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Frutty-Pi (fruit sorter)

Frutty-Pi (clasificador de frutas)

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Abstract

Currently, the inventory management in the IT area is handled with an existing software which not only works as inventory, but also is a responsive generator which is used when equipment is delivered to the user by IT. The software needed improvements that were necessary to continue with its use, this because there are things that do not like the administrators who only have access to that database IT staff of the company GG Cables and Wires Mexico S. De R.L de C.V. For this work was made the call for an intern who could do that job. We were making use of Visual Basic code, so we continued using it to make the necessary corrections so that the software was working in a better way. All this in order to have a better way of use and an improvement in the file management system in order to manage a control by areas with the responsives in a digital way.

Digital, Software, File management

Resumen

Actualmente, el manejo de inventario en el área de IT se maneja con un software existente el cual no solo funciona como inventario, sino que también es un generador de responsivas el cual las responsivas se utilizan cuando se le hace entrega de equipo entregado a Usuario por parte de IT. El software necesitaba de mejoras que eran necesarias para poder continuar con su uso, esto debido a que hay cosas que no gustan a los administradores el cual solo tienen acceso a esa base de datos personal de IT de la empresa GG Cables and Wires México S. De R.L de C.V. Para este trabajo se hizo la convocatoria de un practicante el cual pudiera realizar ese trabajo. Se estaba haciendo uso de código en Visual Basic por lo cual se continuó haciendo uso de él y así mediante ese código realizar las correcciones necesarias para que el software estuviera funcionando de una mejor forma. Todo esto con la finalidad de contar con una mejor forma de uso y una mejora en el sistema de gestión de archivos para así manejar un control por áreas con las responsivas de manera digital.

Digital, Software, Gestión de archivos

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Introduction

The project is carried out in the subject of Internet of Things (IoT) at the Technological University of San Juan del Rio (UTSJR), the activity is the final project of the degree of University Technician so it involves the integration of multiple subjects and technologies for its conclusion. The topic was chosen due to the interest in testing artificial intelligence in the field of microcontrollers such as raspberry-pi and Arduino, in addition to the interest in image analysis from artificial intelligence was another of the most important factors in determining where the project would focus.

The objective planned with this project is to create a vegetable classifier in which with 2 cameras and the help of AI will register each of the vegetables and the state in which they are.

With this we plan to help companies that are engaged in the sale of vegetables or farmers to classify in a simpler way each vegetable and increase production in a more efficient way for them.

Company background

The Technological University of San Juan del Rio, is a Higher Education Institution created in August 1998, which offers young high school graduates, university careers closely linked to the productive sector so that in a short term they can be incorporated into the professional work of the region. Our main objective is to achieve an integral quality education, according to our Quality Management System, so that our students have solid knowledge, practical experience, attitudes and values.

Its vision is to form people with integrity in higher education, through a culture of scientific and technological development and social responsibility, offering quality technological services, through a close link with the different sectors, with the ability to adapt to the environment.

It also seeks to be a global university, a reference of innovation, recognized for the quality of its educational and technological services, the competitiveness of its graduates and its transcendence in the generation and application of knowledge.

The Universidad Tecnológica de San Juan del Río undertakes a Feasibility Study in conjunction with municipal presidents, prominent members of society and local businessmen, from the municipalities of Jalpan de Serra, Pinal de Amoles, Landa de Matamoros and Arroyo Seco; which results in the creation of the Academic Unit of Jalpan de Serra of the UTSJR.

In this way we intend to contribute to the economic development of the region, from the neuralgic point of the area, with technological education that promotes the development of local companies and the creation of micro-enterprises that rationally exploit the vast resources of the region and are responsible with the environment.

Problem Statement

Fruit or vegetable sorting with AI and raspberry PI.

Justification

Fruits and vegetables in bad condition are always a problem when it comes to selecting our food, besides they represent a risk for clueless people who add them to their meals, this is why we thought of eliminating this problem before it arrives to our trusted greengrocers. We plan to do this with our invention.

Overall objective

The objective planned with this project is to create a vegetable sorter in which with 2 cameras and the help of AI will register each of the vegetables and the state they are in.

With this we plan to help companies that are dedicated to the sale of vegetables or farmers to classify in a simpler way each vegetable and increase production in a more efficient way for them.

Scope

Create a vegetable sorter, with the resources of each of the team members, and also for final delivery a fully functional machine that will probably be used in a small greenhouse to optimize the collection and sorting of the products generated, with a delivery date of 30/03/2023.

ISSN 2523-6776

Theoretical framework

Raspberry

It is a low-cost computer with a compact size, the size of a credit card, can be connected to a computer monitor or a TV, and used with a standard mouse and keyboard. It is a small computer running a Linux operating system capable of allowing people of all ages to explore computing and learn programming languages such as Scratch and Python. It is capable of doing most of the tasks typical of a desktop computer, from browsing the internet, playing high-resolution videos, manipulating office documents, to playing games. (PI, 2018, p. 1)

It serves to bring computing to everyone, with it you can perform the most common tasks of a computer, but for only an approximate price of $ 35, with a Raspberry Pi and a Raspbian system you can browse the internet, check email, play videos, use instant messaging applications, etc.. All this in a very small size and at a much lower cost than any other desktop computer (PI, 2018, p. 1).

I wanted to bring computing to all users, with this simple board, but enough to do the most common tasks of any computer, computing is within the reach of all users and even pockets. It has also been introduced for teaching computer science in schools, it can be purchased in batches for the education sector from its own website that will redirect us to the partner distributor for this. (Delgado, 2018, p. 1)

Artificial intelligence

AI can be defined as the ability of computers to do activities that normally require human intelligence. But, to provide a more detailed definition, we could say that AI is the ability of machines to use algorithms, learn from data, and use what they learn in making decisions just as a human would. However, unlike people, AI-based devices do not need to rest and can analyze large volumes of information at a time. Also, the error rate is significantly lower in machines performing the same tasks as their human counterparts. (Rouhiainen 17)

Performance improvements of algorithmic trading strategy: it has already been implemented in various ways in the financial sector.

- Efficient and scalable processing of patient data: this will help make medical care more effective and efficient.

- Predictive maintenance: another tool widely applicable in different industrial sectors.

- Object detection and classification: this can be seen in the autonomous vehicle industry, although it also has potential for many other fields.

- Content distribution on social networks: this is primarily a marketing tool used in social networks, but can also be used to raise awareness among non-profit organizations or to disseminate information quickly as a public service.

- Protection against cybersecurity threats: it is an important tool for banks and systems that send and receive online payments. (Rouhiainen 18)

Machine learning is one of the main approaches to artificial intelligence. Simply put, it is an aspect of computer science in which computers or machines have the ability to learn without being programmed to do so. A typical result would be suggestions or predictions in a particular situation (Rouhiainen 19).

To begin to reflect on the great impact that AI will have on our lives, it is useful to know that AI technologies have begun to develop the ability to see (machine vision), hear (speech recognition) and understand (natural language processing) as never before. Figure 1.4 clearly illustrates this concept. Previously, these abilities belonged only to humans, but in the near future machines and robots will be able to develop them thanks to AI. (Rouhiainen 23)

A well-known phrase often heard in the technology community is that "data is the new oil," a famous quote originally attributed to British mathematician Clive Humby. Today, the most powerful companies in the world are often those that have access to vast amounts of data. But it is also worth noting that it is not only the volume of data that matters in business, but also the quality. Personally, however, I would argue that data is even better than oil. In the years when it was one of the world's most valuable commodities, only a few companies could enjoy its benefits.

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Today, however, because almost anyone can learn the basics of AI and machine learning, using these skills to create valuable tools and having access to free online data sources with ease is a new scenario where everyone will be able to benefit from it. (Rouhiainen 25)

Fruit maturity

The concept of fruit processing is understood within the agricultural market as a set of processes applied to fruit, namely cooling and ripening (Velez and Velez 27).

Fruit may have different degrees of maturity, depending on the type of fruit (Gueche G. C., 2020). The grade of the fruit will always be required by the client, in this case the exporters and suppliers of traditional fruits (Velez and Velez 27).

Traditional fruit exporters mostly trade with fruit processors. This is done in orders with very specific specifications, such as: temperature, number of batches, day of delivery and degree of ripeness of the fruit. (Velez and Velez 28)

The exporting entity named Congelados Ecuatorianos ECUACONGELA S.A., RUC 0992135948001, has the mission of exporting and supplying traditional fruit. This entity has methods and tools for the identification of maturity grades. One of the fruits supplied by this plant is the banana, which, by the way, is the fruit that will be taken as a case study (Velez and Velez 29).

3D Printing

3D printing is the process of creating objects by depositing layers of material on top of each other. 3D printing is referred to as additive manufacturing (AM) instead of traditional subtractive methods, such as CNC milling, when used for industrial production.

The technology has been around for about four decades, invented in the early 1980s. Although 3D printing started out as a slow and expensive technique, extensive technological advances have made today's AM technologies more affordable and faster than ever. ("3D Printing, what is it and how does it work? "1)

When we talk about 3D printer filaments, we are referring to the raw material used to produce the designs. To better understand, this element is similar to the paper used in conventional printers. (Otero 2022, 1)

The uses of 3D printing have increased considerably in recent times. Although we have already hinted at some of them in the introduction to this article, the list of applications is really long. Three-dimensional printers are useful in:

- Medicine. Printing of prostheses, organs or transplants.
- Automotive. Parts for cars and other means of transportation.
- Industry. Product development in industries for different types of businesses.
- Food printing. Obtaining various foods by three-dimensional printing.
- Others. 3D printers have become very recurrent devices in educational centers or in architecture studios.(Otero 2022 1)4

Cameras on Raspberry PI

Adding an "eye" to your Pi is a fantastic way to turn your board into a surveillance camera or a PC that can be used for video chatting. For this purpose, you can opt for compatible camera modules, or you can opt for an HD camera from an established brand, such as Logitech. These devices capture high-definition images and can also record videos for later viewing (" Raspberry Pi cameras Everything you need to know"). RPi camera modules use the special MIPI CSI camera format to use less power, enable faster bandwidth and fit a smaller physical size. In addition, these modules support higher resolution, better frame rate and have reduced latency issues compared to USB cameras (" Best Raspberry Pi Cameras Everything You Need to Know").

React JS

React JS is one of the most popular JavaScript libraries for mobile and web application development. Created by Facebook, React contains a collection of reusable JavaScript code snippets used for building the user interface (UI) called components ("React," 2020, pg 1).

ISSN 2523-6776

To understand how React works it is key that we place ourselves in context, because when you learn web development you gain knowledge of three basic concepts:

- HTML: the semantics, structure and information of the web page; that is, its skeleton.
- CSS: the appearance of our web page.
- JavaScript: basically the brain of our page. It determines what to do based on what happens on it (React App,2020, pg 1).

AI Training

Artificial Intelligence (AI) training is the foundation on which the project rests, so it is our first aspect to discuss. This training is carried out in a total of 3 phases, being these collect samples, model preparation and model export, each with its own processes and unique ways of working, below is shown in a more detailed way each of the phases exposed above, this whole process was carried out with the Google Teachable Machine tool.

Sample collection

This phase consists of collecting and grouping the examples you want the computer to learn by classes or categories. Each class or category will represent an object or element that the artificial intelligence must learn separately, in this case and taking this phase in the context of our project we have created a total of 6 classes, i.e. 2 classes for each fruit depending on its state (fresh or rotten).

The samples are each of the images that will be stored in the categories, on average each category has a total of 1800 photos that were collected from the internet and sometimes even taken by us personally.

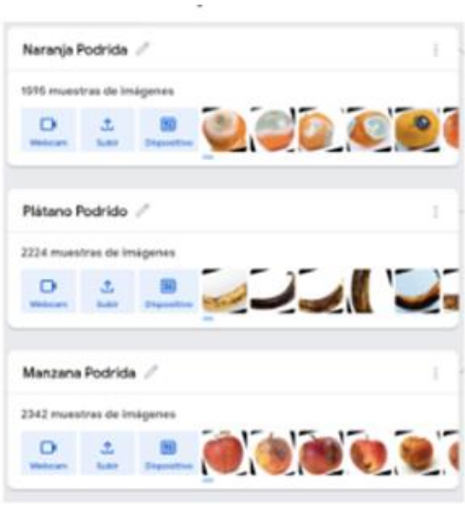

Figure 1 Fruit model 1

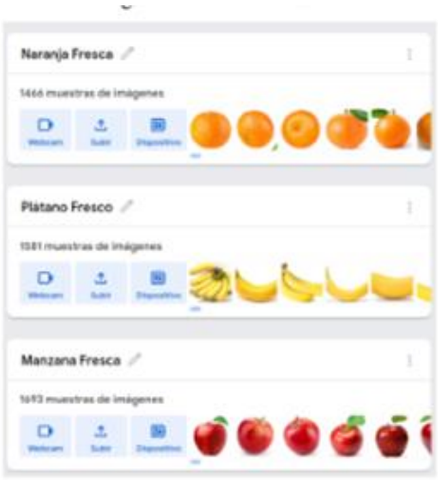

Figure 2 Fruit model 2

The wide variety of images allows us to create a model that predicts much better the multiple environments that can be presented throughout its operation, it is more than clear that it will not always be used under the same conditions.

Model preparation

Prepare the model and test it on the fly to see if it can correctly classify the new examples. In this phase we must take care of 3 aspects that directly influence the result that our model will return, these aspects are: Epochs, batch size and learning rate.

Epochs: When the preparation model has processed all the samples of the preparation data set once, it is said that an epoch has been completed.

ISSN 2523-6776

For example, if 50 epochs are set, the model you are preparing processes the entire preparation data set 50 times. Generally, the larger the number, the better the model will learn to predict the data.

Batch size: A batch is a set of samples that are used in a preparation iteration. For example, let's say you have 80 images and you choose a batch size of 16. This means that the 80 images will be divided into batches of 16, resulting in 5 batches. When the model processes all 5 batches, an epoch will be completed.

The learning rate: Be careful when changing this number! Even the smallest differences can greatly influence the learning efficiency of your model. The settings of all these parameters will determine the quality of the training and how successful the model will be, you have to be careful with the selected values as they determine how long the training will take.

In our case the selected configuration was:

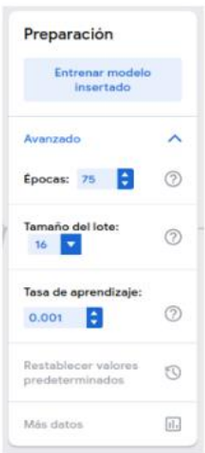

Figure 3 AI training

It should be noted that we did not reach this conclusion from the first iteration, as we needed multiple tests to find the perfect combination.

Export

Export your model for your projects: sites, applications and more. We can download the model or host it online. These are one of the many advantages of using the Teachable Machine tool.

Web Application

However to have a complete project it is necessary to find a way to integrate all our subjects to get the best possible result, that's why it is called an integrative project, in this section we will discuss a little about the web application that we decided to create in order to manage our project from other perspectives.

The operation of the application is summarized in a place where we can observe the information generated by the model in a more intuitive and friendly way, which makes it available for anyone to generate a report with the information it provides.

Interface

The application has a friendly interface for the user in which you can register and with the username and password that you put log in whenever you want, this interface is created so that you can consult the information of the fruits that are stored in the database.

Figure 4 Login app

Libraries

Different libraries were used in order to be able to use code that helped us in the creation of the application, since functions such as being able to use the camera to detect our fruits and compare the images with those in the model of each fruit are required.

Operation

The main objective of this web application is to show the user already registered, the fruits that have been registered in graphs that will be displayed according to the selected day. This graph will show the fruits divided in jars and in rotten making the sum of these fruits depending on which one is and the state of the same one.

ISSN 2523-6776

Server

The server is the one that will be processing the information that the client sends as its user at the moment that the user registers, at the same time that when the fruit is entered it will be sent through the client and the server processes it to save it in the database.

Figure 5 Server 1

Figure 6 Server 2

Client

It is the one that will be sending all the information to the server so that it processes it in the database and returns the functions that the client requested to the server socket, as its registration, the fruits that the client verifies in the classifier.

Figure 7 Client 1

Figure 8 Client 2

Fruit Web Analyzer

This script contains all the code for the identification of the fruits themselves, as we can see there are several lines of code for what is the api of teachable machine for the use of the images of the fruits.

Figure 9 Teachable machine script

Camera image script

The script was made so that the camera can be used with the code and it collected the data sent to make the comparison with the teachable machine images.

Figure 10 Camera script

ISSN 2523-6776

Image comparison

The script was created to compare the image that is being transmitted in the camera with the images of the model of each fruit, whether fresh or rotten, this is done through an if and else if condition that with a link will tell us which fruit is and if it is in good condition or rotten.

Figure 11 Image comparison

Online fruit analyzer

In this page the fruit is analyzed and with the script is compared saying in the box on the right that fruit is and its state of the same, also sending the data of the compared fruit in the database that soon you can consult in the project page.

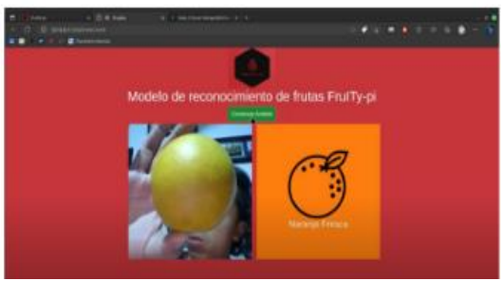

Figure 12 Fruit analyzer

Assembling the fruit sorter

On the table you will place the box where the fruit will be placed, then you will need some lighting for detection, finally you will place the camera in such a way that the camera only shows the base of the box, not the walls of the same with this would be mounted what is the space where the main procedure will be done.

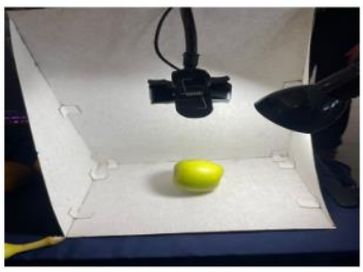

Figure 13 Assembly 1

For the operation of the model will need 1 raspberry and two computers in the raspberry will run the server which receives all the data from the model and performs the analysis and generates statistics in the first computer runs the recognition model which is the one that sends the data and the last computer runs the web page which takes the data from the server.

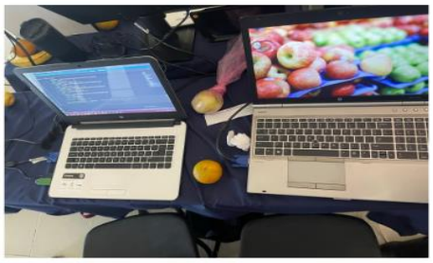

Figure 14 Assembly 2

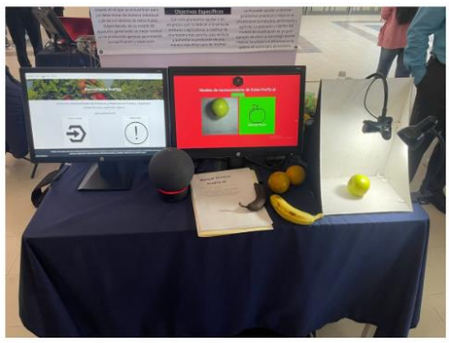

Figure 15 Assembly 3

Here you can see the project completely assembled, where you can see two monitors, one shows the commercial of the product in which it is superficially explained what the project consists of and the other monitor shows the program already running.

Results

The fruit classification model trained by artificial intelligence can be able to classify fruits at different stages of ripeness with high accuracy, using a wide variety of training images. The accuracy of the model can be measured by the percentage of correct classification on a test data set.

In addition, the speed and efficiency of the model can be improved by optimizing the algorithm and choosing appropriate model parameters. An efficient fruit sorting model can process a large amount of fruits in a short period of time, which can significantly improve productivity and efficiency in the food and agricultural industry.

ISSN 2523-6776

Overall, the results of the fruit sorting project can be highly accurate and efficient, which can have a positive impact on the industry and society.

Figure 16 Analyzer Result

Benefits

This project can have several benefits, including:

- Increased accuracy in fruit sorting: AI can be trained to sort fruits by ripeness with high accuracy, which reduces the likelihood of human error and increases efficiency in the fruit sorting process.
- Improved product quality: By sorting fruits by ripeness stage, it can ensure that the products are of high quality and at their optimum ripeness, which can improve the quality and taste of the products.
- Reduced food waste: Accurate sorting of fruits by ripeness can reduce food waste, as fruits can be sorted and used at the right time for consumption or processing.
- Increased efficiency in the supply chain: Quick and accurate sorting of fruits by ripeness can improve efficiency in the supply chain, which can reduce costs and increase productivity.
- Technological innovation in the food industry: The use of artificial intelligence to sort fruits by ripeness is an innovative application of technology in the food industry, which can open up new opportunities for the development of technological solutions in the industry.

Improvements

The following are some improvements that can be considered for the project:

- Increase the diversity of training data: The AI model needs to be trained with a wide variety of images of different types of fruits and at different stages of ripeness, to improve its classification accuracy.
- Incorporating additional information: In addition to images, incorporating additional information such as texture, size, weight, and color of fruits can be considered to improve the accuracy of the classification model.
- Optimize the neural network: Optimization of the neural network and proper selection of hyperparameters can improve the accuracy and efficiency of the classification model.
- Use image preprocessing techniques: Applying image preprocessing techniques such as normalization, cropping, and denoising can improve the quality of the images and thus improve the accuracy of the model.
- Cross-validation: cross-validation can be considered to assess model accuracy and avoid over-fitting.
- Integrating technology with automation systems: Integrating the grading model with automation systems for fruit sorting and packing can improve efficiency in the supply chain and reduce human error.

Conclusions

In conclusion, the fruit classification model trained using artificial intelligence has the potential to be highly accurate and efficient in classifying fruits at different stages of ripeness. The accuracy of the model can be measured using the percentage of correct classification on a test data set. In addition, optimization of the algorithm and proper choice of model parameters can improve its speed and efficiency.

The benefits of this project are diverse. First, higher accuracy in fruit classification is expected, which would reduce human errors and improve efficiency in the selection process. This would lead to an improvement in product quality, as fruits would be sorted at their optimum point of ripeness.

ISSN 2523-6776

Also, accurate sorting of fruits by ripeness would contribute to the reduction of food waste by using fruits at the right time for consumption or processing. In addition, efficiency in the supply chain would be increased through fast and accurate sorting, leading to reduced costs and increased productivity. Finally, this project represents a technological innovation in the food industry by applying artificial intelligence to sort fruits, opening new opportunities for the development of technological solutions in this field.

To improve this project, some improvements can be considered. First, it is important to increase the diversity of the training data, including images of different types of fruits and at different stages of ripeness, to improve the accuracy of the model. In addition, incorporating additional information, such as fruit texture, size, weight, and color, can be considered to further improve the classification accuracy. Optimization of the neural network and proper selection of hyperparameters can also contribute to improving the accuracy and efficiency of the model. The application of image preprocessing techniques, such as normalization, cropping, and denoising, can improve image quality and thus model accuracy. Cross-validation can be used as an additional strategy to assess model accuracy and avoid over-fitting. Finally, integration of fruit sorting technology with automation systems in the supply chain can increase efficiency and reduce human errors in fruit sorting and packing.

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