Vespa Smart Trap – ONE

V2.4, 27-2-2026

Plug & Play – Vision AI detection of *Vespa velutina*

The Vespa Smart Trap is a development project to detect, catch and kill Asian or Yellow Legged Hornets (*Vespa velutina*) and comprises multiple build. This **first part** is a Plug & Play set **VST-ONE**. It is built with off-the-shelf *Seeed Grove* components. The set consist of a Vision AI detection system and is designed to facilitate easy-to-deploy. That means that there is no craftwork like soldering, programming or other engineering required.

The **VST-ONE** enables the recognition of *Vespa Velutina* (Asian hornet), *Vespa crabro* (European hornet) and *Apis mellifera* (honey bee). The user can choose from a variety of actuators to use in their own projects. This development comprises two main components:

- **Seeed Grove Visio AI V2** module with a **Raspberry Camera V1.3/V2.0**, running a **SenseCraft AI model** to recognise the insects species. This module is the heart of the recognition.
- **Seeeduino XIAO ESP32S3** microcomputer, running custom build software to drive actuators of your choice. This part makes it possible to develop your own actions upon recognition.

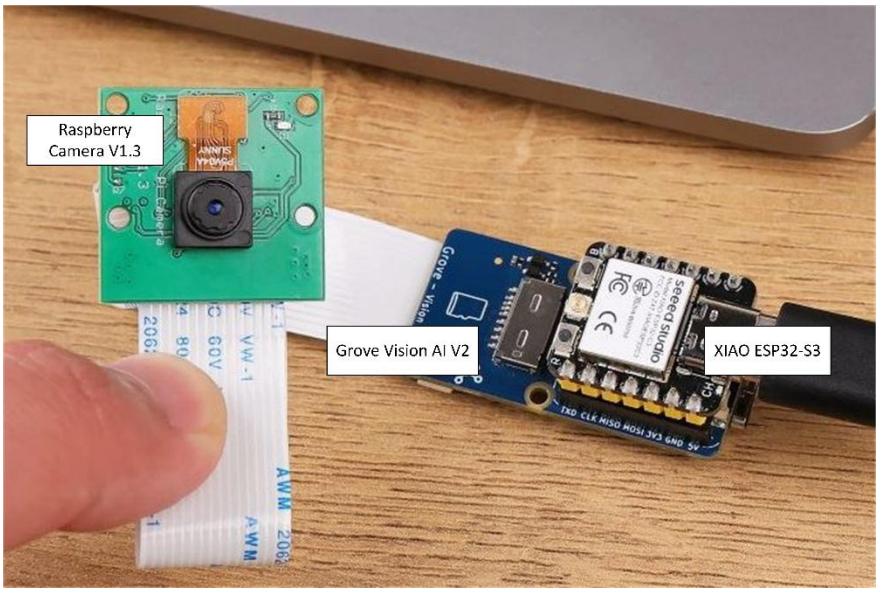


Figure 1. Principal components

Future developments

*The **Vespa Smart Trap (VST)** project will deliver in the future the **physical casing** for the entrapment, comprising a **VST-BASE** versions, extending the development with a **solar powered battery** and **LTE-M communications unit**, capable of sending **SMS** and **IoT messages** and photo uploads for continuous training of the model, and more… Components of this **VST-ONE** version will partially be reusable, like the Seeed Vision AI and Raspberry Camera as well as some actuator components of your choice.*

Bill of materials

The **VST-ONE** development is exclusively designed for these components:

	**Raspberry Camera V1.3** or **V2.0** module, equipped with OV5647 or IMX219 camera sensor *connects to the Seeed Grove Vision AI V2 with a provided flat cable*
	**Seeed Grove Vision AI V2**, a microcomputer highly optimized for image recognition *connects to XIAO-ESP32S3 via I2C on Grove shield for XIAO, requires a Grove cable*
	**XIAO-ESP32S3** microcomputer *plugged into the Grove Base (or Shield) for XIAO*
	**Grove Base (or Shield) for Seeduino XIAO** *connects Grove component via I2C or GPIO connectors, with Grove cables*
	**Grove female (HY2.0) cables**, for connecting the Grove components

Alternative for the **Grove Base (or Shield) for Seeduino XIAO:**

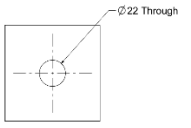
	**Seeeduino XIAO Expansion board**, for display of recognition information *connects Grove component via I2C or GPIO connectors, with Grove cables*

Depending on your project, you can add additional components at your choice, to perform actions upon recognition. The AI model caters for three classes of insects, making is possible to act on detection on one, two or three of the recognised species, according to your demands.

	**Grove Relais**, giving you a potential free NO/NC contact to switch ON/OFF other electrical appliances *connects to GPIO connectors of the Grove Base (or Shield) for XIAO*
	**Grove LED socket**, signals the recognition of a species by different colours *connects to GPIO connectors of the Grove Base (or Shield) for XIAO*

	**Grove Mini I2C Motor driver,** to drive stepper motor *connects to I2C connector of the Grove Base (or Shield) for XIAO*
	**28BYJ-48 Stepper Motor 5V** (runs well on 3,3 Volt too) *connects to Grove Mini I2C Motor driver, requires two cables with JST-PH 2.0 connectors*
	**JST-PH 2.0 cables**, to modify the stepper motor
	**Grove 6-DIP switch**, reserved for choosing presets for program code *connects to I2C connector of the Grove Base (or Shield) for XIAO*
	**Grove I2C hub**, if you need more component connected *connects to I2C connector of the Grove Base (or Shield) for XIAO,* *or is used as a single GPIO signal bus*
seeed studio	Any other **GPIO** or **I2C Grove component**, which may require custom programming on the XIAO microcomputer *connects to the appropriate Grove connectors on the Grove Base (or Shield) for XIAO or Grove I2C hub*

Useful in your build are:

	Grove wrapper, fixtures the Grove component, with 2 and 4 mm nuts & bolts
	Plexiglas base plate, with holes 2, 3 and 4 mm, drilled according to drilling plan
	Screwdriver
	Camera holder
	USB-C data cable, to connected your device for downloading the software

Experimental builds

Two use cases for the **VTS-ONE** development are shown below. The modular concept enables you to build your own project for your needs.

Experiment A, relay and LED

This picture shows an basic experimental build. The **Grove Vision AI module** is connected via a I2C connector from the **Grove Base or Shield for XIAO**. A relay and red LED are connected to a GPIO connector for pin D0, acting upon recognition of a *Vespa Velutina*. In this example both actuators are connected to the same GPIO and the I2C hub is therefore used as a single GPIO signal bus.

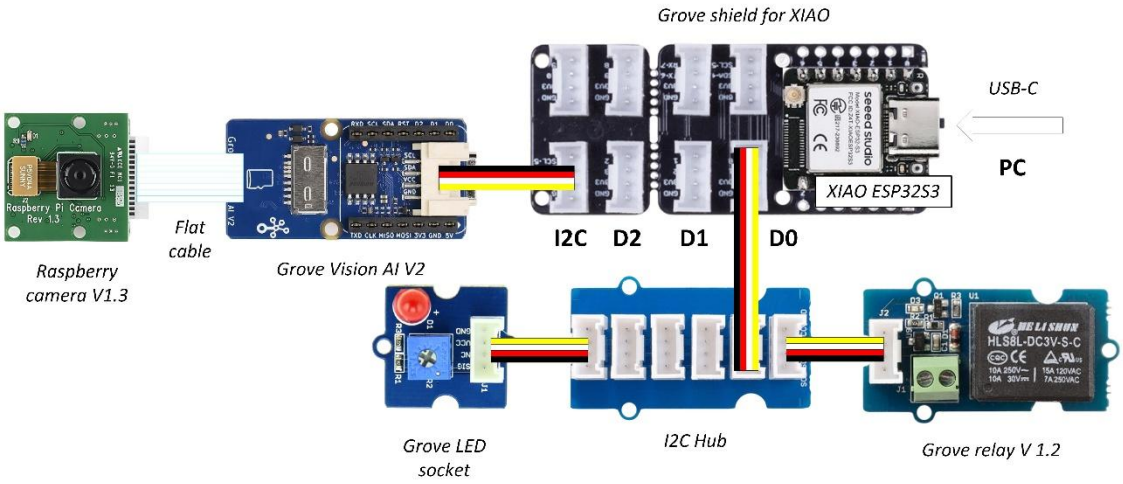


Figure 2. Setup Experiment A – with LED and Relay

The relay can be used to switch other electrical components upon recognition. The LED can be used to signal the recognition of the *Vespa velutina* (both now on D0). If you choose for another Grove GPIO connector, actions occur on recognition of the *Vespula sp.* (D2) or *Vespa crabro* (D1).

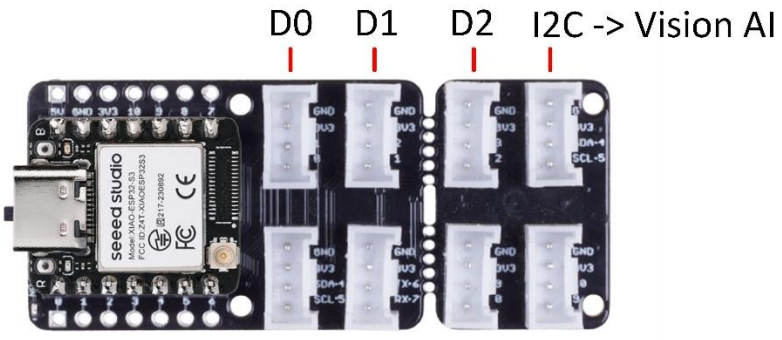


Figure 3. Wiring Experiment A of the Grove Base (or Shield) for XIAO

Experiment B, stepper motor and LED

Another experiment aims the use of I2C communication between Grove components. The I2C Hub is used to connect the **Grove Mini I2C Motor driver**, driving a **24BYJ-48 Stepper Motor**. This picture shows a setup with the alternate **XIAO Expansion Board with OLED display** and a **6-DIP switch module** to select presets for the Stepper Motor rotation angle, direction and cycle duration (see table). It has also one **Grove LED** actuator on the GPIO connector for D0.

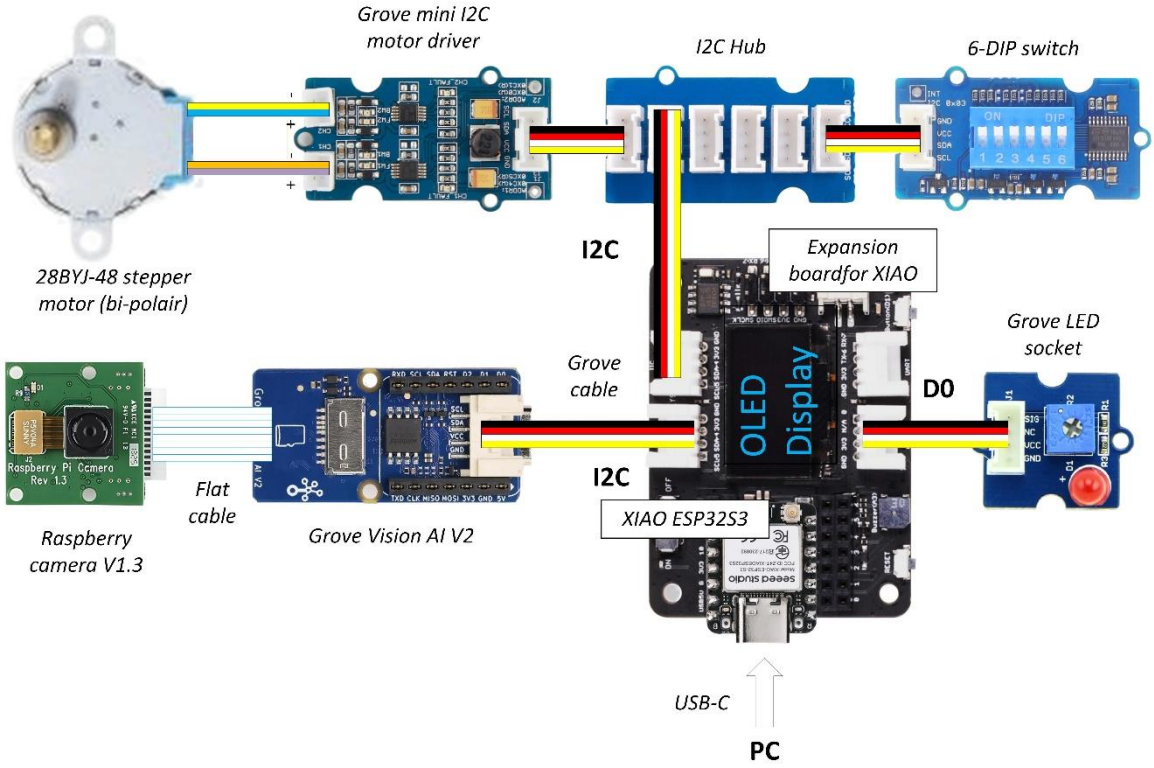


Figure 4. Setup Experiment B – with LED and stepper motor

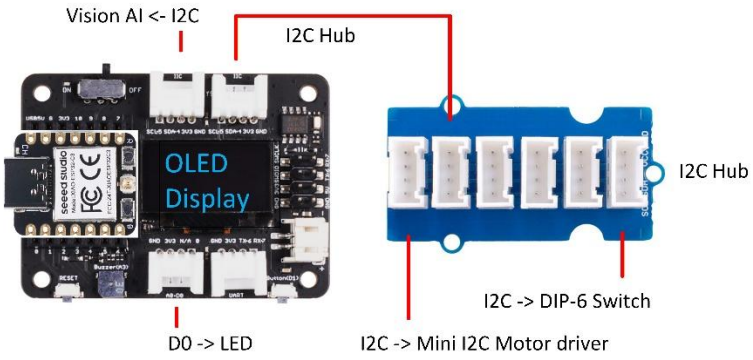


Figure 5. Wiring Experiment B

Stepper motor wiring

The **28BYJ-48 Stepper Motor** is shipped as an unipolair motor, equipped with 5 wires. In this **VST-ONE** development this device is used as a bipolair stepper motor, with two individual coils. In order to connect them to the **Mini I2C Motor driver**, the original 5 pin connecter must be replaced with two small JST-PH 2.0 connectors, like this:

Motor wire	Coil/Winding	Connector	Colour
Orange	A	Connector 1 (CH1)	Black
Pink	A	Connector 1 (CH1)	Red
Yellow	B	Connector 2 (CH2)	Black
Blue	B	Connector 2 (CH2)	Red
Red	red motor wire is **not** used		

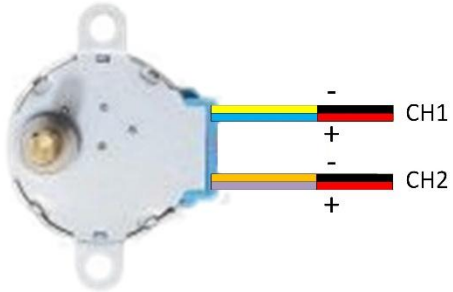


Figure 6. Motor wiring

DIP switch table

The rotation angle, direction and cycle time of the stepper motor can be chosen from preset values according to this table, depending on the DIP-switch settings:

1	2	3	4	5	6	Behaviour
OFF	OFF					Only counter-clockwise(reverse) rotation
ON	OFF					Only clockwise (forward) rotation
OFF	ON					First counter-clockwise(reverse), then clockwise (forward)
ON	ON					First clockwise (forward), then counter-clockwise(reverse)*
		OFF	OFF			Rotate 90 degrees
		ON	OFF			Rotate 180 degrees
		OFF	ON			Rotate 360 degrees
		ON	ON			Rotate 720 degrees*
				OFF	OFF	0 seconds wait between forward/reverse
				ON	OFF	6 seconds wait between forward/reverse
				OFF	ON	30 seconds wait between forward/reverse
				ON	ON	60 seconds wait between forward/reverse*

Without 6-DIP switch module, the stepper motor will use default as if all switches are ON. One cycle consist of:

- First clockwise (forward) 720 degrees rotation
- Pause of 60 seconds
- Then counter-clockwise(reverse) 720 degrees rotation

Motor speed

The 28BYJ-48 is a geared stepper motor, and the total steps per full rotation depend on the motor steps × gearbox ratio of 64:1. Rotation speed is set to 400 steps/s for maximum torque. One full shaft revolution takes therefore 6 seconds.

Deployment of firmware

For the **VST-ONE** development there are 2 parts of firmware available:

- **Vision AI module**, firmware an AI Model for recognition
- **XIAO ESP32S3**. firmware for driving actuators (all-in-one)

Vision AI module

The **Vision AI module** uses the camera to analyse images and compares them to a trained AI model, predicting the insect species with a 4 *classes* for *Vespa velutina (3)*, *Vespula vulgaris and Vespula germanica (2), Vespa crabro (1)* or *Apis mellifera (0) and unknown (NULL)*. The prediction of the classes (*inference*) will be presented in the viewer and communicated to the **XIAO ESP32S3 module** for further processing.

To deploy the firmware, containing the AI model, please follow the instructions:

1. Attach the **Raspberry Camera V1.3** or **2.0** to the **Vision AI module** (see Figure 1. Principal components)
2. Plug the **Vision AI module** in your computer, using an USB-C data cable
3. Surf to https://sensecraft.seeed.cc/ai/model (account creation is not required)
4. Search for a model ***Vespa velutina detection***, select and click **deploy model**
5. Click **Connect Device** and **Confirm**
6. Choose the available COM port and click **Connect.**
7. The model will be deployed immediately. Wait a couple of minutes.
8. After a while you should see camera images. **Do not alter any settings**.

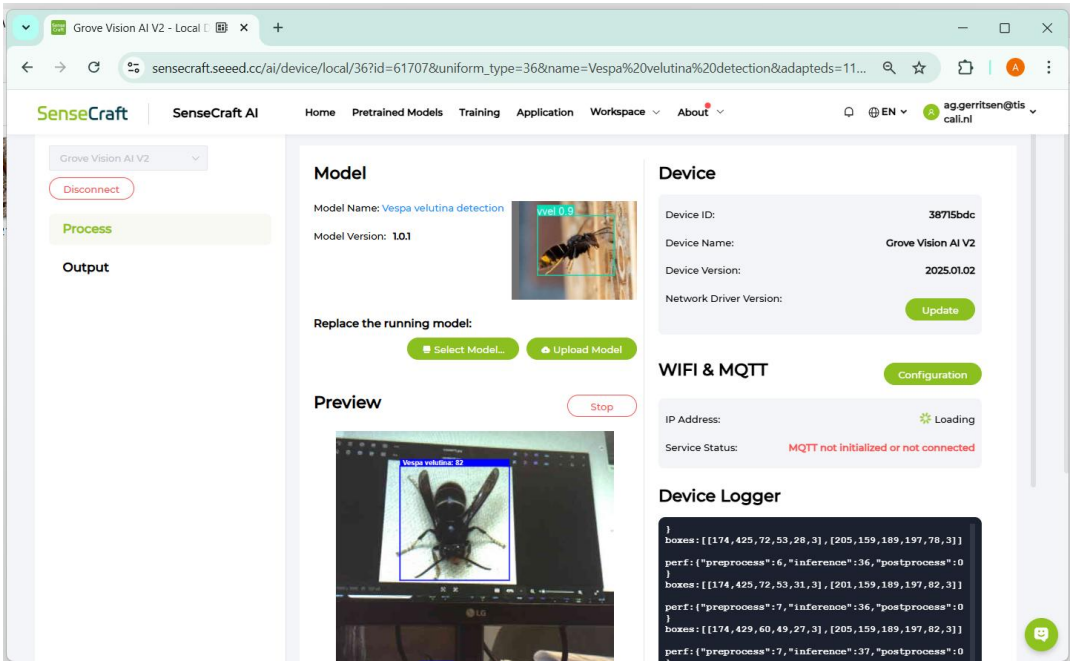


Figure 7. Sensecraft AI website

9. **Testing:** after the flash upload succeeded, point the camera to a picture of a *Vespa velutina*. You now should see image recognition and confidence levels (you can use sample images in the **ZIP download** from the next **XIAO ESP32S3** section).
10. After testing, unplug the USB-C cable for the **Vision AI module**, but keep the camera connected. Your Vision AI module is now ready to use.

XIAO ESP32S3

The **XIAO ESP32S3 module** will drive the actuators in your project. It reads the recognition information form the **Vision AI module**, interprets it and drives predefined actuators like relays, LEDs or motors.

1. Plug the **XIAO EPS32S3 module** in your computer, using an USB-C data cable
2. Download the ZIP file from: https://github.com/aggerritsen/VespaSmartTrap-ONE/
3. Surf to https://espressif.github.io/esptool-js/
4. Click **Connect** and choose the available COM port (Optional click **Erase Flash**)
5. Fill out the correct **Flash Address** and select the downloaded files using **Choose File,** click **Add program** to complete all files form this list:

Flash Address	Program files
0x00000000	bootloader.bin
0x00008000	partitions.bin
0x00010000	firmware.bin

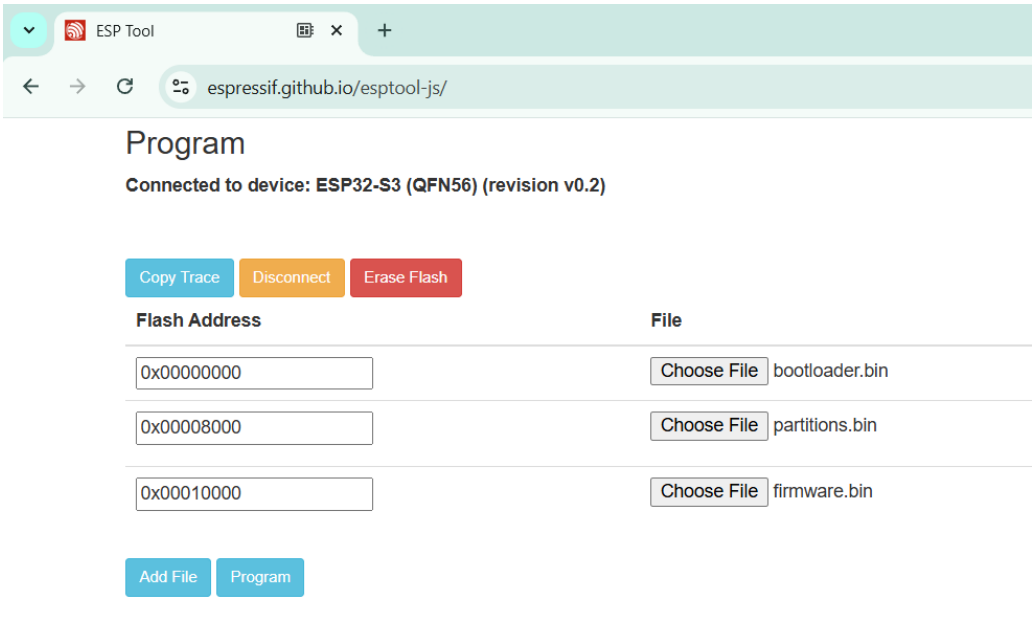


Figure 8. ESP tool website

6. Click **Program** to upload the files, wait a few moment to complete
7. Click **Disconnect** and unplug the **XIAO ESP32S3 module** form your computer. Your XIAO ESP32S3 module is now ready to use.

Testing

To validate that your component are ready for use, perform the following test:

1. Make sure the USB-C cable from your **Vision AI module** is disconnected, keep the camera connected
2. Make sure the USB-C cable from your **XIAO ESP32S3 module** is disconnected
3. Place the **XIAO ESP32S3 module** in the **Seeed Studio Grove Base (or Shield) for XIAO** (see Figure 3. Wiring Experiment A) or the **XIAO Expansion Board** (Figure 5. Wiring Experiment B)
4. Connect your **Vision AI module** to the XIAO ESP32S3 module via the Grove Shield or Grove Expansion box, using a Grove cable.
5. Connect at least 1 **Grove LED** to your GPIO connector D0 with a Grove cable. You can also connect other LEDs to GPIO connectors D1 and D2, but not required.
6. Connect your **XIAO ESP32S3 module** with a USB-C connector to your computer. All other components will be powered through the XIAO ESP32S3 module.
7. If you have a stepper motor, connect the **Grove I2C Mini Motor Driver** and **Stepper Motor** in bipolair mode.
8. You can also connect the **Grove 6-DIP Switch** module to determine motor cycle behaviour. Without the switches a connected motor we use default settings.
9. At start (boot) you will see the LED blinking once for 2 seconds when the XIAO ESP32S3 start. If you have more LEDs on D1 and D2, You will see them blink once, one after another.
10. If you have a Stepper Motor, at start (boot) you will see a full rotation in forward and reverse mode 400 steps/s as defined by the **Grove 6-DIP Switch** settings.
11. If you use the **XIAO Expansion Board** with OLED display, you will see the message *Boot test* during the LED and Stepper Motor test.
12. Point the camera of the **Vision AI module** to an image of an insect:
    a. When you point the camera at an image of a *Vespa velutina*, the D0-led will blink for 1 seconds (*class 3*).
    b. When you point the camera at an image of a *Vespa vulgaris or Vespa Germanica (*aka *Vespula species)*, the D1-LED will blink for 1 seconds *(class 2)*.
    c. When you point the camera at an image of a *Vespa crabro*, the D2-LED will blink for 1 seconds *(class 1)*.
    d. If you do the same with an image of an *Apis mellifera* or any other insect, no LED will blink.
13. If you have a XIAO expansion board with an OLED display, you will see the class, name of the species and the confidence level of the recognition.

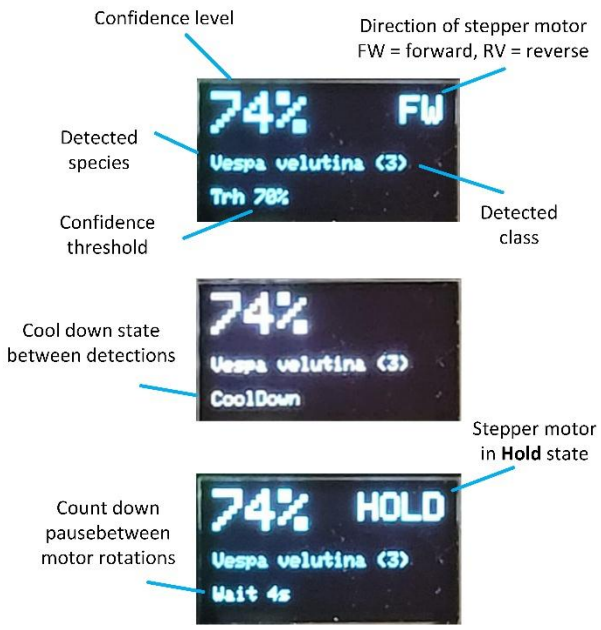


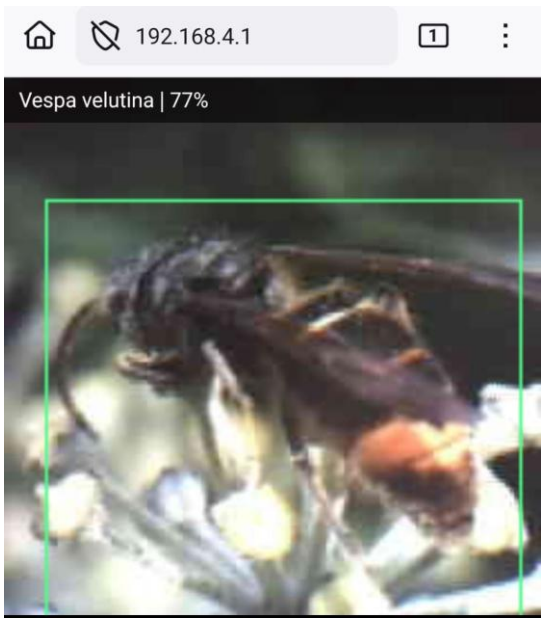
Figure 9. OLED display on XIAO Expansion board

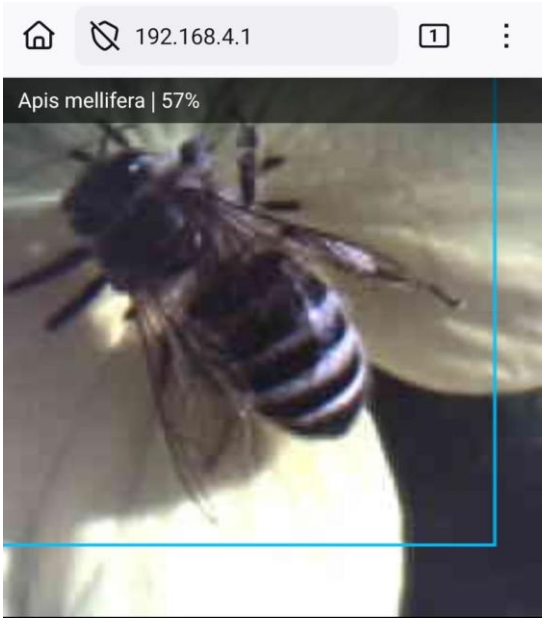
Browser viewer

The image that is captured and analysed can be viewed using a web brower.

1. Connect to the WiFi of the XIAO ESP32S3 with a computer or mobile. Search for an open access point named **VST-ONE-xxxxx** (no password required).
2. Surf to http://192.168.4.1 and follow the inference results, with detected species, confidence level and the detection box.

You can use this to test the device. Note that only images are sent when a positive detection occurs, regardless the confidence threshold.





Support

This development makes part of the Vespa Smart Trap project, conducted by volunteer product of beekeepers and technology partners under de responsibility of **Imkersvereniging Leiden en omstreken** . This project is funded by **WWW-INNO fund**, **Rabobank regio Leiden/Katwijk** and a crowdfunding on **WhyDonate**. Support is available on '*best effort*' upon request via email: ah-val@imkersleiden.nl

Tech talk for experts

The detection is based on Artificial Intelligence, existing of a tiny Yolo Machine Learning model. The model runs autonomous on the modules, without the need of an internet connection. This development runs only on a Seeed Grove Vision AI V2 module using standard firmware from SenseCraft AI. It communicates over I2C protocol to a XIAO-ESP32S3 Micro Compute Unit. Both MCU's use Arduino based software, catering for the use of SSCMA library of SenseCraft and ESP-S3 libraries of Espressif.

The Grove Base/Shield offers a UART connector, four hard wired GPIO pins and two I2C connectors. The expansion board offer a UART, two I2C and one hard wired GPIO pin. These all can be used to connect the optional modules as well as provide the communication in the **VST-BASE** version for LTE-M (SMS/Web), GPS positioning. The 6-DIP switch provides for a series preset actions, like the angle and direction of the rotation of the stepper motor and pulse time for LED's and relays.

For expert programmers, more options are available, like:

- Programmable hard wired GPIO ports 0,1,2 and 3;
- I2C ports, allowing expert programmers to connect to any I2C hub or device at choice;
- UART communication from the XIAO ESP32S3 to other systems.

Source are available at https://github.com/aggerritsen/VespaSmartTrap-ONE/ Future developments may comprise more features upon request, as long as basic functionality can be guaranteed. Send your request to ah-val@imkersleiden.nl

License

Warrenty and liability

Shopping list

Required materials

Number	Name	URL	Unit Price
1	Raspberry Camera V1.3 or V2.0	https://www.tinytronics.nl/nl/sensoren/optisch/camera's-en-scanners/raspberry-pi-compatible-camera-5mp-v1.3 https://www.kiwi-electronics.com/nl/raspberry-pi-camera-module-2-8mp-2359	€ 8,00 € 17.00
1	Grove Vision AI V2	https://www.kiwi-electronics.com/nl/grove-vision-ai-module-v2-20039	€ 18,74
1	XIAO-EPS32-S3	https://www.kiwi-electronics.com/nl/seeed-studio-xiao-esp32s3-voorgesoldeerd-20408	€ 9,50
1	Grove shield for XIAO	https://www.kiwi-electronics.com/nl/grove-shield-voor-seeeduino-xiao-met-accu-management-10097	€ 5,07
1	Grove cable 10 or 20 cm (5 pack)	https://www.tinytronics.nl/nl/kabels-en-connectoren/kabels-en-adapters/grove-compatible/grove-female-compatible-kabel-0.2mm2-4p-10cm https://www.kiwi-electronics.com/nl/grove-universal-4-pin-unbuckled-20cm-cable-5-pack-1888	€ 4,--
Total			**€ 42,54**

Optional materials

Number	Name	URL	Unit Price
1	Seeduino XIAO expansion board	https://www.kiwi-electronics.com/en/seeeduino-xiao-expansion-board-10358	€ 17,53
1…3	Grove Relay V1.3	https://www.kiwi-electronics.com/nl/grove-relais-1896	€ 3,13
1…3	Grove LED Socket R/G/B/Y (LED uitwisselbaar)	https://www.kiwi-electronics.com/nl/grove-led-groen-5mm-241 https://www.kiwi-electronics.com/nl/grove-led-rood-5mm-2746 https://www.kiwi-electronics.com/nl/grove-led-blauw-5mm-2392	€ 2,29
1	Grove Mini I2C motor driver	https://www.kiwi-electronics.com/nl/grove-i2c-mini-motor-driver-2378	€ 13,06
1	Grove 6-DIP switch	https://www.kiwi-electronics.com/nl/grove-6-position-dip-switch-20587	€ 5,45
1	Grove I2C hub	https://www.kiwi-electronics.com/nl/grove-i2c-hub-6-port-9908	€ 1,92
1…6	Grove cables	https://www.tinytronics.nl/nl/kabels-en-connectoren/kabels-en-adapters/grove-compatible/grove-female-compatible-kabel-0.2mm2-4p-10cm	€ 0,80
1	Mini camera holder	https://www.amazon.nl/dp/B0D5XY52SG	€5.57 (3x)
1	Grove wrapper 1x1	https://www.kiwi-electronics.com/nl/grove-yellow-wrapper-1x1-4-pack-2408	€ 2,53
1…2	Grove wrapper 1x2	https://www.kiwi-electronics.com/nl/grove-yellow-wrapper-1x2-4-pack-2235	€ 2,53
2	Kabel voor motor	https://www.kiwi-electronics.com/nl/jst-ph-2-0-kabeltje-10cm-1069	€ 1,80
1	28BYJ-48 bi-polaire stepper motor	https://www.tinytronics.nl/nl/mechanica-en-actuatoren/motoren/stappenmotoren/stappen-motor-met-uln2003-motoraansturing	€ 4,50