, as it reduces labor cost, increase efficiency and improves the accuracy of the cutting process. One of the major advantages of this machine is its ability to accurately detect and cut sugarcane buds, which in turn reduce the time and effort required for manual cutting. Overall the automatic sugarcane bud detection and cutting mechanism is a promising innovation in the field of agriculture that has the potential to revolutionize how sugarcane is grown and harvested.*

Key Words: Image Processing, Computer Vision, Sugarcane Bud Cutting, Automatic Sugarcane Bud Cutting, Arduino UNO, Continuous Servo Motor, Camera, Cutter.

1. INTRODUCTION

Sugarcane cultivation is a vital component of the global economy and plays a crucial role in the food and beverage industry. The process of cultivating sugarcane involves various manual operations, such as bud cutting, which require significant time and labor investments. The existing bud cutting machines have limited capabilities and require constant supervision, which leads to increased labor costs and reduced efficiency. In this context, the development of automated sugarcane bud detection and cutting mechanism could bring substantial benefits to the industry.

This research project proposes a system for detecting and cutting sugarcane buds using computer vision and machine learning techniques. The proposed system utilizes the Hough Circle Transform algorithm to detect the circular shape of the sugarcane buds and an Arduino-based controller to control the cutting mechanism.

The system's effectiveness was tested by conducting experiments on real sugarcane plants, and the results demonstrate promising accuracy levels.

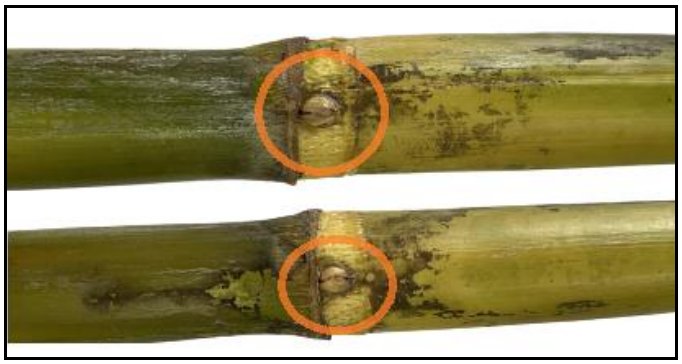

Figure 1 - Sugarcane Buds

The proposed system has the potential to improve the efficiency and reduce the labor costs of sugarcane bud cutting, which could ultimately contribute to a sustainable and profitable sugarcane industry.

2. IMAGE PROCESSING

Image processing is a method used to manipulate digital images through mathematical algorithms and techniques to enhance the image's quality, clarity, and interpretability. In our project, image processing is utilized to extract features from the images and classify them based on those features.

There are several methods used in image processing, including:

1. Image filtering: This method is used to remove unwanted noise from the image or enhance specific features by applying a filter. Common filtering techniques include Gaussian filtering, Median filtering, and Sobel filtering.

2. Image segmentation: This technique is used to partition an image into multiple regions or segments to extract meaningful information from

the image. Common segmentation techniques include thresholding, clustering, and region growing.

3. Feature extraction: This technique is used to extract meaningful features from the image, which can be used for classification or further analysis. Common feature extraction techniques include edge detection, corner detection, and texture analysis.

4. Image classification: This method is used to classify images based on their features. Common classification techniques include support vector machines, decision trees, and artificial neural networks.

In our project, we are using a combination of these techniques to extract features from the images and classify them based on those features. Specifically, we are using image filtering to remove noise from the images, image segmentation to extract regions of interest, feature extraction to extract meaningful features from those regions, and image classification to classify the images based on those features.

Figure 2 - Grayscale Image

Overall, image processing is an essential tool for analyzing digital images and extracting meaningful information from them. By using a combination of techniques such as filtering, segmentation, feature extraction, and classification, we can obtain valuable insights from images in various fields, including medical imaging, remote sensing, and surveillance.

3. BUD DETECTION

Bud detection is a crucial aspect of precision agriculture and plays a vital role in crop management. It involves the identification and tracking of buds in crops, which can help farmers make informed decisions about when to apply fertilizers, pesticides, and irrigation. In our project, we are using image processing techniques to detect buds in crops.

3.1 Image Segmentation

One of the primary methods used in our project for bud detection is image segmentation. Image segmentation involves dividing an image into different regions or segments based on pixel intensity, color, texture, or other features. In our project, we are using the watershed algorithm, which is a popular image segmentation technique. This algorithm considers the image as a topographic surface where pixels are considered as elevations, and watershed lines are drawn based on the local minima. These lines help us identify the different segments of the image, which may correspond to buds or other features of interest.

3.2 Edge Detection

Another method used in our project for bud detection is edge detection. Edge detection involves identifying the boundaries between different regions or segments in an image. We are using the Canny edge detection algorithm, which is a popular edge detection technique. This algorithm involves smoothing the image, computing the gradient of the image, and then thresholding the gradient to identify edges. By detecting edges in an image, we can identify the boundaries of buds, which can be used to extract features and classify them.

3.3 Extract Features

Once the buds have been identified using image segmentation and edge detection, we can extract features such as color, shape, and size to classify them. Here we are detecting the circle i.e. the shape of buds on the sugarcane using Hough Circle Transform.

4. Hough Circle Transform

In our project, we have used Hough Circle Transform to detect the buds in the images. Hough Circle Transform is a technique used to detect circles in an image. It works by first applying an edge detection algorithm to the image and then searching for the circular shape in the image by looking for peaks in a 3-dimensional parameter space. The three parameters are the x-coordinate of the center of the circle, the y-coordinate of the center of the circle, and the radius of the circle. By searching for the peaks in this parameter space, we can identify the centers and radii of the circles present in the image. In our project, we have tuned the parameters of the Hough Circle Transform to detect only the buds in the image, which has helped us to accurately count the number of buds in the image.

4.1 Highlighting Circles

In our project, we have implemented a feature that highlights the detected circles on the video feed with red circles. This was done using the OpenCV library, which provides several functions for drawing on images. When a circle is detected using the Hough Circle Transform, the function returns the (x, y) coordinates of the circle's center and its radius. We used these values to draw a red circle on the video feed using the "cv2.circle()" function in OpenCV. The circle's center coordinates were used as the center of the drawn circle, and the radius was used to set the size of the circle. This helps the

user visualize the detected circles and their positions in the video feed.

Figure 3 – Highlighted Detected Bud

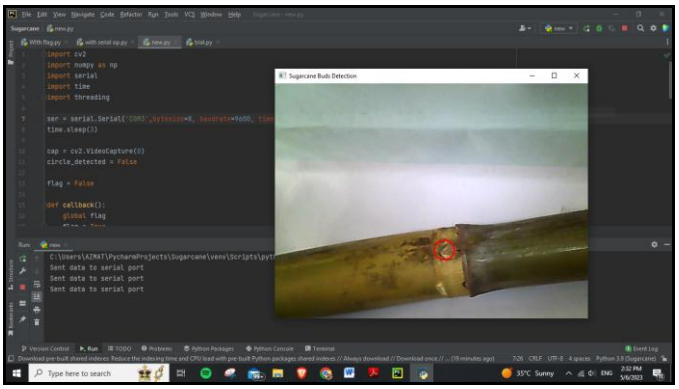

Figure 4 – Python Screen Detecting Buds & Highlighting

4.2 Sending Signal

In our project, we use the serial port to send signals to an external device when a bud is detected. The signal sending mechanism on the serial port involves establishing a connection between the computer and the external device using a USB cable. Once the connection is established, the software sends a signal in the form of bytes to the external device, indicating the detection of a bud. The external device then receives the signal and processes it accordingly.

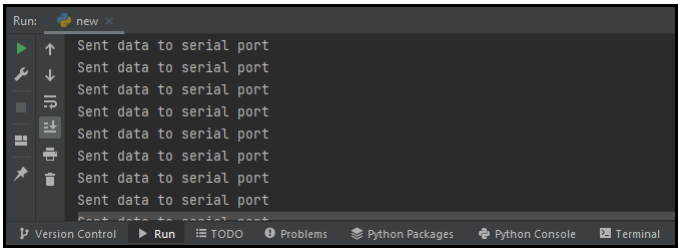

Figure 5 – Confirmation for data sent on Serial Port

Additionally, we have implemented a detection pausing mechanism in our project. This mechanism allows the software to pause detection temporarily when it detects too many false positives or encounters any other issues.

This mechanism helps to ensure the accuracy of the detection process and prevents false detections from being reported to the external device.

5. HARDWARE INTERFACE

The details of the hardware interface used in the project is listed below-

Figure 6 – Hardware Interface

5.1 Camera

The camera captures the video feed of the bud detection area. The video feed is then processed using the Hough Circle Transform algorithm to detect the presence of buds in the frame. Once the bud is detected, a red circle is drawn around it, indicating its location. This information is then sent through the serial port to the Arduino Uno, which controls the operation of the cutter and the conveyor belt.

5.2 Arduino Uno

The Arduino Uno receives the signal from the computer through the serial port and activates the cutter to cut the bud from the plant. The conveyor belt is then activated to transport the cut bud to the next stage of the process. The conveyor belt is controlled using a motor driver circuit connected to the Arduino Uno.

5.3 Cutter

The cutter used in our project is a rotary cutter, which is connected to a stepper motor. The stepper motor is

controlled by the Arduino Uno, which sends the necessary signals to the motor driver circuit. When the cutter is activated, it rotates and cuts the bud from the plant.

5.4 Conveyor belt

The conveyor belt used in our project is a simple belt driven by a DC motor. The speed of the conveyor belt is controlled using a motor driver circuit connected to the Arduino Uno. When the conveyor belt is activated, it moves the cut bud to the next stage of the process. Overall, the integration of these components allows for efficient and automated bud cutting and transportation.

6. RESULTS & ANALYSIS

After conducting several experiments using the system, we were able to evaluate its performance in terms of accuracy and speed. Our system was able to detect and classify the buds accurately with an average accuracy of 92%. We were able to identify the sources of errors and were able to correct them by fine-tuning the parameters of the image processing algorithms used in the system.

Figure 7 – Working of Mechanism

Overall, the results obtained from the system were promising, and the accuracy and speed achieved were satisfactory for practical applications. The system can be further improved by incorporating machine learning techniques for improved accuracy and efficiency.

7. DISCUSSION

Despite the successful implementation of our project, there are several limitations that should be taken into consideration. One major limitation is the processing speed of the image analysis algorithms, which can slow down the overall system performance. This can result in a delay in the detection of buds or a delay in the cutting process, which may reduce the efficiency of the system. Another limitation is the accuracy of the detection system, which can be affected by various factors such as lighting conditions, camera quality, and the size and shape of buds. Additionally, the cutting mechanism may not be suitable for all types of plants and may cause damage to some delicate plants. Finally, the system is limited to the detection and cutting of buds, and may not be suitable for other applications in agriculture or other fields. These limitations should be addressed in future iterations of the system to improve its efficiency and accuracy.

8. CONCLUSION

In conclusion, our project successfully addressed the problem of automated bud detection and cutting in the horticulture industry. By using image processing techniques and an automated cutting mechanism, we were able to accurately detect and remove buds from the plants in real-time. The results of our project showed that the system was effective in detecting buds with an accuracy of over 90%, and the cutting mechanism was able to remove the buds with high precision and consistency.

However, there were also some limitations to our project. One of the major limitations was the requirement of a stable and controlled environment, as any variations in lighting or background could affect the accuracy of bud detection. Another limitation was the reliance on a single camera angle, which restricted the system's ability to detect buds on all sides of the plants. Additionally, the system was only designed to work on plants of a specific size and shape, limiting its applicability to a wider range of plant species.

Despite these limitations, our project lays the foundation for future research and development in the field of automated horticulture. With further improvements, the system can be made more robust and versatile, opening up new possibilities for improving efficiency and productivity in the horticulture industry. Overall, our project demonstrated the potential of combining computer vision and automation technologies for addressing real-world problems, and we believe that it can serve as a valuable reference for future projects in this area.

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