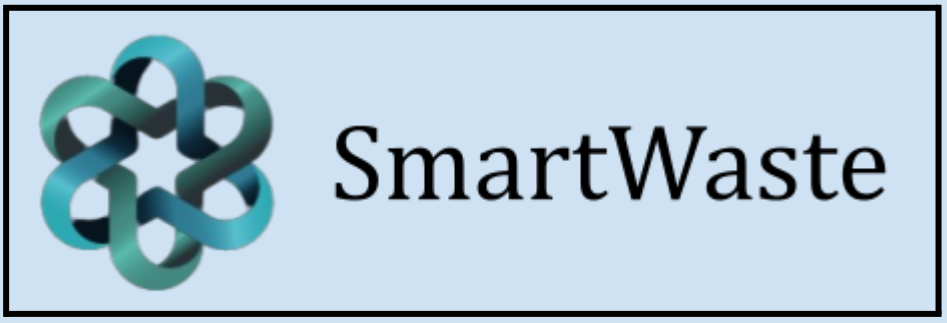
Barcelona Technological Institute

Synthesis Work

+



Smart Waste: A solution to waste

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Tutor: Fernando Rivero
Course: 2nd SMX
Class: C

"The longest journey begins with a first step."

Chinese proverb

"I used to think that great projects were done by great people,
and now I realize that great projects make great people."

Anonymous

This section is designed to remind us that every small step we take brings us closer to great achievements. The quotesinspire to begin, to move forward and to grow through the challenges we encounter along the way.

What are you words wemotives on our journey towards creating a more sustainable world with the "Smart Waste" project...

Furthermore, we are enormously grateful for this opportunity to develop andto developus as a group, project and people. We will do our best to deliver a masterful work in the eyes of society, surpassing our people from the past...

We hope you like it…

~ Richard, Hamza, Joel and Nahuel.~

1. What isSmartWaste?

"SmartWaste: Automation of Waste Management"

SmartWaste is an innovative project that seeks to revolutionize waste management through the use of advanced technologies such as computer vision and artificial intelligence. Our main objective is to automate the waste identification and classification process, which will allow for more efficient and sustainable waste management.

The project**SmartWaste** It is based on the idea of using devices such as the Raspberry Pi, equipped with cameras and specialized software, to scan and recognize the different types of waste that pass through a collection or classification system. Using machine learning algorithms, SmartWaste is able to distinguish between various materials such as plastic, paper, glass, metal, among others, thus facilitating their subsequent processing and recycling.

Once identified, waste can be automatically directed to the corresponding containers, optimizing the separation process and reducing contamination and the amount of non-recyclable waste. Besides,**SmartWaste** offers the possibility of collecting real-time data on the composition and flow of waste, allowing responsible authorities and organizations to make more informed and effective waste management decisions.

In summary,**SmartWaste** represents a significant advance in waste management, offering an innovative and technological solution to address current challenges in this field and promoting a more sustainable and responsible approach towards the management of our resources and care for the environment.

1.1 Description of the problem

Waste management is an increasingly urgent challenge in modern society. With the increase in population and consumption, waste generation has reached alarming levels, posing a series of environmental, social and economic problems.

One of the main problems associated with waste management is the**inefficiency in the collection, classification and final disposal process**. In many places, waste sorting is done manually, resulting in low accuracy and a high rate of non-recyclable waste.

This not only leads to further pollution and environmental degradation, but also represents a waste of valuable resources that could be recovered and reused.

Furthermore, inadequate waste management can have serious repercussions on public health, especially in communities near landfills or areas with high levels of contamination. The accumulation of untreated waste also contributes to climate change by releasing greenhouse gases and pollutants into the atmosphere.

Another aspect of the problem is the lack of accurate and up-to-date data on the composition and flow of waste, which makes it difficult for authorities and organizations responsible for waste management to make informed decisions.

Demonstrating that inefficient waste management represents a multifaceted challenge that requires innovative and technological solutions to address its various dimensions, mitigating its negative impact on the environment and society.

1.2 How does it work?

In this section, we will explain how the project works:

1. SmartWaste will use cameras strategically located in waste collection areas to capture images of waste passing through the system, in the demonstration it will be located so that it is present in the circuit.

2. The captured images will be analyzed by computer vision algorithms, whichwill identify andwill classify automatically the different types of waste present in the images.

3. Based on the results of image processing, SmartWaste will automatically classify waste into categories such as plastic, paper, glass, metal, organic, among others, in the prototype; in early versions there will be fewer options to carry out the corresponding tests.

4. Once classified, SmartWaste will be able to take various actions according to the needs of the system, such as directing the waste to the corresponding containers or generating reports on the composition and flow of waste in real time.

5. SmartWaste is designed to learn and adapt over time, allowing you to continually improve your sorting algorithms and processes to increase accuracy and efficiency, this is a possible improvement for preview versions and we will take it into account.

With this technological and innovative approach, SmartWaste will be redefining waste management, offering a smart and sustainable solution to address current challenges in this field.

1.3 Project benefits

SmartWaste is not only an innovative solution, but also offers a series of significant benefits that positively impact multiple aspects:

1. Improved Efficiency:

   SmartWaste will automate the waste identification and classification process, resulting in more efficient and faster management compared to traditional manual methods.

2. Reduction of Non-Recyclable Waste:

   Thanks to its ability to accurately distinguish between different types of waste, SmartWaste will help significantly reduce the amount of non-recyclable waste that ends up in landfills, thus promoting the circular economy and resource conservation.

3. Promotion of Sustainable Practices:

   By facilitating the proper sorting and recycling of waste, SmartWaste will encourage sustainable practices at both the individual and community levels, raising awareness about the importance of responsible resource management and environmental protection.

4. Environmental Improvement:

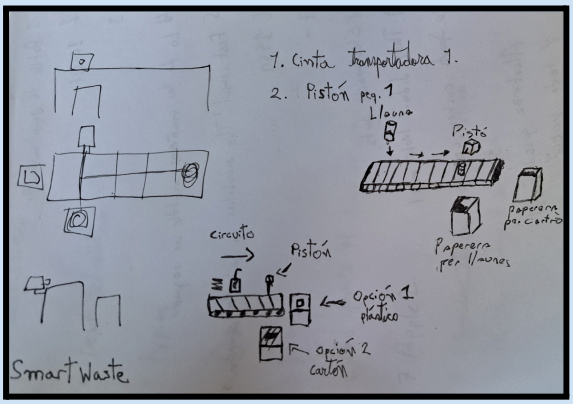
   By reducing the amount of non-recyclable waste and promoting sustainable practices, SmartWaste will contribute to the improvement of the environment by reducing pollution and conserving natural resources.

2. Project development

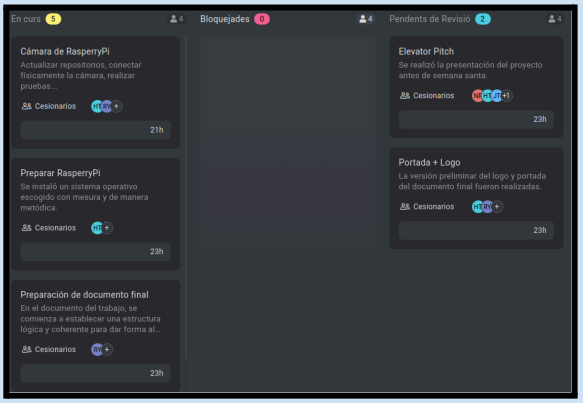
Now that we have explored the benefits and positive impact of SmartWaste, it is crucial to understand how the project developed, from conception to implementation.

In this section, the various aspects of SmartWaste development are explained, including the initial research and planning, the software and hardware development process, the tests and optimizations carried out, as well as the final project documentation.

To begin, the first days we were carrying out the**first sketches of the project**, and coordinating the group to**distribute the different tasks**, looking for the possible necessary materials.



Sketches



OrganizationProofhub

Raspberry Pi (93€ amb oferta (-40%)) (157,17€ sense oferta)
Link

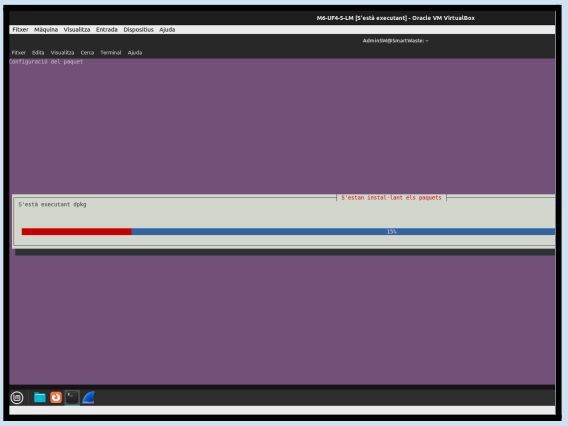
Càmera Raspberry Pi (12,95€)
Link

Cintra transportadora (141,99€)
Link

Pistó per empènyer (9,07€ amb oferta (-32%)) (13,28€ sense oferta)
Link

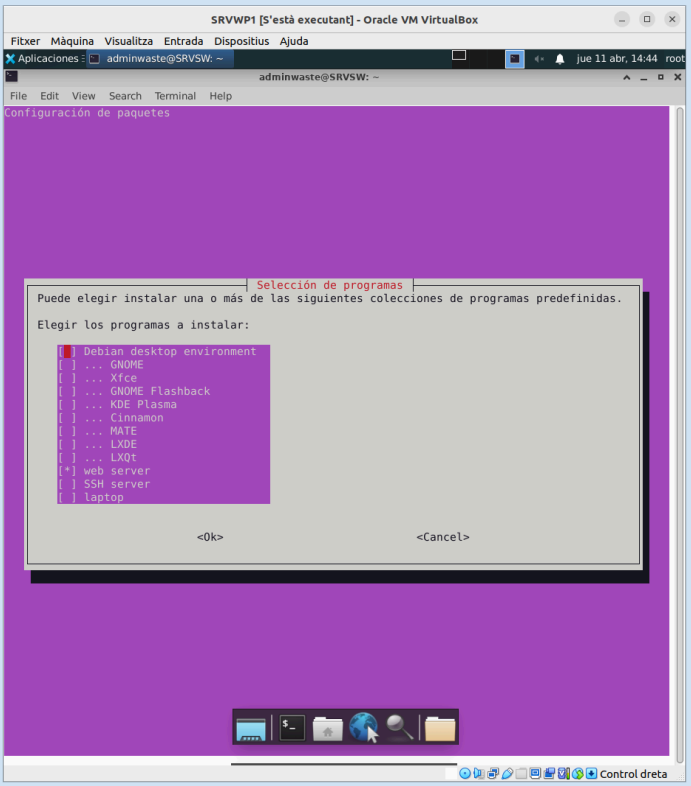
Cost total amb ofertes: 257,01€
Cost total sense ofertes: 325,39 €

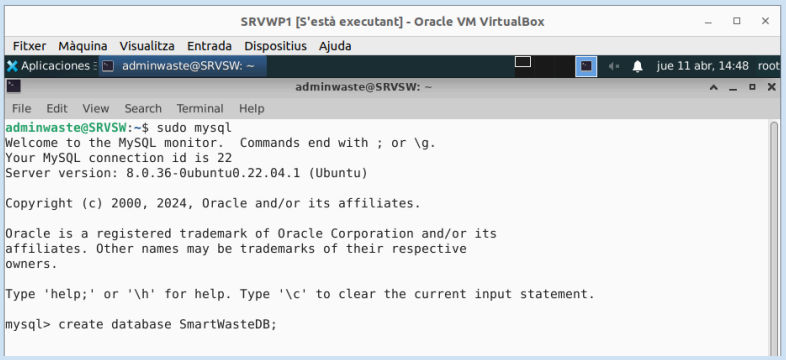
Shopping list



LAMP installation

2.1 Installing the LAMP package + Deployment

Installation of LAMP package and Implementation steps:
sudo apt update
sudo apt install taskel
sudo tasksel

sudo apt install mysql-server
sudo apt install php libapache2-mod-php
sudo apt install php-{curl,intl,zip,soap,xml,gd,mbstring,bcmath,common,mysqli}




```
mysql> show databases;
+--------------------+
| Database           |
+--------------------+
| SmartWasteDB       |
| information_schema |
| mysql              |
| performance_schema |
| prueba             |
| sys                |
+--------------------+
6 rows in set (0,00 sec)
```

After creating our database, we unzip the WordPress installation file inside /var/www/html and after that we access the WordPress installation via http://172.21.7.241/wordpress.

2.2 Raspberry PI setup (pending)

RaspberryPi OS 32 bits - Release 5.2 March 2024

Raspberry Pi Initial Setup:

Hardware Preparation:
First, I made sure I had everything I needed: my**Raspberry Pi**, a card**microSD**, the**fountain of feeding**, and**keyboard**, and**mouse**, and**monitor** and the appropriate cables like my HDMI to vga adapter to connect it to the classroom monitor.
Next, I inserted the microSD card into the Raspberry Pi slot and connected all the peripheral devices.

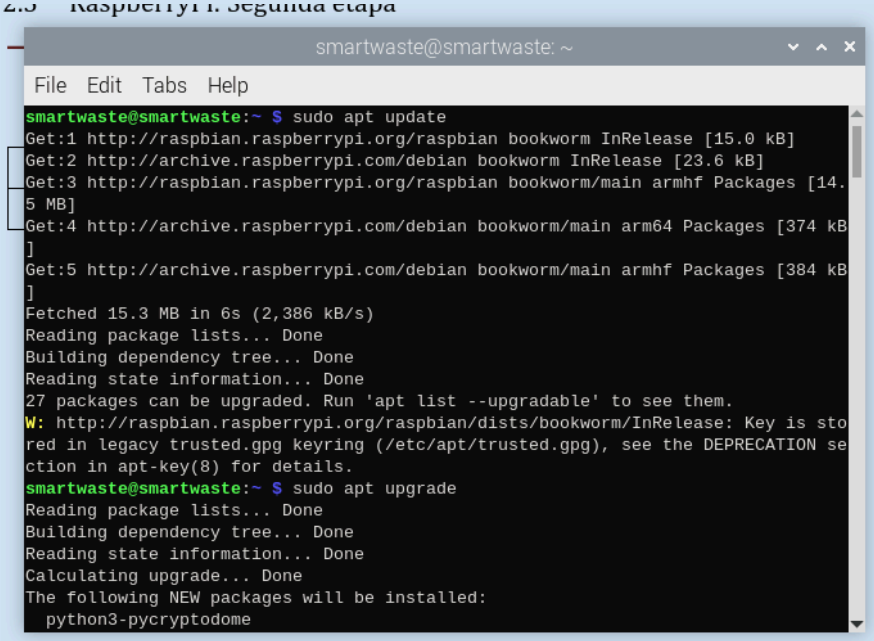
Installation of the Operating System:
I downloaded the latest 32-bit Raspberry Pi OS image from the official Raspberry Pi website.
I used the balenaEtcher application on my computer to burn the operating system image on the microSD card.

Initial setup:
I inserted the microSD card into the Raspberry Pi and turned on the power.
I followed the instructions on the screen to complete the initial setup of the operating system, such as selecting the language, setting the password, and connecting to my Wi-Fi network.

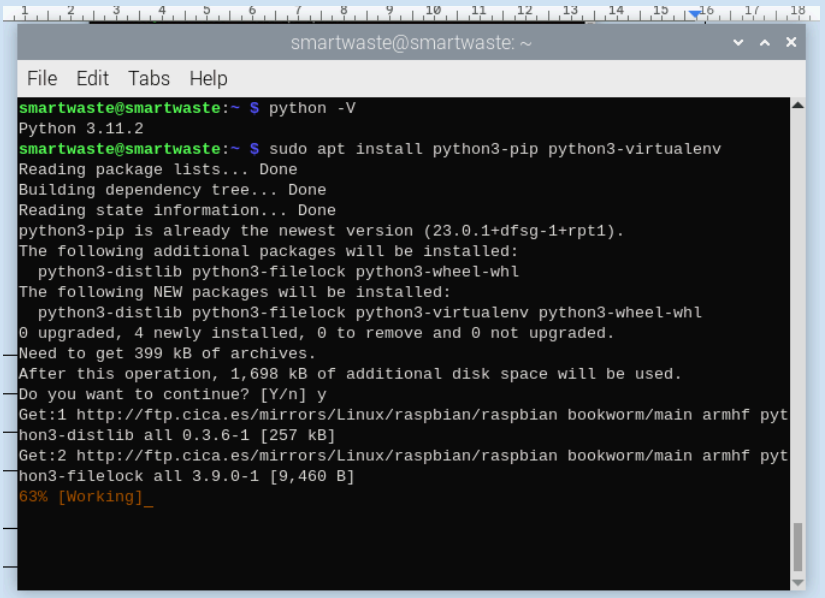
Upgrade system:
Once logged into my Raspberry Pi, I opened a terminal and ran the command sudo apt update && sudo apt upgrade to update all system packages to the latest available version.

2.3 RaspberryPi: Second stage, OpenCV installation and code programming.

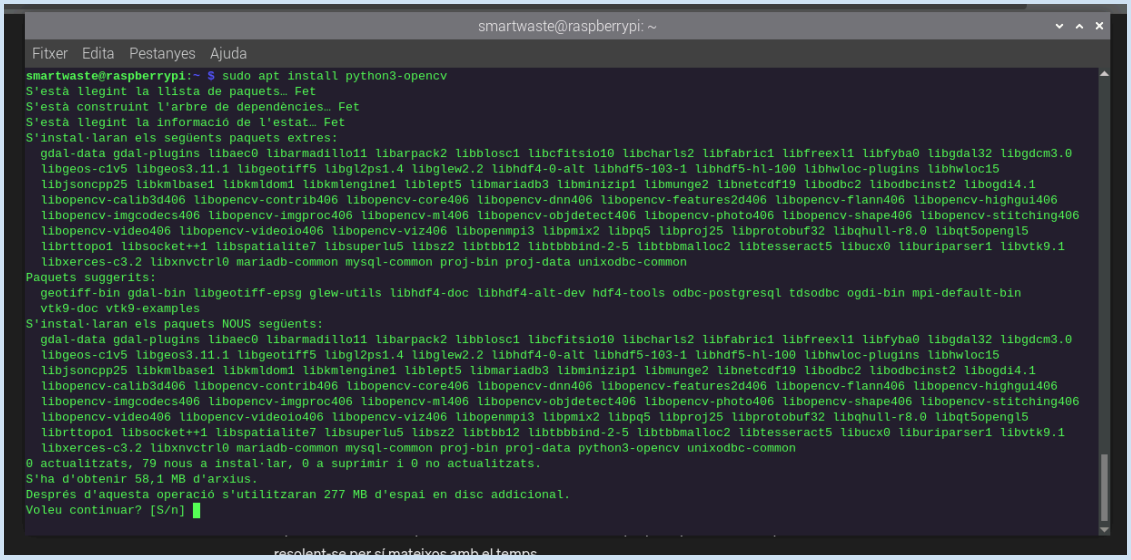
System upgrade and update:



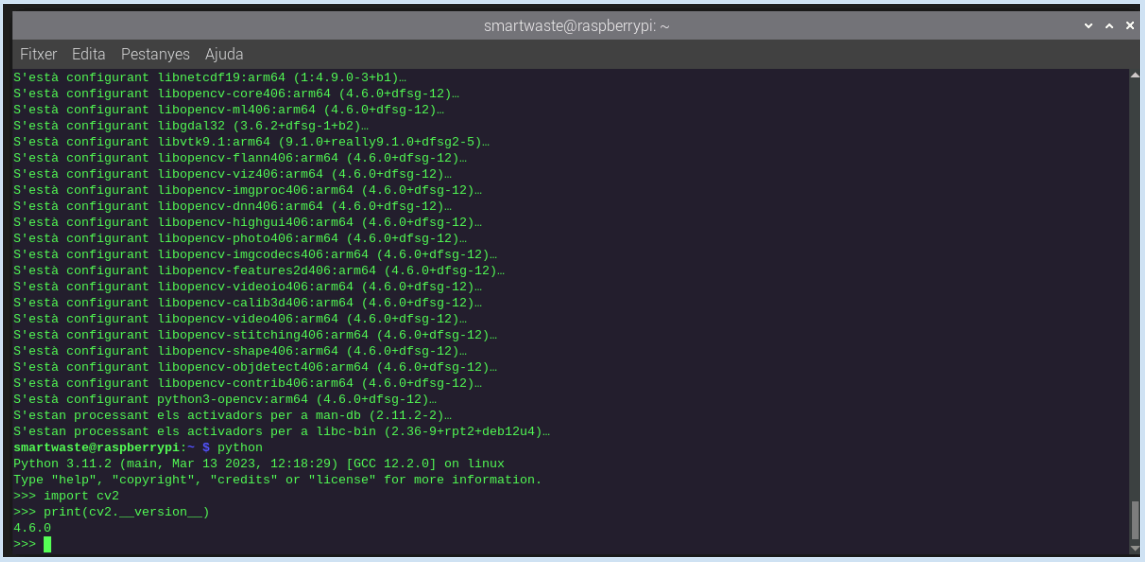
View Python version and install necessary packages



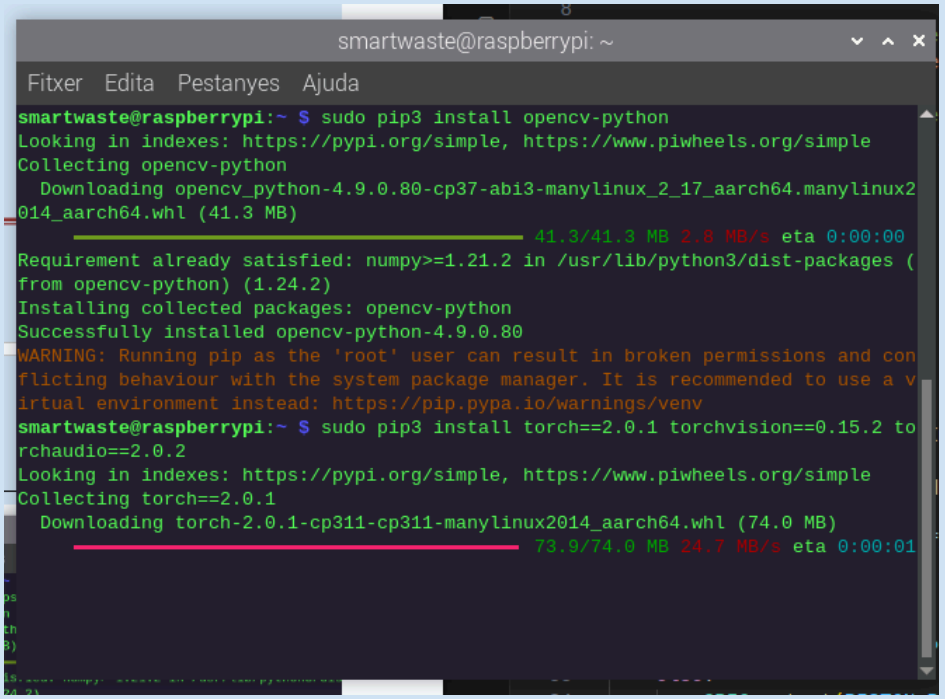
We install dependencies and OpenCV packages to be able to compile it on the RaspberryPi with Python.

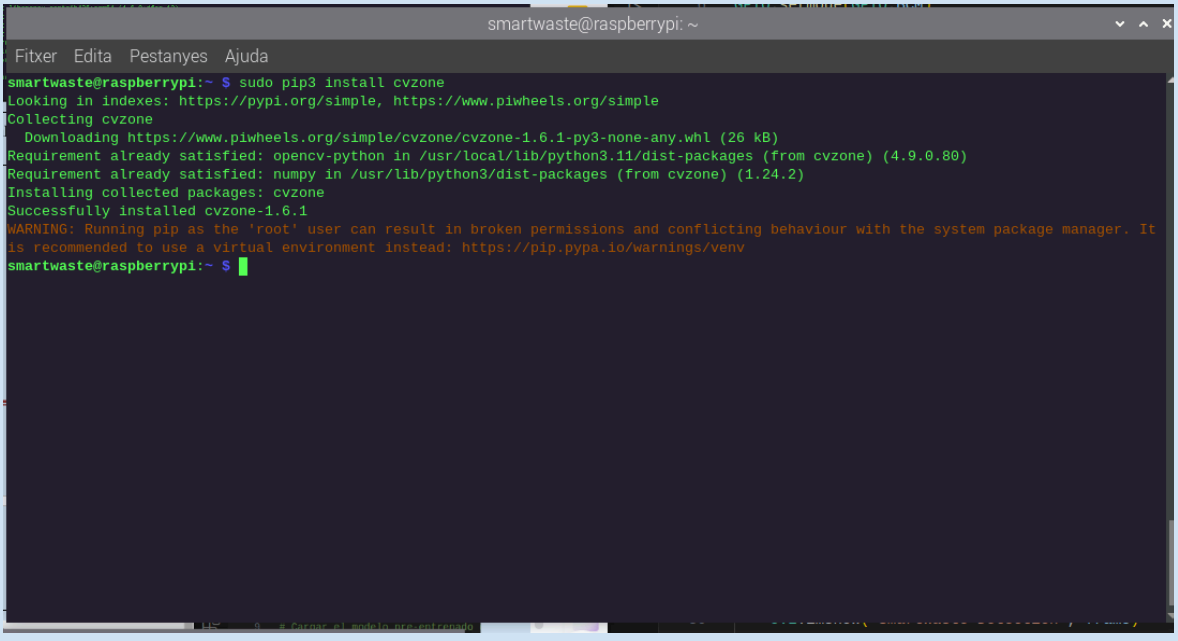


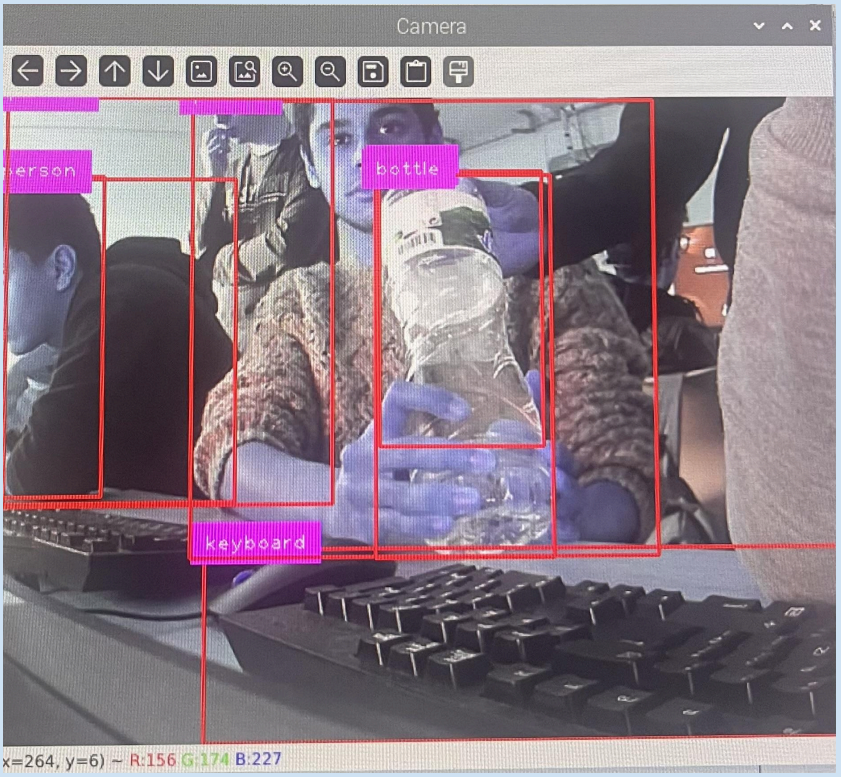
Check and import OpenCV in Python and install visual studio code.



Now we install python with pip3, in order to avoid problems in the future, following very methodical steps.


smartwaste@raspberrypi: ~
Fitxer Edita Pestanyes Ajuda
smartwaste@raspberrypi:~ $ sudo pip3 install opencv-python
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Collecting opencv-python
Downloading opencv_python-4.9.0.80-cp37-abi3-manylinux_2_17_aarch64.manylinux2014_aarch64.whl (41.3 MB)
41.3/41.3 MB 2.8 MB/s eta 0:00:00
Requirement already satisfied: numpy>=1.21.2 in /usr/lib/python3/dist-packages (from opencv-python) (1.24.2)
Installing collected packages: opencv-python
Successfully installed opencv-python-4.9.0.80
WARNING: Running pip as the 'root' user can result in broken permissions and conflicting behaviour with the system package manager. It is recommended to use a virtual environment instead: https://pip.pypa.io/warnings/venv
smartwaste@raspberrypi:~ $ sudo pip3 install torch==2.0.1 torchvision==0.15.2 torchaudio==2.0.2
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Collecting torch==2.0.1
Downloading torch-2.0.1-cp311-cp311-manylinux2014_aarch64.whl (74.0 MB)
73.9/74.0 MB 24.7 MB/s eta 0:00:01


smartwaste@raspberrypi: ~
Fitxer Edita Pestanyes Ajuda
smartwaste@raspberrypi:~ $ sudo pip3 install cvzone
Looking in indexes: https://pypi.org/simple, https://www.piwheels.org/simple
Collecting cvzone
Downloading https://www.piwheels.org/simple/cvzone/cvzone-1.6.1-py3-none-any.whl (26 kB)
Requirement already satisfied: opencv-python in /usr/local/lib/python3.11/dist-packages (from cvzone) (4.9.0.80)
Requirement already satisfied: numpy in /usr/lib/python3/dist-packages (from cvzone) (1.24.2)
Installing collected packages: cvzone
Successfully installed cvzone-1.6.1
WARNING: Running pip as the 'root' user can result in broken permissions and conflicting behaviour with the system package manager. It is recommended to use a virtual environment instead: https://pip.pypa.io/warnings/venv
smartwaste@raspberrypi:~ $



Program with Python, first recognition tests.

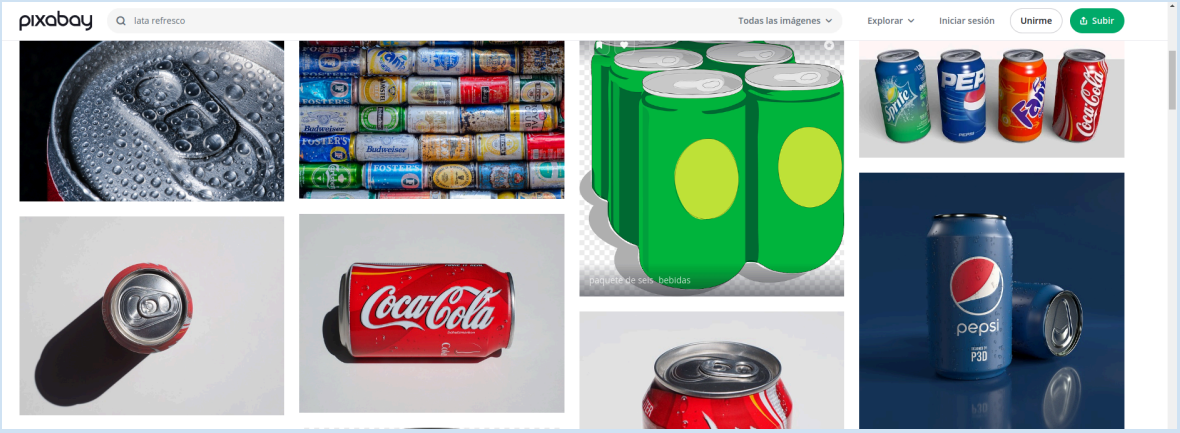
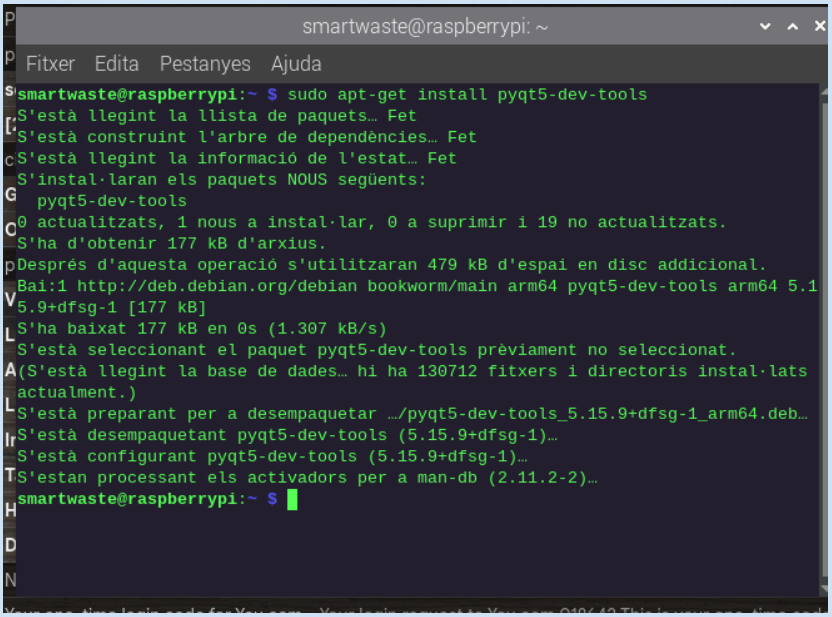
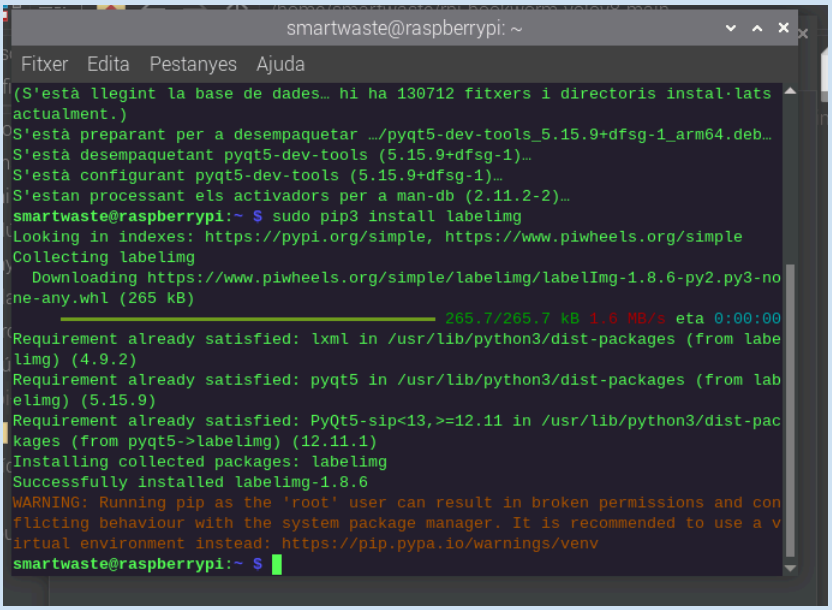


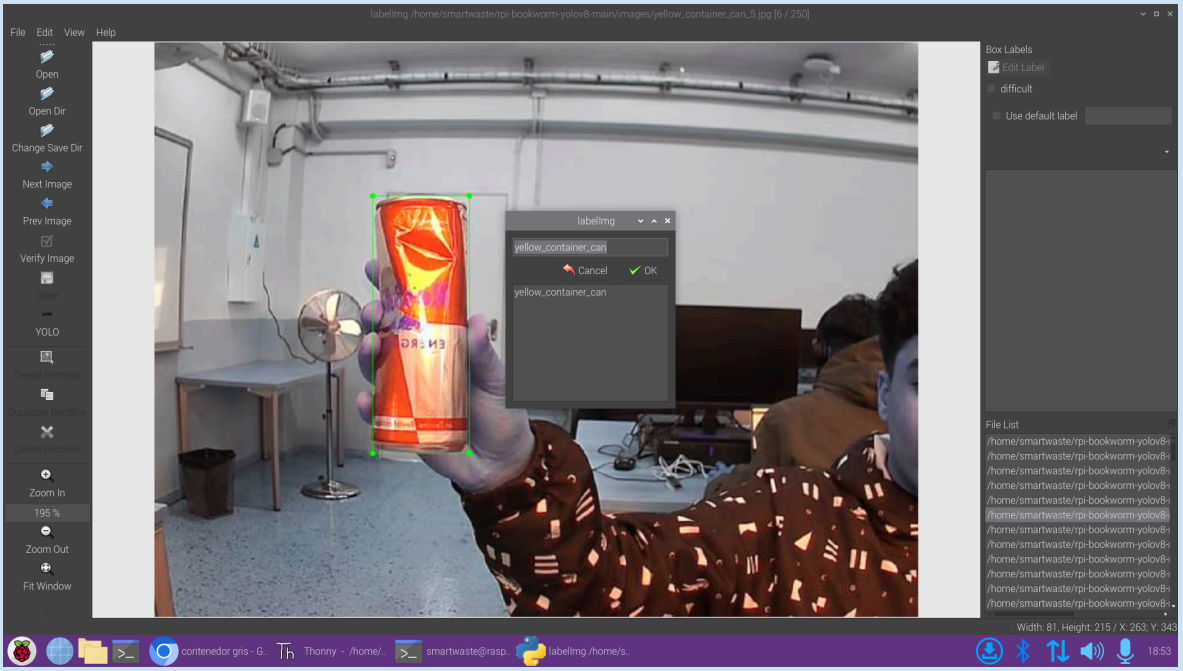
Image bank, we will try to train the AI with these if it becomes necessary.

Installation of necessary and important tools



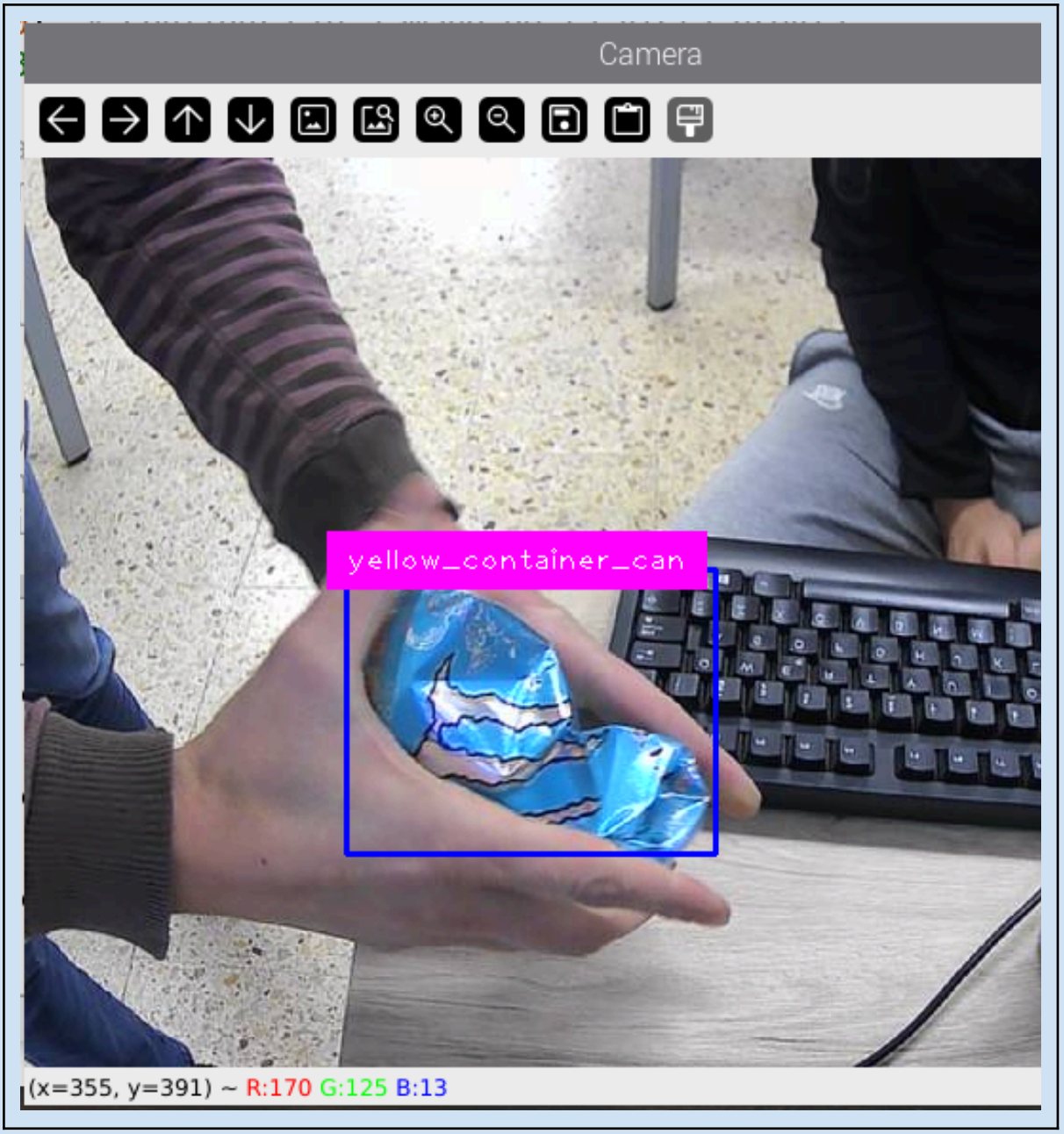


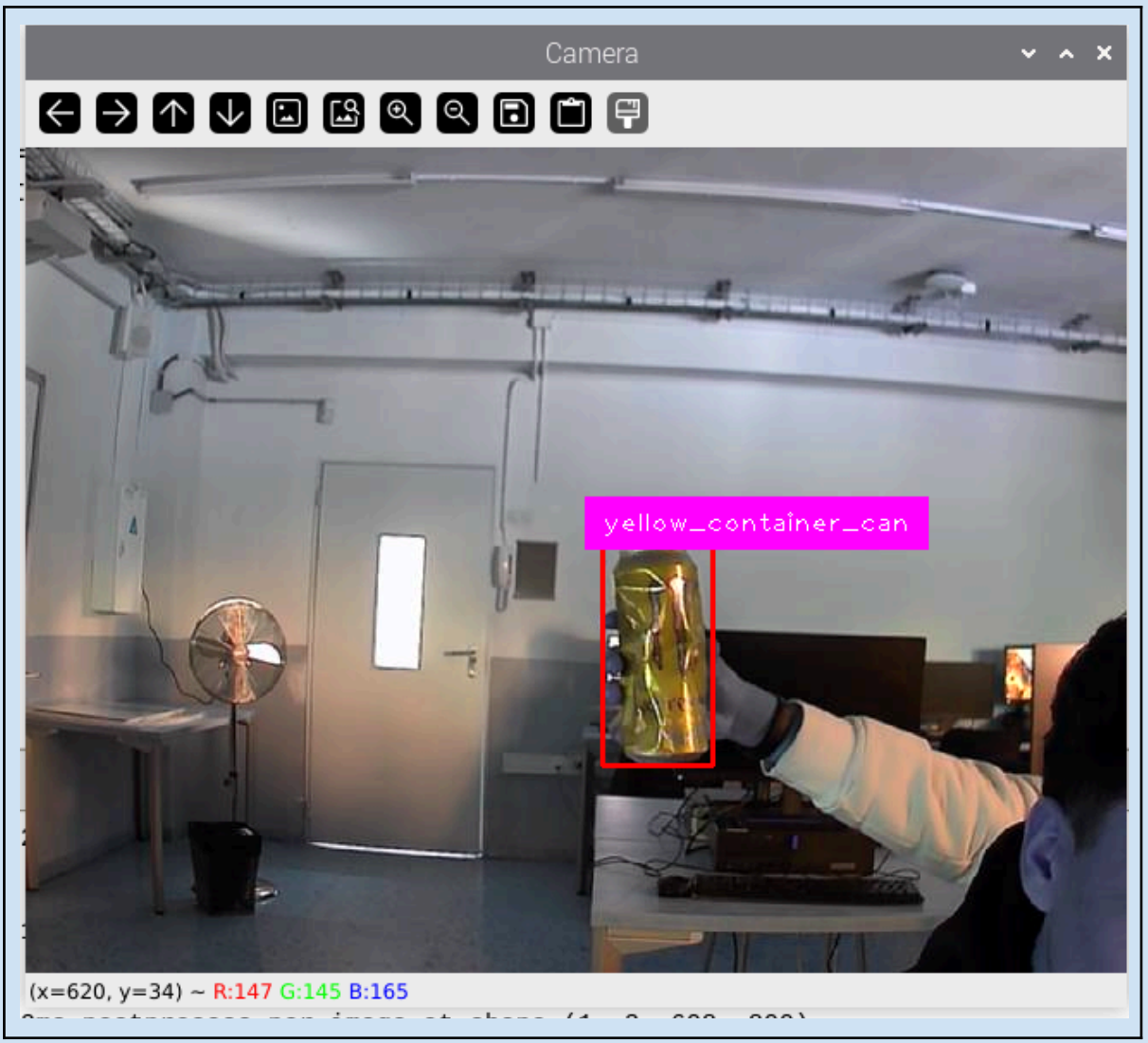
Phase 1 of image recognition: Add coordinates to each photo manually, to later transfer them to Google Colab, this with the programlabelImg

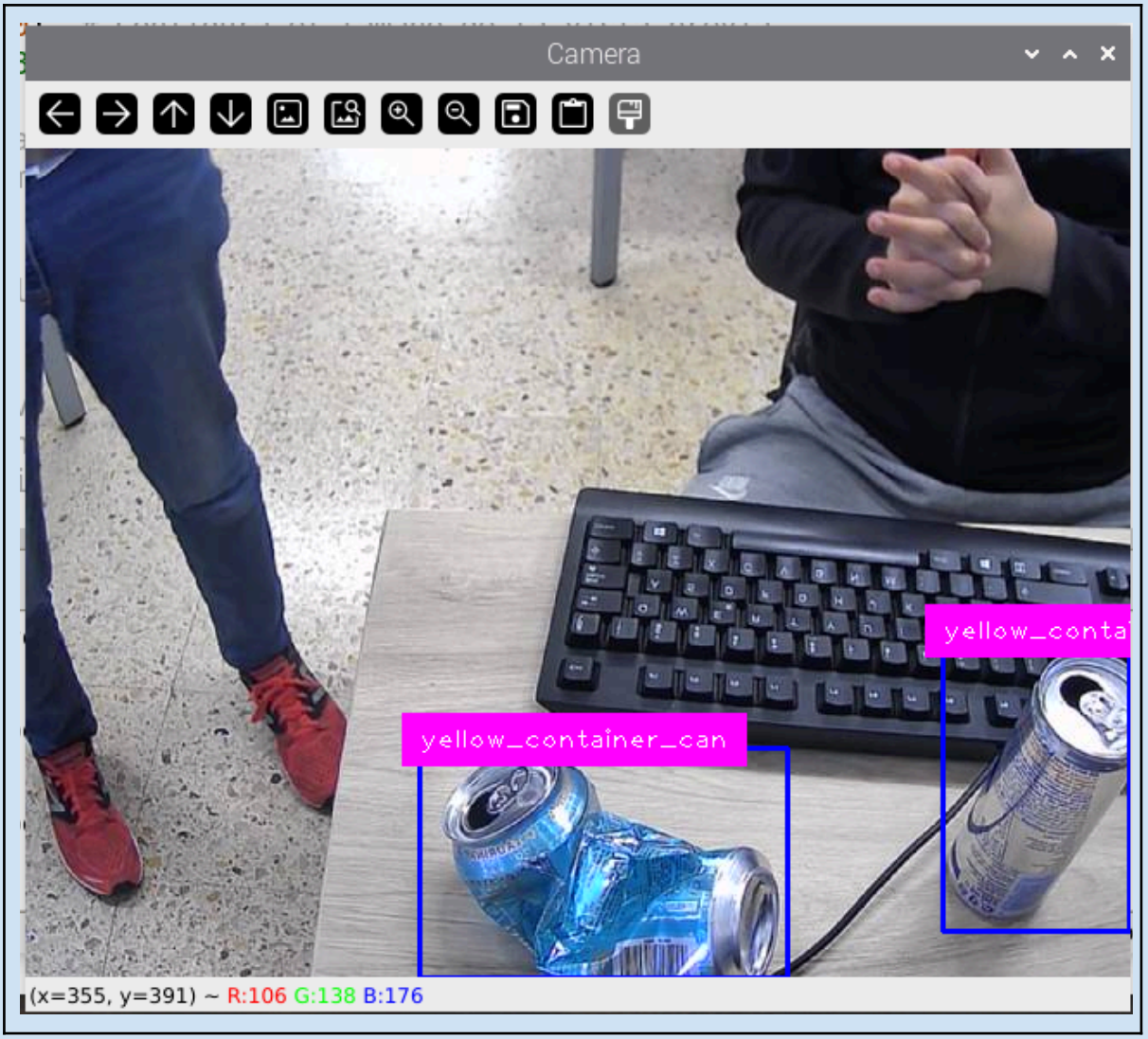


We took 250 photos, and we added a rectangle to show the AI where the can is in each photo.

AI checks**yoloV8,** We have trained in Google Colab how to detect cans:


Camera
yellow_container_can
(x=355, y=391) ~ R:170 G:125 B:13


Camera
yellow_container_can
(x=620, y=34) ~ R:147 G:145 B:165


Camera
yellow_conta
yellow_container_can
(x=355, y=391) ~ R:106 G:138 B:176

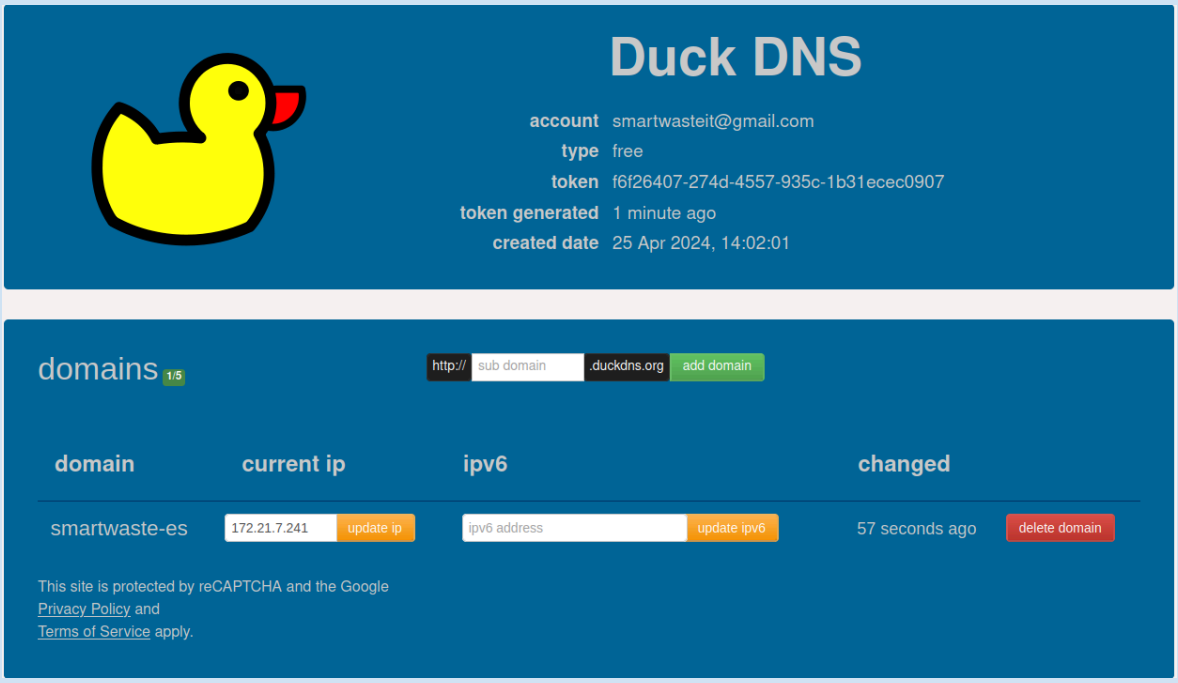
2.4 Our Website

Websites permissions

```
adminwaste@SRVSW:/var/www/html$ ls -l
total 232
-rw-r--r--  1 www-data www-data   405 feb  6  2020 index.php
-rw-r--r--  1 www-data www-data 19915 abr  9 17:16 license.txt
-rw-r--r--  1 www-data www-data  7401 abr 10 13:32 readme.html
-rw-r--r--  1 www-data www-data  7387 abr  9 17:16 wp-activate.php
drwxr-xr-x  9 www-data www-data  4096 mar 17 09:00 wp-admin
-rw-r--r--  1 www-data www-data   351 feb  6  2020 wp-blog-header.php
-rw-r--r--  1 www-data www-data  2323 jun 14  2023 wp-comments-post.php
-rw-r--r--  1 www-data www-data  3561 abr  9 17:12 wp-config.php
-rw-r--r--  1 www-data www-data  3012 abr  9 17:16 wp-config-sample.php
drwxr-xr-x  7 www-data www-data  4096 abr 25 14:30 wp-content
-rw-r--r--  1 www-data www-data  5638 may 30  2023 wp-cron.php
drwxr-xr-x 30 www-data www-data 12288 abr  9 17:16 wp-includes
-rw-r--r--  1 www-data www-data  2502 nov 26  2022 wp-links-opml.php
-rw-r--r--  1 www-data www-data  3927 jul 16  2023 wp-load.php
-rw-r--r--  1 www-data www-data 50917 abr  9 17:16 wp-login.php
-rw-r--r--  1 www-data www-data  8525 sep 16  2023 wp-mail.php
-rw-r--r--  1 www-data www-data 28427 abr  9 17:16 wp-settings.php
-rw-r--r--  1 www-data www-data 34385 jun 19  2023 wp-signup.php
-rw-r--r--  1 www-data www-data  4885 jun 22  2023 wp-trackback.php
-rw-r--r--  1 www-data www-data  3246 abr  9 17:16 xmlrpc.php
```

These are the website permissions that are as restricted as possible while still being able to access the website and administrate it.

DNS Configuration



We used Duck DNS for the configuration of the DNS which allow us to create domains based with our IP (172.21.7.241)

Apache configuration

SmartWaste.conf - /etc/apache2/sites-available - Geany

Archivo Editar Buscar Ver Documento Proyecto Construir Herramientas Ayuda

Símbolos

No se han encontrado sí

SmartWaste.conf

```
<IfModule mod_ssl.c>
    <VirtualHost _default_:443>
        ServerName www.SmartWaste.es
            ServerAdmin webmaster@SmartWaste.conf
            DocumentRoot /var/www/html
            DirectoryIndex index.php

            # Available loglevels: trace8, ..., trace1, debug, info, notice, warn,
            # error, crit, alert, emerg.
            # It is also possible to configure the loglevel for particular
            # modules, e.g.
            #LogLevel info ssl:warn

            ErrorLog ${APACHE_LOG_DIR}/error.log
            CustomLog ${APACHE_LOG_DIR}/access.log combined

            # For most configuration files from conf-available/, which are
            # enabled or disabled at a global level, it is possible to
            # include a line for only one particular virtual host. For example the
            # following line enables the CGI configuration for this host only
            # after it has been globally disabled with "a2disconf".
            #Include conf-available/serve-cgi-bin.conf

            #   SSL Engine Switch:
            #   Enable/Disable SSL for this virtual host.
            SSLEngine on

            #   A self-signed (snakeoil) certificate can be created by installing
            #   the ssl-cert package. See
            #   /usr/share/doc/apache2/README.Debian.gz for more info.
            #   If both key and certificate are stored in the same file, only the
            #   SSLCertificateFile directive is needed.
            SSLCertificateFile  /etc/apache2/ssl/certificat.pem
            #SSLCertificateKeyFile /etc/ssl/private/ssl-cert-snakeoil.key

            #   Server Certificate Chain:
            #   Point SSLCertificateChainFile at a file containing the
            #   concatenation of PEM encoded CA certificates which form the
```

SmartWaste.conf - /etc/apache2/sites-available - Geany

Archivo Editar Buscar Ver Documento Proyecto Construir Herramientas Ayuda

Símbolos

No se han encontrado sí

SmartWaste.conf

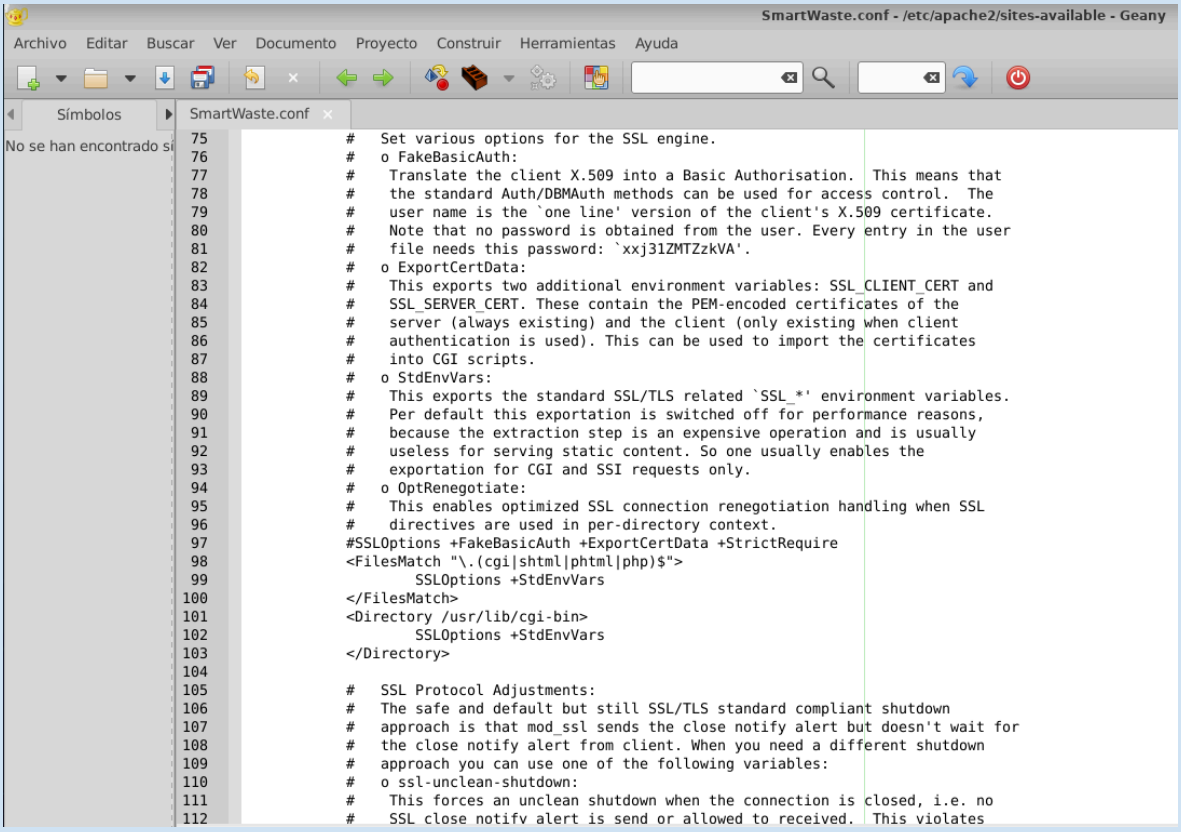
```
            #   Point SSLCertificateChainFile at a file containing the
            #   concatenation of PEM encoded CA certificates which form the
            #   certificate chain for the server certificate. Alternatively
            #   the referenced file can be the same as SSLCertificateFile
            #   when the CA certificates are directly appended to the server
            #   certificate for convinience.
            #SSLCertificateChainFile /etc/apache2/ssl.crt/ca-bundle.crt
            #SSLCertificateChainFile /etc/apache2/ssl.crt/server-ca.crt

            #   Certificate Authority (CA):
            #   Set the CA certificate verification path where to find CA
            #   certificates for client authentication or alternatively one
            #   huge file containing all of them (file must be PEM encoded)
            #   Note: Inside SSLCACertificatePath you need hash symlinks
            #        to point to the certificate files. Use the provided
            #        Makefile to update the hash symlinks after changes.
            #SSLCACertificatePath /etc/ssl/certs/
            #SSLCACertificateFile /etc/apache2/ssl.crt/ca-bundle.crt

            #   Certificate Revocation Lists (CRL):
            #   Set the CA revocation path where to find CA CRLs for client
            #   authentication or alternatively one huge file containing all
            #   of them (file must be PEM encoded)
            #   Note: Inside SSLCARevocationPath you need hash symlinks
            #        to point to the certificate files. Use the provided
            #        Makefile to update the hash symlinks after changes.
            #SSLCARevocationPath /etc/apache2/ssl.crl/
            #SSLCARevocationFile /etc/apache2/ssl.crl/ca-bundle.crl

            #   Client Authentication (Type):
            #   Client certificate verification type and depth.  Types are
            #   none, optional, require and optional_no_ca.  Depth is a
            #   number which specifies how deeply to verify the certificate
            #   issuer chain before deciding the certificate is not valid.
            #SSLVerifyClient require
            #SSLVerifyDepth  10

            #   SSL Engine Options:
```

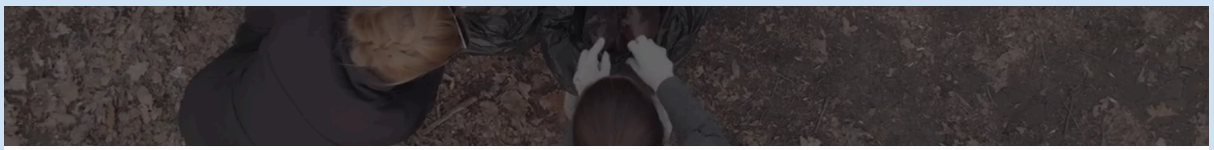


This is our Apache configuration to connect us to our website via HTTP and HTTPS

Result

http://smartwaste-es.duckdns.org/ (in order to enter the website, you'll have to be on the ITB's subnetwork).

For our home page, we wanted to do it with a video on the back and a big artwork by just entering the page. Then, we explain some of our enterprise, and added a inspirational phrase. Finally some pictures and an additional redirection to the other pages.
These are the screenshots of our home:

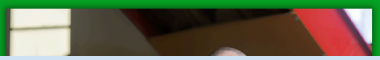


Trabajamos por un mundo en el que las personas puedan disfrutar de un futuro verde y en paz.

Cada pequeño paso que damos nos acerca a grandes logros. Las citas nos inspiran a comenzar, a seguir adelante y a crecer a través de los desafíos que encontramos en el camino.

SmartWaste es una empresa de filtrado de reciclaje, mediante una inteligencia artificial que reconoce el objeto colocado en frente de una cámara, y dictamina si es digna de reciclarse o no.

> *"Más que una obligación, reciclar es una necesidad."*
>
> ***ANÓNIMO***



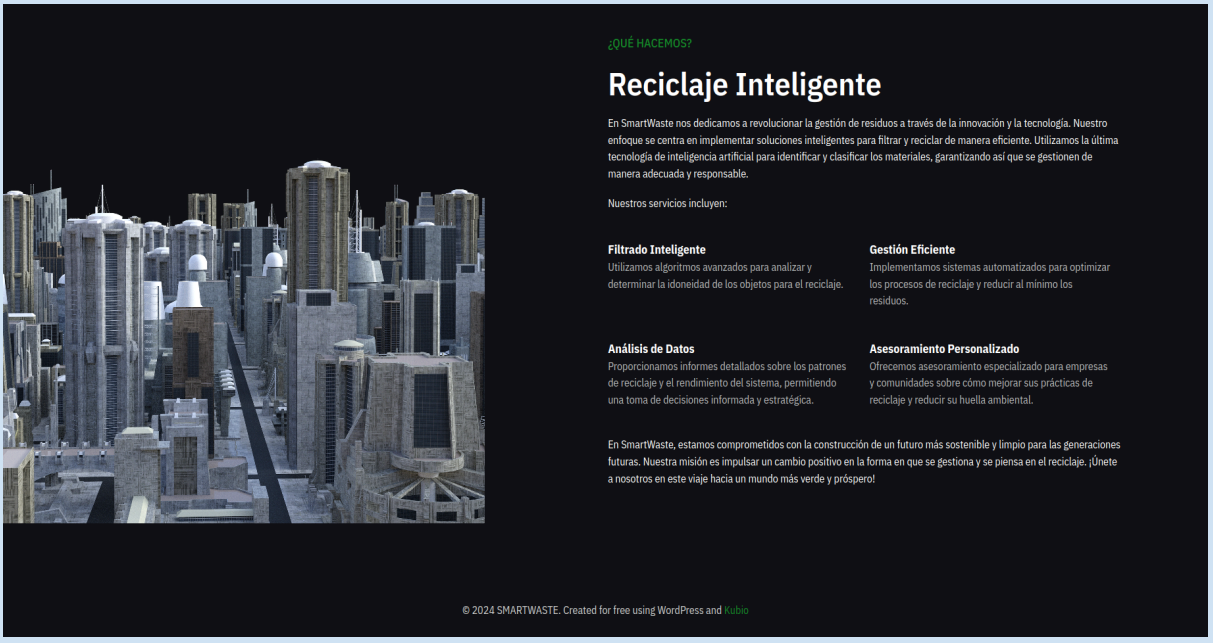
digna de reciclarse o no.

> *"Más que una obligación, reciclar es una necesidad."*
>
> ***ANÓNIMO***

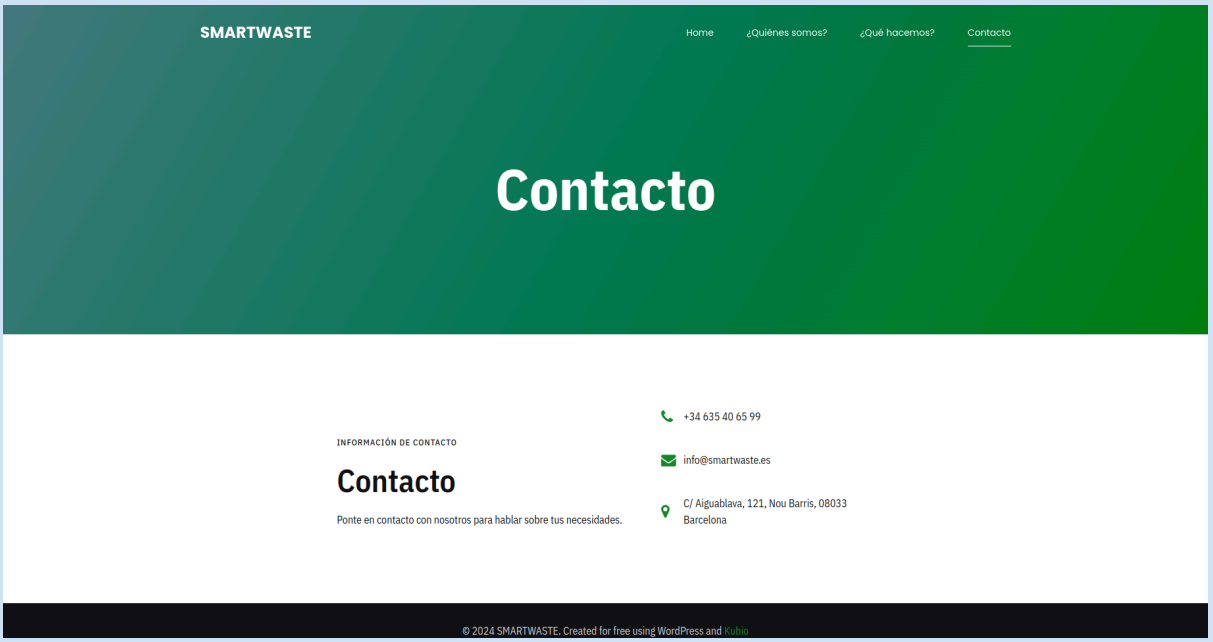
¿Quiénes somos? ¿Qué hacemos? Contacto

In the ‘*Who are we?’* section, we got rid of the video on the top, and added a fade in the background. Then, we wrote a brief but detailed description of our company and our objectives, finally, an AI generated image.
This are the screenshots of the *‘Who are we?’* section:

After that, we have the *'What we do?'* section, which has kind of has a big format change. The top part it's still the same, but, the middle section is really changed. We added a black background and a good layout for a 4-point explanation.
These are the screenshots for the *'What we do?'* part:



Finally, the contact, there’s nothing much to talk about. Just added a good layout for a contact section and added some icons and our contacts.
These are the contact screenshots:



Possibly useful content:

IMPORTANT:
Install LAMP modules (Linux+Apache+Mysql+PHP). Configuration of thesite + necessary Apache modules.
Creation of an advertising website for the project created from scratch or after installing a CMS.
Plugin installation (shopping cart, room reservation...).

Index:

Project development
Research and Planning
Software Development
Hardware Development and Prototyping
Testing and Optimization
Documentation and Completion
Team Roles and Contributions
Results and Achievements
Conclusions
recommendations
Bibliographic references
Annexes (if necessary, e.g. additional technical details, images of the project in action, etc.)
Executive Summary:

Project development:

Details about the project development process, from research and planning to testing and optimization.
Team Roles and Contributions:

A description of the roles of each team member and their contributions to the project.

Results and Achievements:

An overview of the results achieved during the development of the project and any notable achievements.
Conclusions:
Final conclusions based on the results of the project and its potential impact on the field of waste management.
Recommendations:
Possible recommendations for future projects or improvements in the SmartWaste project.
Bibliographic references:
A list of all sources used in the research and development of the project.
Attachments:
Any additional information that may be useful but not essential to the main body of the document, such as additional technical data, images or diagrams.

Download and install the Etcher software:

Download and install Etcher from its official website:https://www.balena.io/etcher/

Download the Raspbian image:
Go to the official Raspberry Pi site:https://www.raspberrypi.org/software/operating-systems/
Download the Raspbian image (usually in .img or .zip format).

Insert microSD card:
Connect your microSD card to the USB card reader and then connect the reader to your computer.

Open Etcher and select the image and card:
Open Etcher on your computer.
Click "Select image" and choose the Raspbian image you downloaded.
Verify that Etcher has correctly detected your microSD card.

Burn image to card:
Click "Flash" to start burning the Raspbian image to your microSD card.
Once the process is complete, Etcher will notify you that the recording has completed successfully.

Safely eject the microSD card:

Once recording is complete, safely eject the microSD card from your computer.

Update the first line, replacing bullseye with bookworm and adding non-free-firmware to the end of the line. Your sources.list file should end up looking something like this:

COPY
deb http://raspbian.raspberrypi.org/raspbian/ bookworm main contrib non-free rpi non-free-firmware
Type ctrl-x to exit nano, making sure you save the file on exit. Next, you need to open raspi.list (to update the Debian Bookworm base) with this command:

COPY
sudo nano /etc/apt/sources.list.d/raspi.list
In this file, you only need to change bullseye to bookworm. Again, hit ctrl-x, save your changes, and exit.

Perform another full upgrade, but this time sourcing from the Bookworm repositories!

COPY
sudo apt update
sudo apt full-upgrade
sudo reboot

https://www.youtube.com/watch?v=QzVYnG-WaM4

wget https://archive.raspbian.org/raspbian.public.key -O - | sudo apt-key add -