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Faculty of Engineering & Information Technology

Computer Engineering Department

Graduation Project 2

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Smart Classification of Date Varieties

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Disclaimer

This paper was accomplished by Manar Jber and Batool Shilleh from the Computer Engineering Department at An-Najah National University. The thoughts expressed in this report are the authors own and do not reflect the view of An-Najah National University, department of Computer Engineering.

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First Chapter

Abstract

The classification of dates in the market plays a pivotal role in achieving fair pricing and profitability for farm owners. However, traditional methods employed for this purpose are arduous, error-prone, and often lack precision. In some instances, farmers resort to random grading methods due to challenges in accurately assessing size and weight factors. To overcome these limitations, our project aims to develop an advanced machine that leverages cutting-edge sensor and camera technology to streamline the date classification process, ensuring fairness for both growers and buyers.

By harnessing the capabilities of sensors and cameras, our innovative solution will revolutionize date classification. As dates traverse the production line, cameras will diligently monitor each fruit, accurately distinguishing between dates and other fruits. Integrated sensors will precisely measure the weight and size of date seeds. Leveraging these data points, the device will employ market-specific criteria and reference standards to classify dates into their respective elite categories.

The implementation of this technology promises a host of benefits. Firstly, it guarantees a more precise and reliable classification process, eliminating the laborious and error-prone manual methods of the past. Secondly, automation provided by the machine ensures increased efficiency, enabling faster throughput and reduced processing time. Lastly, the system minimizes errors, resulting in a fairer pricing structure that benefits both farmers and buyers.

Our research demonstrates a transformative evolution in date grading, marking a significant advancement in the industry. By harnessing the latest advancements in sensor and camera technology, we pave the way for a more efficient, accurate, and equitable market for dates, benefitting all stakeholders involved.

Second Chapter

Introduction

2.1 Background and Significance of Date Palm Cultivation:

In arid areas of the Arabian Peninsula and the Middle East, date palm has persisted for centuries as one of the most significant and ancient fruit crops. Dates have been an important part of the economies, societies, and environments of many countries that cultivate them [1]. Dates have also been a major source of food for local populations. For thousands of years, date farming has been practiced in Palestine. When it comes to date palm growth, development, and ripening, some Palestinian regions' spring and summer climate conditions are ideal. Date farming has recently experienced rapid growth in Palestine, with the cultivated area in the West Bank multiplying several times from 2000 to 2012 and production expected to reach a quantity of 5000 metric tons by 2015 [2].

2.2 Importance of Post-Harvest Processing and Automation:

Date fruit post-harvest processing is an essential step that keeps the fruit fresh until it is consumed, raises the caliber of commercial food products, and lowers fruit waste. Farmers and distributors have traditionally used a time-consuming, ineffective manual quality inspection and selection process to sort and classify agricultural and food products. The exploration of quicker and more precise systems for classifying and sorting agricultural and food products is necessary because human perception is easily misled. A trustworthy approach is the automated computer vision system for sorting and classification [4].

2.3 Advancements in Image Processing and Classification:

A revolution in how we approach complex problems, particularly in the area of classification, has occurred as a result of technological advancements in many different fields. The most recent image processing methods allow us to classify dates according to their size, shape, and weight quickly and accurately. These methods include acquiring and pre-processing images, reading images, and recognizing and classifying significant objects within the images [5].

Dates are divided into three quality categories (grades 1, 2, and 3) according to the specifications of the Palestinian market based on the features that were extracted from them. The third-grade elite dates have measurements of less than 1 cm in width, less than 3 cm in length, and less than 20 grams. Dates falling into the second-grade elite category weigh between 20 and 40 grams, have lengths between 3 and 5 cm, and widths between 2 and 3 cm. Dates weighing more than 40 grams and measuring more than 5 cm in length and 3 cm in width fall into the first-grade elite category.

2.4 Research Gap and Objectives:

The accuracy and automation of date classification using machine learning and image processing techniques have significantly improved in recent studies. It is still necessary to fill in some significant knowledge gaps, though. Exploring more potent machine learning techniques, incorporating additional features beyond size and color, ensuring generalization across various date fruit varieties, handling variations in fruit appearance and ripeness levels, thoroughly comparing the performance of various classification techniques, and addressing issues with image processing in various lighting situations are some of the gaps that need to be filled. The field of date classification will be improved by filling these gaps, and more effective and powerful classification and sorting systems for date fruits will result.

2.5 Research Impact and Aim:

This initiative is aimed at the labor force in the date industry as well as the larger Palestinian market.

With the help of this technology, it aims to greatly simplify the sorting and categorization of dates. This will increase productivity and guarantee consistent product quality, which will benefit farmers, manufacturers, and customers alike.

As a result of this study's findings, the agricultural and food processing sectors will benefit from insightful new knowledge and useful applications that will help manufacturers and farmers raise output and marketability.

Overall, this research has the potential to transform the date industry by improving productivity, quality, and profitability while expanding our understanding of automated classification methodologies.

Third chapter

Constraints, Components and Earlier coursework

3.1 Constraints and Limitations:

3.1.1 Time Limit:

Even though the summer semester is only a few weeks long, the project required more time than this. From creating the shape to applying it and putting all the parts together, it was a real challenge to accept and complete it successfully.

3.1.2 Cost:

We had to remove some features from the project because the cost of some electronic components was prohibitively high and out of our reach.

3.1.3 Image Processing Challenges:

When dealing with differences in date fruit appearances, such as occlusions, uneven lighting, or deformities, image processing algorithms may run into trouble. The achievement of accurate classification results will depend on overcoming these obstacles.

3.1.4 Real-World Testing:

The automated classification system's performance and reliability may need to be further improved by making additional tweaks and adjustments after it is deployed in real-world scenarios.

3.1.5 Environmental Factors:

Environmental factors like dust, humidity, and temperature variations may be present in outdoor date processing facilities, which could affect the system's efficiency and accuracy.

3.1.6 Occupation:

Our project was intended to demonstrate a higher level of performance, and the process would have been more streamlined if we had access to a Raspberry Pi and a touchscreen interface. These components would have allowed us to control various aspects of the project and experiment with functionalities akin to industrial applications. However, obtaining them within the country proved to be a formidable challenge. We had placed an order for these components from abroad more than four months ago, but they were subsequently seized by the Zionist occupation forces. Which delayed us from much work.

3.2 Components:

3.2.1 Hardware components:

Figure 1: Arduino Mega Microcontroller

Figure 2: Raspberry Pi

Figure 3: DC Motor

Figure 4: Coupler

Figure 5: Conveyor Belts

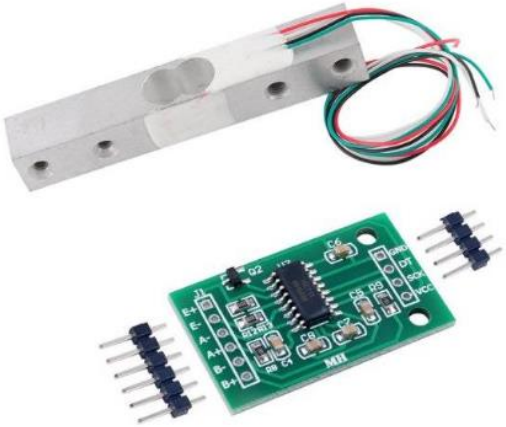

Figure 6: Load Cell + HX711 Amplifier

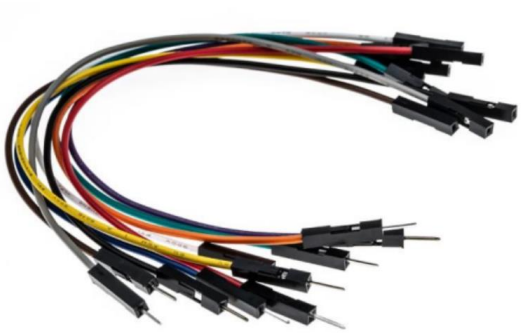

Figure 7: Wires

Figure 8: Esp32

Figure 9: Luxonis OAK-D Camera

Figure 10: touch screen

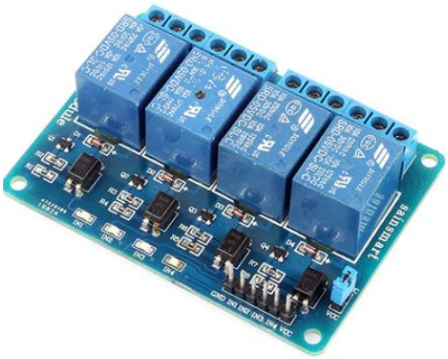

Figure 11: Relay

Figure 12: 4 Air pumps

3.3 Earlier Coursework:

We took a number of courses on microcontrollers, electrical and electronic circuits, in addition to microprocessors, during the education stage of computer engineering, which helped us to expand our knowledge and support us in finishing this project. In addition, through educational courses held during our study period, we learned how to use Arduino and how to write the necessary code.

Fourth chapter

4 Literature review

Numerous studies have addressed the issue of fruit classification in great detail and their desire to classify according to strict criteria in order to increase quality, satisfy consumers, and guarantee that their food is of the highest possible quality. According to a study, deep learning techniques used for automatic date classification result in satisfied customers [6].

According to some studies, it is better to classify dates according to their color, shape, and size to improve quality. In other studies, it was determined that the sugar and fiber content of the dates' internals should be taken into consideration [7].

Researchers have made significant strides in the creation of machine learning and image processing methods for date classification in recent years.

Regional texture descriptors as well as shape and size characteristics are the foundation of the automatic classification system for dates that has been proposed. The classification employs an SVM with an RBF kernel which is a popular supervised machine learning algorithm for classifying and predicting data. It is frequently used in the fields of machine learning and data analysis to solve both linear and nonlinear problems [8]. See figure 1.

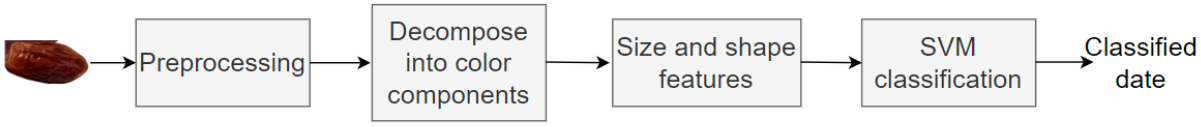

Fig. 1. Diagram for fruits classification system

In our study, we'll work on categorizing dates using image processing to establish the size of the date while utilizing the Raspberry Pi.

The Raspberry Pi's computational ability and GPIO capabilities give a strong stage for picture procurement, whereas the camera module guarantees fine-grained visual information capture. Through an arrangement of picture handling steps, counting edge discovery, color division, and form examination, the framework precisely decides the measure of date natural products. Leveraging the OpenCV library, the Raspberry Pi calculates the measurements of the date natural product in real-time, advertising a non-intrusive and proficient means of agricultural measurement.

Fifth chapter

5 Methodology

5.1System Features and Design:

The primary objective of this endeavor is to conceptualize, fabricate, and actualize a progressive date classification system. This system amalgamates the finesse of image processing for size assessment with the exactitude of weight quantification through sensor technology. This advanced apparatus finds its foundation in a holistic hardware amalgamation, incorporating the Raspberry Pi for oversight, a camera module for intricate image analysis, a conveyor belt for seamless date traversal, and air pumps for meticulous segregation of dates into appropriate receptacles, contingent upon their classification.

A comprehensive exploration was embarked upon to investigate prevailing image processing algorithms and machine learning techniques within the realm of object recognition and classification in addition to using machine learning to check if it is a date, fruit, or something else. Concurrently, an exhaustive examination of weight measurement methodologies was undertaken to ascertain the optimal weight sensor technology. These findings facilitated the judicious selection of pertinent image processing algorithms during the project's design phase, in conjunction with the strategic integration of a weight sensor into the system.

A controlled environment was meticulously orchestrated to harmoniously assemble the constituents that would collectively formulate the hardware configuration. The seamless fusion of a weight sensor and camera module with the Raspberry Pi ensured the uninterrupted capture of images. The orchestration of date movement was artfully executed through a meticulously calibrated conveyor belt system, while air pumps, strategically positioned, warranted the meticulous routing of dates to their designated containers.

Central to the system's operational core, image processing techniques of the highest order were harnessed, as facilitated by the OpenCV platform. The chosen methodology for size assessment underwent adroit customization to discern and assess date dimensions optimally. The

processing endeavor hinged on pivotal visual attributes encompassing diameter and area, enabling the precise identification of each date's size category.

A diverse and encompassing dataset was indispensable for both the training of the image processing algorithm and its rigorous testing. This dataset encompassed a myriad of perspectives, lighting scenarios, and size permutations, ensuring an exhaustive repertoire of date images. Data enrichment techniques, encompassing rotations, mirror imaging, and background variations, were adroitly employed to augment dataset diversity and enhance algorithm resilience.

The classification voyage transpired as dates traversed the conveyor belt. The camera module diligently procured visual inputs for subsequent size assessment, while the weight sensor, with admirable precision, gauged the weight of each date. These composite inputs underwent meticulous processing through the integrated image analysis technique, culminating in the definitive classification of each date, meticulously considering both weight and size attributes.

Stringent and methodical evaluation mechanisms were employed to ascertain the system's efficacy. A panoply of testing scenarios, ranging from diverse date sizes and weights to varying lighting conditions, was meticulously devised. Precision metrics including accuracy, precision, and recall were judiciously computed to quantify the system's acumen in the spheres of accurate categorization and meticulous date segregation.

Sixth chapter

6 Conclusion

The main goal of implementing our devised system and conducting this study was to enhance the efficiency of date classification procedures, offering substantial benefits to stakeholders and beneficiaries within manufacturing facilities. This optimization is expected to result in time, labor, and cost savings, ultimately leading to improved customer satisfaction. Furthermore, this project holds potential for further refinement. The integration of color-based sorting mechanisms, for instance, has the potential to significantly enhance the precision of classification. Such advancements are particularly valuable for the Palestinian market, which faces intricate industrial and production challenges.

Seventh chapter

7 Recommendations

Exploration of Deep Learning Models: Future research can investigate the application of deep learning models, such as convolutional neural networks (CNNs), to enhance the accuracy of date categorization. Deep learning techniques have shown promise in various image recognition tasks and could potentially lead to significant improvements in date classification accuracy.

Incorporation of Color and Texture Analyses: Considering expanding the categorization framework by incorporating color and texture analyses. These additional elements could provide a more comprehensive understanding of date fruit properties, enabling more precise classification and quality assessment.

Real-time Monitoring Capabilities: To adapt to dynamic changes in fruit conditions and environmental factors, it is recommended to develop real-

time monitoring capabilities. This would allow for continuous adjustments and optimizations in the date classification process, ensuring consistent quality and efficiency.

Integration of IoT Devices: Exploring the integration of Internet of Things (IoT) devices to collect real-time data from the date fruit processing and sorting systems. IoT sensors can provide valuable insights into environmental conditions, humidity levels, and other factors that may impact date quality and sorting.

Eighth chapter

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