

OW-SmellDigital / bme680-sensor

This library enables the wireless automation of:

1. Synthesis of resistance profiles of environments exposed to a variety of scents, using Owidget-SmellDigital's proprietary olfactometer for scent stimuli emission, and Bosch BME680 environmental sensor.
2. Build, train, and deploy machine learning (ML) models with synthesized data to identify scents present in the environment.

These functionalities are implemented on Raspberry Pi 4 to enable **remote operation**, as data collection can take a long time.

Prerequisites

Products

- A soldered BME680 Breakout - <https://shop.pimoroni.com/products/bme680>
- Raspberry Pi 4 (4GB) - <https://www.raspberrypi.com/products/raspberry-pi-4-model-b/>
- OWidget's Proprietary Olfactometer - <https://www.ow-smelldigital.com/ourproducts>
- 1 USB-C to USB-C cable
- 1 USB-C to power source cable

Installations and Libraries

Follow the guide below from Pimoroni for soldering and setting up the MOX sensor with RaspberryPi:

- <https://learn.pimoroni.com/article/getting-started-with-bme680-breakout>

If you wish to use the RaspberryPi remotely, follow the guide below to install VNC Viewer:

- <https://www.realvnc.com/en/connect/download/viewer/raspberrypi/>

With the USB-C to USB-A cable, connect the Olfactometer to the RaspberryPi. This will show up as a COM port on the Raspberry Pi. The script will connect to the occupied port if only one port is used. If more than one port is used, specify the one used for RaspberryPi in **src/constants.py**

The data synthesis algorithm is built atop Pimoroni's BME68x, providing a direct interface to the sensor, the contents of which are included in this repository. We include the link to the original repository:

- <https://github.com/pimoroni/bme680-python>

The other software libraries required are listed in the requirements.txt file of the repository. Primarily it consists of Flask, Pandas, Scikitlearn, TsFresh, and Pytorch. To install the necessary packages on a new Raspberry Pi, run the following command in the terminal:

```
pip install -r requirements.txt
```

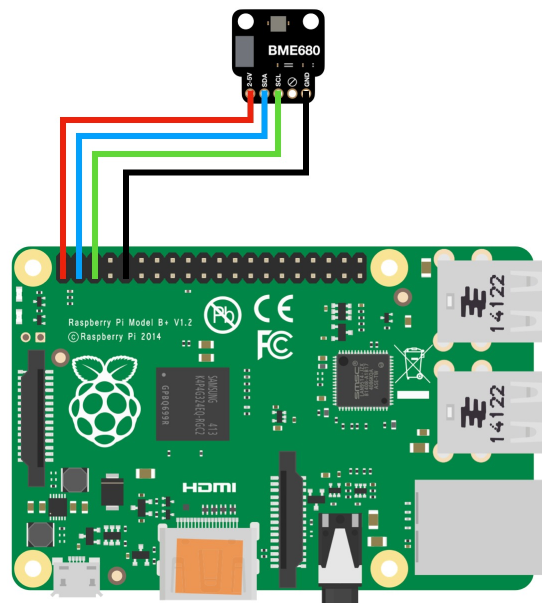
Or use the following command to update the packages:

```
pip install --upgrade package_name
```

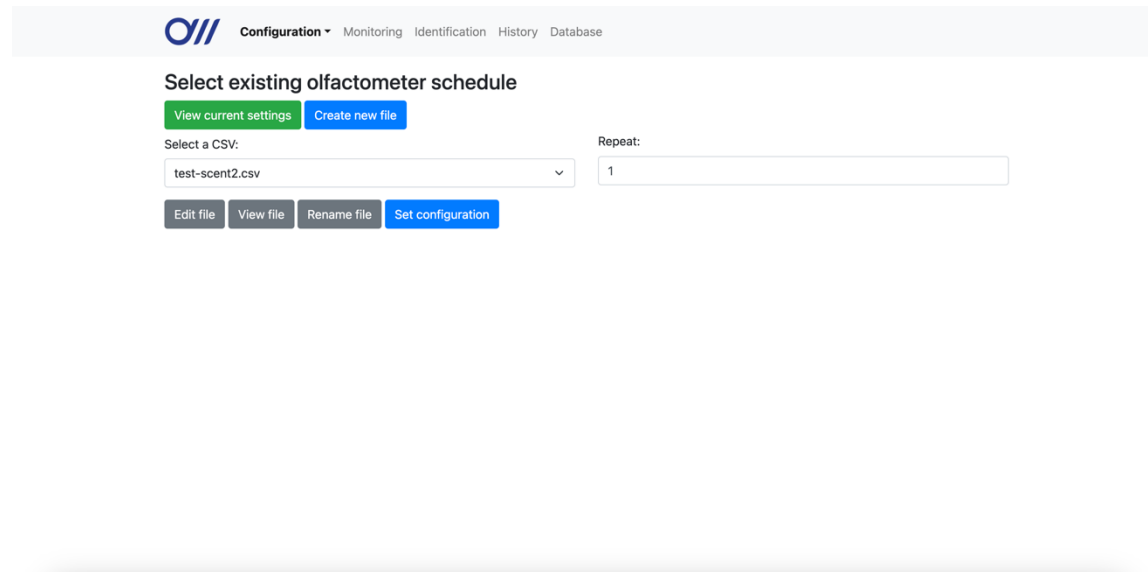
Set-up

To connect the olfactometer, connect it to the Raspberry Pi via USB, and write the port it is connected to in OLFAC_PORT in the file src > setUp > constants.py.

To connect the sensor, use pins shown in the diagram below:



After setting the fixed IP address for the machine, run `src > gui > app.py` to start the application. This sets up the user interface, which can be accessed through opening the web application using the fixed IP on any web browser.



User guide

Each page can be navigated to by clicking the respective links in the bar at the top of the application.

[Olfactometer configuration \(/config-olfac\)](/config-olfac)

This page controls the olfactometer's settings. The configuration is stored as a schedule in a CSV file containing the olfactometer channel number, scent ID and duration of emission in seconds for each emission in the schedule. Each line in the CSV file has the following format:

Channel_number|Scent_ID|Duration

Select existing olfactometer schedule

View current settings

Create new file

Select a CSV:

test-scent2.csv

Repeat:

1

Edit file

View file

Rename file

Set configuration

View current settings: Displays settings currently loaded on the olfactometer as shown below:

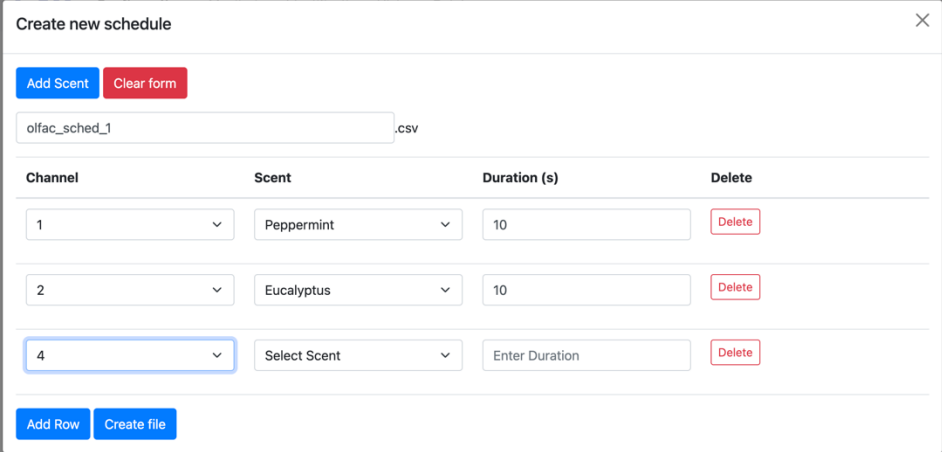
The screenshot shows a modal dialog box titled "Preview olfactometer settings" with a close button (X) in the top right corner. The dialog contains a table with the following data:

Channel	Scent ID	Duration
1	1	10
2	2	10
3	3	10
4	4	10
5	6	10

The background of the screenshot shows the "Select olfactometer schedule" interface with the "View current settings" button highlighted in green. The "Select a CSV:" dropdown is set to "test_run.csv".

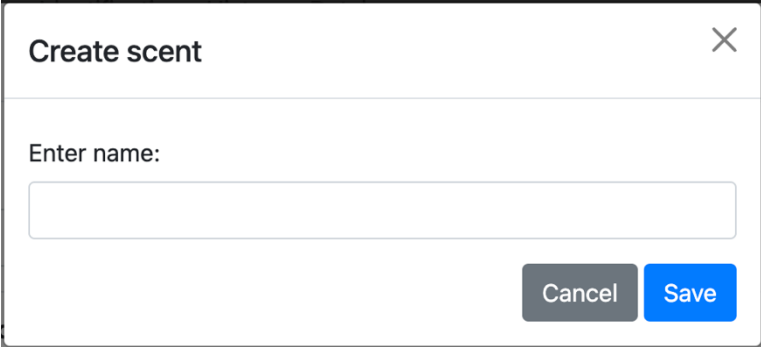
Create new file: Opens dialogue to create and save new olfactometer configuration file as shown below. Enter a file name and fill in the schedule, then click "Create file" button to save the new configuration. Click "Add row" button to add a new scent emission to the

schedule, and the “Delete” button to remove an emission from the schedule.



Channel	Scent	Duration (s)	Delete
1	Peppermint	10	Delete
2	Eucalyptus	10	Delete
4	Select Scent	Enter Duration	Delete

- Add scent: Opens popup to create a new scent by entering a desired name. The scent is added to the database, which can be viewed on the scents database page (more information below in scent database section).



- Clear form: Clears all fields in the table.
- Add row: Adds a new row to the schedule / profile table.
- Create file: Creates configuration file from information entered in table.

The user can select an existing configuration for the olfactometer, saved as CSV files, from the dropdown list. The user can also key in the number of times to repeat the selected schedule when running a session (default = 1).

Edit file: Opens a popup similar to the “Create file” popup, with the configuration from the currently selected file filled into the table automatically. Allows user to edit the configuration stored in the currently selected file.

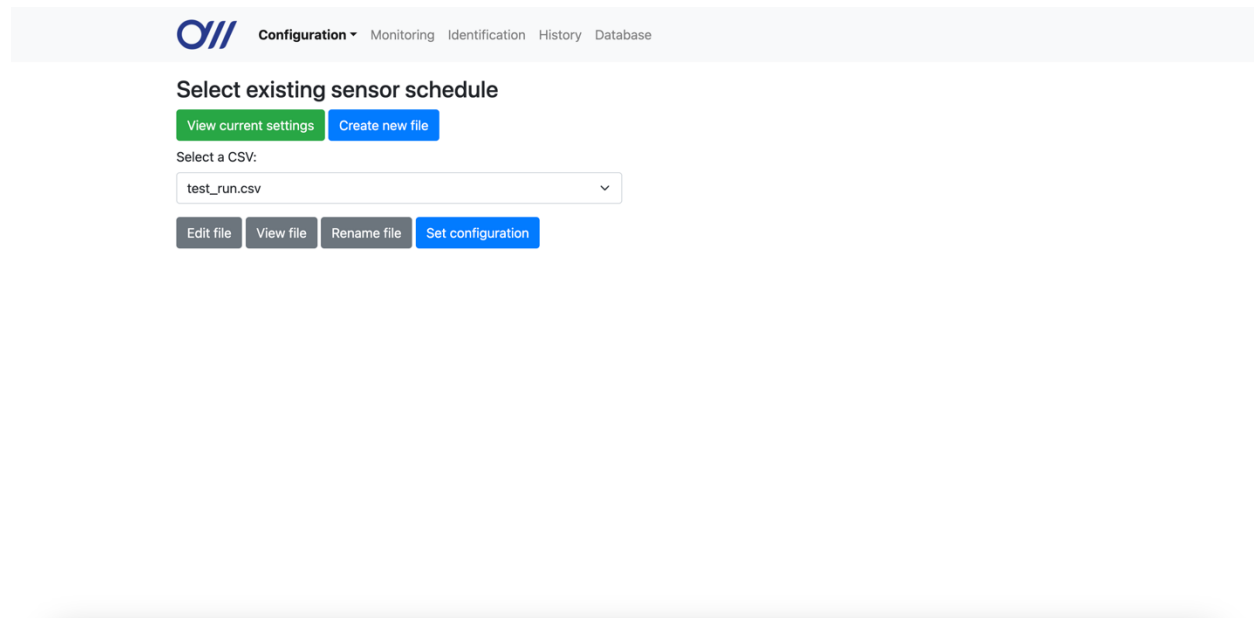
View file: Opens a popup displaying the contents of the file. Allows user to view the configuration stored in the currently selected file, laid out similarly to the to the popup for “View current settings”.

Rename file: Opens a popup to allow them to enter and submit the desired new file name to rename the file currently selected.

Sensor configuration (/config-sensor)

This page controls the gas sensor’s settings. The configuration is stored as a profile in a CSV file containing the heater temperature in degrees Celsius and heating duration in milliseconds for each temperature in the profile. Each line in the CSV file has the following format:

Heater_temperature|Heater_duration



This page functions similarly to the olfactometer configuration page but is connected to the gas sensor instead of the olfactometer. The file creation popup has the temperature and duration fields in place of the olfactometer schedule’s fields, as shown below:

Create new schedule
✕

Clear form

.csv

Temperature (°C)	Duration (ms)	Delete
100	100	Delete
150	100	Delete
250	Enter Duration	Delete

Add Row
Create file

Monitoring

This page allows the user to start and stop data collection, and view the data being collected.



The user can start and stop the data collection session using the button in the top right. The button changes from “Start” to “Stop” when a session is currently running, and vice versa when there is no active session.

When a session is running, the data (temperature, pressure, humidity and resistance) will be automatically displayed in the live graph as data is collected by the sensor. The user can choose which of the four values to plot by selecting it from the dropdown list.

Identification page (/identification)

This page allows the user to create, train and use machine learning (ML) models to identify gases.

ML Model

Select a model: model_dir

Edit name Download Add training

Date created: 2024-03-16 21:55:14

Classes: 1, 2, 3, 4

View relevant features

Search for CSV file:

Start date: dd/mm/yyyy, --:-- End date: dd/mm/yyyy, --:--

Identify a file: Enter valid date range above...

Identify

Training results

Classification report

precision	recall	f1-score	support
3	0.29	1.00	0.44
4	0.50	0.50	0.50
2	0.00	0.00	0.00
1	0.00	0.00	0.00

accuracy 0.33 18
macro avg 0.20 0.38 0.24 18
weighted avg 0.17 0.33 0.21 18

Confusion matrix

4	0	0
2	2	0
5	1	0
3	1	0

Training loss

1.65 Loss

Test accuracy

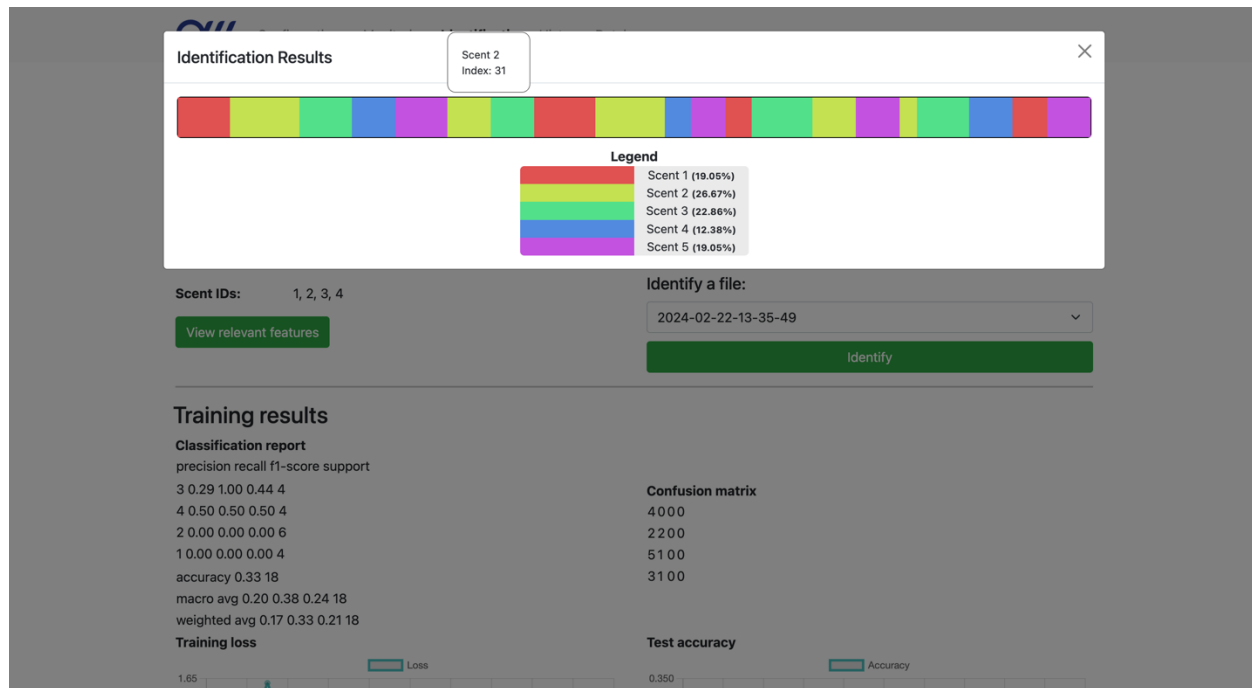
0.350 Accuracy

First, the user selects a model from the dropdown list. Once a model is selected, the model information, training results and identification fields will appear.

Information about the model is displayed on the left, along with the following buttons:

- Edit name: Opens a popup to enter and submit the desired new model name to rename the currently selected model.
- Download: Downloads the model files in a zipped file.
- Add training: Walks user through the steps for training a model. (More information below)
- View relevant features: Opens table displaying the filtered features relevance table of the model in a new tab.

To the right of the model information are fields for identifying a scent from a data file. Entering a range of dates using the “Start date” and “End date” fields automatically fills the dropdown list with any files found within that range. Selecting a file from the dropdown list and pressing the “Identify” button runs identification the selected file using the selected model. The results are displayed in a popup once identification finishes. Hovering over any segment of the displayed bar shows the identified scent and its index.



On pressing the “Add training” button, a popup appears to select between easy (one-click) training and advanced training. Once a training mode has been selected and the “Next” button is pressed, popups appear for each step of the training process.

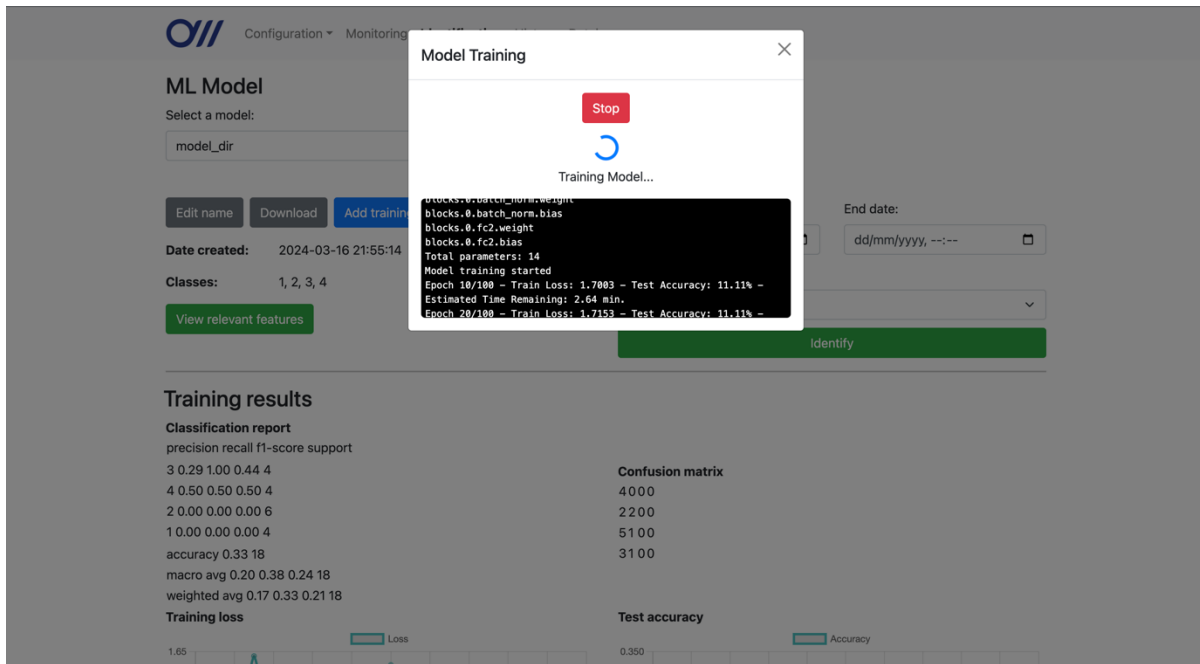
Easy training:

- Step 1: Select a file by searching with a range of dates
- Step 2: Loading screen with live update messages while the model is trained.

Advanced training:

- Features step 1: Specify a range of dates. All files within this range of dates will be used.
- Features step 2: Select between automatic and advanced feature selection
 - o Automatic: Moves to next step without any custom input values
 - o Advanced: Allows user to key in phrases to filter features by name (retain and discard strings) and n-significant value

- Model trainer step 1: Enter test size (float value between 0 and 1) for selecting relevant columns
- Model trainer step 2: Select between automatic and simple selection for setting block configuration
 - o Automatic: Moves to next step without any custom input values
 - o Simple: Allows user to key in number of blocks
- Model trainer steps 3-5: Loading screen with live update messages while the model is constructed, prepared and trained.



While training is running, pressing the “Stop” button in the popup immediately stops the training process.

Training results

Classification report

precision recall f1-score support

3 0.29 1.00 0.44 4

4 0.50 0.50 0.50 4

2 0.00 0.00 0.00 6

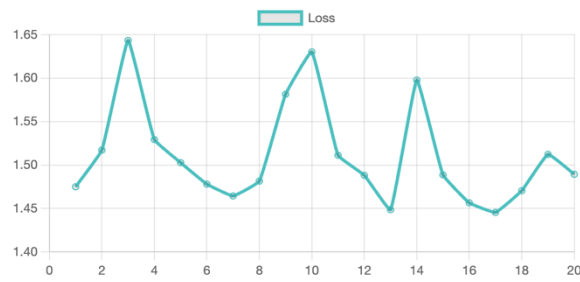
1 0.00 0.00 0.00 4

accuracy 0.33 18

macro avg 0.20 0.38 0.24 18

weighted avg 0.17 0.33 0.21 18

Training loss



Confusion matrix

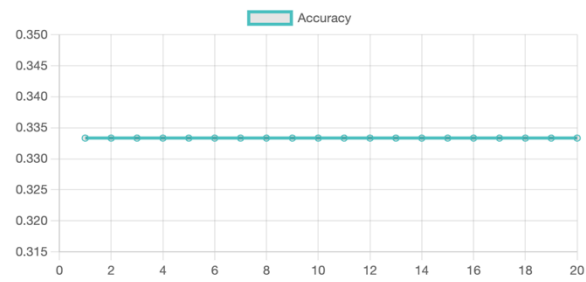
4 0 0

2 2 0 0

5 1 0 0

3 1 0 0

Test accuracy




Once training is completed, the classification report, confusion matrix, training loss graph and test accuracy graph are displayed at the bottom of the page. The user can zoom in and out of the graphs to view the data in closer detail.

ML Model

Select a model:

To create a new model, the user should select “Create new...” from the dropdown list. An input field appears for the user to key in a name for the new model. The user is then taken through the same steps to train the model. The new model is saved only after training is completed.

History (/history)

 Configuration ▾ Monitoring Identification **History** Database

Identification history

Last updated: 11:24, 19 Mar 2024

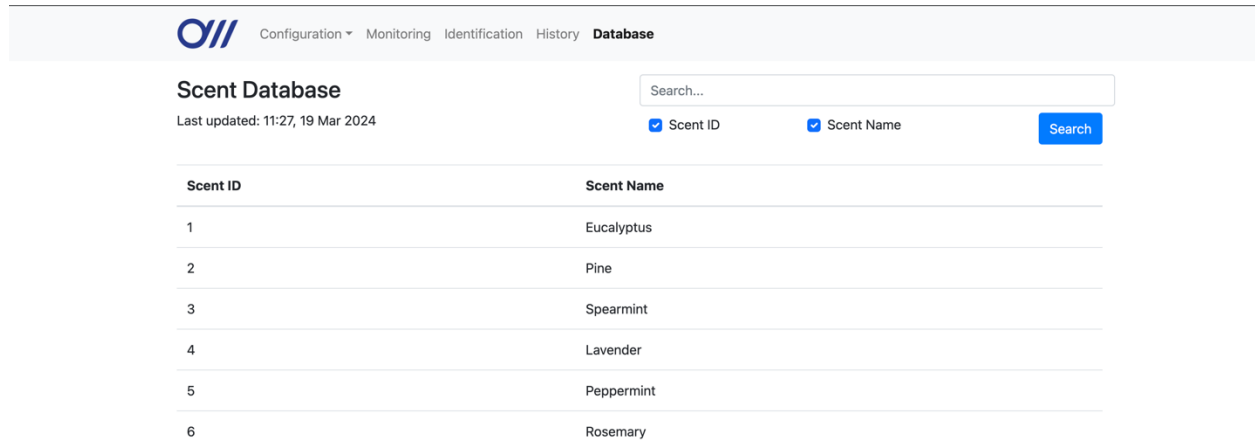
Start date: End date:

CSV Date Scent ID

CSV File	Results	Model Used	Date Identified
2024-02-22-13-35-49	<input type="button" value="Show Result"/>	1	2024-03-17-12-17-23
2024-03-01-11-17-20	<input type="button" value="Show Result"/>	2	2024-03-19-11-24-13

This page displays a history of files which the user has run identification on. Each record has the results, model used, and date identified for each file. On clicking “Show Result”, a pop-up is displayed showing the identification results, similar to the one on the identification page. In the top right, the user can search the identification history by file name (by specifying a range of dates) or by the name of the result. They can choose between the two options by clicking the buttons under the search fields. On pressing the “Search” button, the page is reloaded to display the results in the table.

Scent database (/scent-database)



The screenshot displays the 'Scent Database' interface. At the top, there is a navigation bar with a logo and menu items: Configuration, Monitoring, Identification, History, and Database. Below the navigation bar, the title 'Scent Database' is shown, along with a search bar and two checked checkboxes for 'Scent ID' and 'Scent Name'. A 'Search' button is located to the right of the checkboxes. Below the search area, a table lists six scents with their corresponding IDs and names.

Scent ID	Scent Name
1	Eucalyptus
2	Pine
3	Spearmint
4	Lavender
5	Peppermint
6	Rosemary

This page displays a database of all scents stored in the database, and their corresponding IDs. The user can search for a scent by the scent's ID, name, or both, using the search fields in the top right of the page. On pressing the "Search" button, the page is reloaded to display the results in the table.