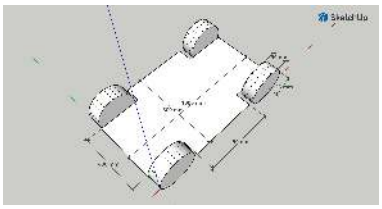
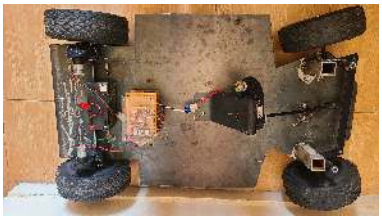
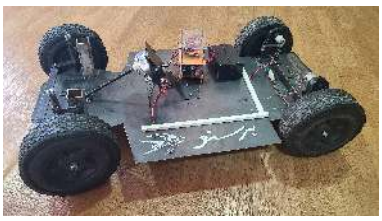
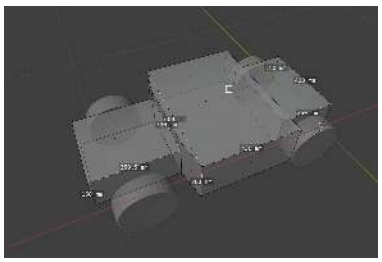
swallow

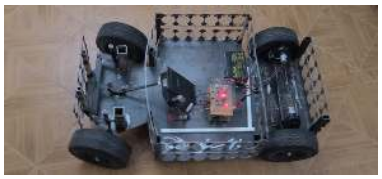
`swallow` is a family of UGVs named after the Iranian film “The Swallows Return to Their Nest” (پرستوها به لانه برمی‌گردند) from the 1940s (wikipedia), (irmdb), (pictures), (pictures). arzhang and rangin belong to this family.

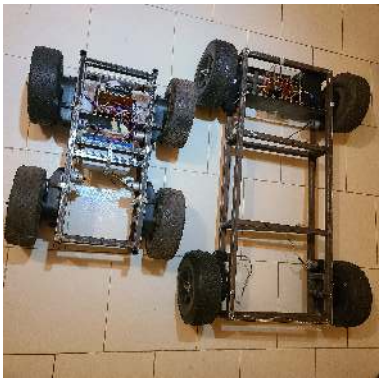
- analog control
- digital control

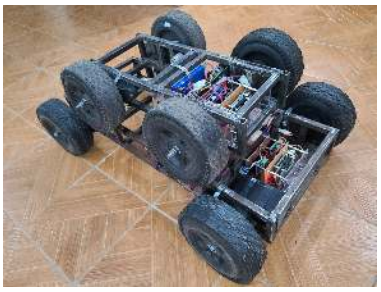



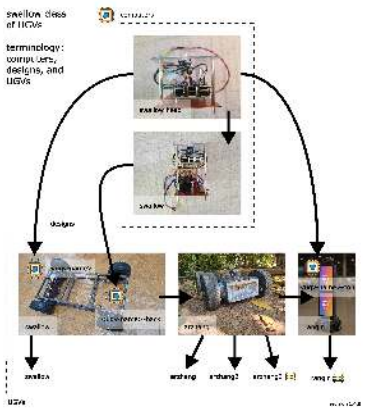



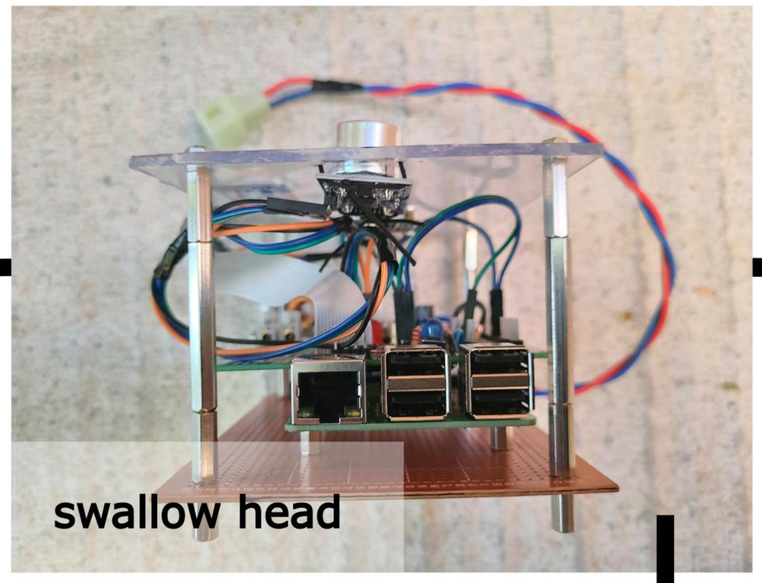


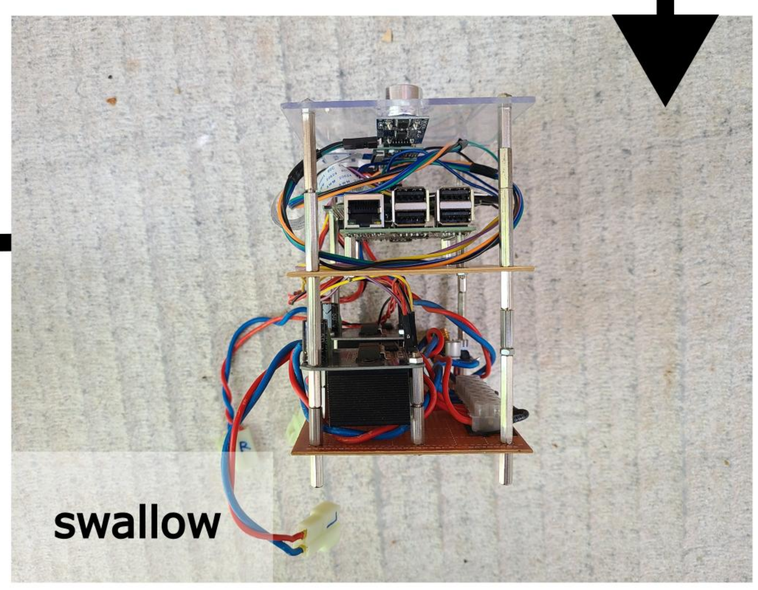

terminology:
computers,
designs, and
UGVs

swallow class of UGVs

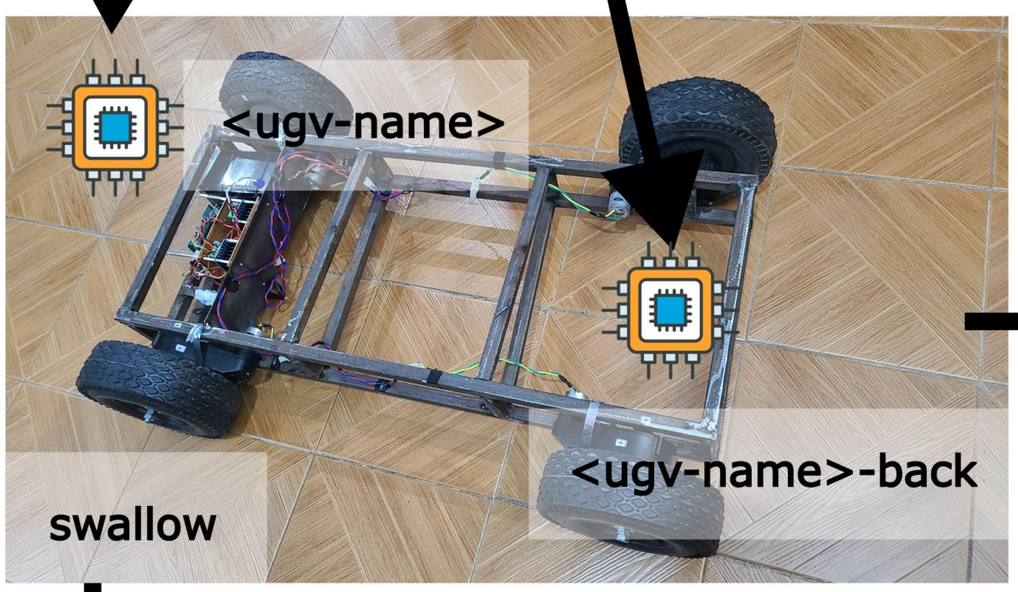
terminology: computers, designs, and UGVs

computers





designs



UGVs

swallow

arzhang

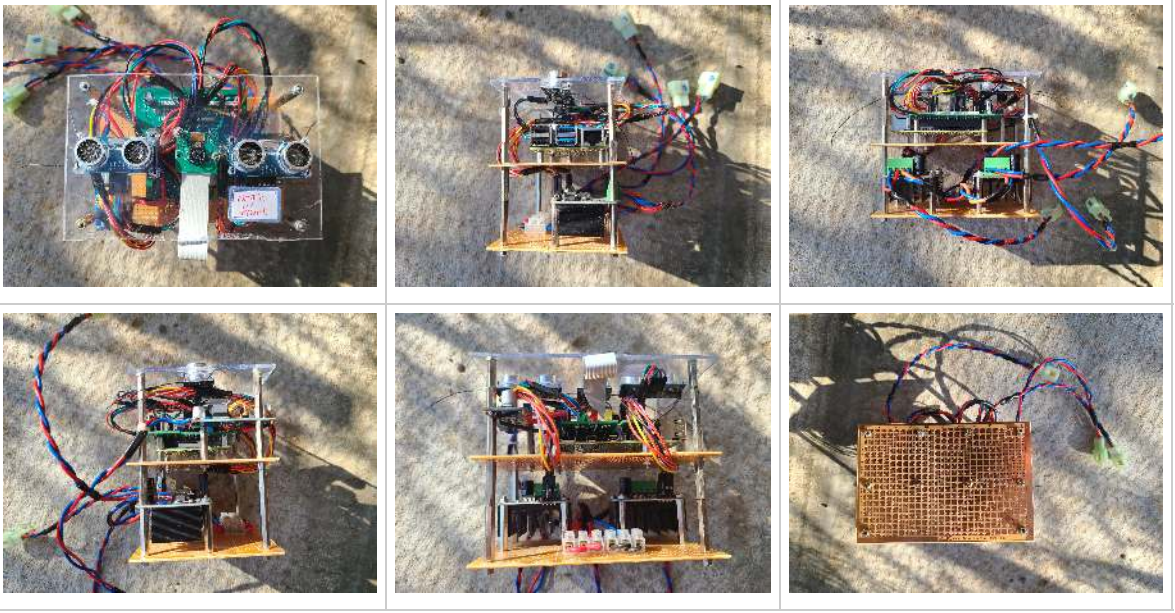
arzhang2

arzhang3

rangin

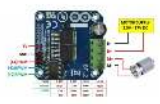
swallow

- minimum hardware for UGV control.
- Raspberry Pi, 5 MP camera, 2+2 ultrasonic sensors, 2 x 12 VDC 43A DC motor drivers.
- width x height x length: 140 mm x 95 mm x 130 mm
- terraform.
- previous versions: v1, v2, v3, v4, v5.



parts

swallow-head + ⬇️

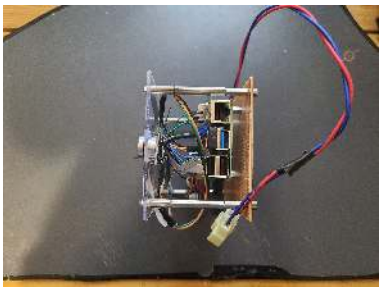
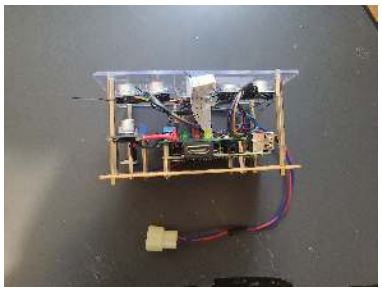
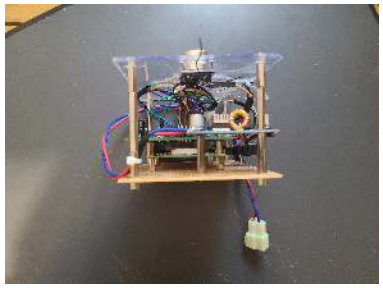
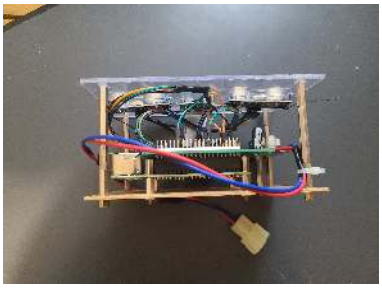
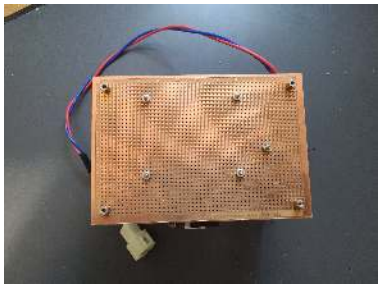
43 A, H-Bridge Motor Driver	auto power connectors	nuts, bolts, and spacers	single-sided PCB, 14 cm x 9.5 cm	solid cable 1-1.5 mm^2	white terminal
					
2 x	2 females	M3: (4 x nut + 8 x 25 mm spacer + 4 x 30 mm spacer)		20 cm x (red + black/blue)	8 x

1. 43 A, H-Bridge Motor Driver: 2 x.
2. auto power connectors: 2 females.

3. nuts, bolts, and spacers: M3: (4 x nut + 8 x 25 mm spacer + 4 x 30 mm spacer).
4. single-sided PCB, 14 cm x 9.5 cm.
5. solid cable 1-1.5 mm^2: 20 cm x (red + black/blue).
6. white terminal: 8 x.

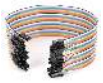
swallow-head

- head of swallow computer, without the DC motor drivers.
- width x height x length: 140 mm x 95 mm x 75 mm
- used for swallow design backs and rangin tops.
- previous versions: v1.

parts

16 AWG wire  40 cm x (red + black/blue)	HC-SR04: ultrasonic-sensor  4 x	LED, ~2 V forward voltage, 10-20 mA  green + red + yellow + 4 x blue	Polyfuse, 1.1 A hold, 2.2 A trip, 16 V, resettable, through-hole, e.g., MF-R110  optional	Raspberry Pi Camera, V1.3https://www.raspberrypi.com/documentation/accessories/camera.html 	Raspberry Pi. 	Resistor, 1/4 watt, 5% tolerance  7 x 330-470 Ω + 4 x 2.2 kΩ + 4 x 3.3 kΩ	SD card, 32 GB 	TVS diode, unidirectional, 600 W, 6.8 V clamp, e.g. P6KE6.8A, DO-15 package 	XL4015: 8 - 36 VDC -> 1.25 - 32 VDC, 5A 

auto power connectors	capacitor, 470 µF to 1000 µF, 16 V or 25 V, Electrolytic, 105 °C rated if possible.	dupont cables, female to female	green terminal	nuts, bolts, and spacers	pin headers	plexiglass, 2 mm or 2.5 mm thickness	push button	single-sided PCB, 14 cm x 9.5 cm	solid cable 1-1.5 mm^2
 1 female		 1 x 30 cm + 1 x 10 cm	 2 x	 M2: (2 x bolt + 4 x nut + 2 x 5 mm spacer) + M2.5: (4 x bolt + 4 x nut + 8 x 10 mm spacer) + M3: (1 x bolt + 5 x nut + 5 x 25 mm spacer + 8 x 15 mm spacer + 4 x 5 mm spacer)	 1 x (female, 2 x 40) -> 2 x 20 + 2 x (male, 1 x 40) -> 4 x 1 + 2 x 20 + 1 x (male, 2 x 40) -> 2 x 2 x 6	14 cm x 9.5 cm			 10 cm x (red + black/blue)
strong thread  1 m									

1. 16 AWG wire: 40 cm x (red + black/blue).
2. HC-SR04: ultrasonic-sensor: 4 x.
3. LED, ~2 V forward voltage, 10-20 mA: green + red + yellow + 4 x blue.
4. Polyfuse, 1.1 A hold, 2.2 A trip, 16 V, resettable, through-hole, e.g., MF-R110: optional.
5. Raspberry Pi Camera, V1.3https://www.raspberrypi.com/documentation/accessories/camera.html.
6. Raspberry Pi..

7. Resistor, 1/4 watt, 5% tolerance: 7 x 330-470 Ω + 4 x 2.2 kΩ + 4 x 3.3 kΩ.
8. SD card, 32 GB.
9. TVS diode, unidirectional, 600 W, 6.8 V clamp, e.g. P6KE6.8A, DO-15 package.
10. XL4015: 8 - 36 VDC -> 1.25 - 32 VDC, 5A.
11. auto power connectors: 1 female.
12. capacitor, 470 µF to 1000 µF, 16 V or 25 V, Electrolytic, 105 °C rated if possible..
13. dupont cables, female to female: 1 x 30 cm + 1 x 10 cm.
14. green terminal: 2 x.
15. nuts, bolts, and spacers: M2: (2 x bolt + 4 x nut + 2 x 5 mm spacer) + M2.5: (4 x bolt + 4 x nut + 8 x 10 mm spacer) + M3: (1 x bolt + 5 x nut + 5 x 25 mm spacer + 8 x 15 mm spacer + 4 x 5 mm spacer).
16. pin headers: 1 x (female, 2 x 40) -> 2 x 20 + 2 x (male, 1 x 40) -> 4 x 1 + 2 x 20 + 1 x (male, 2 x 40) -> 2 x 2 x 6.
17. plexiglass, 2 mm or 2.5 mm thickness: 14 cm x 9.5 cm.
18. push button.
19. single-sided PCB, 14 cm x 9.5 cm.
20. solid cable 1-1.5 mm^2: 10 cm x (red + black/blue).
21. strong thread: 1 m.

aliases: swallow

dataset

```
@swallow \
    dataset \
    combine \
    [count=<count>,~download,~recent,sequence=<3>,~split,upload] \
    [-|<object-name>] \
    [--datasets <object-name-1>+<object-name-2>] \
    [--test_ratio 0.1] \
    [--train_ratio 0.8]
 . combine swallow datasets.
@swallow \
    dataset \
    download \
    [~metadata,navigation|yolo]
 . download the swallow dataset.
@swallow \
    dataset \
    edit \
    [~download,navigation|yolo]
 . edit the swallow dataset.
@swallow \
    dataset \
    list \
    [~download,navigation|yolo]
 . list the swallow dataset.
@swallow \
    dataset \
    upload \
    [~metadata,navigation|yolo]
 . upload the swallow dataset.
```

debug

```
@swallow \
    debug \
    [~upload] \
    [-|<object-name>] \
    [--generate_gif 0] \
    [--save_images 0]
 . debug swallow.
```

env

```
@swallow \
    env \
    cp \
    [<env-name>]
 . cp swallow swallow-raspbian-<env-name>.env.
@swallow \
    env \
    list
```

```
 . list swallow envs.
@swallow \
    env \
    set \
    bps | full_keyboard | steering \
    0 | 1
 . set env.
   bps: BLUER_SBC_SWALLOW_HAS_BPS (currently: 0)
   full_keyboard: BLUER_SBC_SWALLOW_HAS_FULL_KEYBOARD (currently: 0)
   steering: BLUER_SBC_SWALLOW_HAS_STEERING (currently: 1)
```

keyboard

```
@swallow \
    keyboard \
    test \
    [dryrun] \
    [--keys 1234567890-+/.]
 . test keyboard.
```

select-target

```
@swallow \
    select_target \
    [--host <hostname>] \
    [--loop 0]
 . select swallow target.
```

ultrasonic-sensor

```
@swallow \
    ultrasonic \
    review \
    [~download,upload] \
    [.|<object-name>] \
    [--frame_count <-1>] \
    [--gif 0] \
    [--rm_blank 0]
 . review ultrasonic sensor data.
@swallow \
    ultrasonic \
    test \
    [~upload] \
    [-|<object-name>] \
    [--export 0] \
    [--frame_count <-1>] \
    [--gif 0] \
    [--log 0] \
    [--max_m 0.80] \
    [--rm_blank 0]
 . test ultrasonic sensors.
```

video

```
@swallow \
    video \
    play \
    [--dryrun 1] \
    [--download 0] \
```

```
    [--engine mpv | vlc] \
    [--loop 0] \
    [--object_name <rangin-video-list-1>] \
    [--timeout <-1 | 10>] \
    [--video <loading|1>]
 . play <object-name>/<video>.
@swallow \
    video \
    playlist \
    cat \
    [download]
 . cat swallow playlist.
@swallow \
    video \
    playlist \
    download \
    [filename=<filename>,policy=different|doesnt_exist|none]
 . download swallow playlist.
@swallow \
    video \
    playlist \
    edit \
    [download]
 . edit swallow playlist.
@swallow \
    video \
    playlist \
    upload \
    [filename=<filename>,public,zip]
 . upload swallow playlist.
```

rangin-video-list-1

```
messages:
  loading:
    filename: loading_circle_bars.mp4
    source: https://www.videezy.com/backgrounds/14052-loading-circle-bars
  warning:
    filename: vecteezy_flashing-neon-warning-text-video-good-for-danger-
sign_6299554.mp4
    source: https://www.vecteezy.com/video/6299554-flashing-neon-warning-
text-video-good-for-danger-sign-illustrations
playlist:
- filename: 731d19dc3ec2f52c626eb575d61bf19b51289493-1080p.mp4
  source: https://www.aparat.com/v/d14c1r8
- filename: d166d435a33dfd7e77b29ceaa96d2cb312692024-480p.mp4
  source: https://www.aparat.com/v/a79o81f
```

swallow: digital: design: parts

a swallow computer + an optional swallow-head computer at the back + 2 optional swallow-head computers at the top + ⬇️

1. 12 VDC motor, 20-45 W: type 2, 2 x right + 2 x left.
2. AC to DC power adapter: 12V DC, 1 A.
3. DC power plug, 5.5 mm.
4. Gearboxed DC Motor, 12 V (3-24 V), 3A, 120 RPM, 1:91, 15 Kg cm: 4 x, replacement gearboxes.
5. Rechargeable sealed lead acid battery: 12 V, 7.2 Ah.
6. auto power connectors: 4 pairs.
7. heavy duty pipe clamp: 4 x 350+ mm.
8. on/off DC switch with indicator led: 12V DC 10 A.
9. power wheel wheels: 4 x .

12 VDC motor, 20-45 W  type 2, 2 x right + 2 x left	AC to DC power adapter  12V DC, 1 A	DC power plug, 5.5 mm 
Gearboxed DC Motor, 12 V (3-24 V), 3A, 120 RPM, 1:91, 15 Kg cm  4 x, replacement gearboxes	Rechargeable sealed lead acid battery  12 V, 7.2 Ah	auto power connectors  4 pairs

heavy duty pipe clamp  4 x 350+ mm	on/off DC switch with indicator led  12V DC 10 A	power wheel wheels  4 x

swallow: digital: design: terraform

Raspbian 64-bit

> ⭐ preferred.
>
> ⚠️ on 32-bit, opencv, torch, and other modules install with challenges, and likely at lower versions.

1. follow RPi (use 64-bit + headless or not).

2. run in another terminal and paste the seed 🌱 into the ssh window.

```
@seed swallow_raspbian clipboard
```

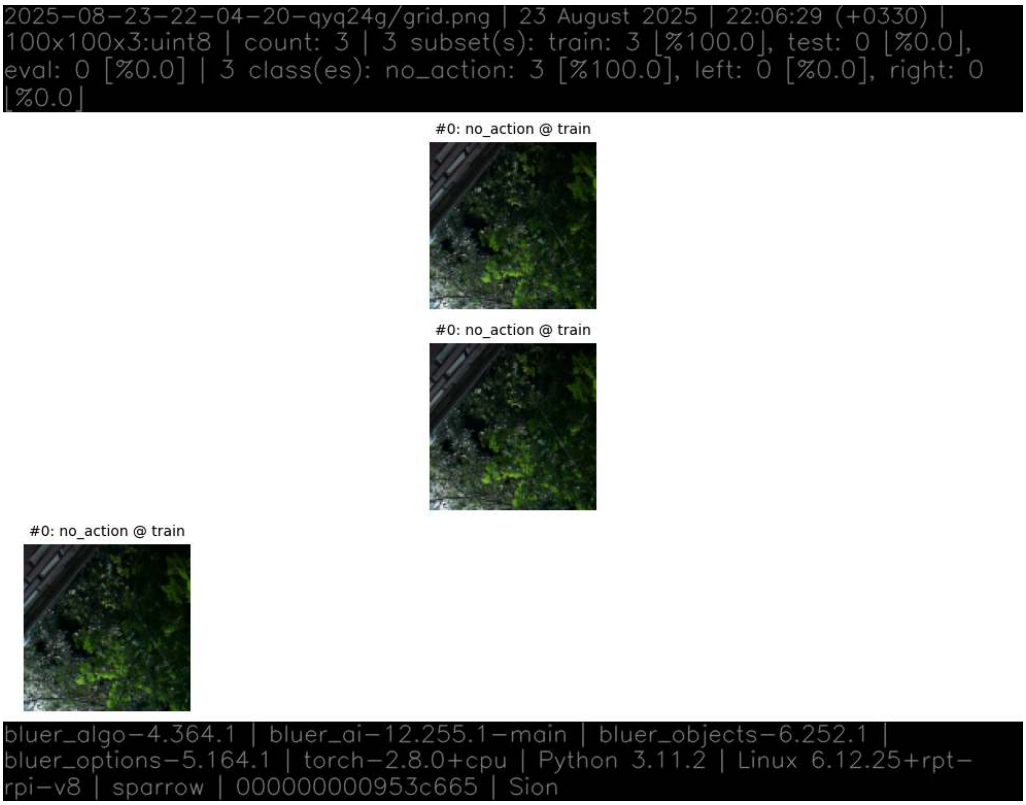
3. run,

```
@bps install
```

4. run,

```
@swallow env cp navigation
@swallow env set full_keyboard 1
@init; @select; @session start
```

now press `t`, then `w`, and wait for ~20 seconds (or press `a`, `d`), then press `i`. an dataset should be uploaded that contains a few frames from the camera.



image

5. run,

```
@swallow env cp yolo
@swallow env set full_keyboard 1
@swallow env set bps 1
@init; @select; @session start
```

6. the terraform is complete, shut down the machine,

```
@host shutdown
```

▶ Ubuntu 64-bit

Raspberry Pi

1. Open Raspberry Pi Imager and select `Operating System` -> `Raspberry Pi OS (other)` and select an image, either lite (headless) or full (with GUI).

   ℹ️ A 32-bit legacy image, such as `Bullseye`, has better compatibility with the camera, but will be more challenging when trying to install the latest OpenCV and torch. **64-bit images, are, therefore, recommended**.

2. Then press `Shift+Ctrl+X` to open `Advanced options`, select `Set hostname`, and enter a unique host name, the select `Set username and password` and set the user to `pi` and the password to `abcli2025`. Then select `Configure wireless LAN` and set the SSID and password. In `Services` select `Enable SSH` and `Use password authentication` and press `Save`. Proceed to write the SD Card.

3. After the write is complete, eject the SD card, insert it into the Raspberry Pi, turn the motherboard on, and wait for the motherboard to boot.

Headless

4. run `@seed headless_rpi clipboard` (or `headless_rpi_64_bit`). now, run `@ssh rpi <host-name>` and paste the seed 🌱 into the ssh window.

5. Run `sudo raspi-config` -> `Interfacing Options` -> enable `Camera` (only needed on older versions) and other interfaces as needed, then go to `System Options` -> `Boot / Auto Login` and select `Console Autologin`.

With UI

4. run `@seed rpi_64_bit clipboard`. now, run `@ssh rpi <host-name>` and paste the seed 🌱 into the ssh window.

5. Run `sudo nano /boot/config.txt` (or `/boot/firmware/config.txt` in later versions) and uncomment the line that reads `#hdmi_force_hotplug=1`, if it exists. If you wish to rotate the screen, add one of the following to the end of this file and then reboot:

```
display_rotate=0
display_rotate=1
display_rotate=2
display_rotate=3
```

6. go to `Preferences` -> `Raspberry Pi Configuration` -> `Interfaces` and change the following to `Enabled`: `Camera:`, `I2C`, and `SSH`, as needed.

known issues

1. on `rpi4b` headless install raises `ERROR: Wheel 'tensorflow' located at /home/pi/tensorflow-2.2.0-cp37-cp37m-linux_armv7l.whl is invalid.`

2. `pyarrow` may cause an “illegal instruction” error. this will stop plugins from loading. to recognize if this is the case, run,

```
@plugins list_of_external
```

the output should look like,

```
4 external plugin(s): bluer_algo, bluer_objects, bluer_sbc, bluer_ugv
```

if “illegal instruction” was printed, run,

```
pip uninstall -y pyarrow
```

3. rpi may reboot at the first pytorch inference, because of under-voltage. to validate, run,

```
dmesg
```

look for,

```
[   12.064503] hwmon hwmon1: Undervoltage detected!
[   16.093659] hwmon hwmon1: Voltage normalised
```

swallow computer electrical diagram

with steering (obsolete)

Steering

with differential drive

Rear Right

Front Right

16 AWG

16 AWG

Rear Left

Rear Right

BTS7960

Motor1 Drive

B-, B+, M+, M- 2

Motor2 Drive

DC Motors:
12 VDC,
20-45 W
9000 RPM

Rear Left

Front Left

LED
~2 V forward voltage
10–20 mA

3 x

12: Motor 1 RPWM

32: Motor 1 LPWM

28 AWG

6:GND

⚠ twisted 22 AWG

33: Motor 2 RPWM

35: Motor 2 LPWM

Capacitor
470 µF to 1000 µF
16 V or 25 V
Electrolytic
105 °C rated If possible
as close to the PI as possible

Polyfuse1.1 A hold
2.2 A trip, 16 V, resettable
through-hole, e.g., MF-R110

TVS diode, unidirectional
600 W, 6.8 V clamp
e.g. P6KE6.8A, DO-15 package

2:5V

16: TRigger 1 36: TRigger 4

18: Echo 1 38: Echo 3

22: Echo 2 40: Echo 4

37: push button

31: Trigger 3

29: Trigger 2

11,
13,
15

Resistor
330–470 Ω
¼ watt
5% tolerance

Raspberry PI 3B+

Adjust the output to precisely 5.1V reduce: CCW

⚠ twisted, 18 AWG

PI 5V

PI GND

XL4015

HC-SR04

ultrasonic sensors

TRigger: 16, 29, 31, 36

2.2kΩ

Echo: 18, 22, 38, 40

3.3kΩ

330–470Ω

swallow-head

6.94 V

0.00 A

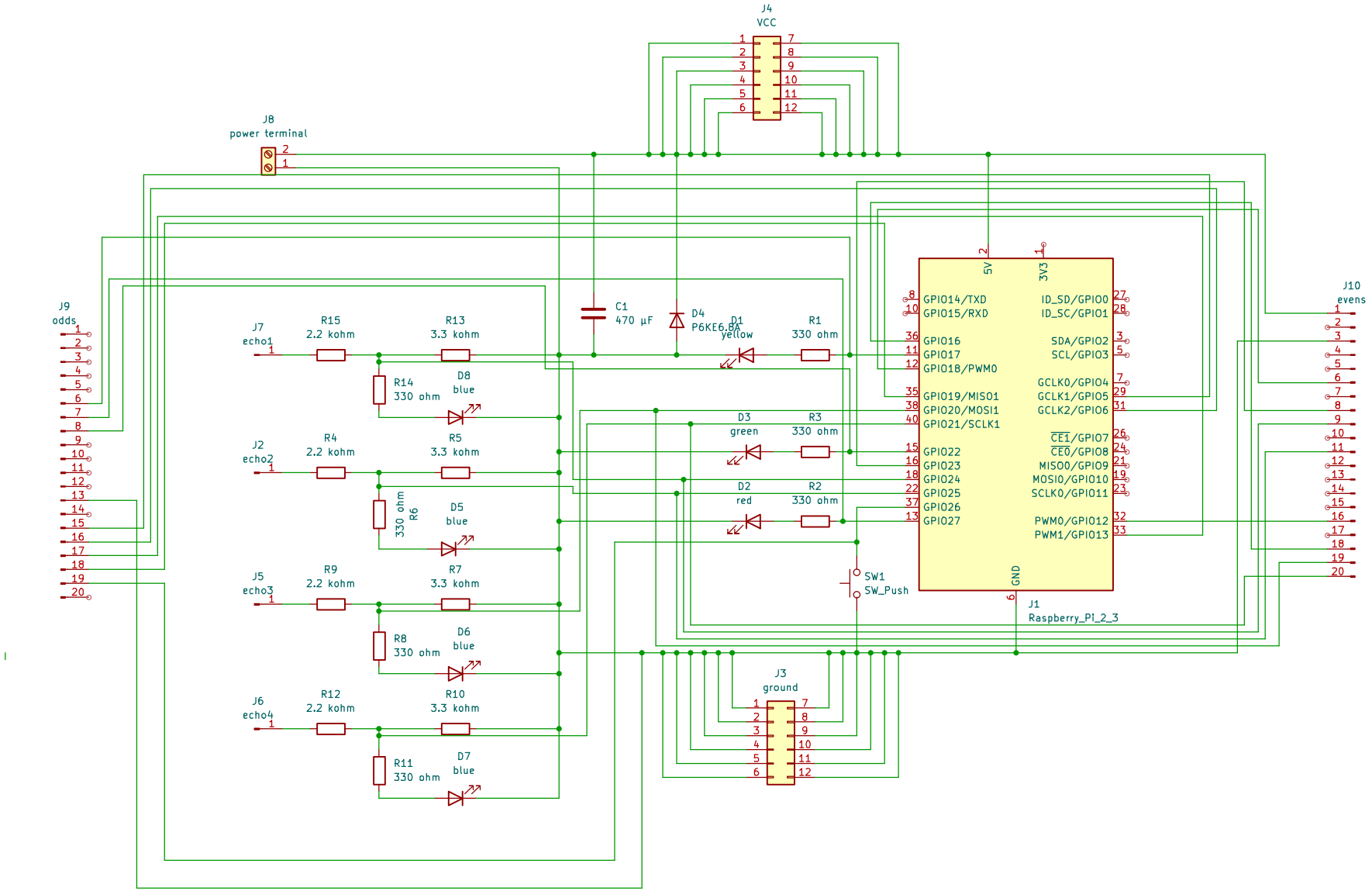
DC voltmeter ammeter
panel mount
4-30 VDC, 10A

12V DC
10 A

12V DC, 1 A

12 V SLA /
3S, 11.1 V LiPo

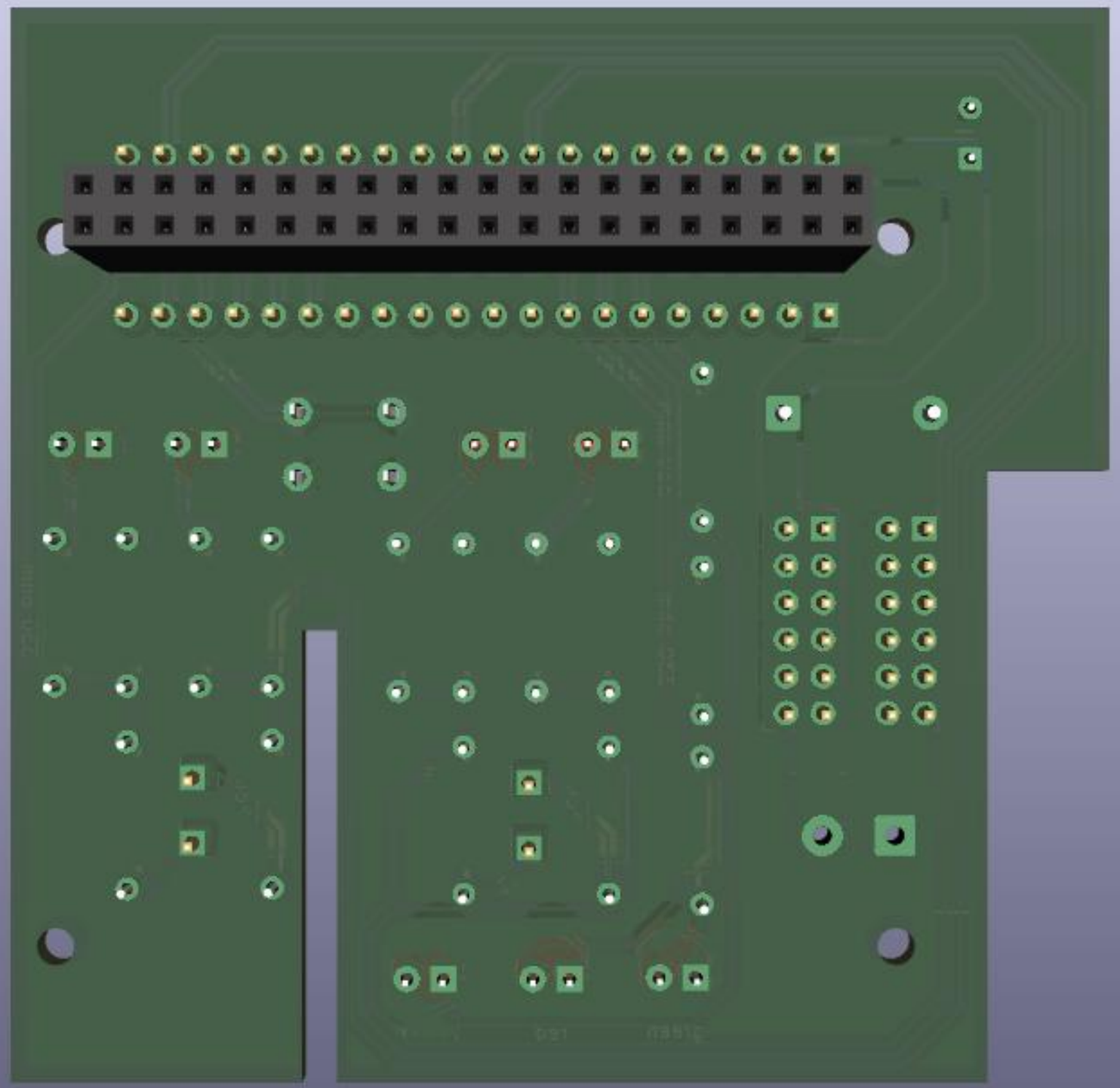
revision 1.21.0

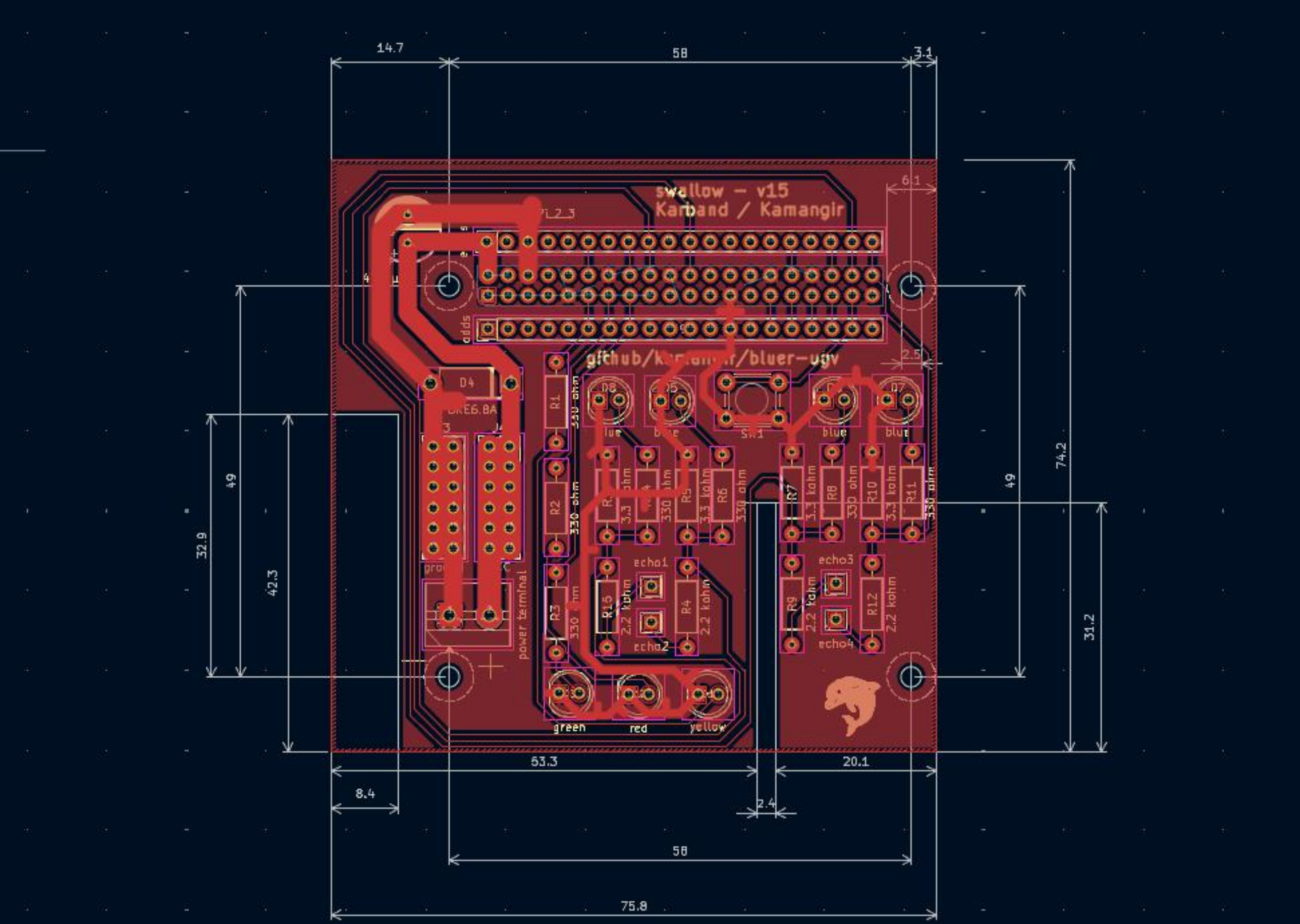


swallow shield

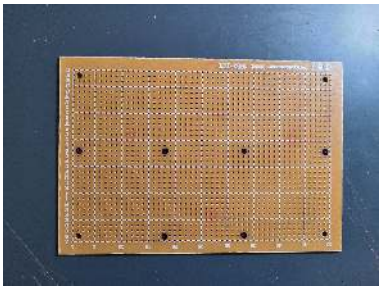
v15

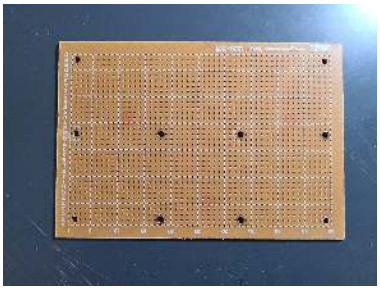
swallow – v15
Karband / Kamangir
Raspberry_PI_2_3
evens
odds
470 µF
P6KE6.8A
J3
J4
power terminal
330 ohm
github/kamangir/bluer-ugv
blue
blue
SW1
blue
blue
3.3 kohm
330 ohm
3.3 kohm
330 ohm
2.2 kohm
2.2 kohm
echo1
echo2
3.3 kohm
330 ohm
3.3 kohm
330 ohm
2.2 kohm
2.2 kohm
echo3
echo4

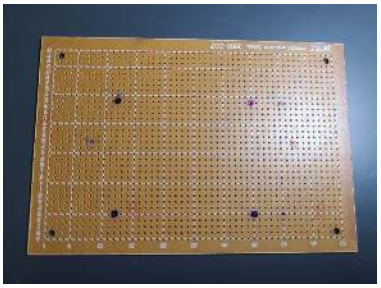


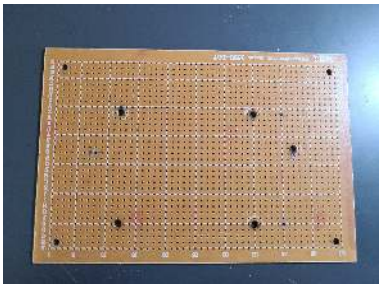

14.7
58
3.1
6.1
2.5
swallow – v15
Ka band / Kamangir
github/kamangir/bluer-uav
ddds
power terminal
D4
SKE6.8A
R1
330 ohm
R2
R3
R15
2.2 kohm
R4
R5
R6
R7
R8
R9
R10
R11
R12
echo1
echo2
echo3
echo4
SW1
blue
green
red
yellow
74.2
49
46
42.3
32.9
31.2
53.3
20.1
8.4
2.4
58
75.8

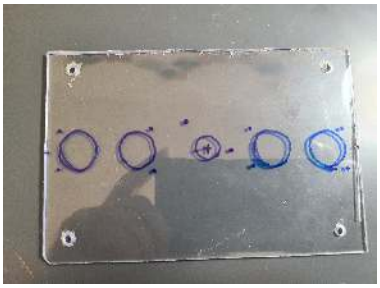
swallow: digital: design: computer: box

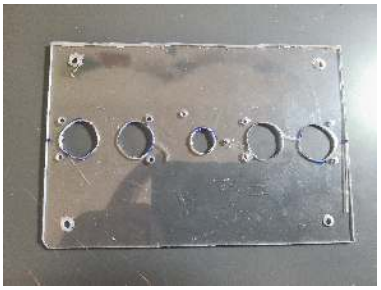








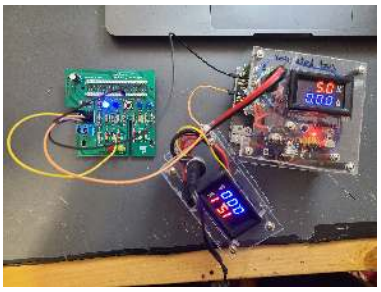


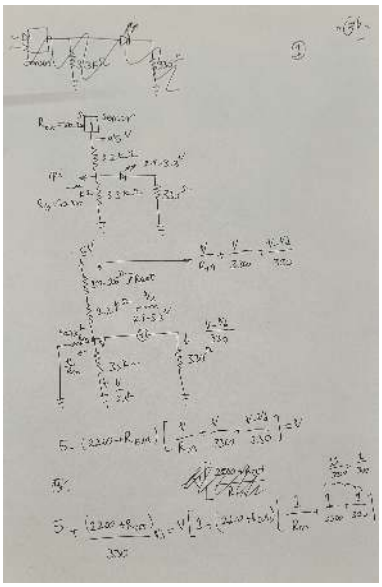


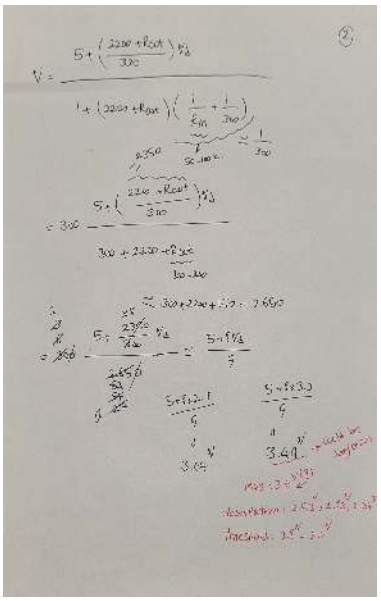
swallow: digital: design: computer: testing

connect adapter-bus and regulated-bus and the additional connections (see figure).

- validate green, red, blue leds.
- validate sw.
- validate echo conditioning. between 2.0 VDC and 3.3 VDC is safe. 2.53 VDC - 2.83 VDC have been observed.

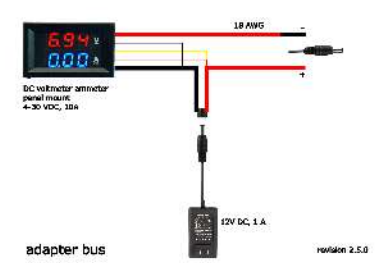


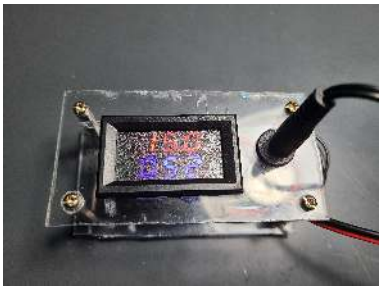


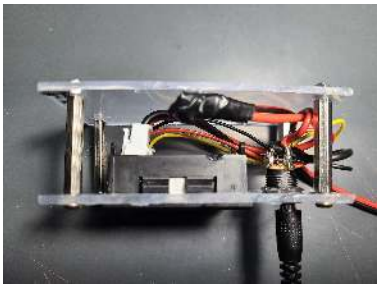
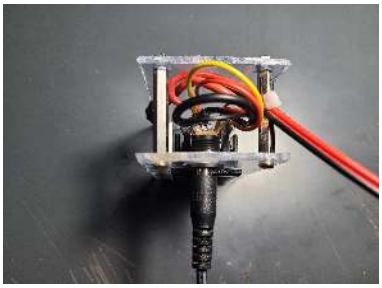
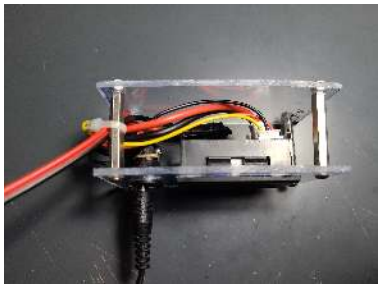
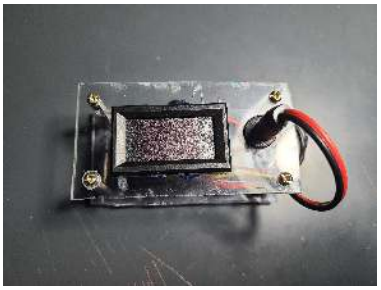
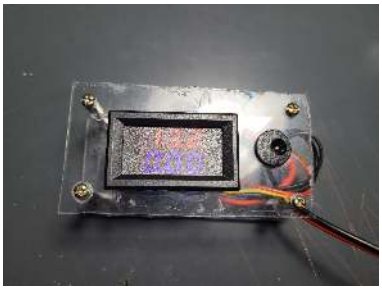


adapter-bus

a non-regulated, ~1 A, DC bus.





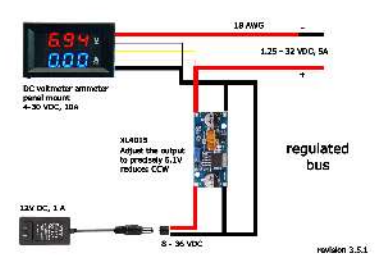

parts

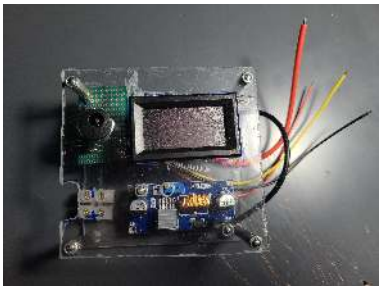
DC power jack, 5.5 mm	DC power plug, 5.5 mm	DSN-VC288, panel mount, 4-30 VDC, 10A, voltmeter ammeter
		

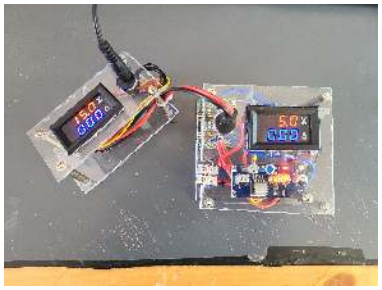
1. DC power jack, 5.5 mm.
2. DC power plug, 5.5 mm.
3. DSN-VC288, panel mount, 4-30 VDC, 10A, voltmeter ammeter.

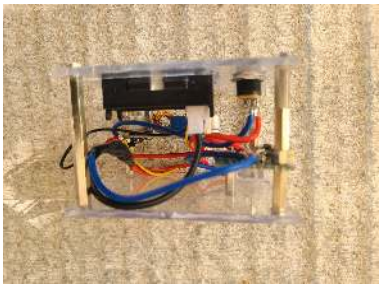
regulated-bus

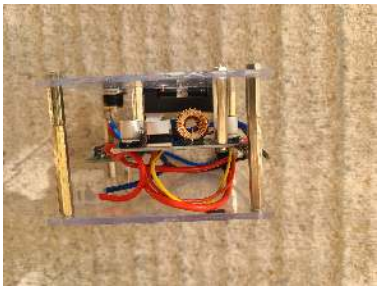
a regulated, 1.25 - 32 VDC, 5A, bus based on XL4015

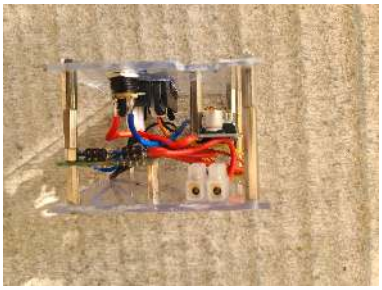


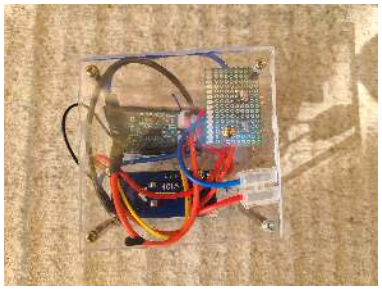


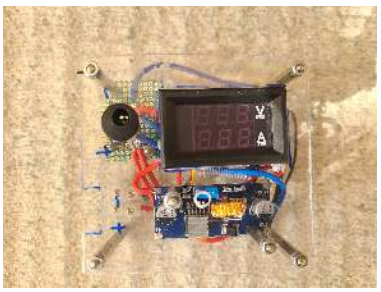


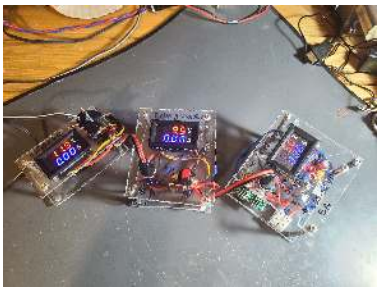












parts

DC power plug, 5.5 mm	DSN-VC288, panel mount, 4-30 VDC, 10A, voltmeter ammeter	XL4015: 8 - 36 VDC -> 1.25 - 32 VDC, 5A	double-sided PCB, 9 cm x 7 cm	nuts, bolts, and spacers	pin headers	plexiglass, 2 mm or 2.5 mm thickness	white terminal
			 10 x 15 holes	 M3: (7 x bolt + 7 x nut + 1 x 5 mm spacer + 7 x 15 mm spacer + 2 x 25 mm spacer + 3 x 35 mm spacer)	 2 x (2 x 3, 90 degree)	2 x 88 cm x 88 cm	 2 x

1. DC power plug, 5.5 mm.
2. DSN-VC288, panel mount, 4-30 VDC, 10A, voltmeter ammeter.
3. XL4015: 8 - 36 VDC -> 1.25 - 32 VDC, 5A.
4. double-sided PCB, 9 cm x 7 cm: 10 x 15 holes.
5. nuts, bolts, and spacers: M3: (7 x bolt + 7 x nut + 1 x 5 mm spacer + 7 x 15 mm spacer + 2 x 25 mm spacer + 3 x 35 mm spacer).
6. pin headers: 2 x (2 x 3, 90 degree).
7. plexiglass, 2 mm or 2.5 mm thickness: 2 x 88 cm x 88 cm.
8. white terminal: 2 x.

swallow: digital: design: computer: power

swallow head: - Raspberry Pi 4B (CPU/GPU busy, Wi-Fi + BLE on): ~ 1.3–1.5 A -> ~ 6.6–7.7 W - Raspberry Pi Camera (capturing video): ~ 200–250 mA -> ~ 1.0–1.3 W - 4 × HC-SR04 (all active): ~ 15 mA each → ~ 60 mA -> ~ 0.3 W - HDMI connection: ~ 50 mA -> 0.25 W

total: ~ 10 W ~= ~1.8 A @ 5.1 V DC ~= 1 A @ 12 V DC (90% efficiency)

swallow: - 4 x BTS7960 logic side: ~ 10–20 mA -> 0.1 W (will consider included in ⬆️) - 4 x DC motors: 1 A (freely-rotating) - 4 A (stalled) per motor ==

4A ~= 8 A -> ~ 100 W

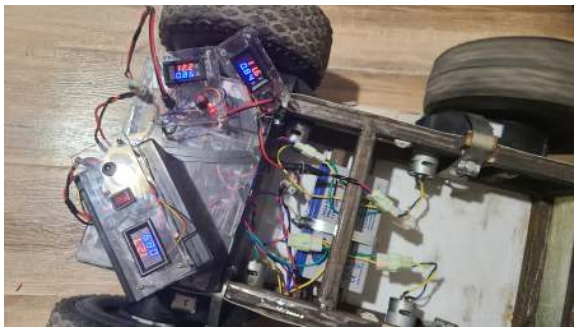
total: - mostly idling: 1 A == 12 W - cruising driving: 1 A + 4 x 1 A = 5 A == 60 W - aggressive driving: 1 A + 4 x 2 A = 9 A == 108 W

option	battery	rated Wh	usable Wh	aggressive Driving	cruising driving	mostly idling
SLA						
1	7.2 Ah ⭐	86 Wh	50–65 Wh	28–37 min	50–70 min	4–5.5 h
2	12 Ah	144 Wh	85–110 Wh	48–62 min	1.4–1.8 h	7–9 h
3	18 Ah	216 Wh	130–165 Wh	73–92 min	2.2–2.8 h	11–14 h
4	20 Ah	240 Wh	145–180 Wh	81–100 min	2.5–3.0 h	12–15 h
5	30 Ah	360 Wh	215–270 Wh	2.0–2.5 h	3.6–4.6 h	18–22 h
LiPo						
6	7 Ah	78 Wh	66 Wh	37 min	67 min	33.0 h ❓
7	10 Ah	111 Wh	94 Wh	52 min	96 min	47.2 h ❓
8	15 Ah	166 Wh	142 Wh	79 min	2.40 h	70.8 h ❓
9	20 Ah	222 Wh	189 Wh	105 min	3.20 h	94.3 h ❓
10	25 Ah	278 Wh	236 Wh	2.20 h	4.00 h	117.9 h ❓

option	battery	rated Wh	usable Wh	aggressive Driving	cruising driving	mostly idling
11	30 Ah	333 Wh	283 Wh	2.65 h	4.80 h	141.5 h ?

SLA: 12 V, 60–75% usable capacity.

LiPo: 3S, 11.1 V nominal, 85% usable capacity.



SLA vs. LiPo

- Weight: LiPO ≈ ⅓ the weight of SLA for the same Ah.
- Cost in Iran: LiPO ≈ 2–3× more expensive than SLA per Ah.
- Lifetime: LiPO lasts 5–10× more cycles (much cheaper per cycle).
- Safety:
  - SLA: very stable, heavy, low fire risk.
  - LiPO: safe if BMS is good; RC LiPo is riskier.
- Complexity:
  - SLA: simple, just charge and use.
  - LiPO: needs proper charger + BMS awareness, but gives better performance.

swallow: digital: design: computer: naming

- `<ugv-name>` or `<ugv-name>-front`: a swallow computer that watches the front and controls the motors.
- `<ugv-name>-back`: a swallow-head computer that watches the back.
- 2 x `<ugv-name>-top`: two swallow-head computer that watch the sides (`-left` and `-right`).

swallow: digital: design: rpi-pinout

Responsibility	Function	Physical Pin	GPIO	Notes
Motor 1, FW	PWM	12	18	PWM0, Steering / Right
Motor 1, BW	PWM	32	12	PWM0 (alternate), Shares PWM0 with GPIO 18
Motor 2, FW	PWM	33	13	PWM1, Rear / Left
Motor 2, BW	PWM	35	19	PWM1 (alternate), Shares PWM1 with GPIO 13
Green LED	Digital Output	11	17	
RED LED	Digital Output	13	27	
Blue LED	Digital Output	15	22	
Push Button	Digital Input	37	26	
Sensor 1, Trigger	Digital Output	16	23	
Sensor 2, Trigger	Digital Output	29	5	
Sensor 3, Trigger	Digital Output	31	6	
Sensor 4, Trigger	Digital Output	36	16	
Sensor 1, Echo	Digital Input	18	24	
Sensor 2, Echo	Digital Input	22	25	
Sensor 3, Echo	Digital Input	38	20	
Sensor 4, Echo	Digital Input	40	21	

swallow: digital: design: operation

keyboard

event	full keyboard	numpad
debug off	v	9
debug on	b	7
exit	*i	*7
mode = action	g	1
mode = none	y	5
mode = training	t	3
reboot	*p	*5
shutdown	*o	*9
special key	z	.
speed backward	s	2
speed forward	w	8
steer left	a	4
steer right	d	6
stop		0
ultrasonic off	n	-
ultrasonic on	m	+
update	*u	*1

*: special key.

to enable full keyboard:

```
@swallow env set full_keyboard 1
```

the range of numpad is ~10-20 m range, noticeably lower than that of the full keyboard, which is ~50 m, see village-6 for details.

leds

- green: control loop.
- red:
    - flashing:
        - motor update.
        - action / training.
        - release the push button to update.
        - setpoint update.
    - solid: release the push button to shutdown.
- yellow:
    - command received.
    - mousepad activity.
- blue: ultrasonic sensor echo.

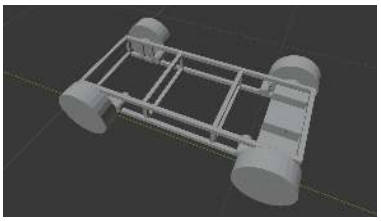
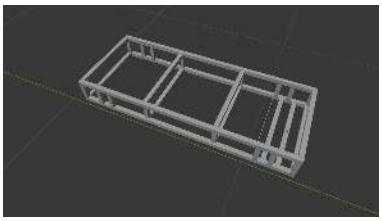
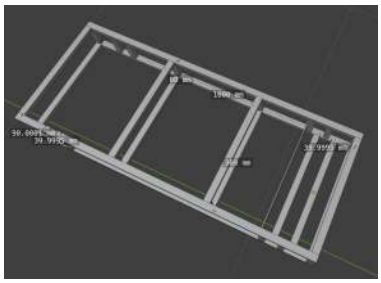
▶ mouse pad (obsolete)

push button

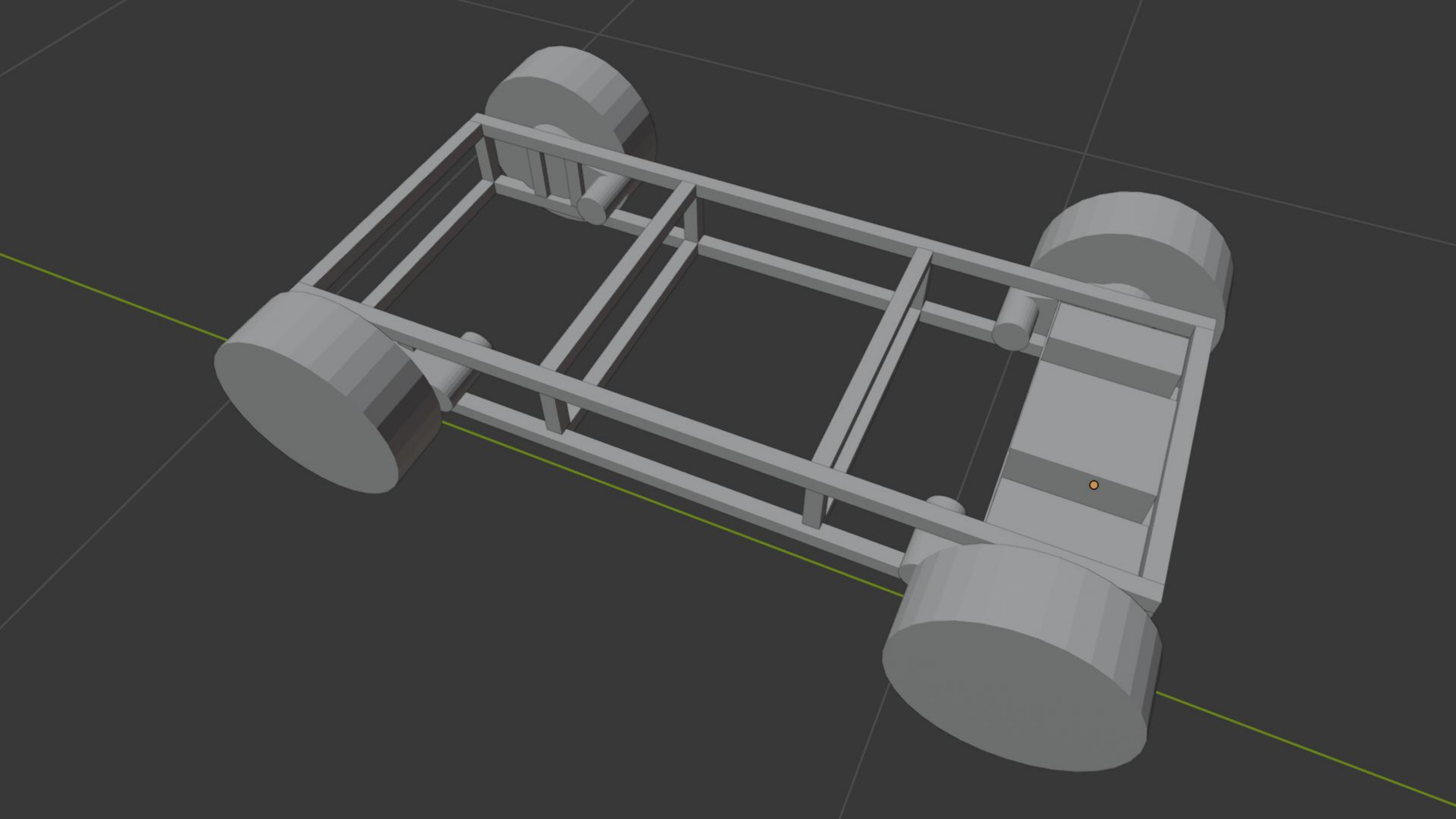
- hold for 5 seconds: update.
- hold for 10 seconds: shutdown.
- hold for > 15 seconds: skip.

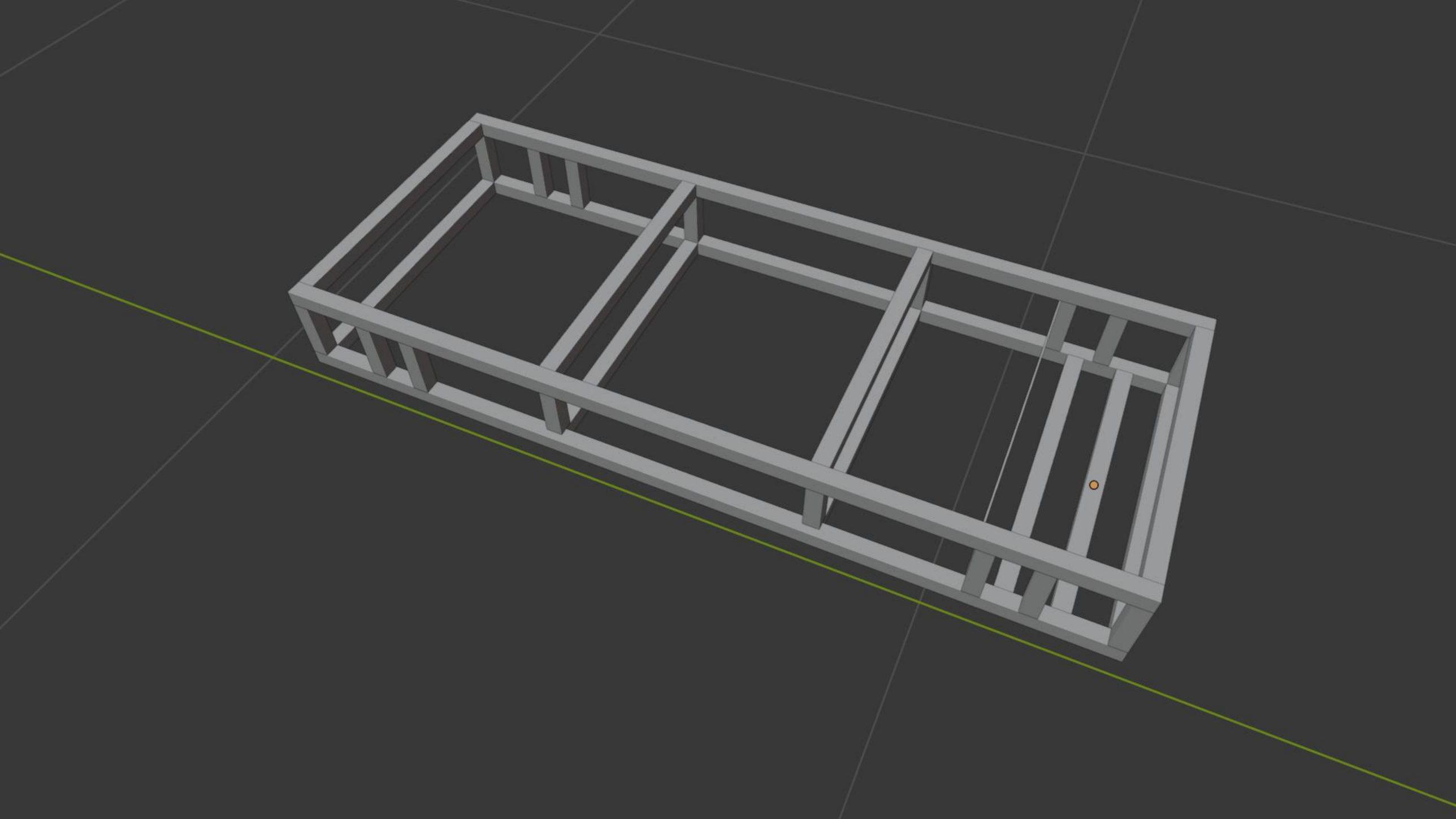
swallow: digital: design: mechanical

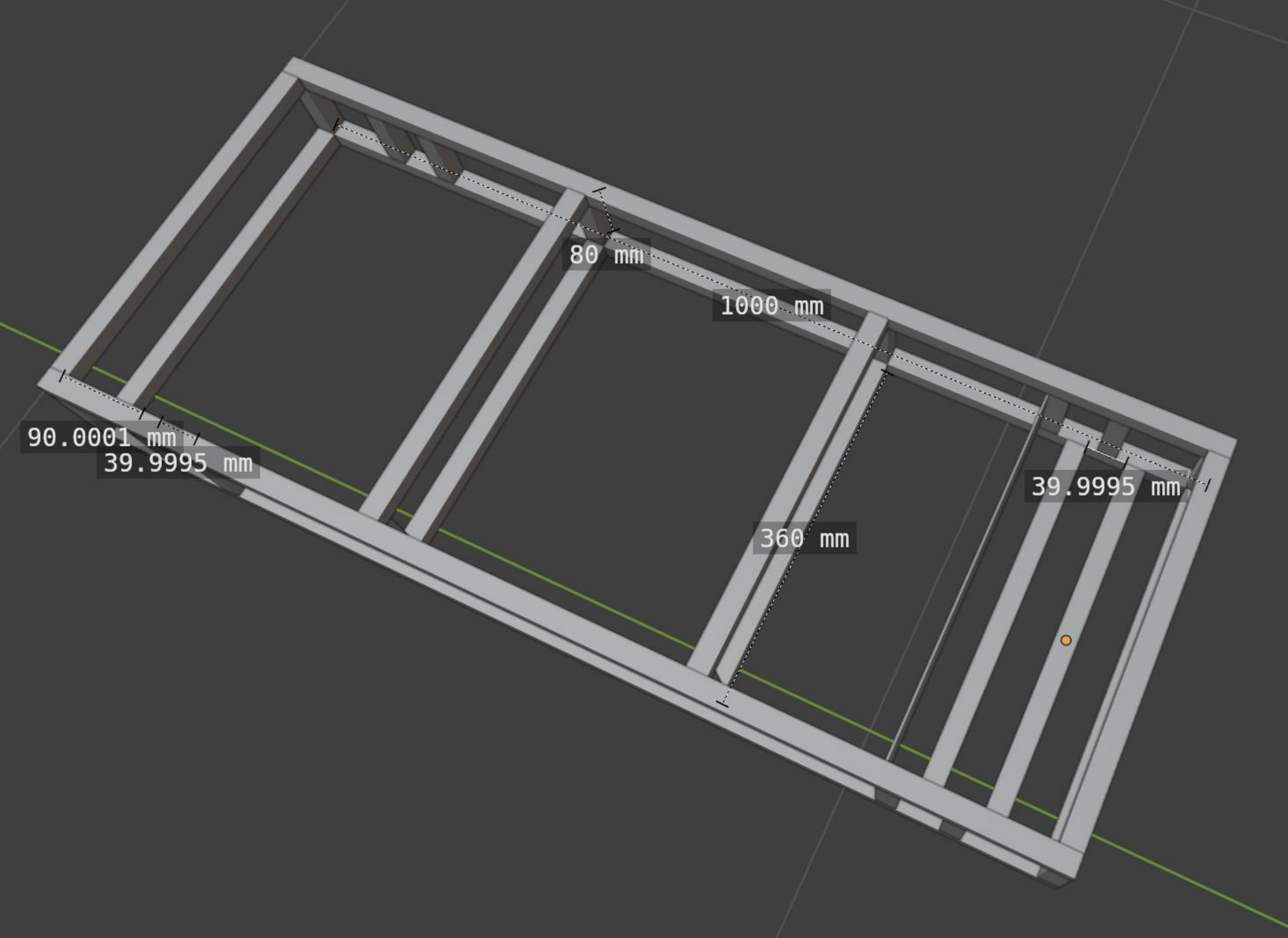
- Blender files
- material: 2 x 20 mm x 20 mm x 1.5 mm x 6000 mm
- parts:
  - 4 x 1000 mm
  - 10 x 360 mm
  - 16 x 80 mm
  - total: 8520 mm (8.5 m)
  - cut into 4 x (1000 mm + 360 mm = 1360 mm) + 3 x (360 mm + 4 x 80 mm = 680 mm) + (3 x 360 mm + 4 x 80 mm = 1400 mm) ~= 1500 mm

- v1






80 mm
1000 mm
90.0001 mm
39.9995 mm
360 mm
39.9995 mm

swallow: digital: design: ultrasonic-sensor: dev

test

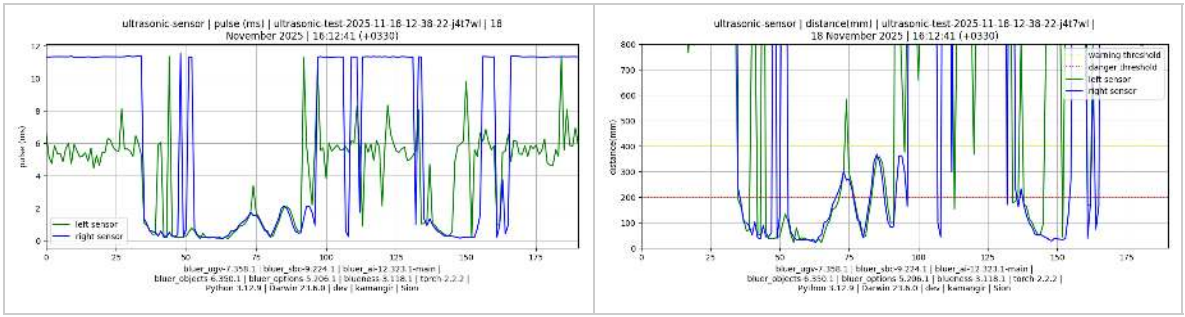
using ultrasonic_sensor-v8.py.

```
🐬 left: no detection  | pulse= 11.33 ms | dist≈ 1943 mm
🐬 left: no detection  | pulse= 11.37 ms | dist≈ 1949 mm
🐬 left: detection  | pulse=  0.93 ms | dist≈  159 mm
🐬 left: detection  | pulse=  0.98 ms | dist≈  168 mm
```

using ultrasonic_sensor-v9.py.

```
🐬 left    : no detection    ,  11.31 ms ==  1939 mm | right   : no detection    ,  11.32 ms ==  1941 mm
🐬 left    : no detection    ,   5.27 ms ==   904 mm | right   : no detection    ,  11.28 ms ==  1935 mm
🐬 left    : detection       ,   4.50 ms ==   772 mm | right   : no detection    ,   4.75 ms ==   814 mm
🐬 left    : detection       ,   4.34 ms ==   745 mm | right   : detection ,   4.63 ms ==   795 mm
```

```
@rpi
@select ultrasonic-test-$(@timestamp)

@swallow ultrasonic test - .
@.

@mac
@select $BLUER_UGV_ULTRASONIC_SENSOR_TEST_OBJECT

@assets publish \
    extensions=png,push

@upload public,zip
@.
```



ultrasonic-test-2025-11-18-12-38-22-j4t7wl

review

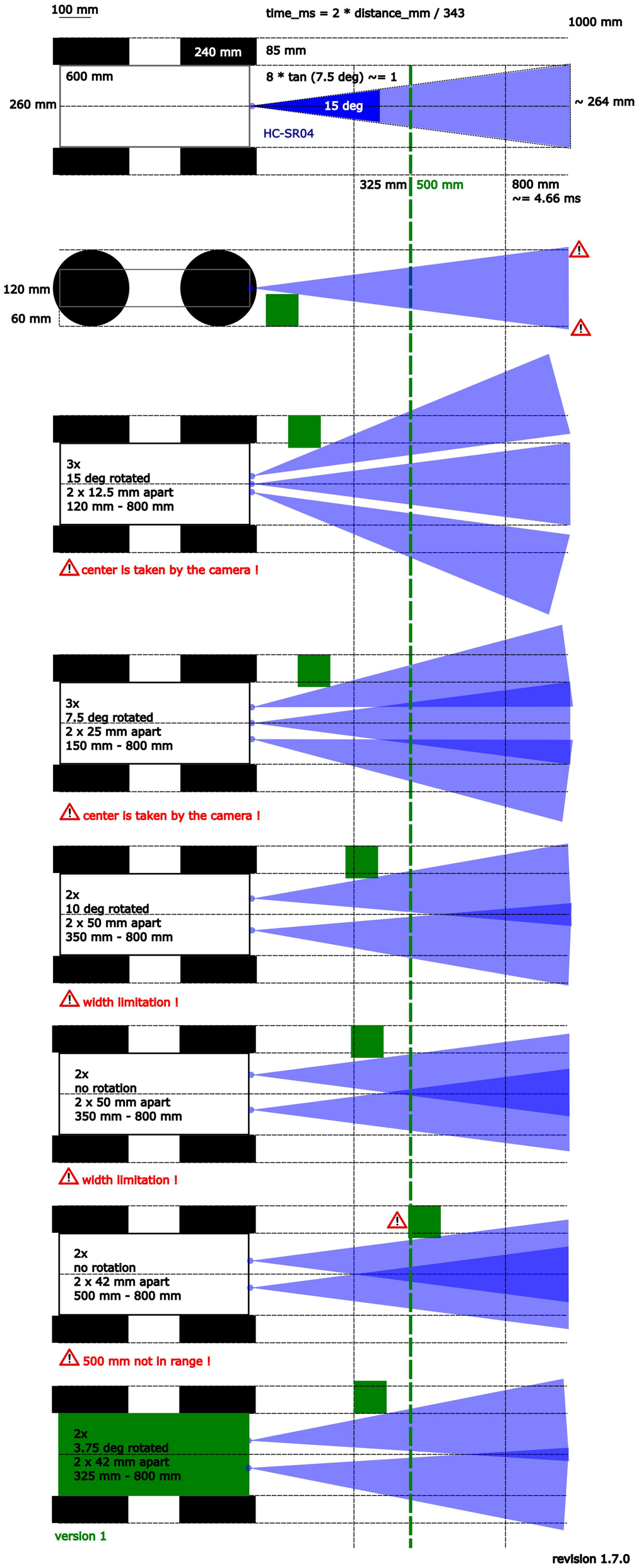
```
@select $BLUER_UGV_ULTRASONIC_SENSOR_TEST_OBJECT

@swallow ultrasonic review download

@assets publish \
    extensions=gif,push

@upload public,zip
```

image
image

ultrasonic-test-2025-11-18-12-38-22-j4t7wl

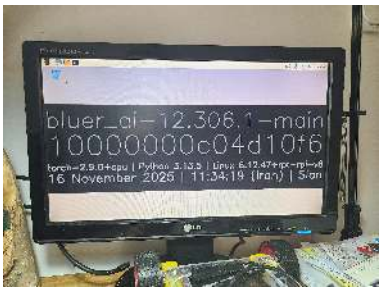
in session

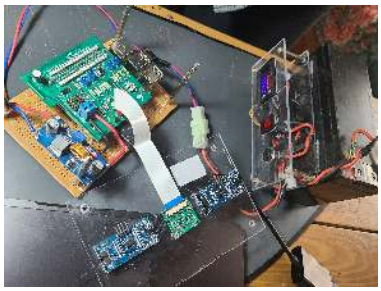
ultrasonic sensors: geometry design

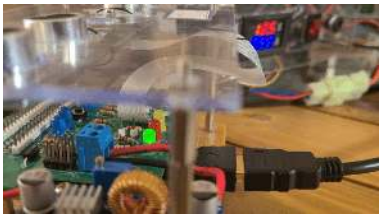


swallow: digital: design: testing

- test the computer.
- disconnect the shield from the XL4015 and connect the computer to the battery bus. validate that the red LED on the XL4015 turns on.
- adjust XL4015 at 5.1 V.
- separate the shield from the rpi, connect power to the shield, turn the power on, validate no 💥, turn the power off.
- install the shield on the rpi, screw the shield, connect the monitor (for rpi4b: to the hdmi port closer to the USB port) and the keyboard, turn the power on, validate full operation, shutdown, power off.
- wire the ultrasonic sensors, turn the power on, validate that ultrasonic sensors log warning and danger, `@swallow debug`, test the camera, shutdown, power off.





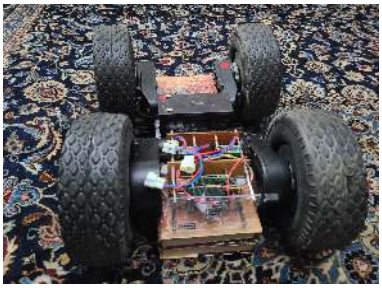
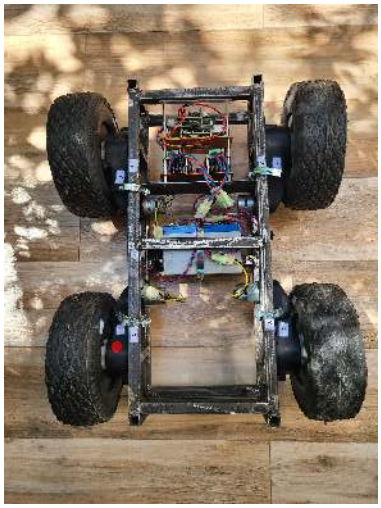
arzhang

> swallow's little sister, formerly known as `sparrow`, `arzhang` (ارژنگ) is named after the demon in the Shahnameh. It embodies noble strength and quiet defense.

- design
- algo






















arzhang: design: specs

- dimensions: 300 mm x 600 mm
- speed: 10 km / h (max)
- weight: ~15 kg
- wheel diameter: 20 cm (270 RPM) - 30 cm (180 RPM)
- motor + gearbox: metal, 90-degree, 180 - 270 RPM, 12 V, 10 kg cm torque.
- drives: 50 – 100 W

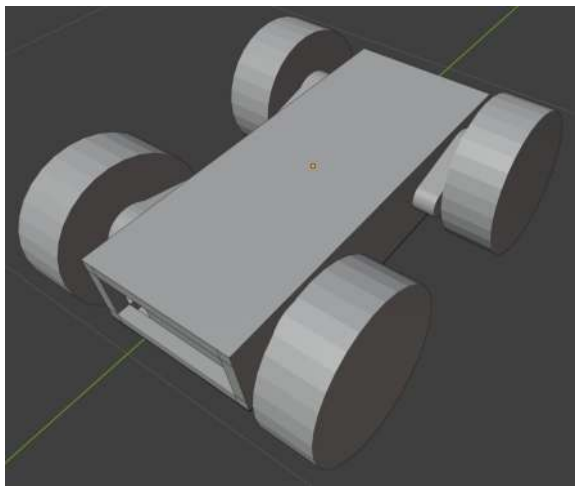
speed calculations

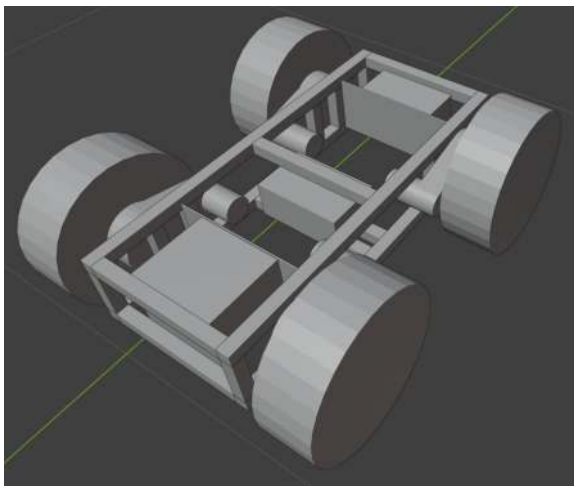
- 90 RPM * 20 cm * 3.14 = 5,652 cm / min = 56.52 m / min == 3,4 km / h
- 270 RPM ~= 10 km / h

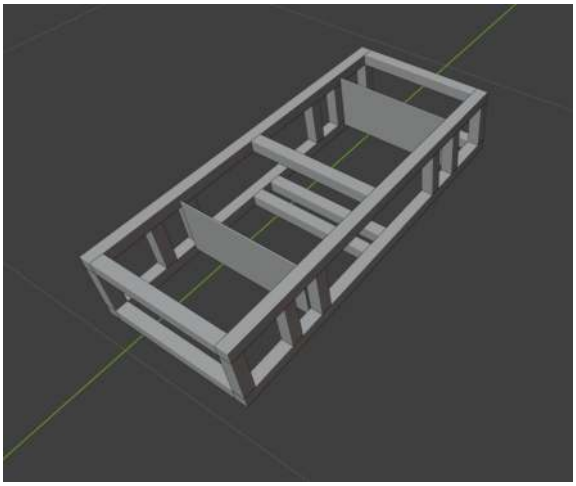
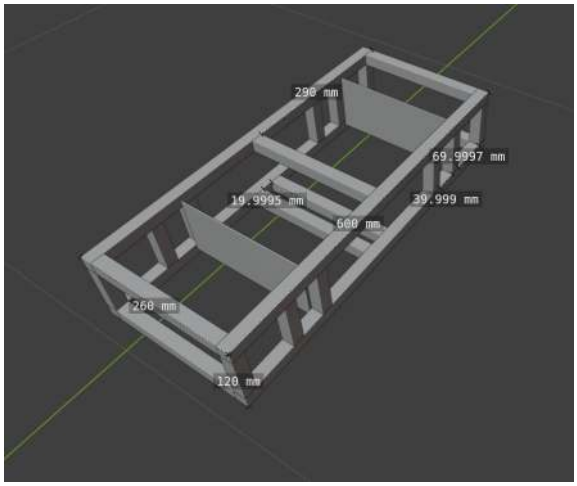
arzhang: design: mechanical

- Blender files
- metal profile: 20 mm x 20 mm x 1.5 mm x 6000 mm
  - parts:
    - 4 x 600 mm
    - 7 x 220 mm
    - 12 x 80 mm
    - total: 5060 mm (5.06 m)
  - cut into 4 x (600 mm + 2 x 220 mm + 3 x 80 mm = 1280 mm) ~= 1500 mm
- metal sheet:
  - 2 x 220 mm x 120 mm x 2 mm (1, if one-headed)
- plexiglass
  - 260 mm x 600 mm x 2 mm
- thin metal sheet
  - 260 mm x 600 mm x 0.5 mm
- fiberglass
  - 2 x 120 mm x 600 mm
  - 260 mm x 120 mm (if one-headed)
- velcro
  - 1720 mm x 20 mm

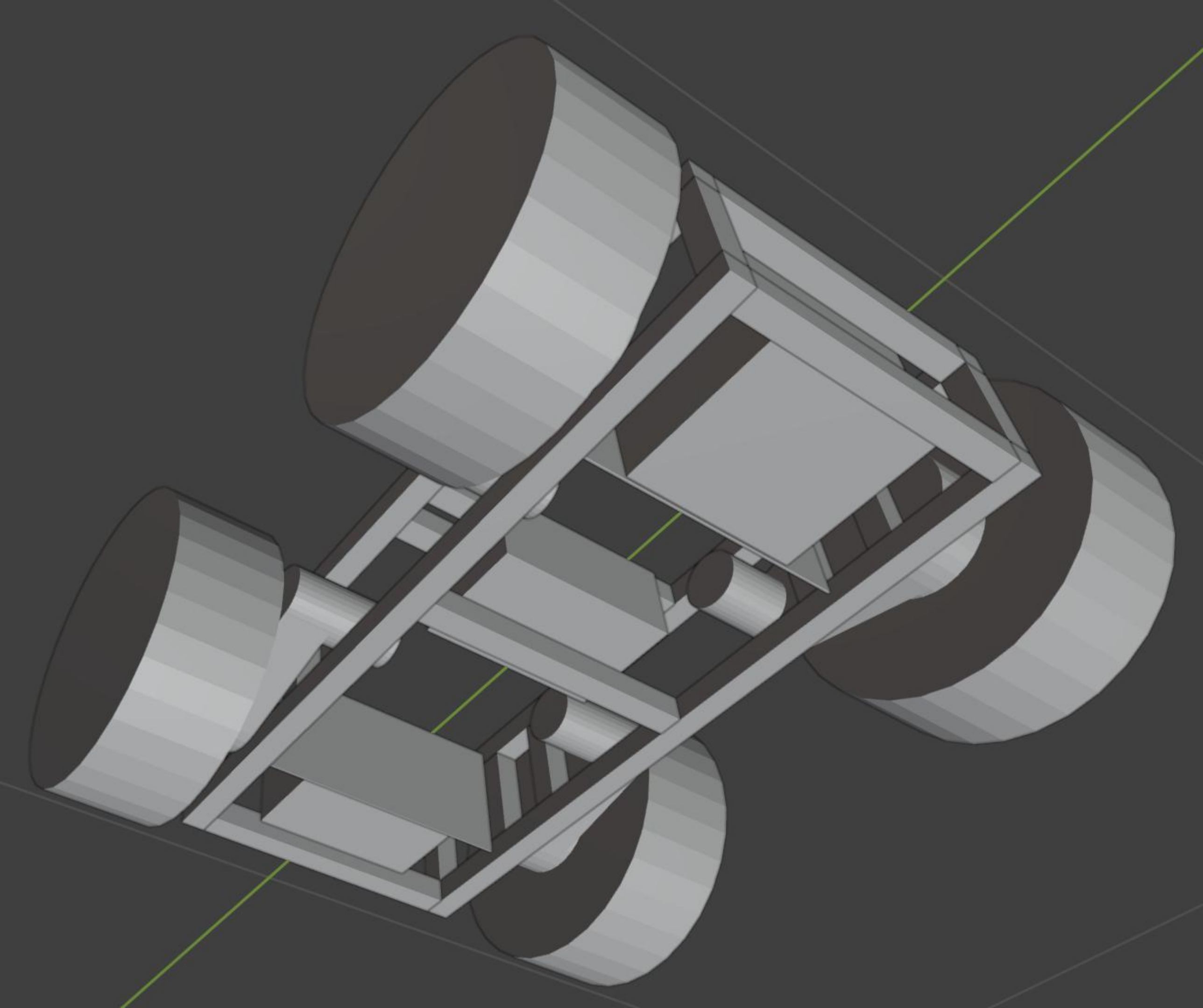
⏰ mechanical build takes ~4 hours.

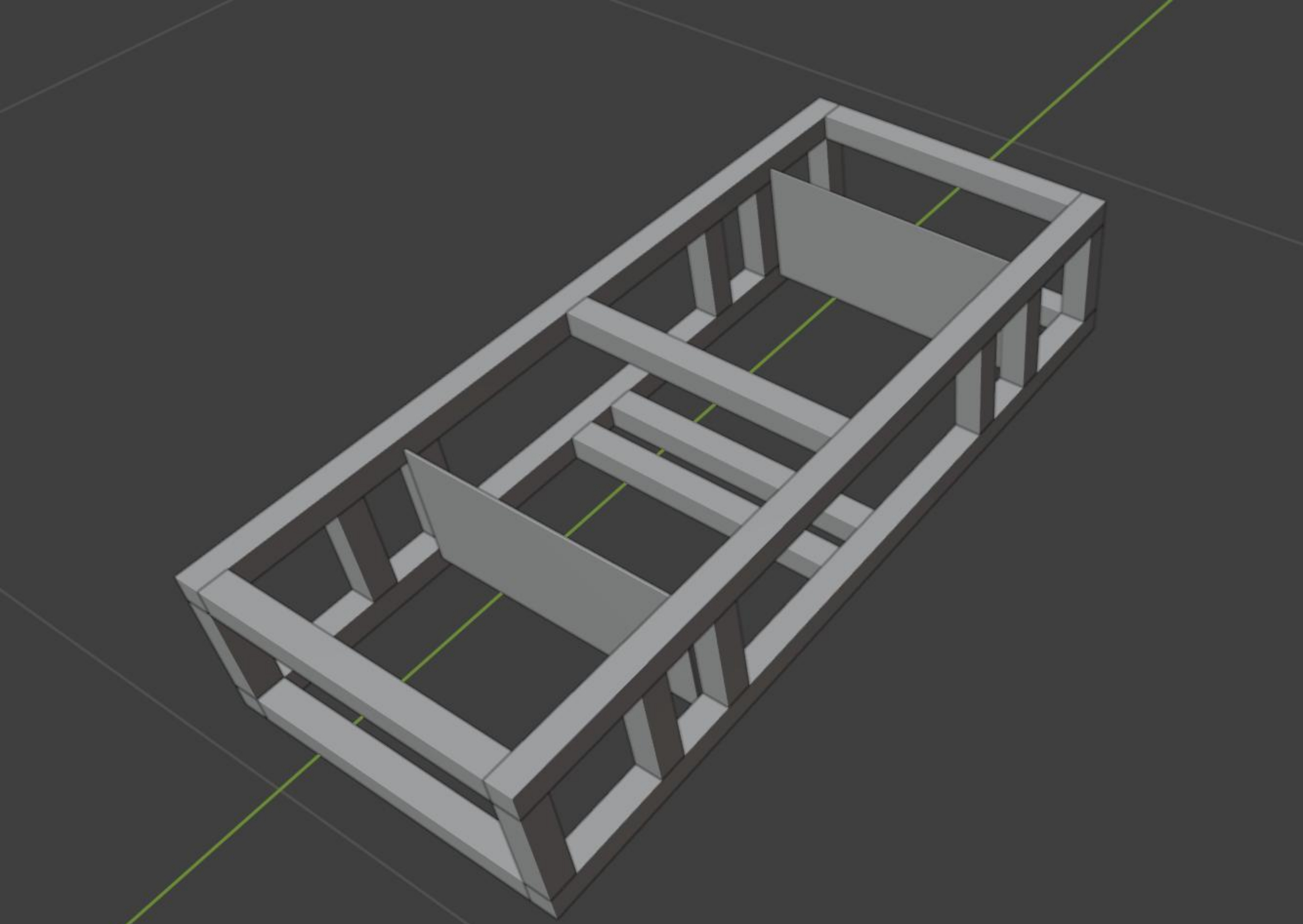


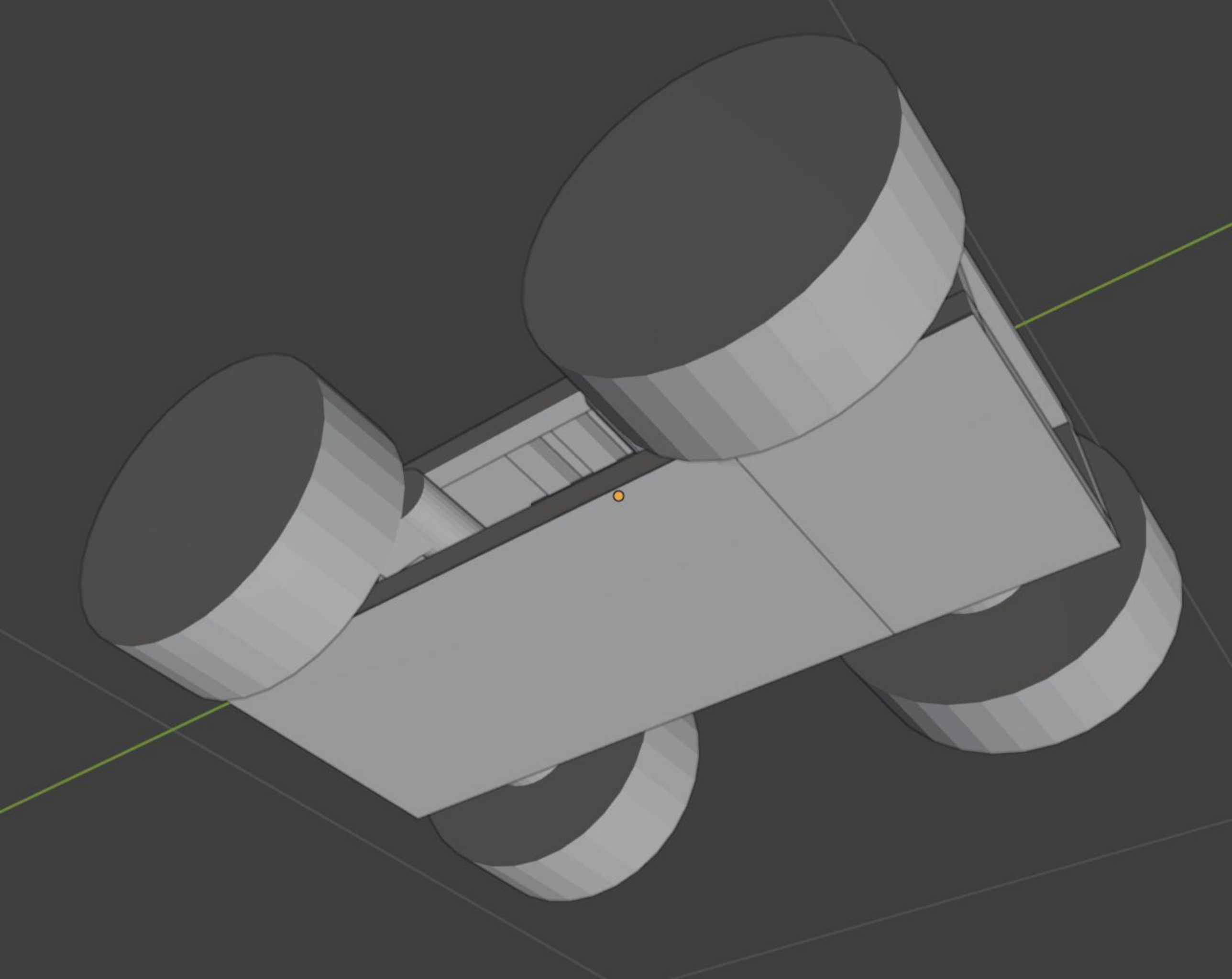


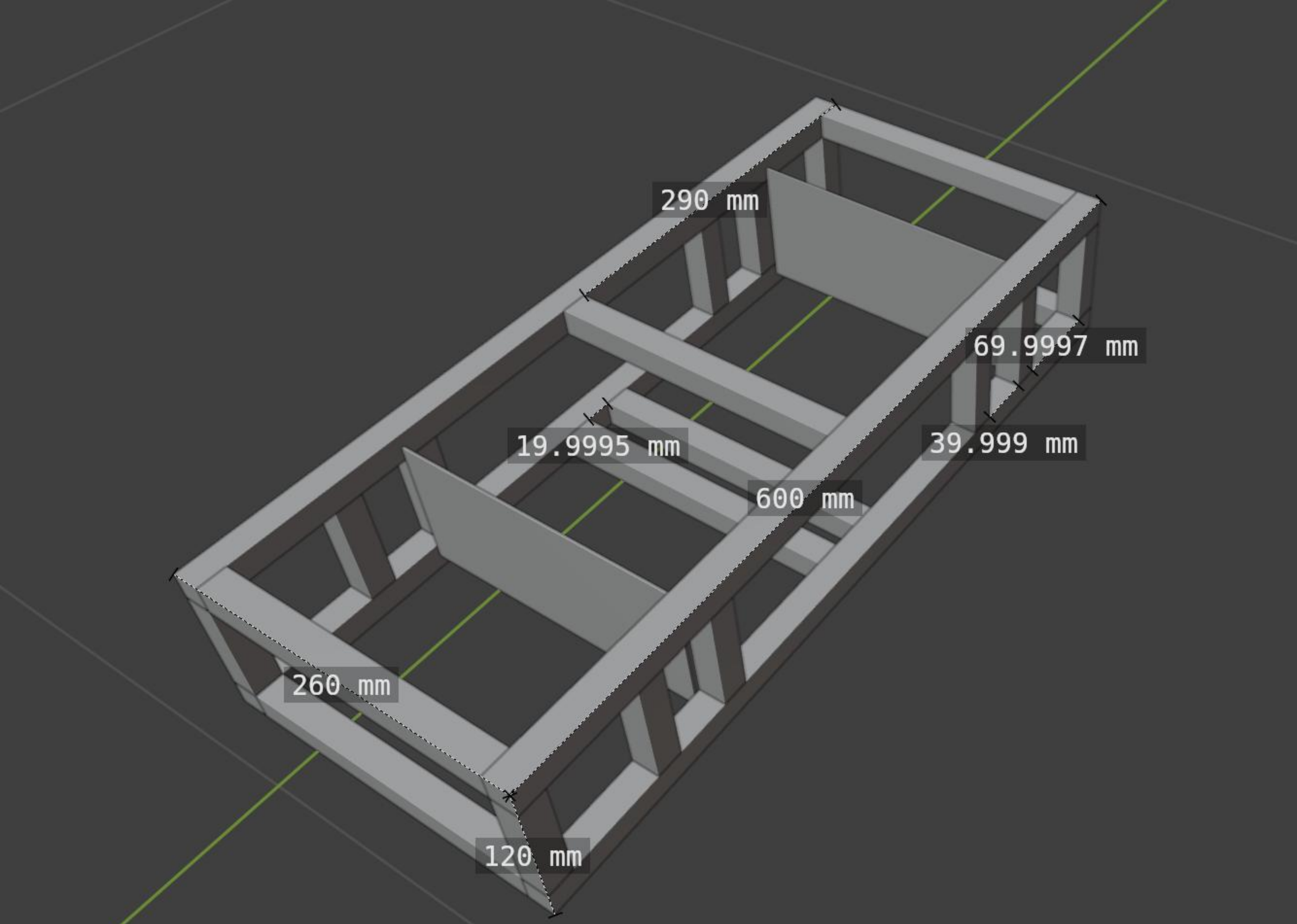
<table>
<tr>
<td>  </td>
<td> 
</td>
</tr>
<tr>
<td>  </td>
<td>  </td>
</tr>
</table>

- v1








290 mm
69.9997 mm
19.9995 mm
39.999 mm
600 mm
260 mm
120 mm

arzhang: design: power

- uses swallow computer power.
  - swallow: 60 W
  - swallow-head: 10 W
- total: 70 W ~= 6 A @ 12 V DC

runtime	energy needed	ideal capacity @ 12 V	LiPo Ah (practical)	SLA Ah (practical)
1 h	70 W	6 Ah	7 Ah	12 Ah ⭐
2 h	140 W	12 Ah	13 Ah	24 Ah
3 h	210 W	18 Ah	19 Ah	36 Ah
4 h	280 W	23 Ah	26 Ah	48 Ah
5 h	350 W	29 Ah	32 Ah	60 Ah

SLA: 85%, LiPo: 90%

swallow: digital: algo: driving

driving with a keyboard.

```
@swallow env cp driving
```

swallow: digital: algo: navigation

navigation using an @algo/image_classifier.

```
@swallow env cp navigation
```

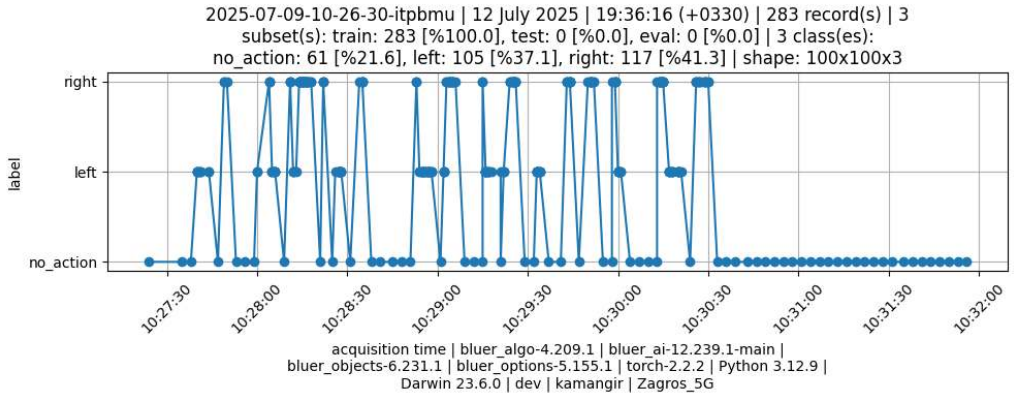
- dataset
- model

swallow: digital: algo: navigation: dataset: collection: validation

Start `swallow`, press `t` (to start training), drive for 5 minutes, press `i` (to exit).

```
@select
@session start

@select 2025-07-09-10-26-30-itpbmu

@download - .
@upload public,zip .
@assets publish \
    extensions=png,push . \
    --prefix grid
```

image



image

[2025-07-09-10-26-30-itpbmu]

```
dataset:
  class_count: 3
  classes:
    0: no_action
    1: left
    2: right
  count: 283
  shape:
  - 100
  - 100
  - 3
  source: 00000000c74cf7d2
  subsets:
    eval: 0
    test: 0
    train: 283
```

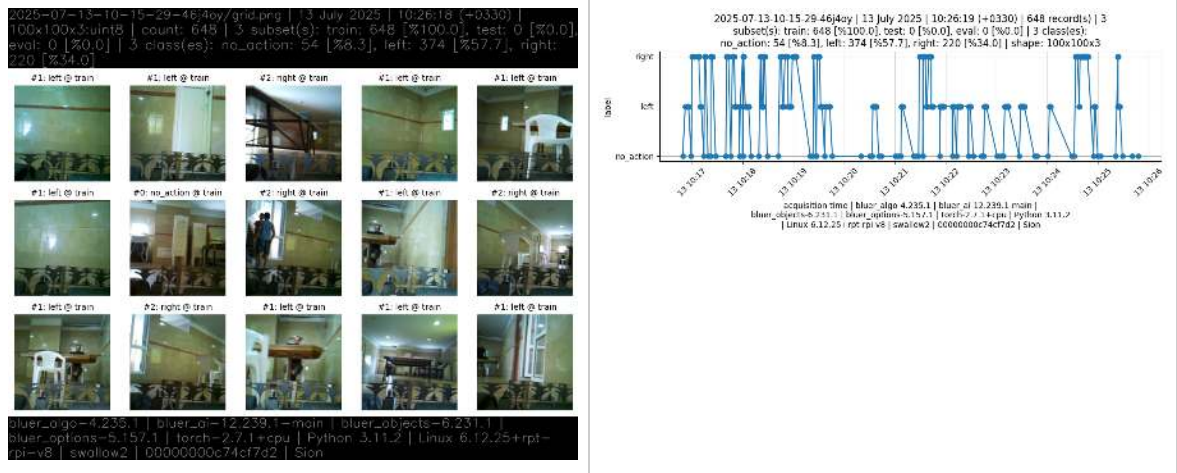
swallow: digital: algo: navigation: dataset: collection: one

```
@list log \
    $(@list filter \
        $(@swallow dataset list) \
        --contains $(@today))
```

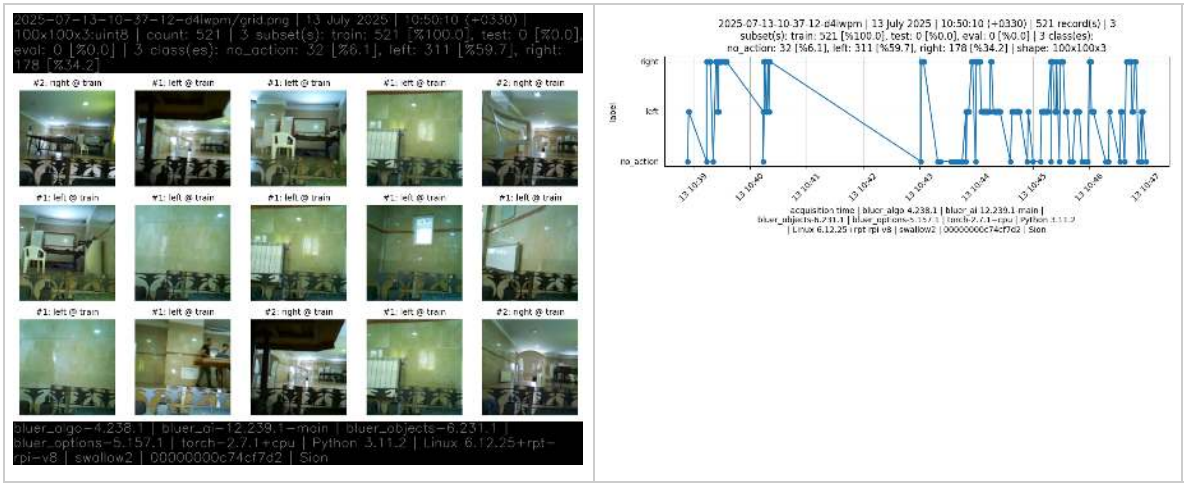
list of 3 item(s): 2025-07-13-10-15-29-46j4oy, 2025-07-13-10-37-12-d4iwpm, 2025-07-13-12-55-54-cx5mhk.

```
runme() {
    local object_name
    for object_name in $(@list filter \
        $(@swallow dataset list) \
        --contains $(@today) | tr , " "); do
        @select $object_name

        @download policy=doesnt_exist .
        @upload public,zip .
        @assets publish \
            extensions=png,push . \
            --prefix grid
    done
}

runme
```

2025-07-13-10-15-29-46j4oy



2025-07-13-10-37-12-d4iwpm

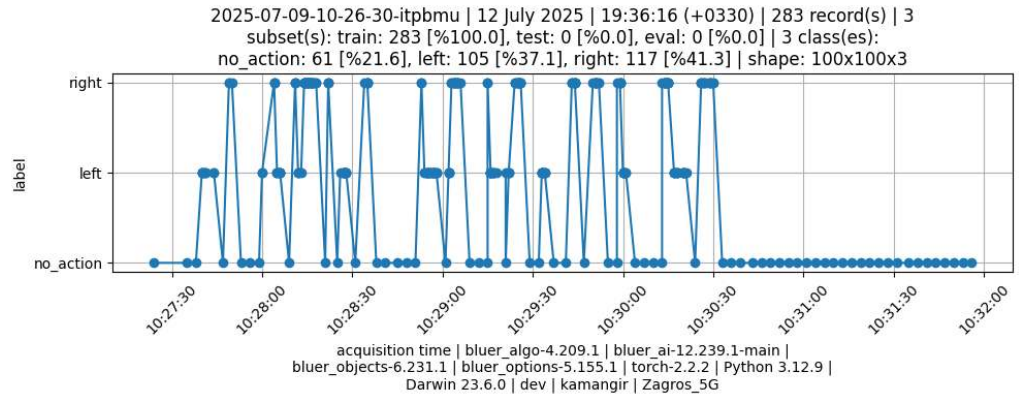


2025-07-13-12-55-54-cx5mhk

swallow: digital: algo: navigation: dataset: review

```
@select 2025-07-09-10-26-30-itpbmu

@algo image_classifier dataset review - .

@upload public,zip .
@assets publish \
    extensions=png,push . \
    --prefix grid
```

image



image

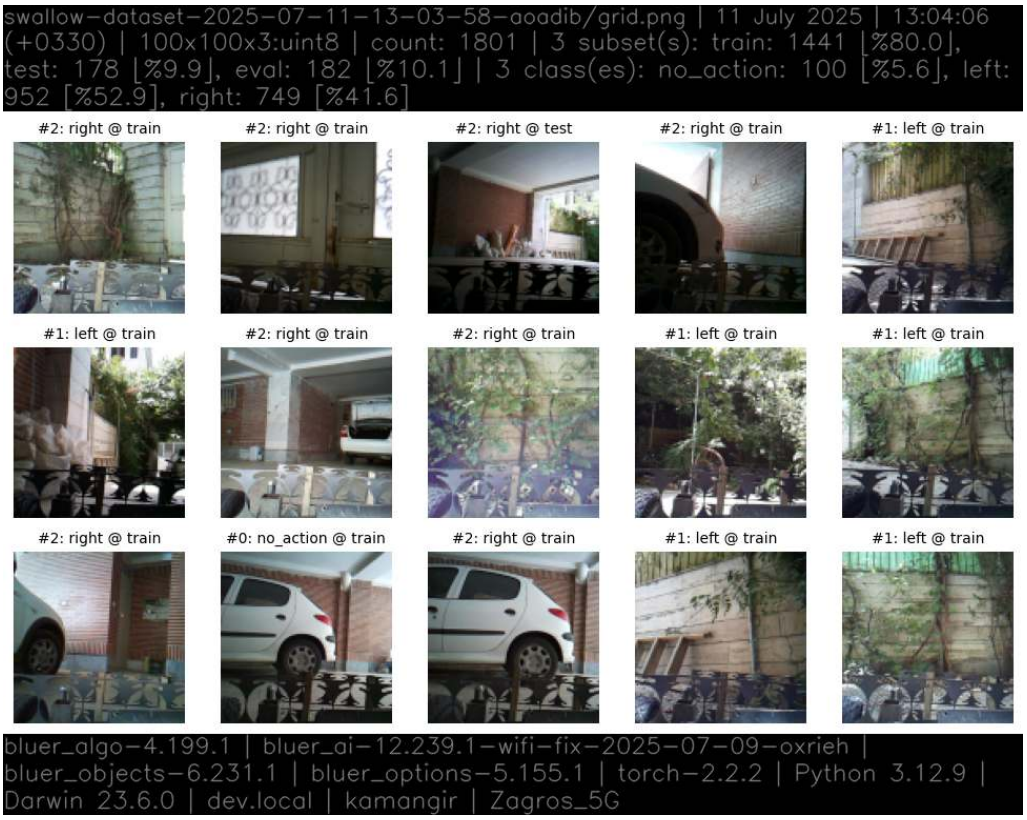
2025-07-09-10-26-30-itpbmu

```
dataset:
  class_count: 3
  classes:
    0: no_action
    1: left
    2: right
  count: 283
  shape:
  - 100
  - 100
  - 3
  source: 00000000c74cf7d2
  subsets:
    eval: 0
    test: 0
    train: 283
```

swallow: digital: algo: navigation: dataset: combination: validation

uses collection/validation.

```
@select swallow-dataset-$(@timestamp)

@swallow dataset combine \
    count=2 .

@upload public,zip .
@assets publish \
    extensions=png,push . \
    --prefix grid
```



image

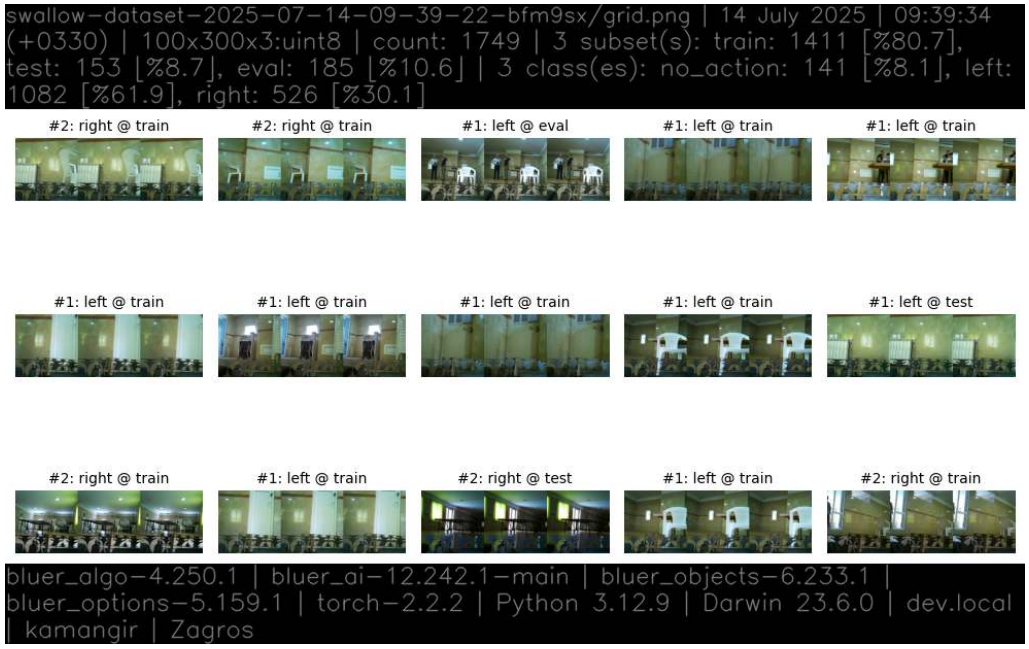
[swallow-dataset-2025-07-11-13-03-58-aoadib]

```
dataset:
  class_count: 3
  classes:
    0: no_action
    1: left
    2: right
  contains:
  - 2025-07-09-11-16-52-4zo4zc
  - 2025-07-09-11-34-19-bcoh75
  count: 1801
  shape:
  - 100
  - 100
  - 3
  subsets:
    eval: 182
    test: 178
    train: 1441
```

swallow: digital: algo: navigation: dataset: combination: one

uses collection/one.

```
@select swallow-dataset-$(@timestamp)

@swallow dataset combine \
    sequence=3 . \
    --datasets $(@list filter \
        $(@swallow dataset list) \
        --contains 2025-07-13)

@upload public,zip .
@assets publish \
    extensions=png,push . \
    --prefix grid
```



image

swallow-dataset-2025-07-14-09-39-22-bfm9sx

```
dataset:
  class_count: 3
  classes:
    0: no_action
    1: left
    2: right
  contains:
  - 2025-07-13-10-15-29-46j4oy
  - 2025-07-13-10-37-12-d4iwpm
  - 2025-07-13-12-55-54-cx5mhk
  count: 1749
  shape:
```

```
- 100
- 300
- 3
subsets:
  eval: 185
  test: 153
  train: 1411
```

swallow: digital: algo: navigation: model: validation

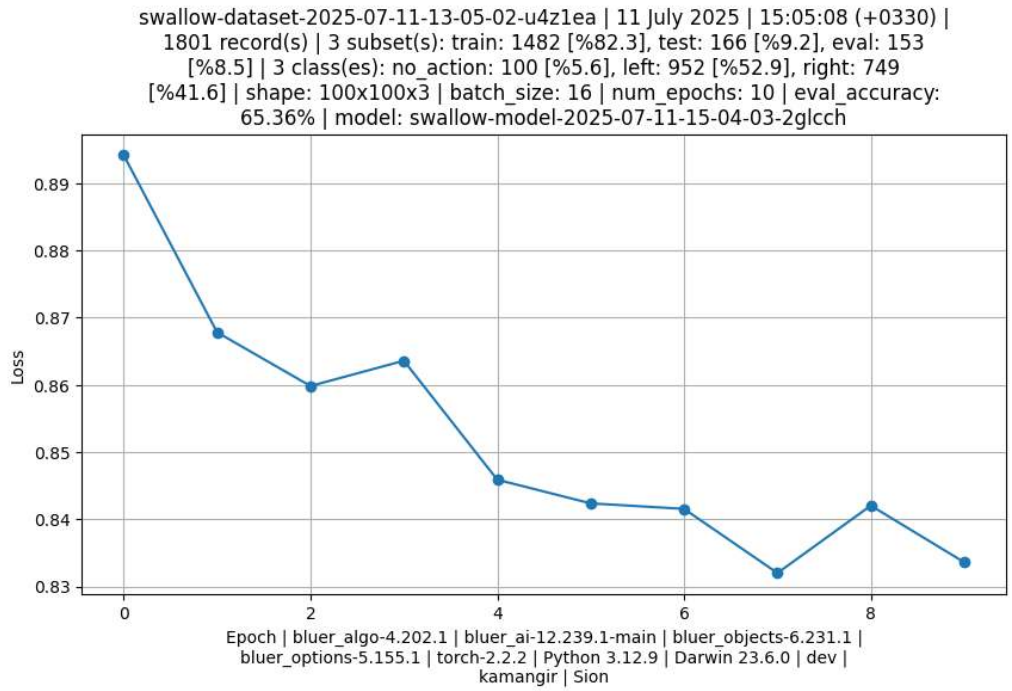
uses combination/validation.

```
@select swallow-dataset-$(@timestamp)

@swallow dataset combine \
    count=2 .

@upload public,zip .
@assets publish \
    extensions=png,push . \
    --prefix grid

@select swallow-model-$(@timestamp)

@image_classifier model train upload .. .

@upload public,zip .
@assets publish \
    extensions=png,push .
```

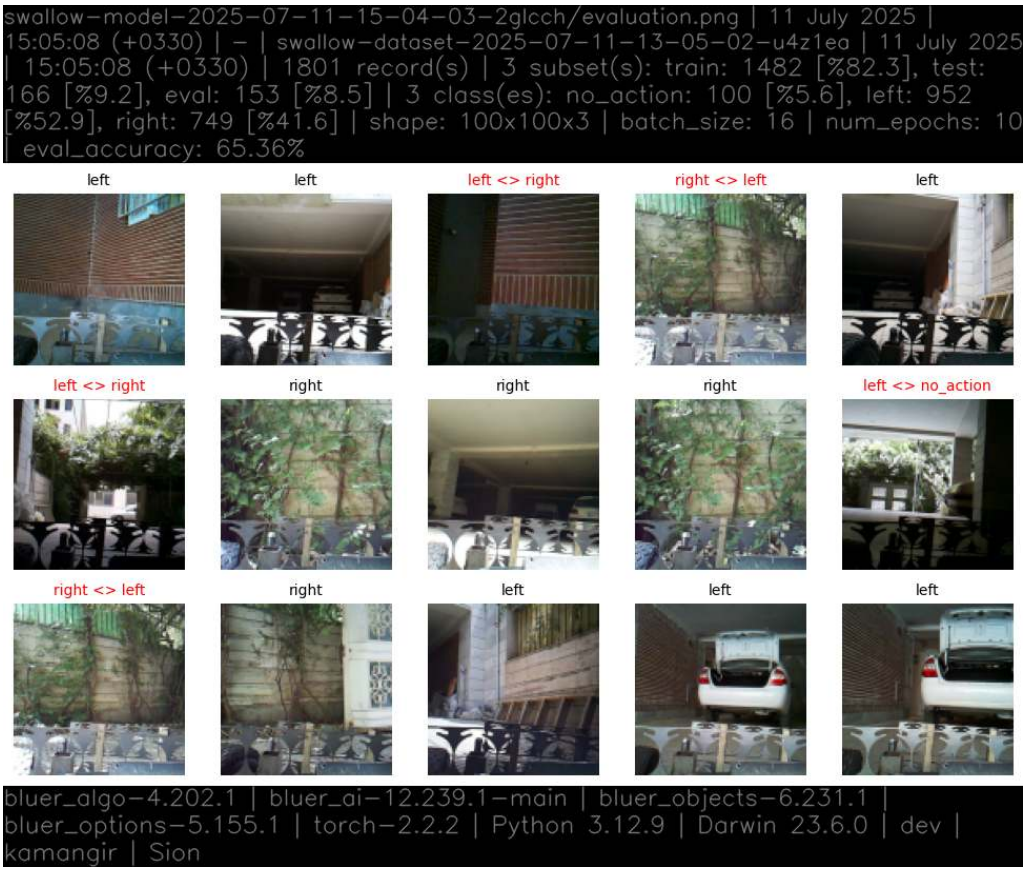
image

swallow-dataset-2025-07-11-13-05-02-u4z1ea

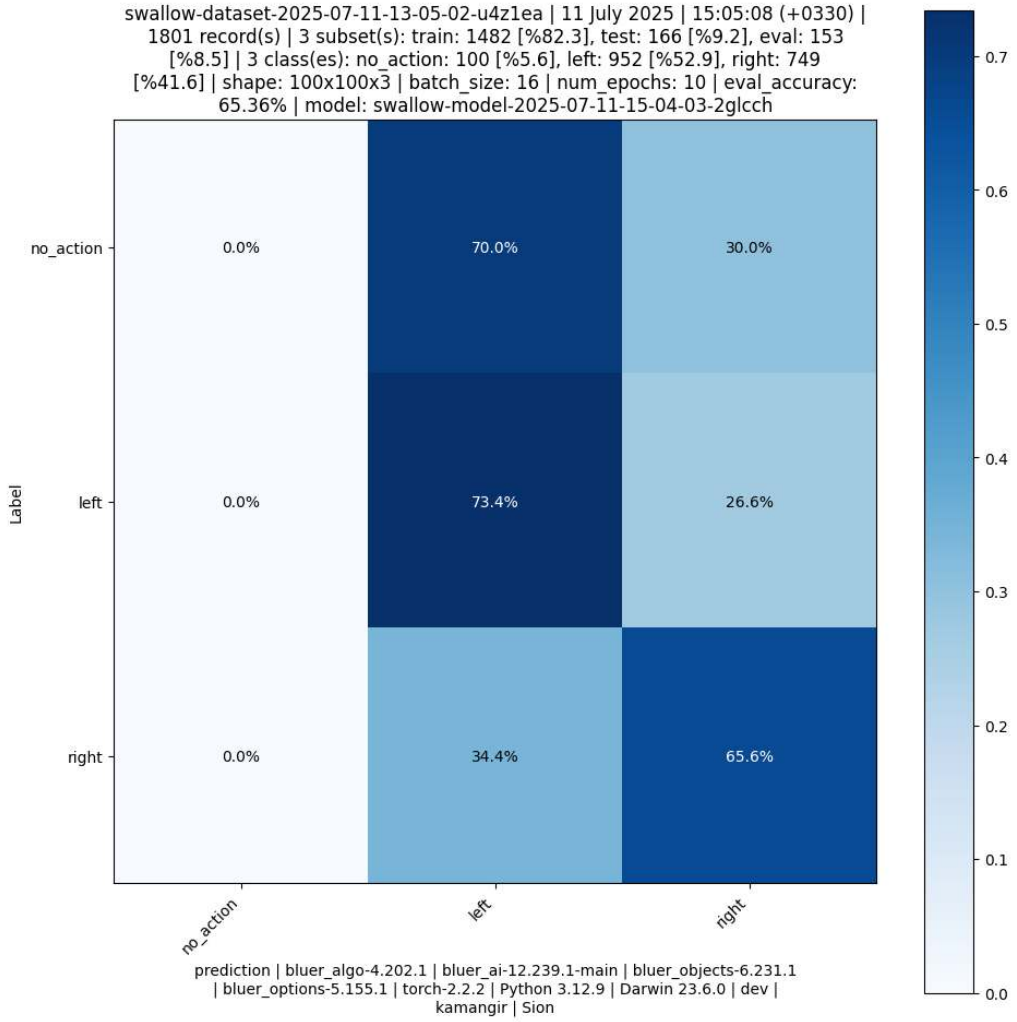
```
dataset:
  class_count: 3
  classes:
    0: no_action
    1: left
    2: right
  contains:
  - 2025-07-09-11-16-52-4zo4zc
  - 2025-07-09-11-34-19-bcoh75
  count: 1801
  shape:
  - 100
  - 100
  - 3
  subsets:
    eval: 153
    test: 166
    train: 1482
```



image


swallow-model-2025-07-11-15-04-03-2glcch/evaluation.png | 11 July 2025 | 15:05:08 (+0330) | - | swallow-dataset-2025-07-11-13-05-02-u4z1ea | 11 July 2025 | 15:05:08 (+0330) | 1801 record(s) | 3 subset(s): train: 1482 [%82.3], test: 166 [%9.2], eval: 153 [%8.5] | 3 class(es): no_action: 100 [%5.6], left: 952 [%52.9], right: 749 [%41.6] | shape: 100x100x3 | batch_size: 16 | num_epochs: 10 | eval_accuracy: 65.36%
left
left
left <> right
right <> left
left
left <> right
right
right
right
left <> no_action
right <> left
right
left
left
left
bluer_algo-4.202.1 | bluer_ai-12.239.1-main | bluer_objects-6.231.1 | bluer_options-5.155.1 | torch-2.2.2 | Python 3.12.9 | Darwin 23.6.0 | dev | kamangir | Sion

image



image

[swallow-model-2025-07-11-15-04-03-2glcch]

```
model:
  dataset:
    class_count: 3
    classes:
      0: no_action
      1: left
      2: right
    count: 1801
    shape:
    - 100
    - 100
    - 3
  evaluation:
    class_accuracy:
      0: 0.0
      1: 0.7341772151898734
      2: 0.65625
    eval_accuracy: 0.6535947712418301
  inputs:
    batch_size: 16
    num_epochs: 10
  training:
    loss:
    - 0.8941771462861343
    - 0.8678298002956045
    - 0.8598417815891838
```

- 0.863602487181845
- 0.8459089610740723
- 0.8423866080208186
- 0.8415681831588951
- 0.8320272445035206
- 0.8420564680286103
- 0.8336275264962643

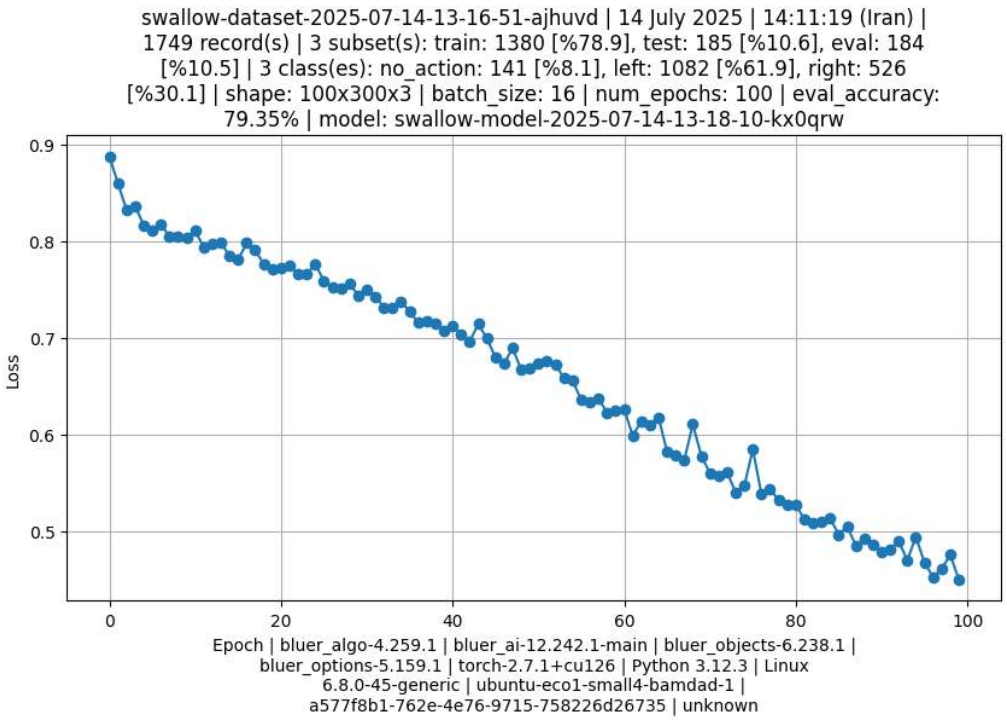
swallow: digital: algo: navigation: model: one

uses combination/one.

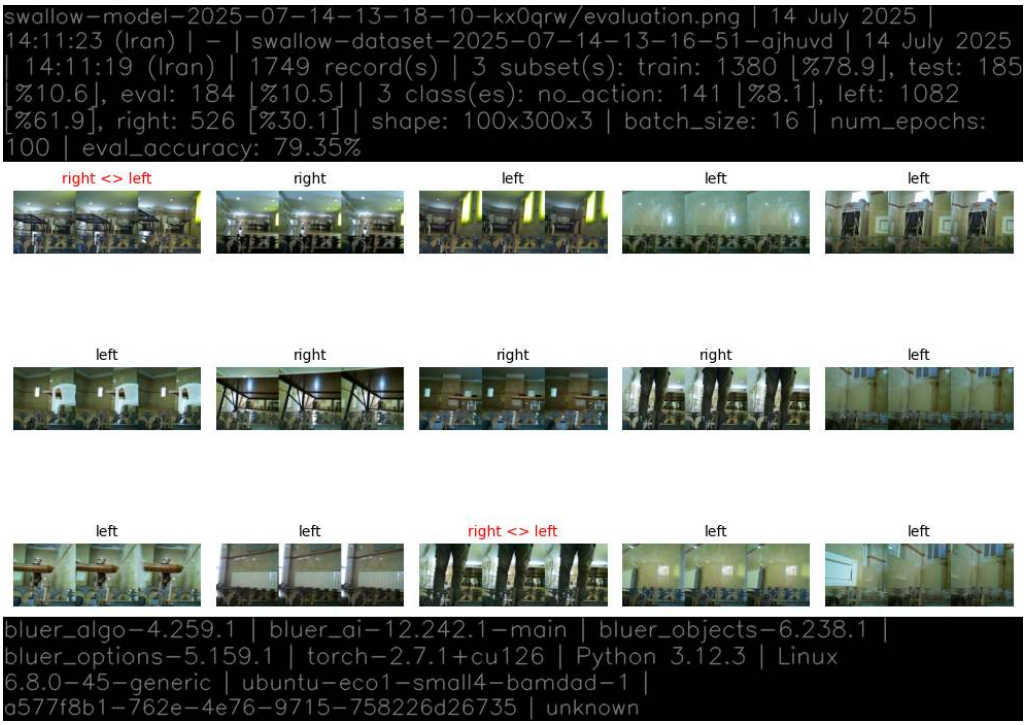
```
@arvan ssh <ip-address>
@arvan seed
# Ctrl+V

@select swallow-dataset-$(@timestamp)

@swallow dataset combine \
    sequence=3 . \
    --datasets $(@list filter \
        $(@swallow dataset list) \
        --contains 2025-07-13)

@upload filename=metadata.yaml .
@assets publish \
    extensions=png,push . \
    --prefix grid

@select swallow-model-$(@timestamp)

@image_classifier model train upload .. . \
    --num_epochs 100

@upload public,zip .
@assets publish \
    extensions=png,push .

@select swallow-prediction-test-$(@timestamp)

@algo image_classifier model prediction_test \
    upload ... .. .

@assets publish \
    extensions=png,push .
```

image

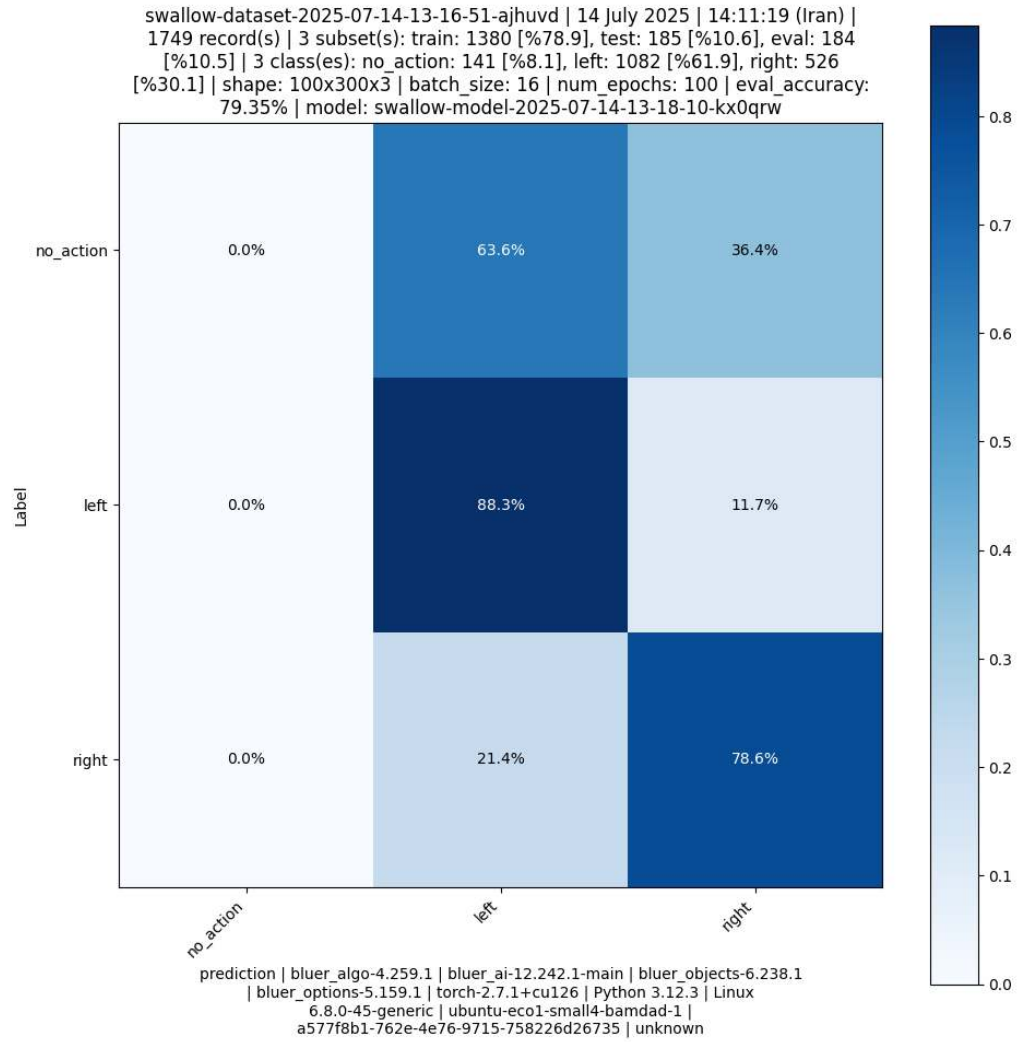
▶ metadata



image



image



image

[swallow-model-2025-07-14-13-18-10-kx0qrw]

▶ metadata

---

swallow-prediction-test-2025-07-14-14-13-57-ngywj1 | 14 July 2025 | 14:14:30 (Iran) | model: swallow-model-2025-07-14-13-18-10-kx0qrw | 3 class(es): #0: no_action, #1: left, #2: right | shape: 100x300x3 | prediction: right [#2] | correct | took 398 ms | bluer_algo-4.259.1 | bluer_ai-12.242.1-main | bluer_objects-6.238.1 | bluer_options-5.159.1 | torch-2.7.1+cu126 | Python 3.12.3 | Linux 6.8.0-45-generic | ubuntu-eco1-small4-bamdad-1 | a577f8b1-762e-4e76-9715-758226d26735 | unknown

image

▶ metadata

aliases: image-classifier

dataset

```
@image_classifier \
    dataset \
    ingest \
    [clone,count=<100>,source=fruits_360,upload] \
    [-|<object-name>] \
    [--class_count -1] \
    [--test_ratio 0.1] \
    [--train_ratio 0.8]
 . ingest -> <object-name>.
@image_classifier \
    dataset \
    review \
    [~download,upload] \
    [.|<object-name>]
 . review <object-name>.
@image_classifier \
    dataset \
    sequence \
    [~download,length=<2>,upload] \
    [.|<source-object-name>] \
    [-|<destination-object-name>]
 . <source-object-name> -sequence-> <destination-object-name>.
```

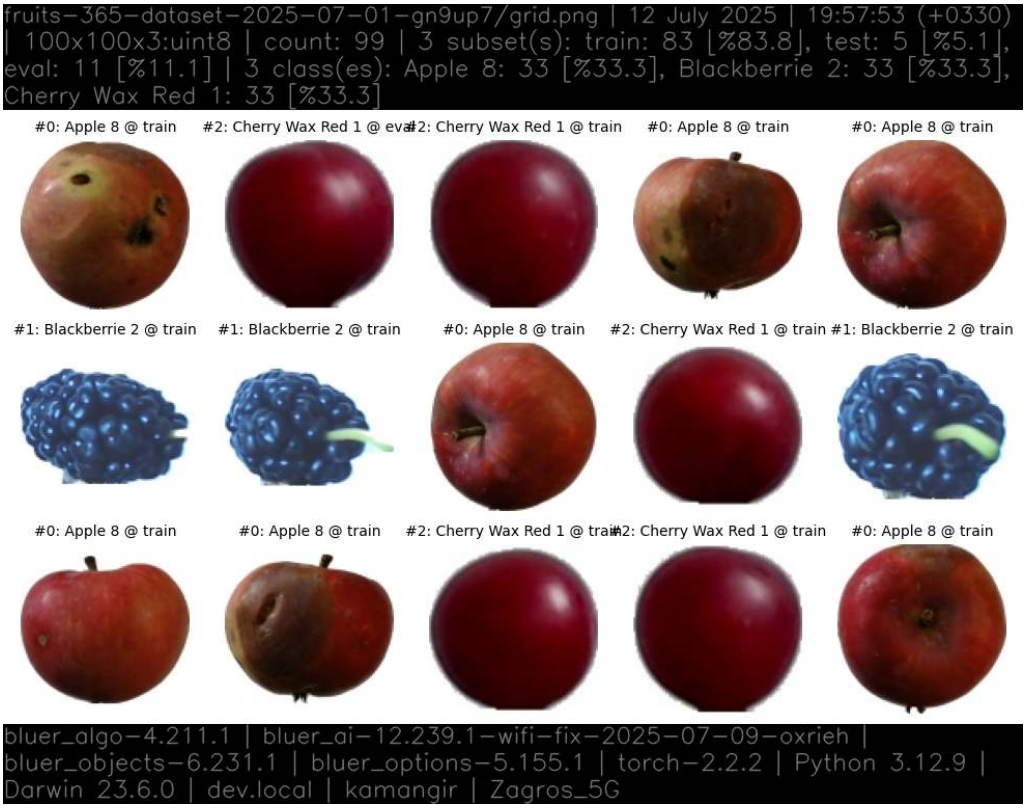
model

```
@image_classifier \
    model \
    prediction_test \
    [~download,upload] \
    [..|<dataset-object-name>] \
    [.|<model-object-name>] \
    [-|<prediction-object-name>]
 . test prediction.
@image_classifier \
    model \
    train \
    [~download,upload] \
    [.|<dataset-object-name>] \
    [-|<model-object-name>] \
    [--batch_size 16] \
    [--num_epochs 10]
 . train.
```

image-classifier: dataset: ingest

- continues https://github.com/kamangir/image-classifier-2.
- uses https://github.com/fruits-360/fruits-360-100x100

```
@select fruits-365-dataset-$(@@timestamp)

@algo image_classifier dataset ingest \
    clone,count=100,source=fruits_360,upload . \
    --class_count 3

@upload public,zip .
@assets publish \
    extensions=png,push .
```



image

[fruits-365-dataset-2025-07-01-gn9up7]

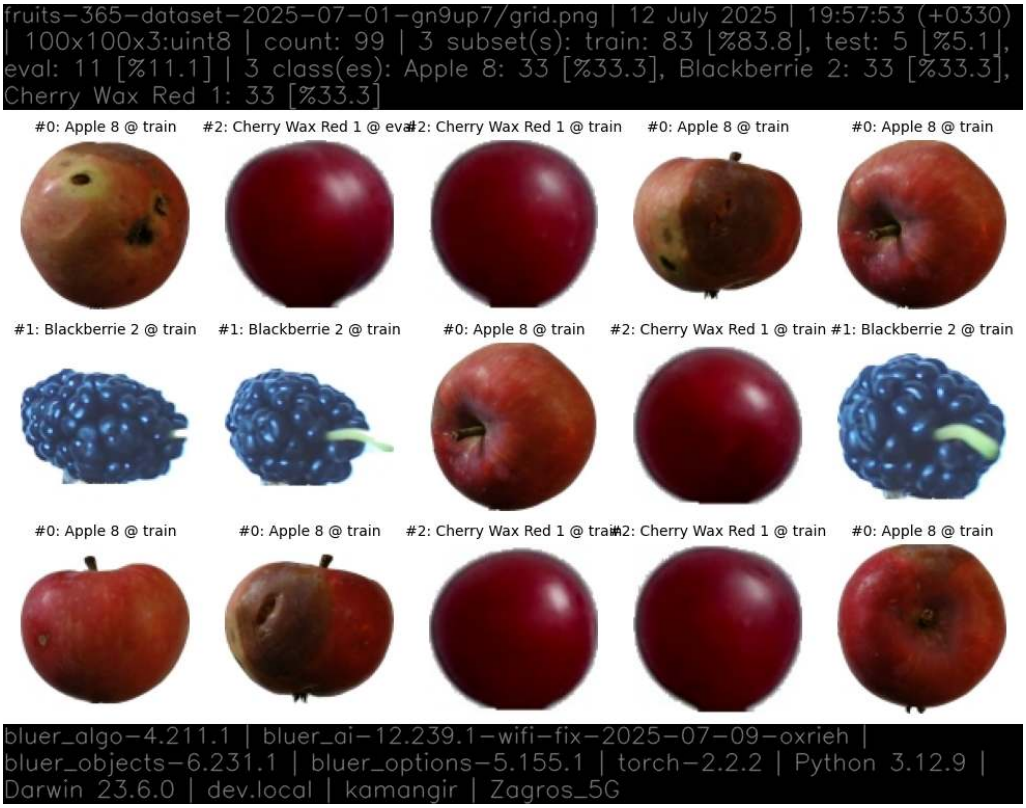
```
dataset:
  class_count: 3
  classes:
    0: Apple 8
    1: Blackberrie 2
    2: Cherry Wax Red 1
  count: 99
  ratios:
    eval: 0.09999999999999998
    test: 0.1
    train: 0.8
```

```
shape:
- 100
- 100
- 3
source: fruits_360
subsets:
  eval: 11
  test: 5
  train: 83
```

image-classifier: dataset: review

uses ingest.

```
@select $BLUER_ALGO_FRUITS_360_TEST_DATASET

@algo image_classifier dataset review - .

@upload public,zip .
@assets publish \
    extensions=png,push .
```



image

fruits-365-dataset-2025-07-01-gn9up7

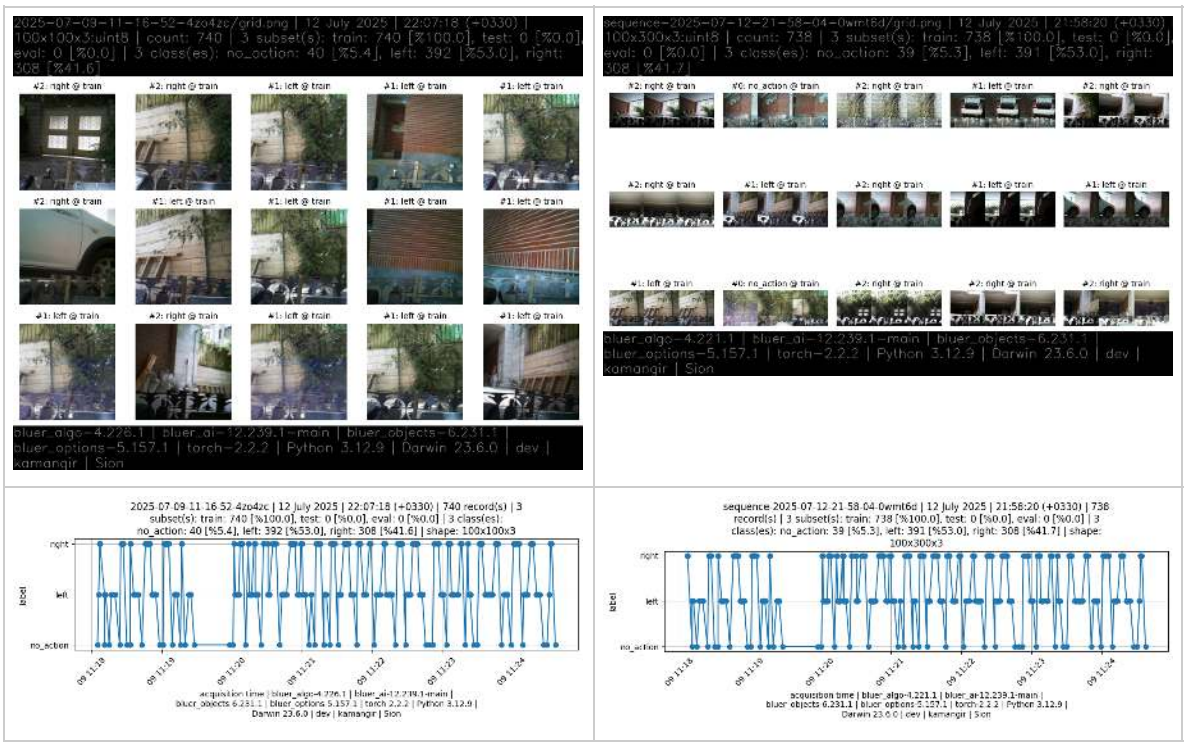
```
dataset:
  class_count: 3
  classes:
    0: Apple 8
    1: Blackberrie 2
    2: Cherry Wax Red 1
  count: 99
  ratios:
    eval: 0.09999999999999998
    test: 0.1
    train: 0.8
  shape:
  - 100
  - 100
```

```
- 3
source: fruits_360
subsets:
  eval: 11
  test: 5
  train: 83
```

image-classifier: dataset: sequence

uses bluer-ugv/swallow/digital/dataset/combination.

```
@select 2025-07-09-11-16-52-4zo4zc

@upload public,zip .
@assets publish \
    extensions=png,push . \
    --prefix grid

@select sequence-$(@timestamp)

@algo image_classifier dataset sequence \
    ~download,length=3 .. .

@upload public,zip .
@assets publish \
    extensions=png,push . \
    --prefix grid
```



[2025-07-09-11-16-52-4zo4zc](2025-07-09-11-16-52-4zo4zc)

```
dataset:
  class_count: 3
  classes:
    0: no_action
    1: left
    2: right
  count: 740
  shape:
```

```
  - 100
  - 100
  - 3
  source: 00000000c74cf7d2
  subsets:
    eval: 0
    test: 0
    train: 740
```

---

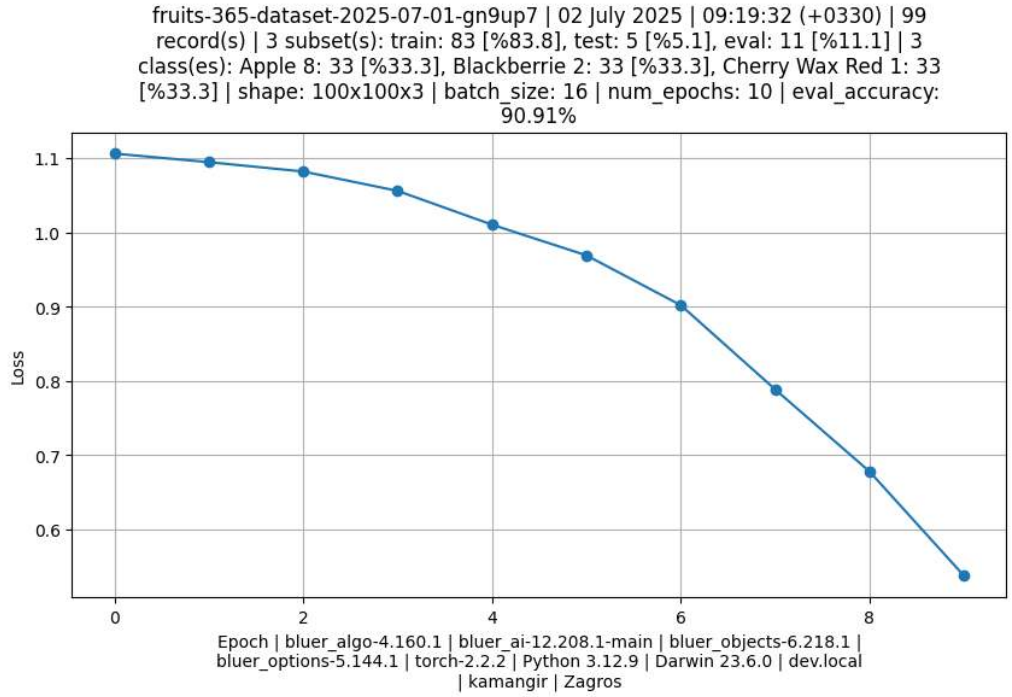
sequence-2025-07-12-21-58-04-0wmt6d

```
dataset:
  class_count: 3
  classes:
    0: no_action
    1: left
    2: right
  count: 738
  length: 3
  shape:
  - 100
  - 300
  - 3
  source: 2025-07-09-11-16-52-4zo4zc
  subsets:
    eval: 0
    test: 0
    train: 738
```

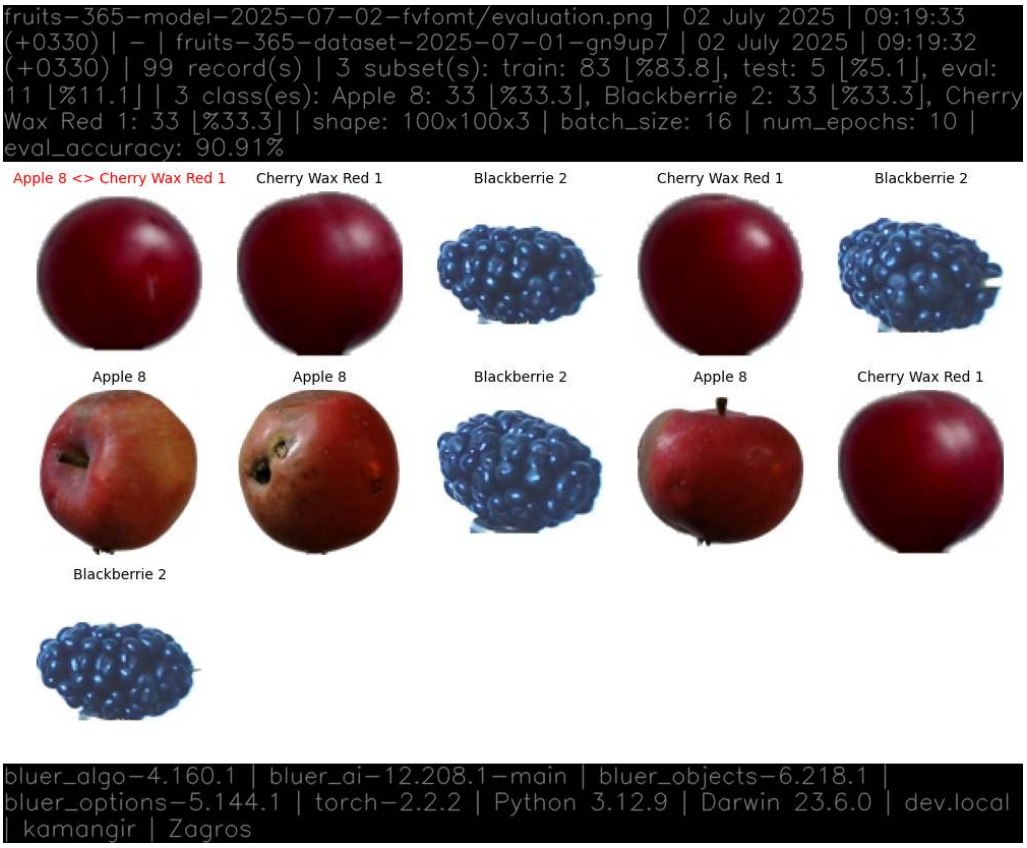
image-classifier: model: train: small

uses ingest.

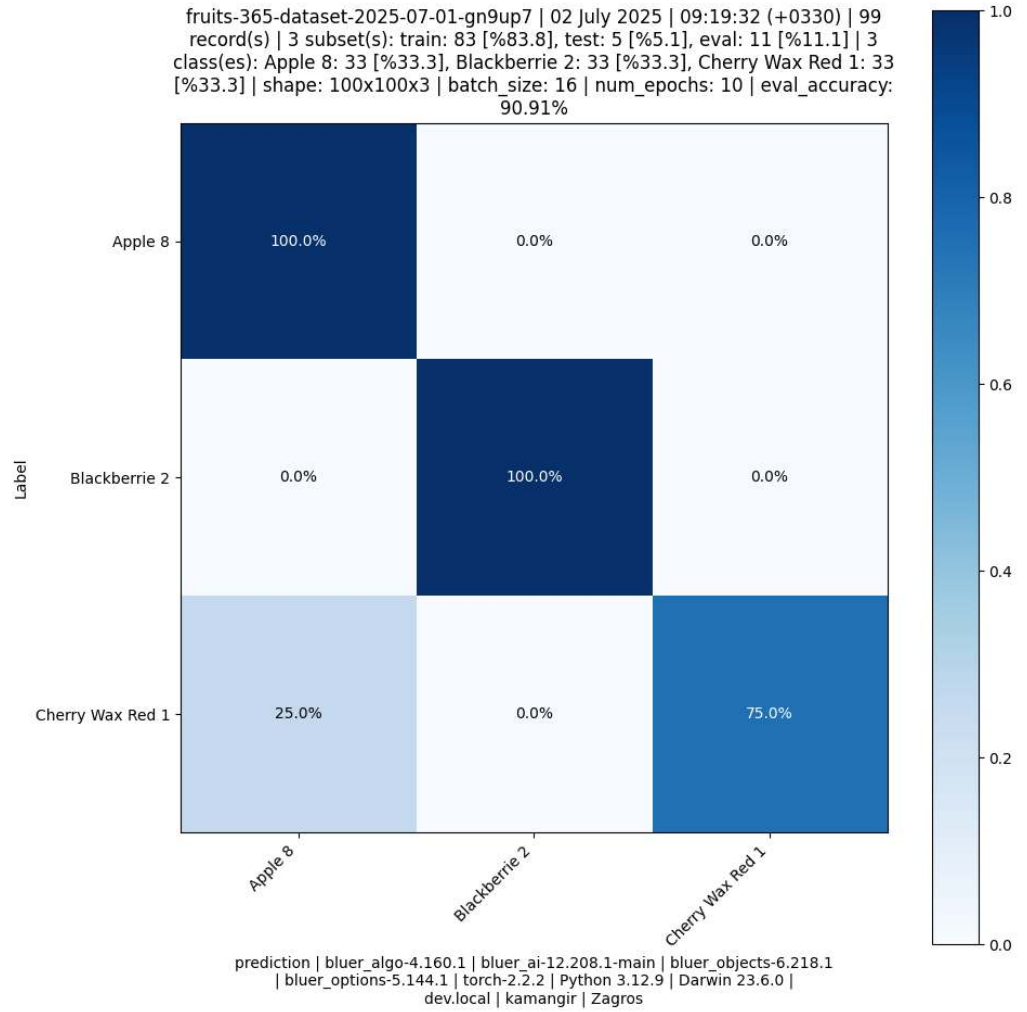
```
@select $BLUER_ALGO_FRUITS_360_TEST_DATASET
@select fruits-365-model-$(@@timestamp)

@algo image_classifier model train \
    upload .. .

@upload public,zip .
@assets publish \
    extensions=png,push .
```



image


fruits-365-model-2025-07-02-fvfomt/evaluation.png | 02 July 2025 | 09:19:33 (+0330) | - | fruits-365-dataset-2025-07-01-gn9up7 | 02 July 2025 | 09:19:32 (+0330) | 99 record(s) | 3 subset(s): train: 83 [%83.8], test: 5 [%5.1], eval: 11 [%11.1] | 3 class(es): Apple 8: 33 [%33.3], Blackberrie 2: 33 [%33.3], Cherry Wax Red 1: 33 [%33.3] | shape: 100x100x3 | batch_size: 16 | num_epochs: 10 | eval_accuracy: 90.91%
Apple 8 <> Cherry Wax Red 1
Cherry Wax Red 1
Blackberrie 2
Cherry Wax Red 1
Blackberrie 2
Apple 8
Apple 8
Blackberrie 2
Apple 8
Cherry Wax Red 1
Blackberrie 2
bluer_algo-4.160.1 | bluer_ai-12.208.1-main | bluer_objects-6.218.1 | bluer_options-5.144.1 | torch-2.2.2 | Python 3.12.9 | Darwin 23.6.0 | dev.local | kamangir | Zagros

image


fruits-365-dataset-2025-07-01-gn9up7 | 02 July 2025 | 09:19:32 (+0330) | 99 record(s) | 3 subset(s): train: 83 [%83.8], test: 5 [%5.1], eval: 11 [%11.1] | 3 class(es): Apple 8: 33 [%33.3], Blackberrie 2: 33 [%33.3], Cherry Wax Red 1: 33 [%33.3] | shape: 100x100x3 | batch_size: 16 | num_epochs: 10 | eval_accuracy: 90.91%
Label
Apple 8
Blackberrie 2
Cherry Wax Red 1
100.0%
0.0%
0.0%
0.0%
100.0%
0.0%
25.0%
0.0%
75.0%
Apple 8
Blackberrie 2
Cherry Wax Red 1
1.0
0.8
0.6
0.4
0.2
0.0
prediction | bluer_algo-4.160.1 | bluer_ai-12.208.1-main | bluer_objects-6.218.1 | bluer_options-5.144.1 | torch-2.2.2 | Python 3.12.9 | Darwin 23.6.0 | dev.local | kamangir | Zagros

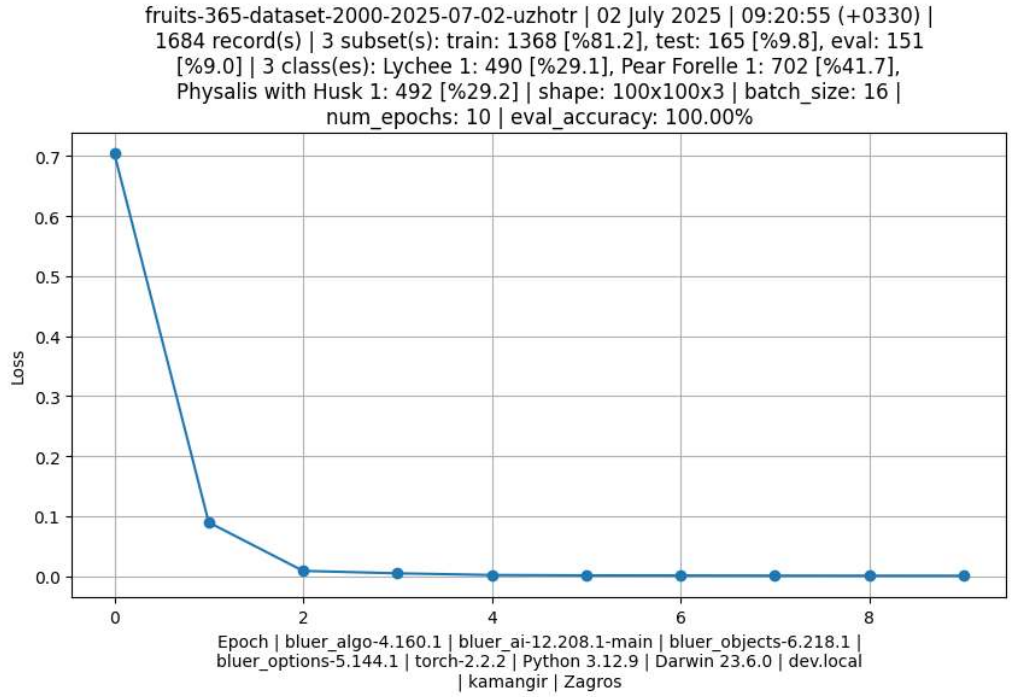
image

fruits-365-model-2025-07-02-fvfomt

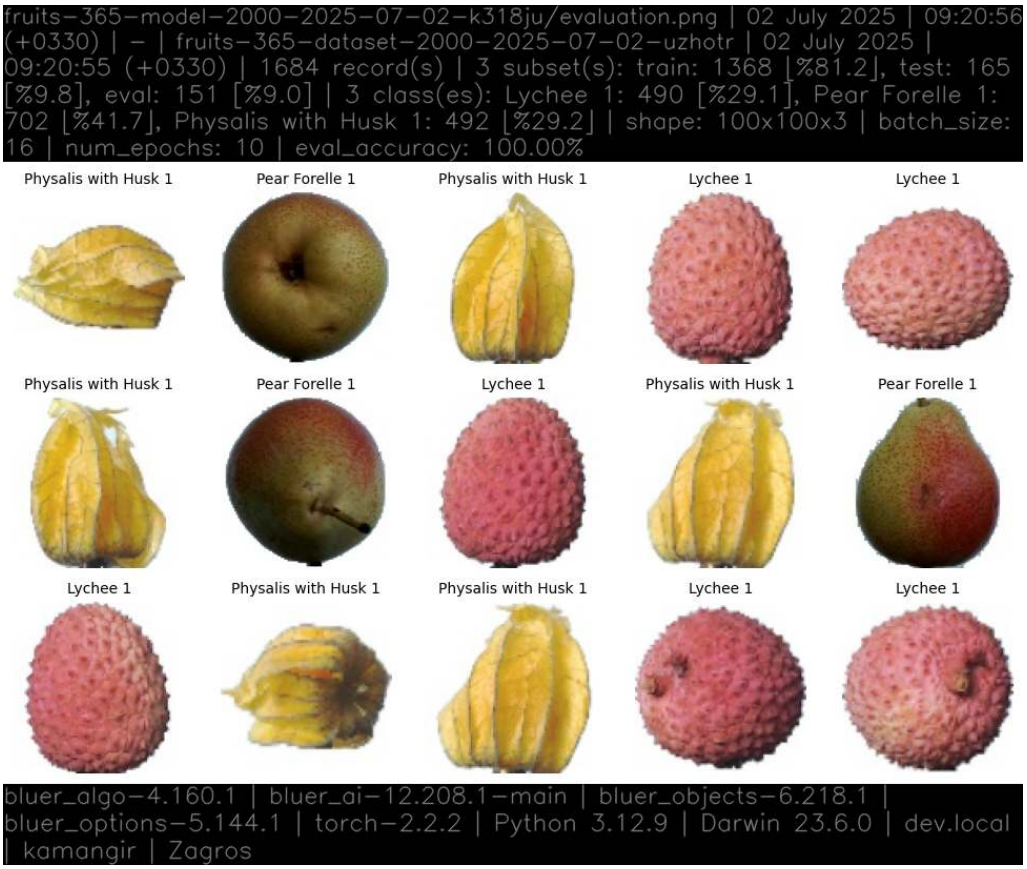

```
model:
  dataset:
    class_count: 3
    classes:
      0: Apple 8
      1: Blackberrie 2
      2: Cherry Wax Red 1
    count: 99
    shape:
    - 100
    - 100
    - 3
  evaluation:
    class_accuracy:
      0: 1.0
      1: 1.0
      2: 0.75
    eval_accuracy: 0.9090909090909091
  inputs:
    batch_size: 16
    num_epochs: 10
  training:
    loss:
    - 1.1059847007314842
    - 1.0944474734455707
    - 1.081830551825374
    - 1.0557171982454967
    - 1.0102007518331688
    - 0.9688218681209059
    - 0.9016210835382162
    - 0.7881300334470818
    - 0.6774013846753592
    - 0.5369924443313875
```

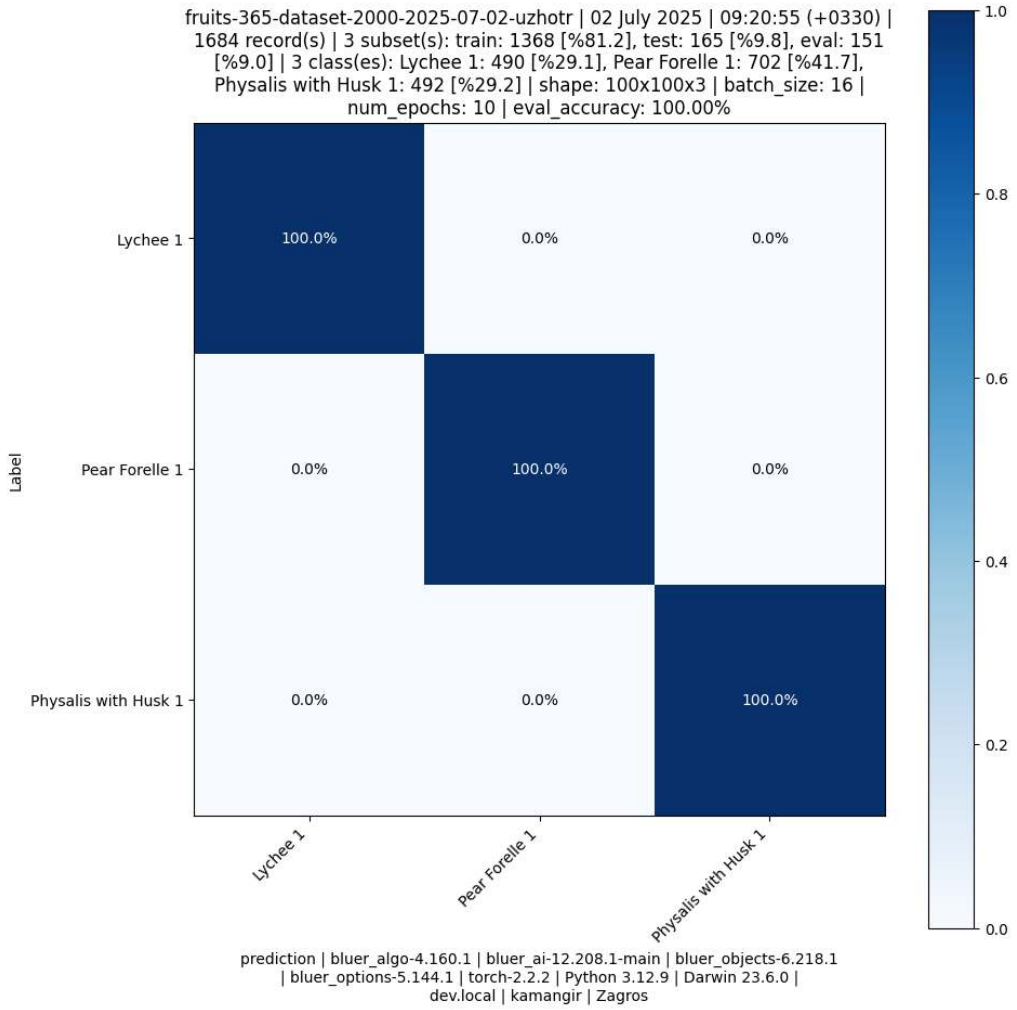
image-classifier: model: train: large

```
@select fruits-365-dataset-2000-$(@@timestamp)

@algo image_classifier dataset ingest \
    clone,count=10000,source=fruits_360 . \
    --class_count 3

@select fruits-365-model-2000-$(@@timestamp)

@algo image_classifier model train \
    ~download,upload .. .

@upload public,zip .
@assets publish \
    extensions=png,push .
```



image


fruits-365-model-2000-2025-07-02-k318ju/evaluation.png | 02 July 2025 | 09:20:56 (+0330) | - | fruits-365-dataset-2000-2025-07-02-uzhotr | 02 July 2025 | 09:20:55 (+0330) | 1684 record(s) | 3 subset(s): train: 1368 [%81.2], test: 165 [%9.8], eval: 151 [%9.0] | 3 class(es): Lychee 1: 490 [%29.1], Pear Forelle 1: 702 [%41.7], Physalis with Husk 1: 492 [%29.2] | shape: 100x100x3 | batch_size: 16 | num_epochs: 10 | eval_accuracy: 100.00%
Physalis with Husk 1
Pear Forelle 1
Physalis with Husk 1
Lychee 1
Lychee 1
Physalis with Husk 1
Pear Forelle 1
Lychee 1
Physalis with Husk 1
Pear Forelle 1
Lychee 1
Physalis with Husk 1
Physalis with Husk 1
Lychee 1
Lychee 1
bluer_algo-4.160.1 | bluer_ai-12.208.1-main | bluer_objects-6.218.1 | bluer_options-5.144.1 | torch-2.2.2 | Python 3.12.9 | Darwin 23.6.0 | dev.local | kamangir | Zagros
image



image

[fruits-365-model-2000-2025-07-02-k318ju]


```
model:
  dataset:
    class_count: 3
    classes:
      0: Lychee 1
      1: Pear Forelle 1
      2: Physalis with Husk 1
    count: 1684
    shape:
    - 100
    - 100
    - 3
  evaluation:
    class_accuracy:
      0: 1.0
      1: 1.0
      2: 1.0
    eval_accuracy: 1.0
  inputs:
    batch_size: 16
    num_epochs: 10
  training:
    loss:
    - 0.7043376307912738
    - 0.08943271208881286
    - 0.008551867894572343
```

- 0.004447948475223993
- 0.0016600372687074743
- 0.0010692106054555244
- 0.0008688547763543214
- 0.0006009176277234873
- 0.0004981696757456296
- 0.0004295692094449789

image-classifier: model: prediction: dev

uses train.

image_classifier_prediction.ipynb

image_classifier-prediction-2025-07-02-13-33-50-lgr380 | 02 July 2025 | 13:33:50 (+0330) | model: fruits-365-model-2025-07-02-fvfomt | 3 class(es): #0: Apple 8, #1: Blackberrie 2, #2: Cherry Wax Red 1 | shape: 100x100x3 | prediction: Apple 8 [#0] | correct | took 015 ms | bluer_algo-4.179.1 | bluer_ai-12.208.1 | bluer_objects-6.220.1 | bluer_options-5.144.1 | torch-2.2.2 | Python 3.12.9 | Darwin 23.6.0 | | Jupyter-Notebook

image

```
prediction:
  elapsed_time: 0.015111207962036133
  predicted_class: 0
```

image-classifier: model: prediction: rpi

uses train.

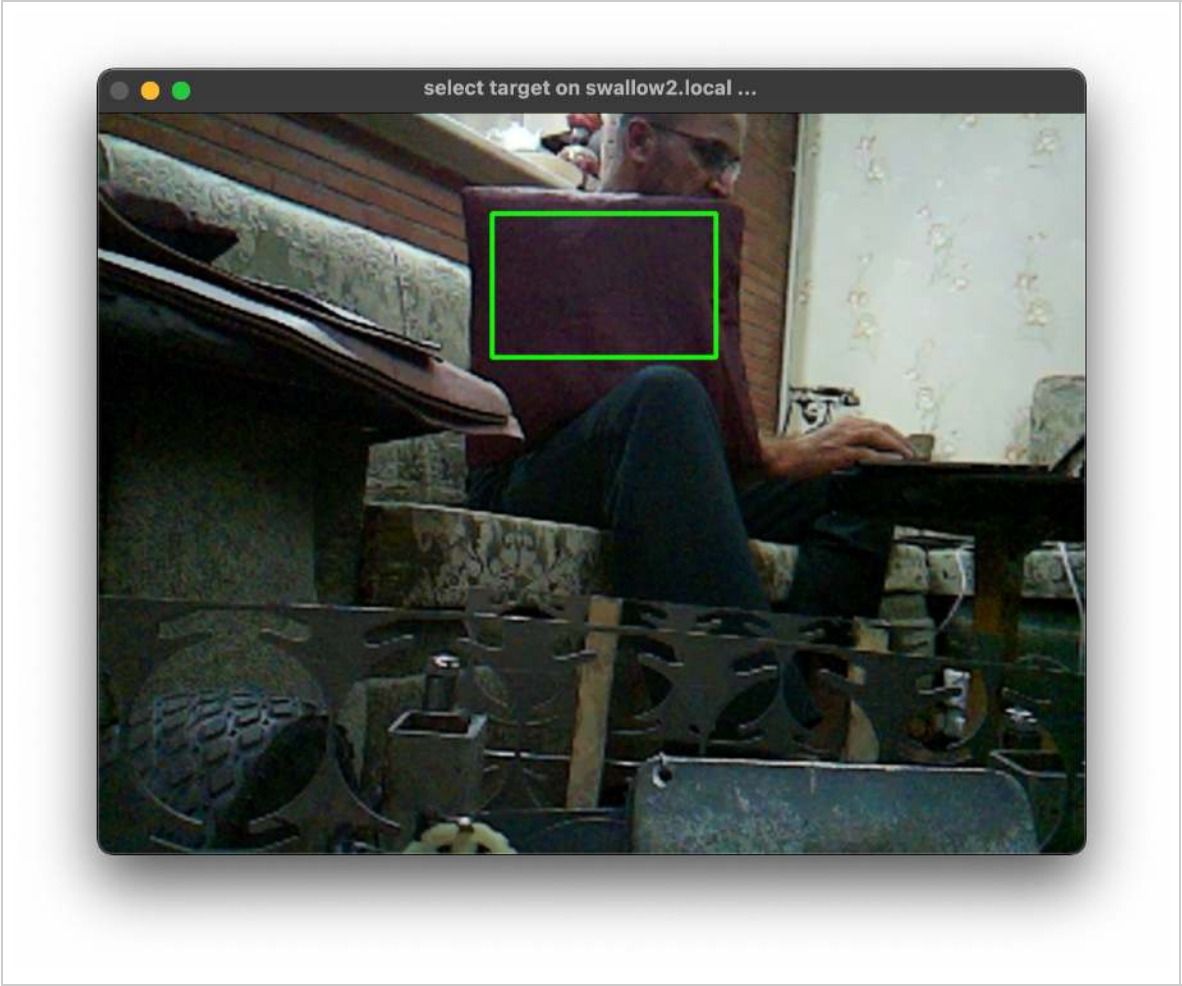
```
@algo test what=test_bluer_algo_image_classifier_model_prediction_test \
    upload
```

image_classifier-prediction-2025-07-02-16-11-03-0kb1d3 | 02 July 2025 | 16:11:39 (+0330) | model: fruits-365-model-2025-07-02-fvfomt | 3 class(es): #0: Apple 8, #1: Blackberrie 2, #2: Cherry Wax Red 1 | shape: 100x100x3 | prediction: Apple 8 [#0] | correct | took 081 ms | bluer_algo-4.185.1 | bluer_ai-12.208.1-main | bluer_objects-6.220.1 | bluer_options-5.139.1 | torch-2.4.1 | Python 3.8.10 | Linux 5.4.0-1129-raspi | swallow | 7p7yq | Sion

image

```
prediction:
  elapsed_time: 0.08102989196777344
  predicted_class: 0
```

swallow: digital: algo: tracking



target tracking using an @algo/tracker.

```
@swallow env cp tracking
```

aliases: tracker

```
@algo \
    tracker \
    [algo=camshift|meanshift,camera,~download,dryrun,sandbox,upload] \
    [-|<object-name>] \
    [--frame_count <10>] \
    [--log 1] \
    [--show_gui 1] \
    [--verbose 1]
 . run algo.
```

tracker

target tracking for a ugv using mean/cam-shift.

- sandbox: sandbox/mean-cam-shift
- camshift
- meanshift

> ℹ️ conclusion: `camshift` tracks distinct colors robustly and adjusts to object size.

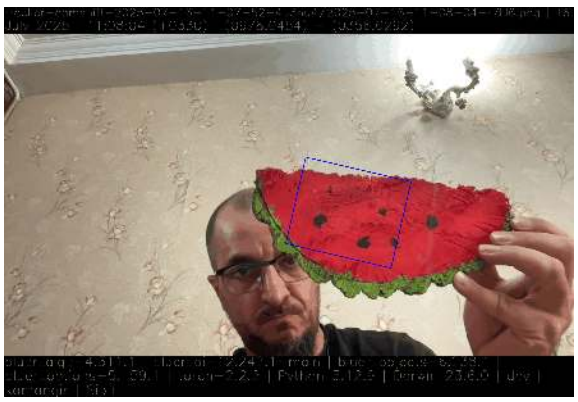
tracker: camshift

on a video file

```
@select tracker-camshift-$(@timestamp)

@algo tracker \
    algo=camshift . \
    --log 1

@assets publish \
    extensions=gif,push .
```

on camera feed

```
@select tracker-camshift-$(@timestamp)

@algo tracker \
    algo=camshift,camera . \
    --log 1 \
    --show_gui 1

@assets publish \
    extensions=gif,push .
```



tracker: meanshift

on a video file

```
@select tracker-meanshift-$(@timestamp)

@algo tracker \
    algo=meanshift . \
    --log 1

@assets publish \
    extensions=gif,push .
```

on camera feed

```
@select tracker-meanshift-$(@timestamp)

@algo tracker \
    algo=meanshift,camera . \
    --log 1 \
    --show_gui 1

@assets publish \
    extensions=gif,push .
```

swallow: digital: algo: yolo

target tracking using an @algo/yolo.

```
@swallow env cp yolo
```

- training a 256x256 model

```
@swallow debug
```

swallow: digital: algo: yolo: train

training a `256 x 256` model.

ingest

```
@select coco128-$(@@timestamp)

@yolo dataset ingest - . \
    --classes person

@yolo dataset review \
    ~download .

@upload public,zip

@assets publish \
    extensions=png,push .
```

coco128-2025-09-16-ko2aq9

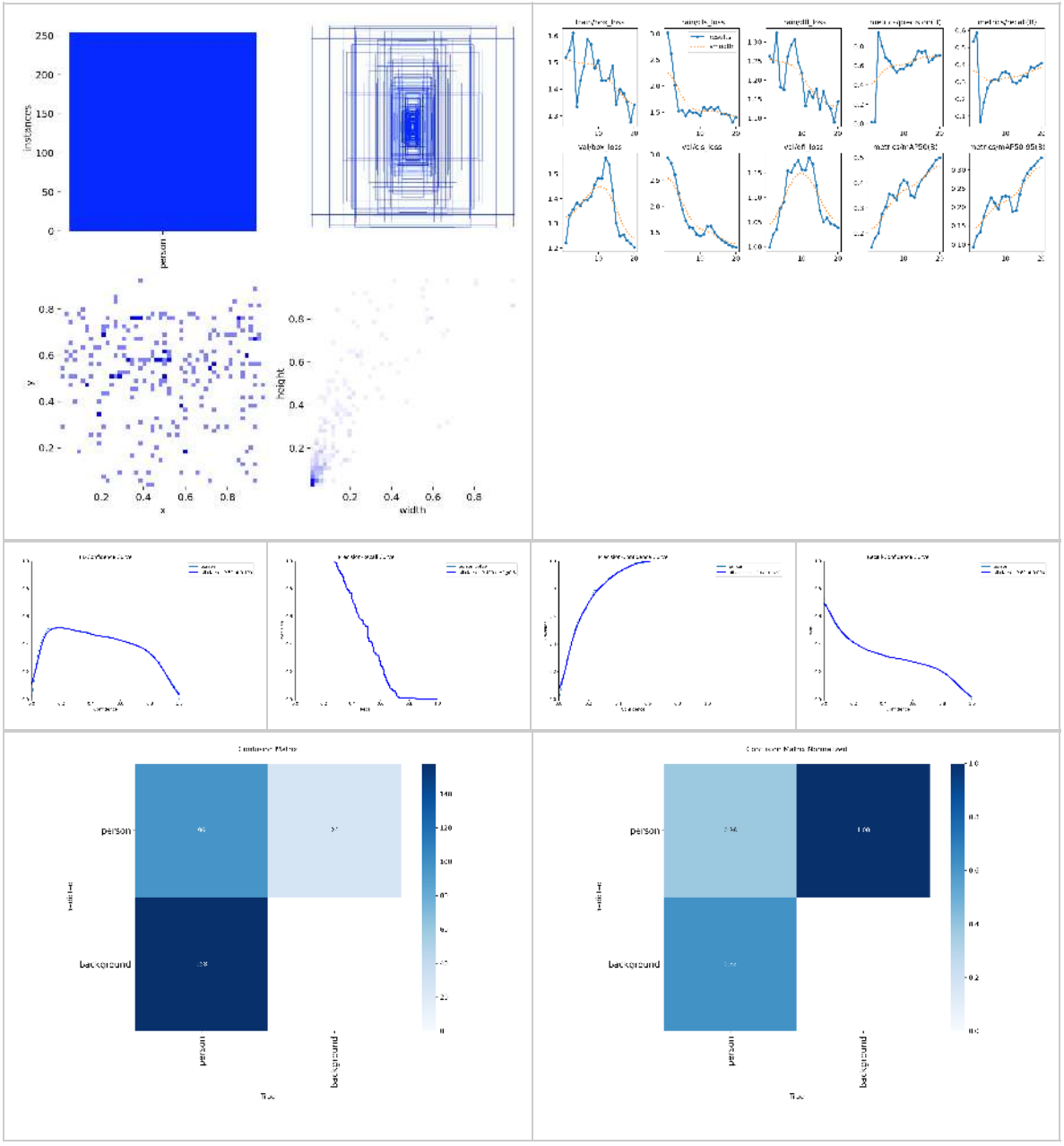
image

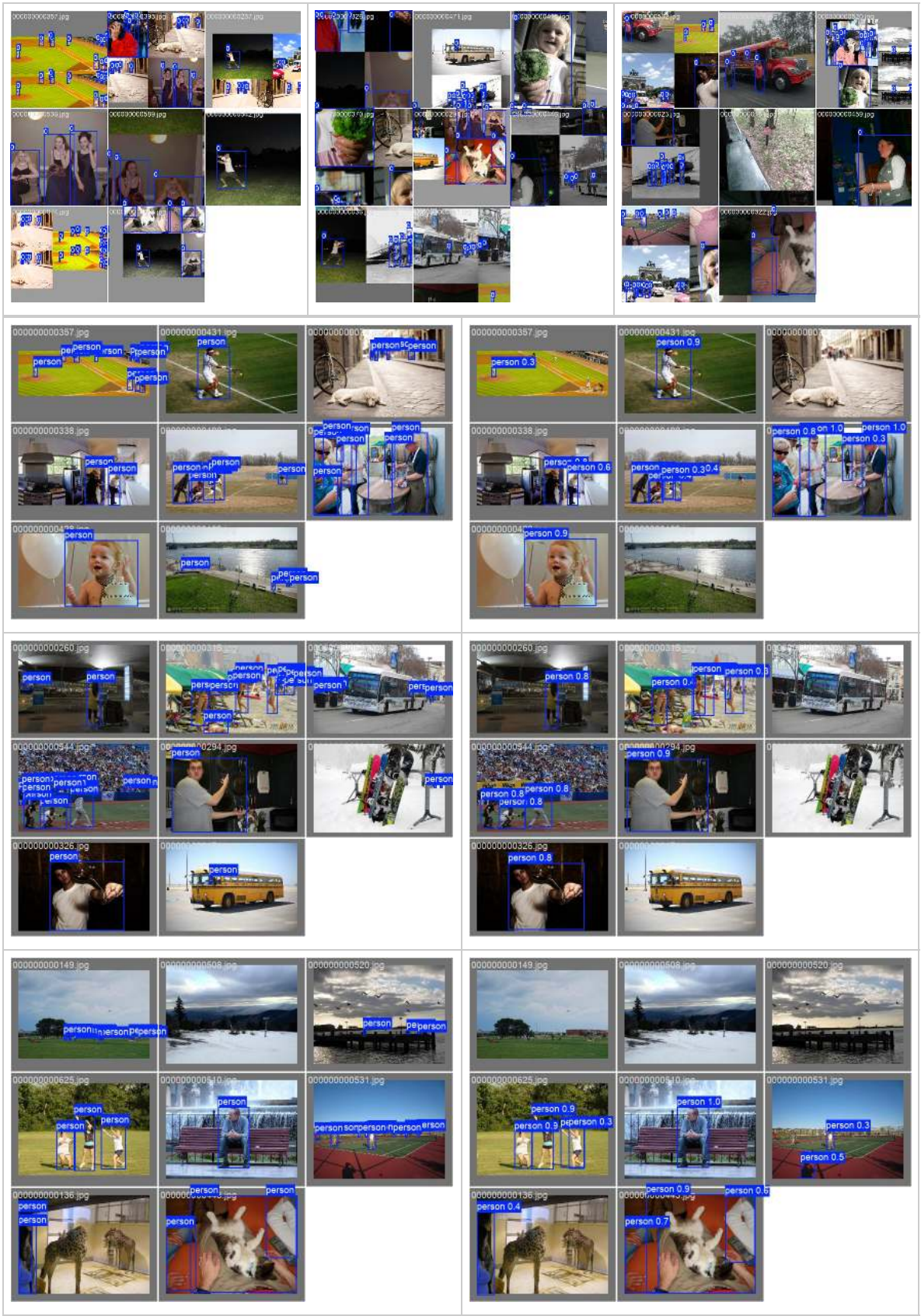
```
dataset:
  count: 61
names:
  0: person
source: coco_128
train: coco128/images/train2017
val: coco128/images/train2017
```

train

```
@select coco128-model-$(@@timestamp)

@yolo model train \
    ~download,upload .. . \
    --epochs 20 \
    --image_size 256

@upload public,zip

@assets publish \
    extensions=jpg+png . \
    --prefix train/

@assets publish \
    extensions=jpg+png,push . \
    --prefix validation/
```

coco128-model-2025-09-16-meb4if



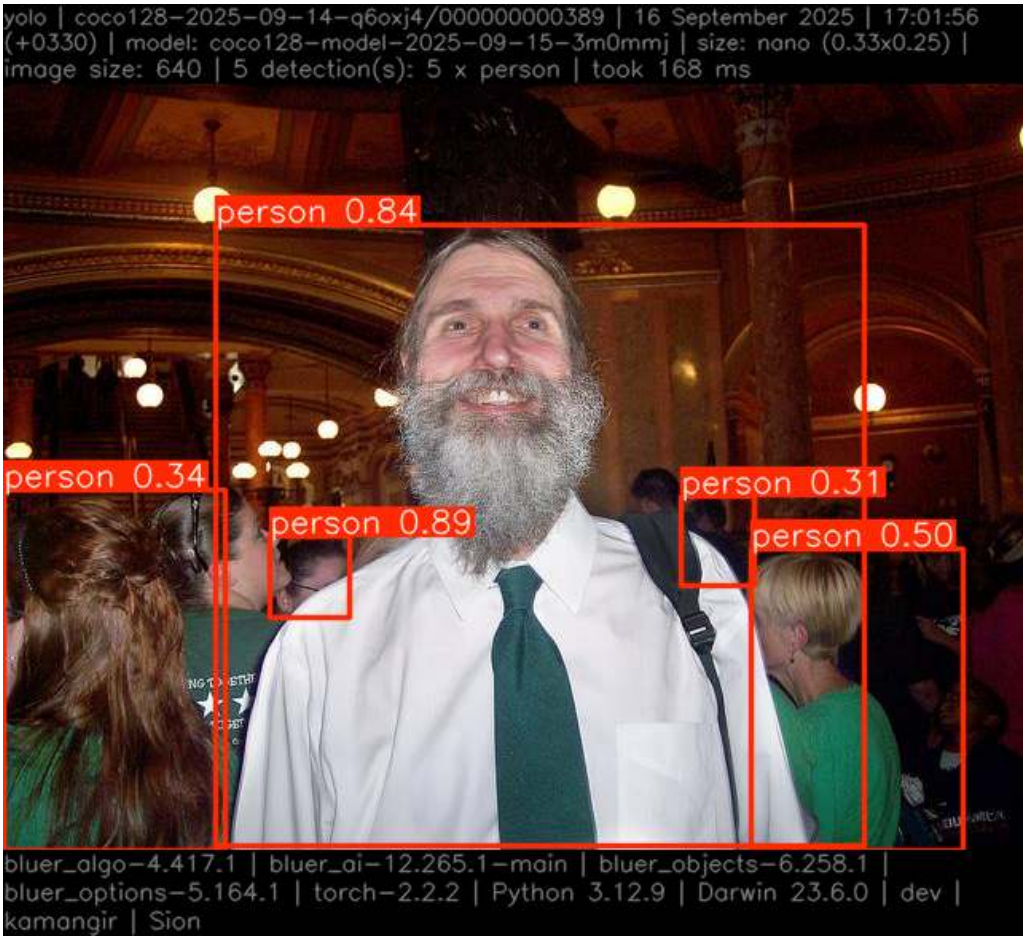


▶ metadata

predict

```
@select yolo-prediction-test-$(@timestamp)

@yolo model prediction_test \
```

```
    upload \
    $BLUER_ALGO_COCO128_TEST_DATASET \
    $BLUER_UGV_SWALLOW_YOLO_MODEL . \
    --record_index 3

@assets publish extensions=png,push
```



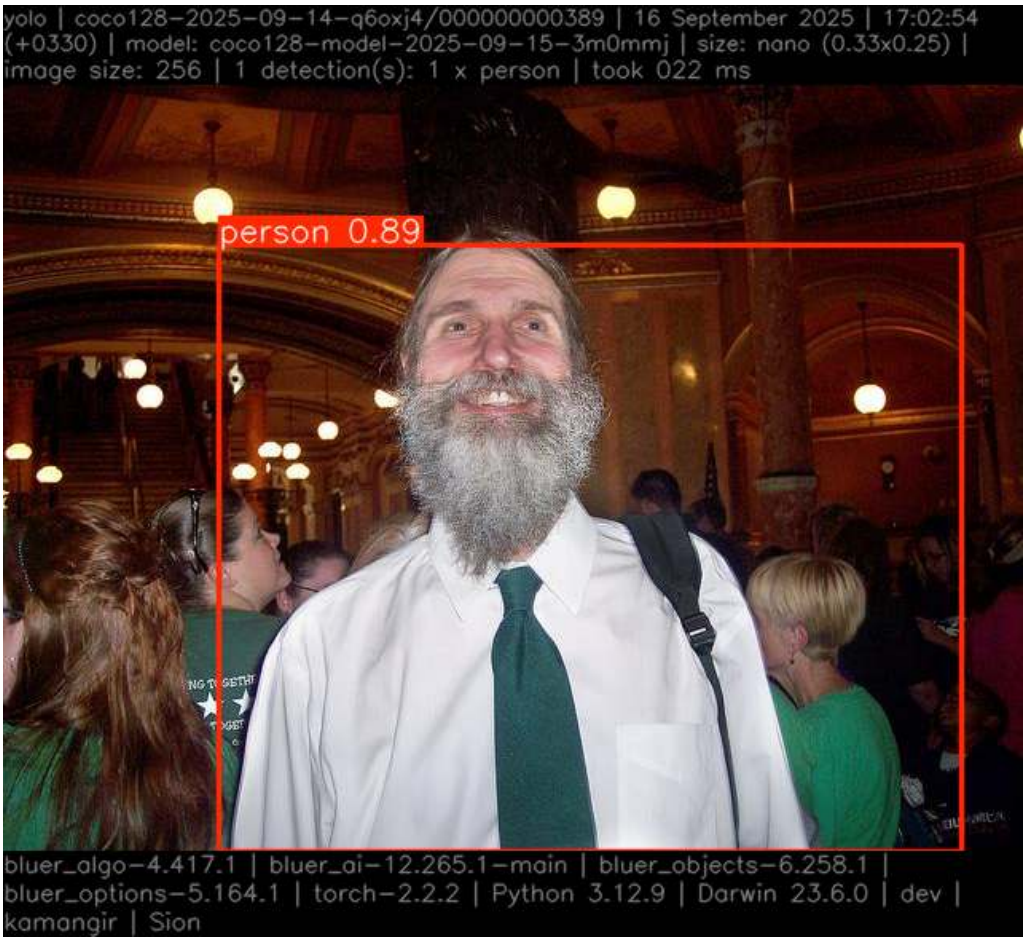
image

```
000000000389:
  detections:
  - bbox_xyxy:
    - 167.85377502441406
    - 283.70269775390625
    - 217.58558654785156
    - 334.81072998046875
    class_id: 0
    confidence: 0.8922585248947144
    label: person
  - bbox_xyxy:
    - 133.1409912109375
    - 88.43701171875
    - 540.6605834960938
    - 477.65869140625
    class_id: 0
    confidence: 0.842871367931366
    label: person
  - bbox_xyxy:
    - 469.0397644042969
    - 291.564697265625
    - 602.921875
    - 480.0
    class_id: 0
```

```
    confidence: 0.49844595789909363
    label: person
  - bbox_xyxy:
    - 0.58984375
    - 254.95266723632812
    - 139.97897338867188
    - 480.0
    class_id: 0
    confidence: 0.33697929978370667
    label: person
  - bbox_xyxy:
    - 425.3193359375
    - 258.2589416503906
    - 471.283935546875
    - 314.4782409667969
    class_id: 0
    confidence: 0.31127116084098816
    label: person
  elapsed_time: 0.16768479347229004
  image_size:
  - 480
  - 640
```

predict (256)

```
@select yolo-prediction-test-$(@timestamp)

@yolo model prediction_test \
    upload \
    $BLUER_ALGO_COCO128_TEST_DATASET \
    $BLUER_UGV_SWALLOW_YOLO_MODEL . \
    --record_index 3 \
    --image_size 256

@assets publish extensions=png,push
```

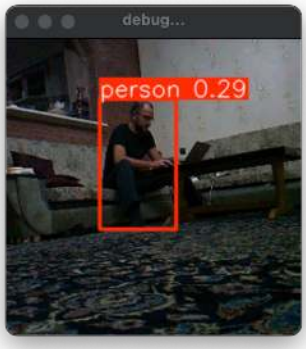


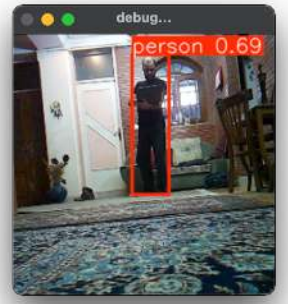
image


```
000000000389:
  detections:
  - bbox_xyxy:
    - 135.89393615722656
    - 100.03055572509766
    - 601.81640625
    - 480.0
    class_id: 0
    confidence: 0.8894820213317871
    label: person
  elapsed_time: 0.022478818893432617
  image_size:
  - 480
  - 640
```


predict (rpi)

```
@select swallow-debug-$(@timestamp)

@swallow debug .

@assets publish extensions=gif,push
```


debug...
person 0.29


debug...
person 0.69


debug...
person 0.88


debug...
person 0.95


debug...
person 0.87

aliases: yolo

dataset

```
@yolo \
    dataset \
    ingest \
    [dryrun,source=coco_128,upload] \
    [-|<object-name>] \
    [--classes all | person+boat] \
    [--verbose 1]
 . ingest -> <object-name>.
@yolo \
    dataset \
    review \
    [~download,upload] \
    [.|<object-name>] \
    [--verbose 1]
 . review <object-name>.
```

model

```
@yolo \
    model \
    prediction_test \
    [~download,upload] \
    [..|<dataset-object-name>] \
    [.|<model-object-name>] \
    [-|<prediction-object-name>] \
    [--image_size 640] \
    [--record_index 0] \
    [--warmup 0]
 . test prediction.
@yolo \
    model \
    train \
    [~download,upload] \
    [.|<dataset-object-name>] \
    [-|<model-object-name>] \
    [--batch 8] \
    [--device cpu | 0 | 0,1] \
    [--epochs 30] \
    [--from_scratch 1] \
    [--image_size 640] \
    [--model_size nano | small | medium | large | xlarge] \
    [--validate 0] \
    [--verbose 1] \
    [--workers 4]
 . train.
```

yolo: dataset: ingest-and-review

full

```
@select coco128-$(@@timestamp)

@yolo dataset ingest \
    upload .

@yolo dataset review \
    ~download .

@upload public,zip .
@assets publish \
    extensions=png,push .
```

image

[coco128-2025-09-14-q6oxj4]

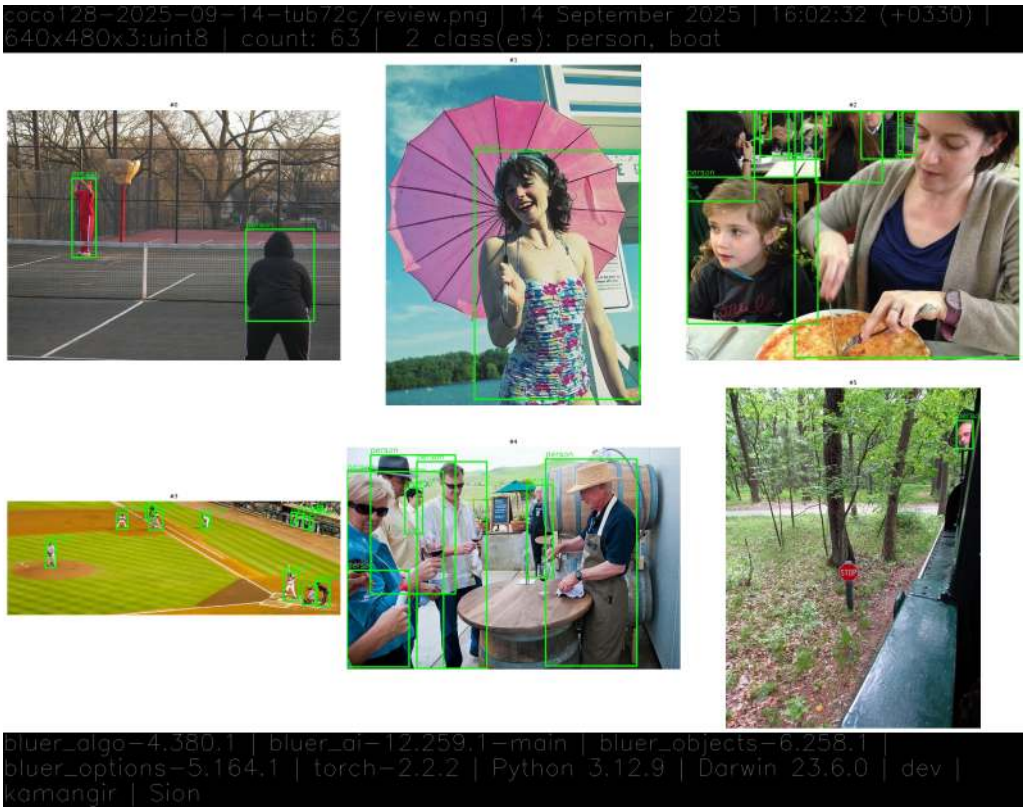
```
dataset:
  count: 126
names:
  0: person
  1: bicycle
  2: car
  3: motorcycle
```

```
4: airplane
5: bus
6: train
7: truck
8: boat
9: traffic light
10: fire hydrant
11: stop sign
12: parking meter
13: bench
14: bird
15: cat
16: dog
17: horse
18: sheep
19: cow
20: elephant
21: bear
22: zebra
23: giraffe
24: backpack
25: umbrella
26: handbag
27: tie
28: suitcase
29: frisbee
30: skis
31: snowboard
32: sports ball
33: kite
34: baseball bat
35: baseball glove
36: skateboard
37: surfboard
38: tennis racket
39: bottle
40: wine glass
41: cup
42: fork
43: knife
44: spoon
45: bowl
46: banana
47: apple
48: sandwich
49: orange
50: broccoli
51: carrot
52: hot dog
53: pizza
54: donut
55: cake
56: chair
57: couch
58: potted plant
59: bed
60: dining table
61: toilet
62: tv
63: laptop
64: mouse
65: remote
66: keyboard
67: cell phone
68: microwave
```

```
  69: oven
  70: toaster
  71: sink
  72: refrigerator
  73: book
  74: clock
  75: vase
  76: scissors
  77: teddy bear
  78: hair drier
  79: toothbrush
source: coco_128
train: coco128/images/train2017
val: coco128/images/train2017
```

select classes

```
@select coco128-$(@@timestamp)

@yolo dataset ingest \
    upload . \
    --classes person+boat

@yolo dataset review \
    ~download .

@upload public,zip .
@assets publish \
    extensions=png,push .
```



image

[coco128-2025-09-14-tub72c]

```
dataset:
  count: 63
```

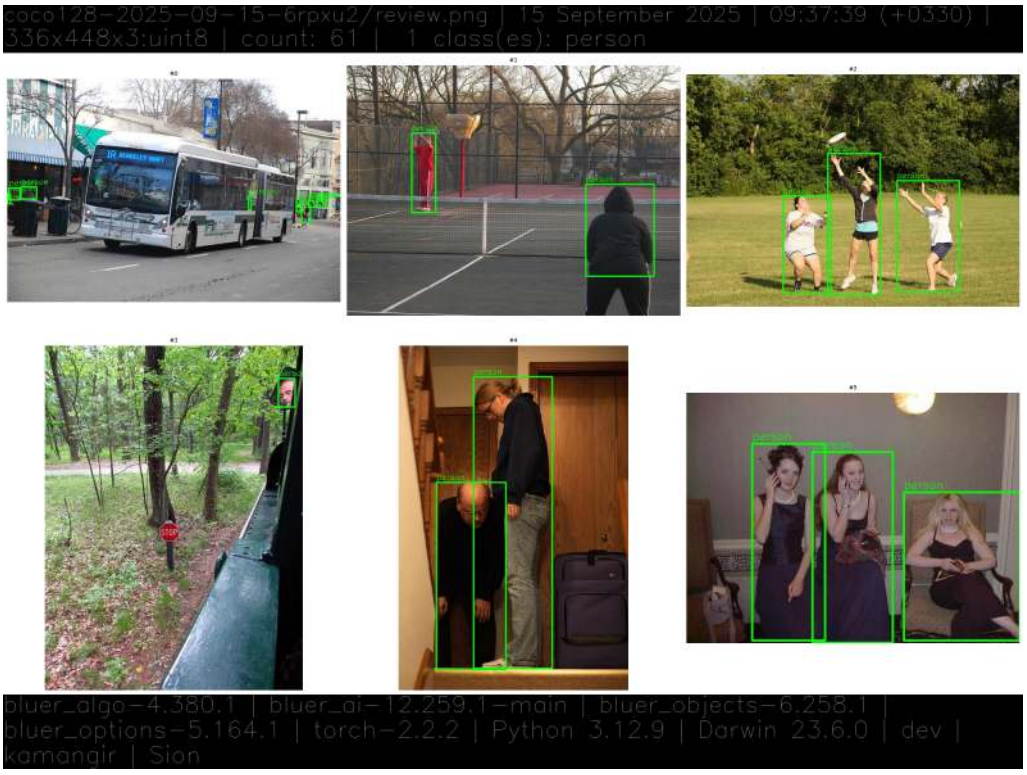
```
names:
  0: person
  1: boat
source: coco_128
train: coco128/images/train2017
val: coco128/images/train2017
```

yolo: model: validation

ingest

```
@select coco128-$(@@timestamp)

@yolo dataset ingest - . \
    --classes person

@yolo dataset review \
    ~download .

@upload public,zip

@assets publish \
    extensions=png,push .
```

coco128-2025-09-15-6rpxu2



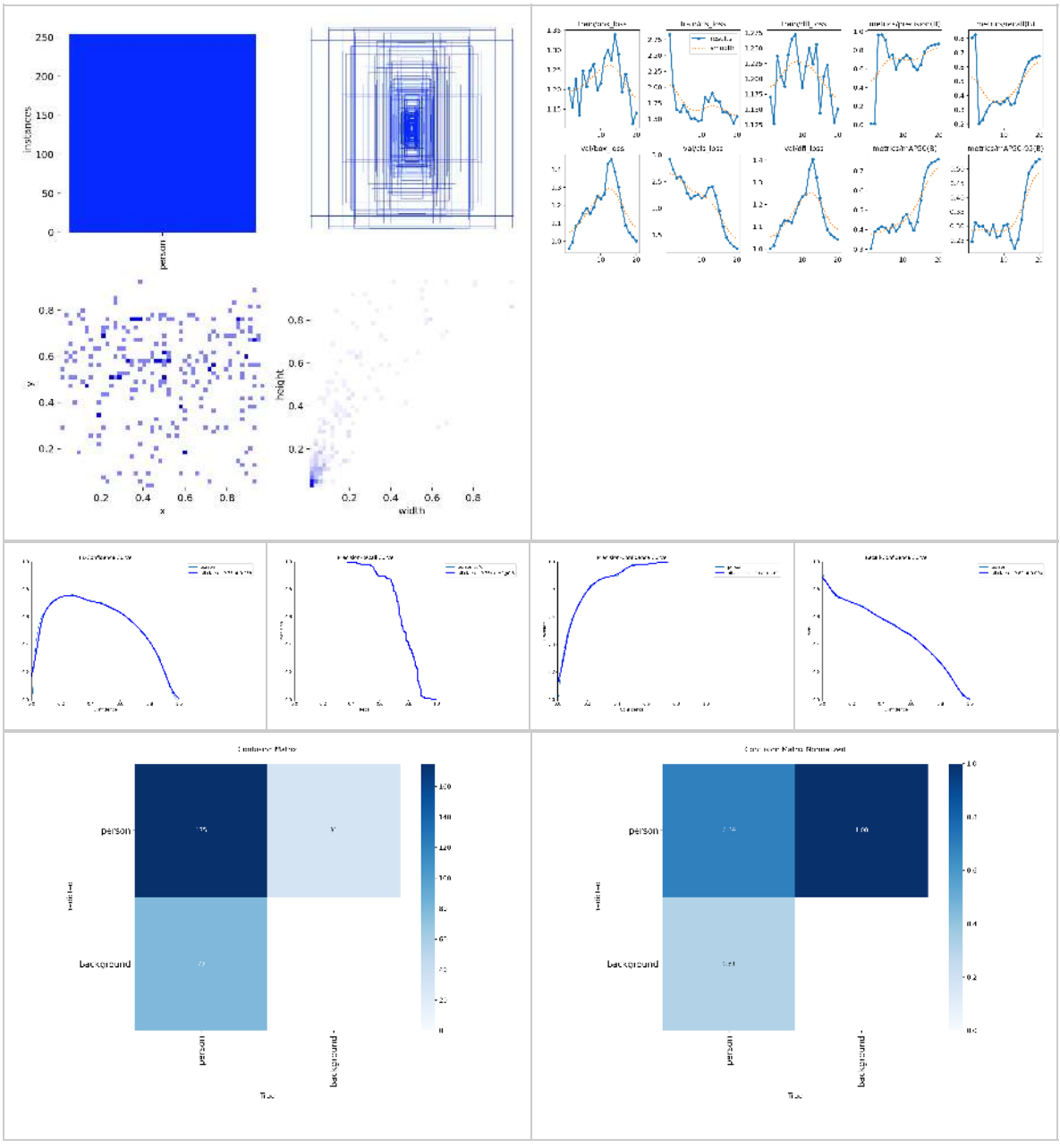
image

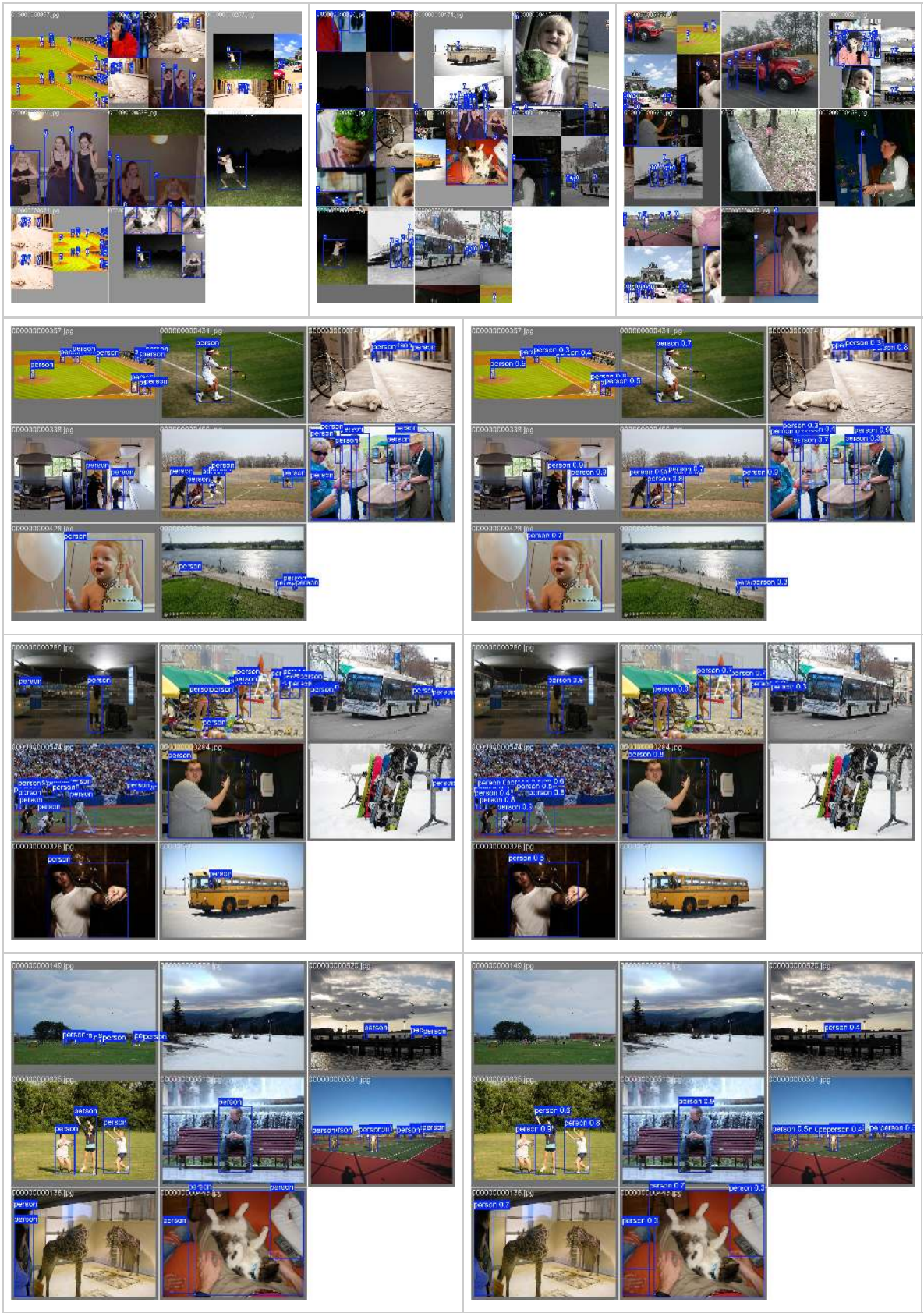
```
dataset:
  count: 61
names:
  0: person
source: coco_128
train: coco128/images/train2017
val: coco128/images/train2017
```

train

```
@select coco128-model-$(@@timestamp)

@yolo model train \
    ~download,upload .. . \
    --epochs 20

@upload public,zip

@assets publish \
    extensions=jpg+png . \
    --prefix train/

@assets publish \
    extensions=jpg+png,push . \
    --prefix validation/
```

[coco128-model-2025-09-15-3m0mmj]





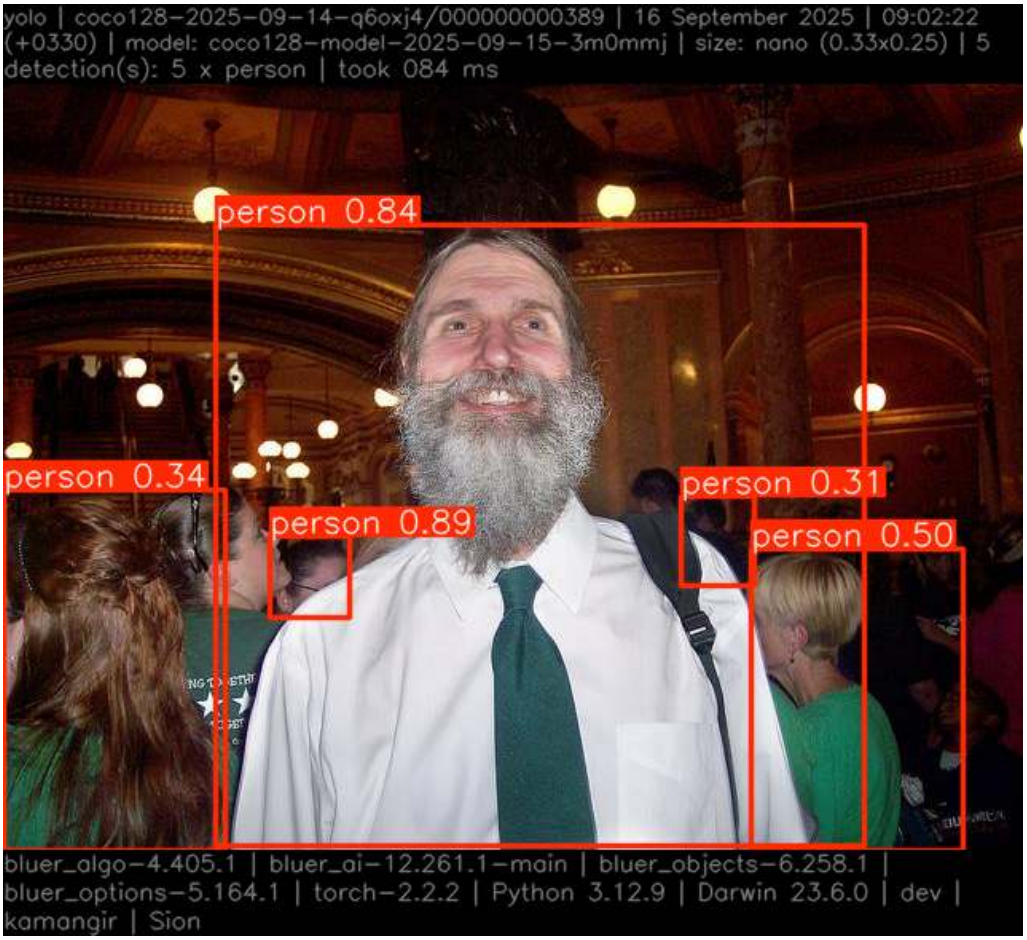
▶ metadata

predict (dev)

[yolo_prediction.ipynb]

predict

```
@select yolo-prediction-test-$(@timestamp)

@yolo model prediction_test \
    upload \
    $BLUER_ALGO_COCO128_TEST_DATASET \
    $BLUER_ALGO_COCO128_TEST_MODEL . \
    --record_index 3

@assets publish extensions=png,push
```



image

```
000000000389:
  detections:
  - bbox_xyxy:
    - 167.85377502441406
    - 283.70269775390625
    - 217.58558654785156
    - 334.81072998046875
    class_id: 0
    confidence: 0.8922585248947144
    label: person
  - bbox_xyxy:
    - 133.1409912109375
    - 88.43701171875
    - 540.6605834960938
    - 477.65869140625
    class_id: 0
    confidence: 0.842871367931366
    label: person
```

```
  - bbox_xyxy:
    - 469.0397644042969
    - 291.564697265625
    - 602.921875
    - 480.0
    class_id: 0
    confidence: 0.49844595789909363
    label: person
  - bbox_xyxy:
    - 0.58984375
    - 254.95266723632812
    - 139.97897338867188
    - 480.0
    class_id: 0
    confidence: 0.33697929978370667
    label: person
  - bbox_xyxy:
    - 425.3193359375
    - 258.2589416503906
    - 471.283935546875
    - 314.4782409667969
    class_id: 0
    confidence: 0.31127116084098816
    label: person
  elapsed_time: 0.08387088775634766
  image_size:
  - 480
  - 640
```


predict (rpi)

```
@select yolo-prediction-test-$(@timestamp)

@yolo model prediction_test \
    upload \
    $BLUER_ALGO_COCO128_TEST_DATASET \
    $BLUER_ALGO_COCO128_TEST_MODEL . \
    --record_index 3

@assets publish extensions=png,push
```

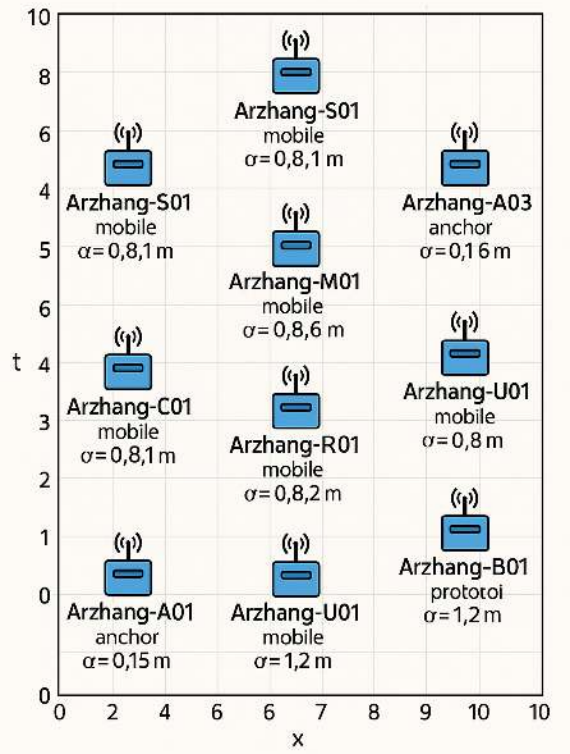
image

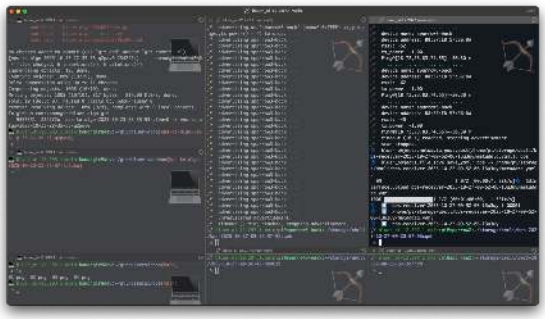

```
000000000419:
  detections:
  - bbox_xyxy:
    - 124.66294860839844
    - 121.88188934326172
    - 170.0297393798828
    - 281.0235595703125
    class_id: 0
    confidence: 0.7116779088973999
    label: person
  - bbox_xyxy:
    - 455.524658203125
    - 231.17758178710938
    - 635.5400390625
    - 478.5752868652344
    class_id: 0
    confidence: 0.4342321455478668
    label: person
  elapsed_time: 2.339571714401245
  image_size:
  - 480
  - 640
```

bps

bluer-positioning system.

> A distributed, serverless positioning mesh where every Raspberry Pi acts as both a tag and a local estimator: each node continuously advertises a compact BLE packet containing its node ID, mobility flag, and its current best-estimate pose (x,y,σ,seq), and simultaneously scans for neighbor adverts to collect RSSI + neighbor poses. Anchors are marked static with known coordinates and low uncertainty; mobiles fuse anchors + neighbor pseudo-ranges (RSSI→distance, calibrated per site) with a lightweight weighted least-squares + EKF/Covariance-Intersection step, adapt advertising/scan rates when moving, and use short rolling HMAC tokens to prevent simple spoofing. The result is a gossiping swarm that converges locally to consistent positions, degrades gracefully to coarse proximity when RF is noisy, and can be migrated later to UWB without changing the peer-to-peer protocol.





ℹ️ works on rpi only.

ℹ️ tx-power is not implemented in rpi. nominal value: 10-12 dBm. -1: indicates unknown.

aliases: bps

```
@bps \
    beacon \
    [~start_bluetooth] \
    [-|<object-name>] \
    [--generate 1] \
    [--sigma <4.0>] \
    [--simulate 1] \
    [--spacing <2.0>] \
    [--timeout <10.0 | -1>] \
    [--x <1.0>] \
    [--y <2.0>] \
    [--z <3.0>]
 . start beacon.
@bps \
    generate \
    [-] \
    [-|<object-name>] \
    [--as_str <x>,<y>,<z>,sigma] \
    [--only_validate 1] \
    [--sigma <4.0>] \
    [--simulate 1] \
    [--x <1.0>] \
    [--y <2.0>] \
    [--z <3.0>]
 . generate a ping.
@bps \
    install
 . install bps.
@bps \
    introspect \
    [~start_bluetooth,verbose,unique_bus_name=<1:234>]
 . introspect <1:234>.
@bps \
    loop \
    start \
    [simulate,upload] \
    [-|<object-name>]
 . start bps loop.
@bps \
    loop \
    stop \
    [rpi,wait] \
    [<machine-name>]
 . stop bps loop.
@bps \
    receiver \
    [~start_bluetooth,upload,verbose] \
    [-|<object-name>] \
    [--grep <sparrow+swallow>] \
    [--timeout <10>]
 . start receiver.
@bps \
    receiver \
    [~python,~start_bluetooth,verbose]
 . start receiver.
@bps \
```

```
    review \
    [~download,upload] \
    [.|<object-name>]
 . review <object-name>.
@bps \
    set_anchor \
    clear | <1.1,2.2,3.3,4.4>
 . set bps anchor.
@bps \
    simulate \
    timing \
    [upload] \
    [-|<object-name>] \
    [--length <1200>] \
    [--anchors <4>] \
    [--nodes <3>] \
    [--ta1 <20>] \
    [--ta2 <40>] \
    [--tr1 <20>] \
    [--tr2 <40>] \
    [--verbose 1]
 . simulate timing.
@bps \
    start_bluetooth \
    [verbose]
 . start bluetooth.
@bps \
    test \
    [~start_bluetooth,verbose]
 . d-bus ping test.
```

bps: literature

- Research Progress of Wireless Positioning Methods Based on RSSI - 2024

  A modern survey of RSSI-based positioning techniques across BLE, Wi-Fi, ZigBee, and 5G. It explains theoretical limitations of RSSI (path-loss variability, multipath fading) and outlines correction strategies.

- Bluetooth indoor positioning system based on improved RSSI data - 2024

- Peer-To-Peer UWB Ranges as a Source of Training Data for Estimating BLE RSSI Path-Loss Exponents - 2022

  Proposes using precise UWB peer-to-peer ranges to calibrate BLE path-loss parameters automatically. Shows how multi-modal measurements improve BLE localization accuracy by up to 40%.

- A Survey of Robot Swarms' Relative Localization Methods - 2022

  A comprehensive review of how robot swarms estimate relative positions using sensors such as BLE, UWB, infrared, and vision. It categorizes algorithms by communication type, sensing range, and scalability.

- From Robot Self-Localization to Global-Localization: An RSSI Based Approach" (ArXiv) - 2021

  presents a **simulation-based** method for enabling groups of mobile robots to localize themselves in GPS-denied environments. Some robots act as fixed beacons, broadcasting signals whose received strength (RSSI) is used by other robots to estimate their global position **through geometric reconstruction**. The approach was tested only in simulation (Webots) and not on physical robots. Reported average errors were about 0.6 m with 10 % Gaussian noise, 1.4 m with 20 % noise, and ≈0.1 m in near-ideal short-range conditions (3–3.5 m from beacons); within about 6 m of beacons, the total error remained under 1 m.

- Bluetooth Low Energy Technology Applied to Indoor Positioning Systems: An Overview - 2020

- RSSI Filtering Methods Applied to Localization using Bluetooth Low Energy - 2020

  Focuses on the signal-processing side of BLE localization. It evaluates Kalman filters, moving averages, and histogram-based smoothing to mitigate RSSI noise.

- Indoor localization using radio beacon technology - 2018

- Precise Realtime Indoor Localization With Raspberry Pi And Ultra-Wideband Technology (Decawave DWM1001 Developement Boards)

bps: mathematics: timing

optimizing advertise/receive cycle timing - continues v1.

problem setup

each machine runs the following infinite loop:

1. **advertise** for t_a seconds
2. **receive** (scan) for a random duration $U(t_{r1}, t_{r2})$ seconds

each process, advertise ($x = a$) or receive ($x = r$), takes:

- t_{xo} seconds to open
- t_{xc} seconds to close

define the total per-phase overhead:

$t_{as} = t_{ao} + t_{ac}$

$t_{rs} = t_{ro} + t_{rc}$

goal: Choose t_a, t_{r1}, and t_{r2} to maximize the expected number of advertisements received among all machines.

---

derivation

total cycle duration:

$T = t_a + t_{as} + t_{rm} + t_{rs}$

where,

$$ t_{rm} = \frac{1}{2}(t_{r1} + t_{r2}) : \text{mean receive time} $$

for many unsynchronized machines, the expected overlap fraction between “me listening” and “others advertising” is proportional to:

$$ P \propto \frac{t_a}{T} * \frac{t_{rm}}{T} $$

optimal relationship

for a fixed T,

$t_a + t_{rm} = T - (t_{as} + t_{rs})$

is fixed and P is maximized when,

$$ t_a = t_{rm} = \frac{1}{2}(T - t_{as} - t_{rs}) $$

$$ P \propto \frac{1}{4} \left(1 - \frac{t_{as} + t_{rs}}{T}\right)^2 $$

therefore larger T is more optimal for higher overlap.

the expected reaction time is,

$$ R \propto T - t_a = \frac{1}{2}(T + t_{as} + t_{rs}) $$

therefore, smaller T is more optimal for faster reaction.

summary

- match advertise and mean receive times: $t_a = (t_{r1} + t_{r2})/2$
- keep both much longer than $t_{as} + t_{rs}$
- add 10–30% jitter to t_{r1}/t_{r2} to avoid synchronization collisions
- choose smaller t_a to for faster reaction.

practical choices

system parameters,

t_{ao}	t_{ac}	t_{as}	t_{ro}	t_{rc}	t_{rs}
~1 s	~0 s	~1 s	~3 s	~0.5 s	~ 3s

chose:

- t_a = 30 s
- r_{r1} = 24 s
- r_{r2} = 36 s
- jitter: 20 %
- T: 64 s
- P: ~ 22%
- R: 34 s

bps: mathematics: localization

BLE Localization Cost Function with σ

This document defines the mathematical model used to estimate the position of a UGV based on BLE advertisements.
Each beacon advertises its position (x_i, y_i, z_i) and uncertainty σ_i along with its transmitted power.

---

1. RSSI–Distance Model

The received signal strength indicator (RSSI) is related to distance by the log-distance path-loss model:

$$\text{RSSI}_i = P_{\text{tx},\,i} - 10\, n_i \log_{10}(d_i) + \varepsilon_i$$

where:

- $P_{\text{tx},\,i}$ is the transmit power (dBm) of beacon i
- n_i is the path-loss exponent (≈ 2 for open space, higher indoors)
- ε_i is zero-mean Gaussian noise with standard deviation $\sigma_{\text{rssi},\,i}$

Rearranging gives an estimate of the distance to beacon i:

$$d_i = 10^{(P_{\text{tx},\,i} - \text{RSSI}_i)/(10\, n_i)}$$

---

2. Measurement Model

Let the UGV's unknown position be

$$\mathbf{p} = (x, y, z)$$

Each beacon i has a known position

$$\mathbf{p}_i = (x_i, y_i, z_i)$$

The measured distance d_i relates to the true distance by

$$r_i(\mathbf{p}) = \|\mathbf{p} - \mathbf{p}_i\| - d_i$$

where r_i is the residual of beacon i.

---

3. Variance and σ Incorporation

Each measurement has an associated variance s_i^2 that combines:

1. Range noise from RSSI
2. Beacon's advertised position uncertainty

3.1 Range variance (from RSSI noise)

Using first-order error propagation:

$$ \mathrm{Var}(d_i) \approx \left(\frac{\partial d_i}{\partial \mathrm{RSSI}_i} \right)^2 \mathrm{Var}(\mathrm{RSSI}_i) \;=\; \left(\frac{\ln(10)}{10\, n_i} \, d_i \right)^2 \sigma_{\mathrm{rssi},i}^2 $$

(All variables are scalar; this is KaTeX-safe.)

3.2 Beacon position variance

If a beacon advertises an isotropic uncertainty σ_i:

$\mathrm{Var}_{\mathrm{beacon},\, i} \approx \sigma_i^2$

3.3 Total variance per measurement

$s_i^2 = \mathrm{Var}(d_i) + \mathrm{Var}_{\mathrm{beacon},\, i}$

---

4. Weighted Least Squares Cost Function

The UGV's estimated position $\hat{\mathbf{p}}$ minimizes

$$ J(\mathbf{p}) = \sum_i \frac{r_i(\mathbf{p})^2}{s_i^2} = \sum_i \frac{ \left(\|\mathbf{p} - \mathbf{p}_i\| - d_i \right)^2 }{s_i^2} $$

This is equivalent to maximum likelihood estimation under Gaussian noise with heterogeneous variances.

---

5. Estimating Global σ

After solving for $\hat{\mathbf{p}}$, compute the overall uncertainty:

$$ \hat{\sigma} = \sqrt{ \frac{1}{N - 3} \sum_i r_i(\hat{\mathbf{p}})^2 } $$

where N is the number of beacons and 3 is the number of position parameters (x, y, z).

---

6. Robust Form (Optional)

To reduce the effect of outliers (for example, multipath), replace the quadratic cost with a robust loss such as Huber or Cauchy:

$$ J(\mathbf{p}) = \sum_i \rho\!\left(\frac{r_i(\mathbf{p})}{s_i} \right) $$

where $\rho(\cdot)$ is a smooth function that limits the influence of large residuals.

---

7. Summary

Symbol	Meaning
$\mathbf{p}$	Current UGV position (x, y, z)
$\mathbf{p}_i$	Beacon i position (x_i, y_i, z_i)
d_i	Distance inferred from RSSI
r_i	Residual = geometric distance – estimated distance
s_i	Combined standard deviation per beacon
σ_i	Advertised beacon position uncertainty
$\hat{\sigma}$	Estimated global uncertainty

The weighted least-squares estimator is:

$$ \hat{\mathbf{p}} = \arg\min_{\mathbf{p}} \sum_i \frac{ \left(\|\mathbf{p} - \mathbf{p}_i\| - d_i\right)^2 }{s_i^2} $$

bps: validations

- test -> introspect
- beacon -> receiver
- loop: 2 rpis, 3 rpis
- review
- data collection
- live: 1 rpi, 2 rpis, 2 rpis, anchor + 2 nodes

bps: validations: test-introspect

```
@bps install
```

```
@bps test
```

```
🪄  bluer_algo.bps.utils.test: connected to system bus with unique name:
:1.19
🪄  exported org.example.Hello at /org/example/Hello
🪄  run in another terminal: "@bps introspect unique_bus_name=:1.19"
```

in another terminal,

```
@bps introspect unique_bus_name=:1.19
```

```
s "Pong"
```

validate in the first window,

```
🪄  bluer_algo.bps.utils.test.ping() called by busctl!
```

tested on 2 rpis.

bps: validations: beacon-receiver

```
@bps beacon - - \
    --generate 1 \
    --sigma $(@random --float 1) \
    --x $(@random --float 1) \
    --y $(@random --float 1) \
    --z $(@random --float 1) \
    --timeout 60
```

on another rpi,

```
@bps receiver upload - \
    --grep sparrow+swallow \
    --timeout 10

history:
- hostname: sparrow3-back
  rssi: -52
  sigma: 88.34217834472656
  tx_power: -1.0
  x: 33.44688415527344
  y: 45.99796676635742
  z: 94.80066680908203
- hostname: sparrow3-back
  rssi: -51
  sigma: 88.34217834472656
  tx_power: -1.0
  x: 33.44688415527344
  y: 45.99796676635742
  z: 94.80066680908203
ping:
  hostname: sparrow2
  rssi: -1.0
  sigma: 1000.0
  tx_power: -1.0
  x: 0.0
  y: 0.0
  z: 0.0
```

bps: validations: loop-2

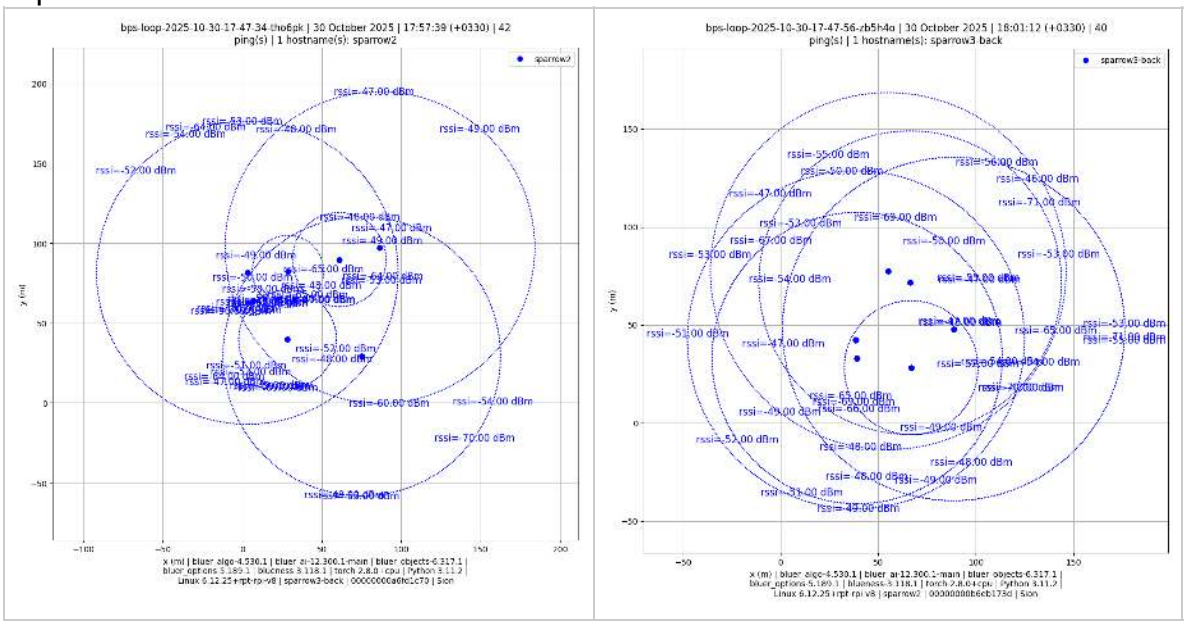
on 2 rpis,

```
@bps loop start simulate,upload
```

after a few minutes,

```
@bps loop stop [rpi <machine-name>]
```

▶ publication



▶ bps-loop-2025-10-30-17-47-34-tho6pk/metadata

▶ bps-loop-2025-10-30-17-47-56-zb5h4o/metadata

bps: validations: loop-3

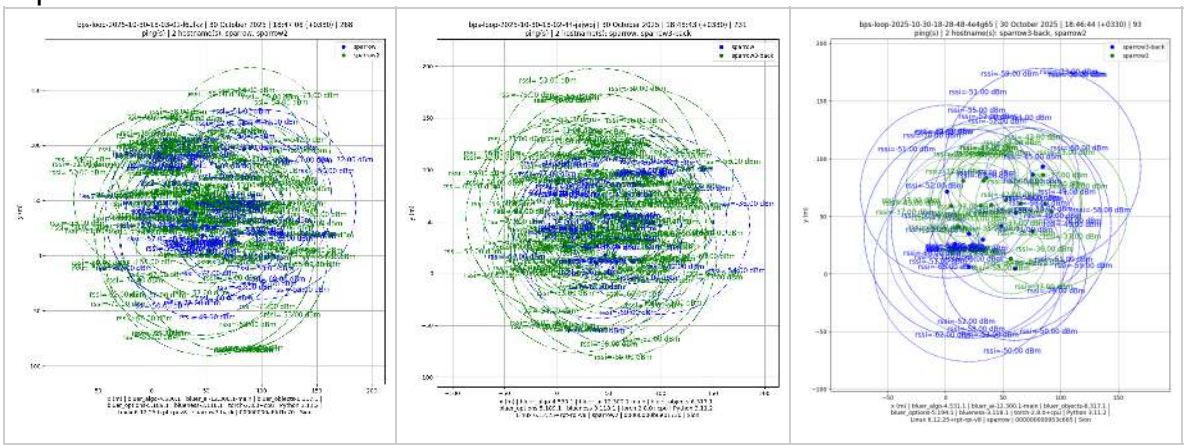
on 3 rpis,

```
@bps loop start simulate,upload
```

after a few minutes,

```
@bps loop stop [rpi <machine-name>]
```

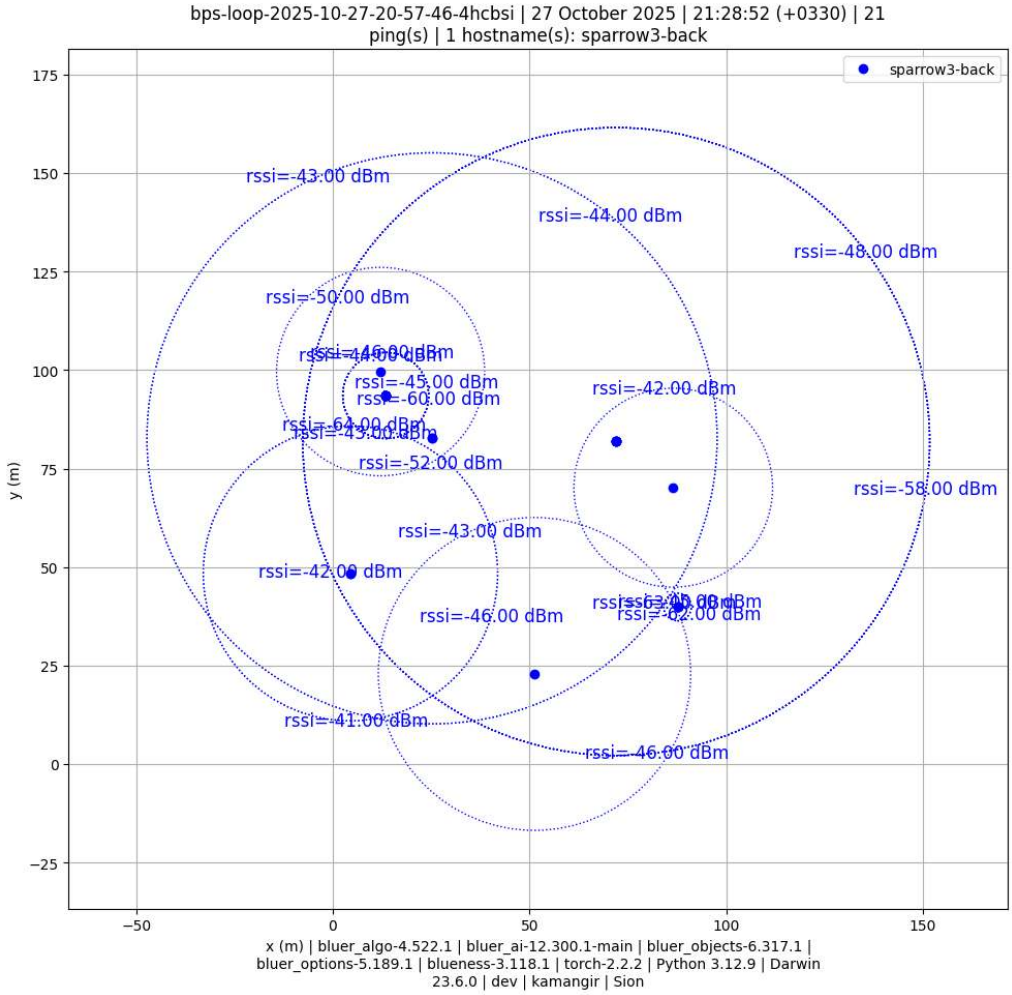
▶ publication



▶ bps-loop-2025-10-30-18-03-01-l6ulkz/metadata
▶ bps-loop-2025-10-30-18-02-44-jajwbj/metadata
▶ bps-loop-2025-10-30-18-28-48-4e4g65/metadata

bps: validations: review

```
@select bps-loop-2025-10-27-20-57-46-4hcbsi

@bps review upload .

@assets publish \
    extensions=png,push .
```



image

▶ metadata

bps: validations: data-collection

on 1 rpi:

```
@select bps-stream-$(@timestamp)
@bps generate - . \
    --sigma 1.0 \
    --x 0 \
    --y 0 \
    --z 0
@bps loop start upload .
```

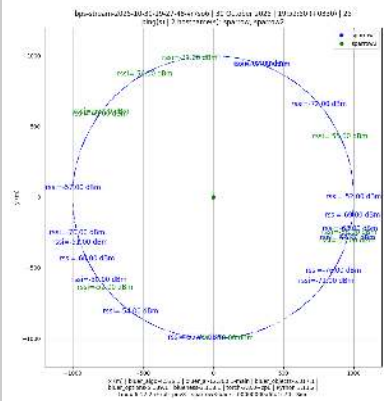
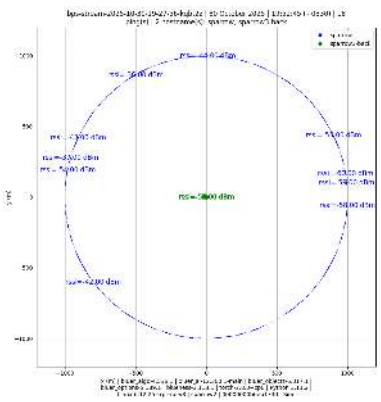
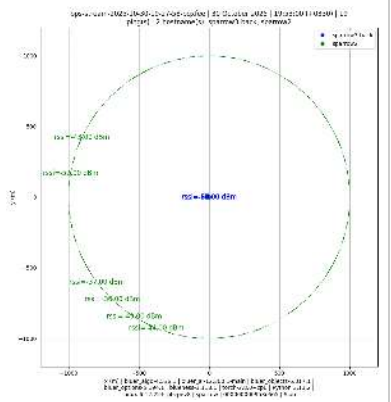
on 2 rpis,

```
@bps loop start upload
```

after a few minutes,

```
@bps loop stop [rpi <machine-name>]
```

▶ publication

bps-stream-2025-10-30-19-27-48-vr7so6	bps-stream-2025-10-30-19-27-56-kqbt2z	bps-stream-2025-10-30-19-27-58-pqxfee
		

▶ bps-stream-2025-10-30-19-27-48-vr7so6/metadata
▶ bps-stream-2025-10-30-19-27-56-kqbt2z/metadata
▶ bps-stream-2025-10-30-19-27-58-pqxfee/metadata

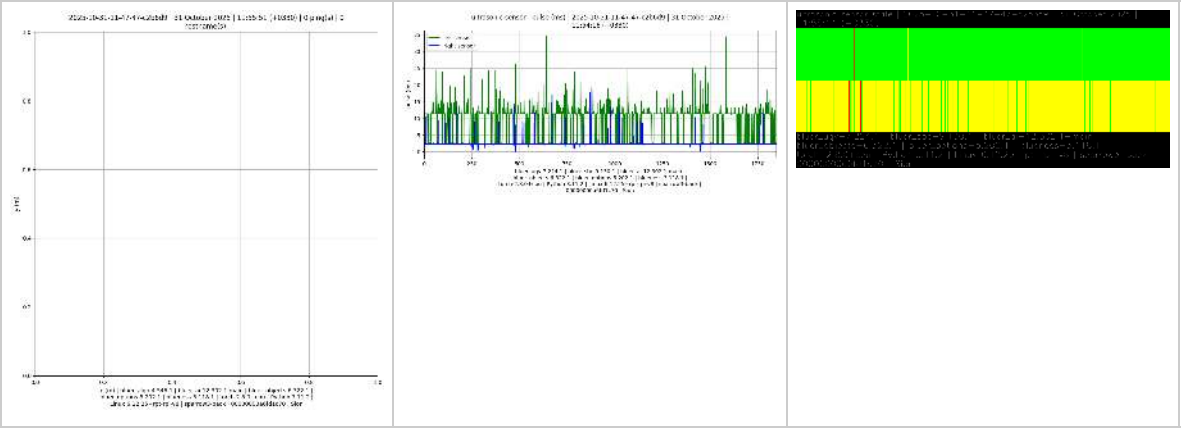
bps: validations: live-1

on one rpi,

```
@swallow env set bps 1

@env HAS_BPS

BLUER_SBC_SWALLOW_HAS_BPS=1

@select; @session start
```

▶ publication

2025-10-31-11-47-47-c2b6d9

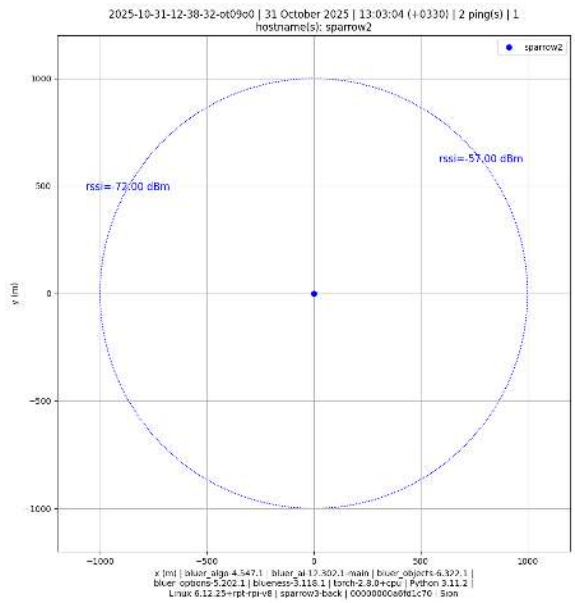
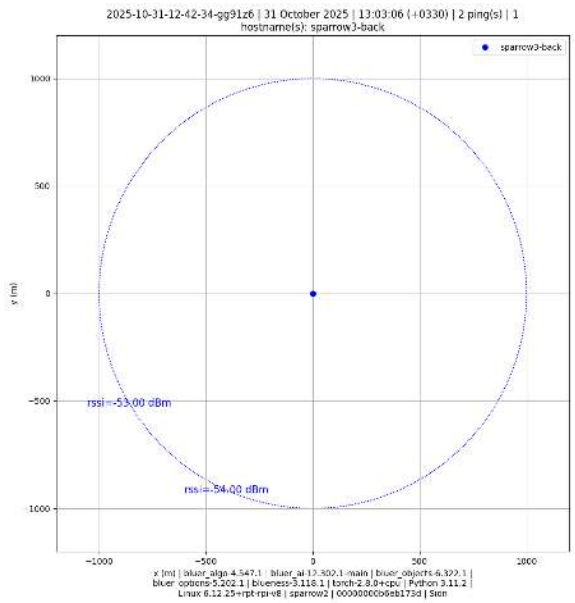
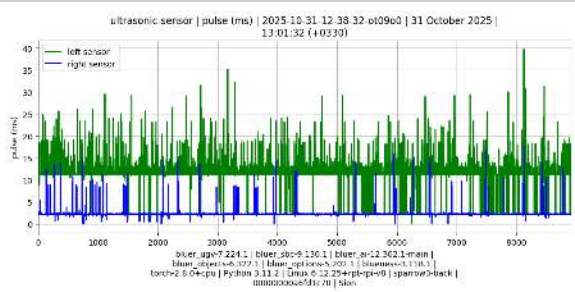
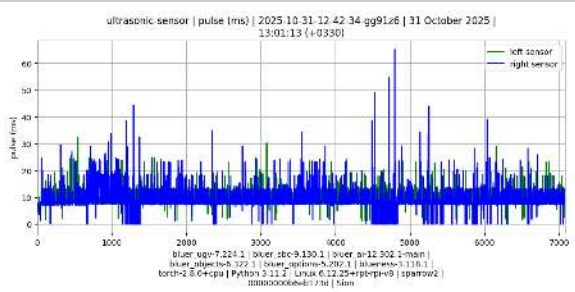
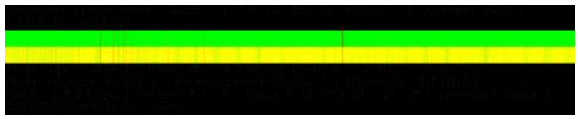
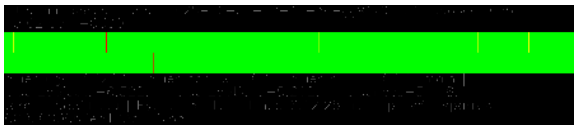


bps: validations: live-2

on 2 rpis,

```
@select; @session start
```

▶ publication

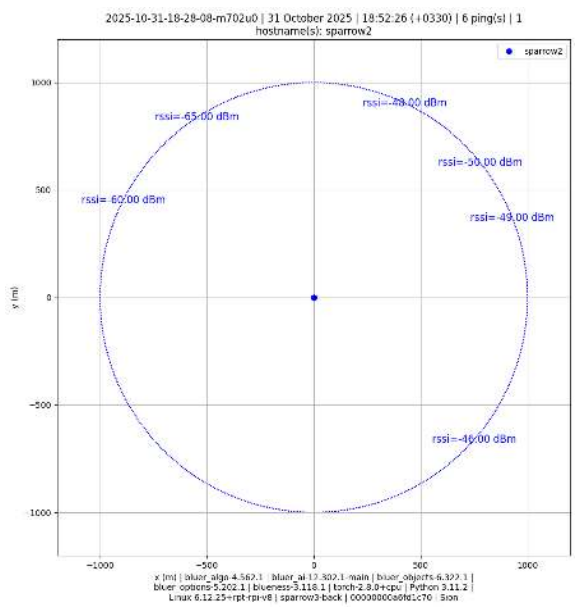
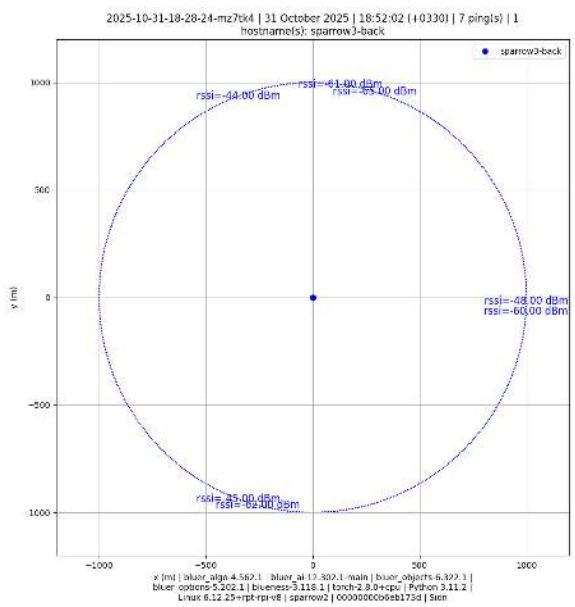
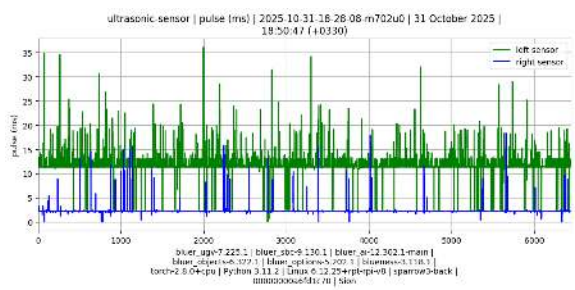
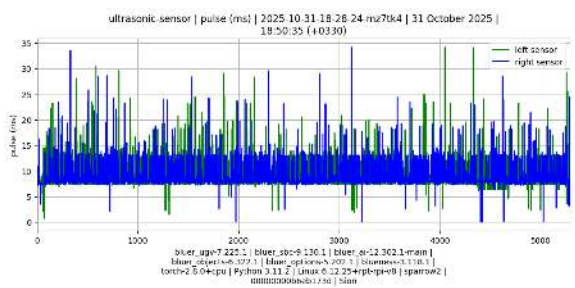
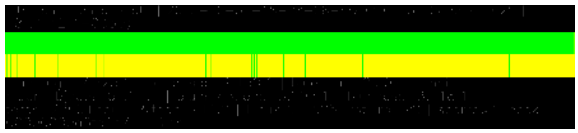
[2025-10-31-12-38-32-ot09o0](#)	[2025-10-31-12-42-34-gg91z6](#)
	
	
	

bps: validations: live-2b

on 2 rpis, continues live-2 after timing adjustments.

```
@select; @session start
```

▶ publication

2025-10-31-18-28-08-m702u0	2025-10-31-18-28-24-mz7tk4
	
	
	

bps: validations: live-3

on 3 rpis (1 anchor), continues live-2b with an anchor.

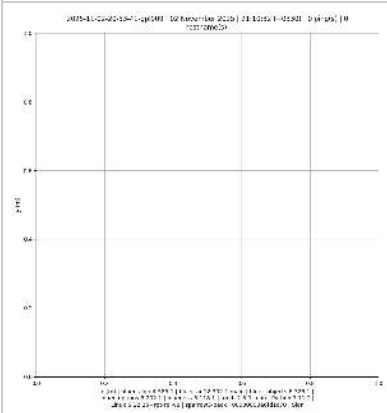
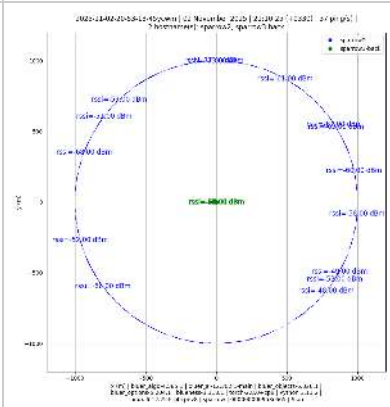
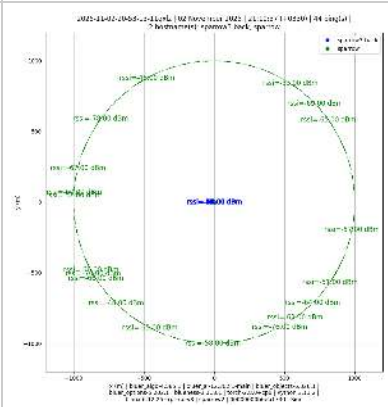
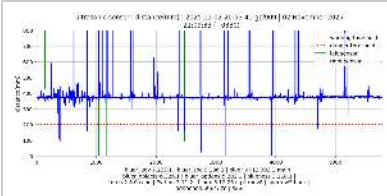
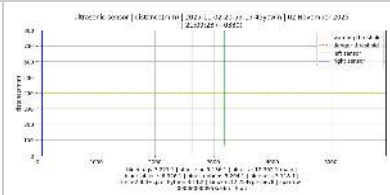
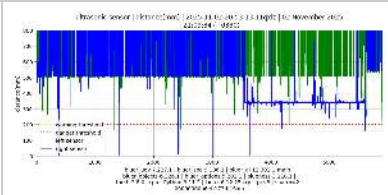
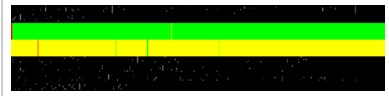
on the anchor run,

```
@bps set_anchor 0,0,0,1
```

on all run,

```
@select; @session start
```

▶ publication

2025-11-02-20-53-41-gpl909	2025-11-02-20-53-13-45ycwm	2025-11-02-20-53-13-11qxlz
		
		
		

bps: simulations: timing

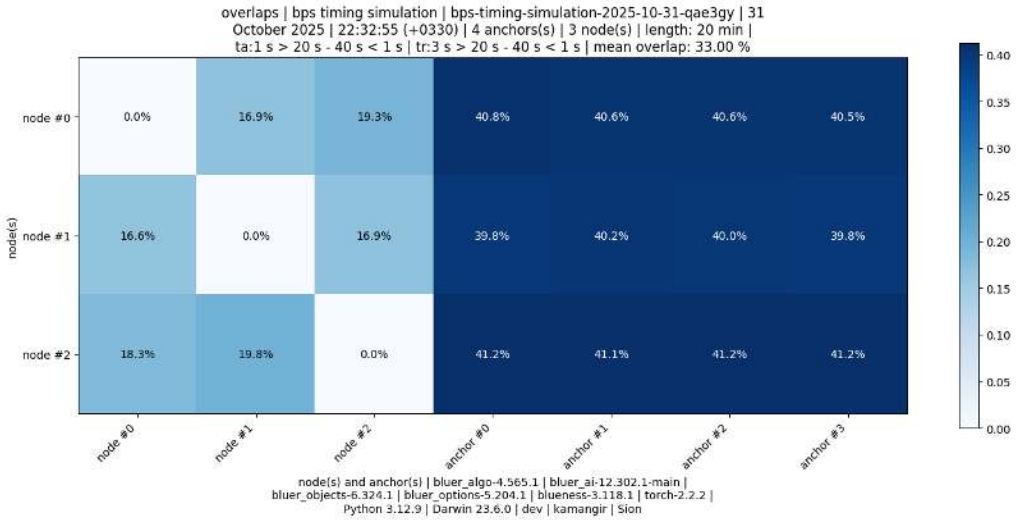
continues v1.

3 nodes

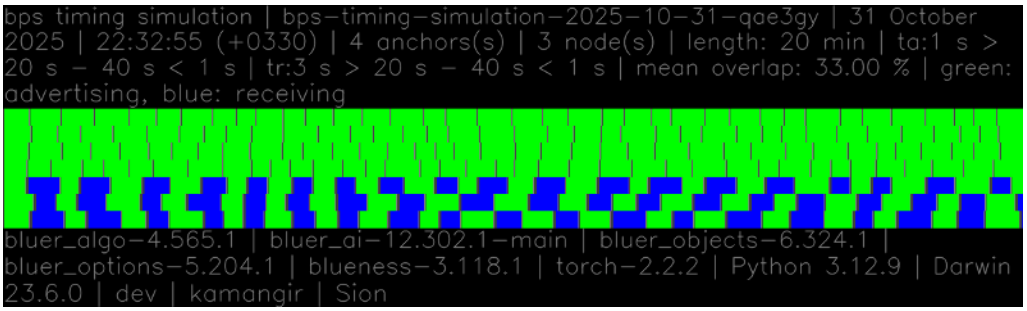
```
@select bps-timing-simulation-$(@@timestamp)

@bps simulate timing upload .

@assets publish extensions=png,push .
```

mean overlap: 0.33

▶ metadata



image



image

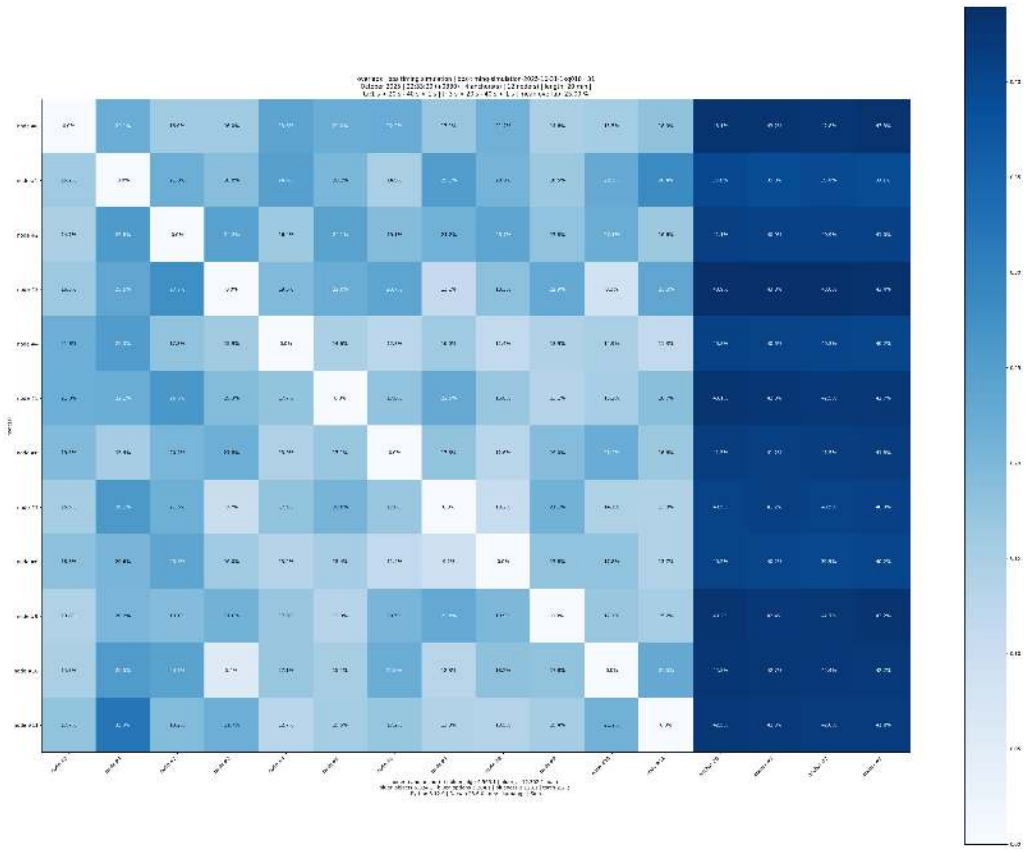
12 nodes

```
@select bps-timing-simulation-$(@@timestamp)

@bps simulate timing upload . \
    --nodes 12
```

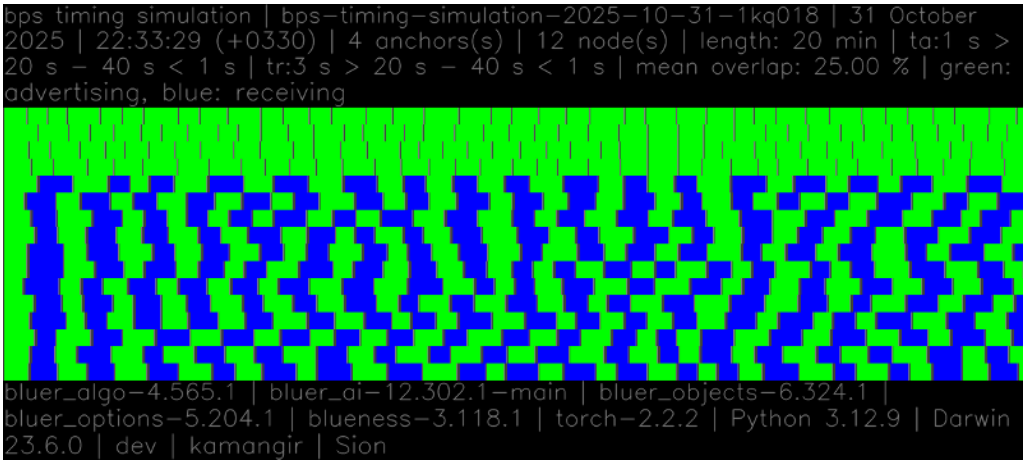
```
@assets publish extensions=png,push .
```

mean overlap: 0.25

▶ metadata



image



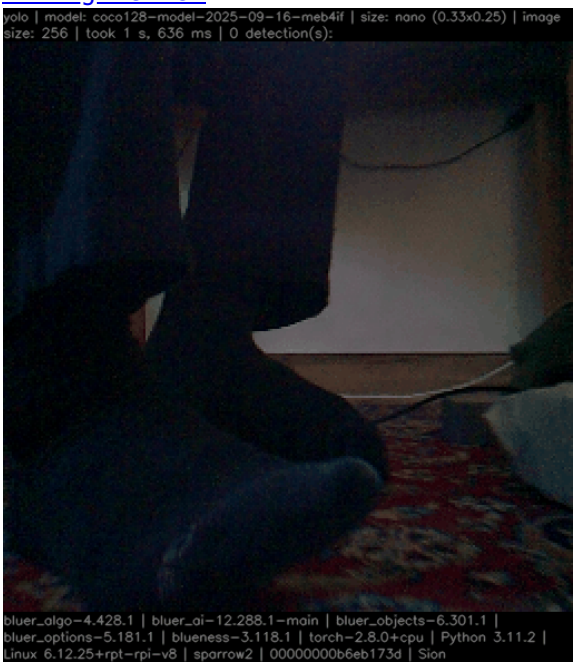
image

validations

- timing-review
- village-1
- village-2
- village-3
- village-4
- village-5
- village-6
- village-7

village-1 	village-2 
village-3 	village-4 

timing-review



village-5

village-6

village-7

validations: timing-review

UGV(s): 🐬 arzhang2

single thread

```
::  in 1 min called 8 function(s):
::  #   0 - ClassicalUltrasonicSensor: called 388 time(s), total 46 s, avg
120 ms
::  #   1 - ClassicalYoloCamera: called 388 time(s), total 29 s, avg 076 ms
::  #   2 - ClassicalKeyboard: called 388 time(s), total 489 ms, avg 001 ms
::  #   3 - ClassicalLeds: called 388 time(s), total 081 ms, avg < 1 ms
::  #   4 - ClassicalRightMotor: called 388 time(s), total 072 ms, avg < 1
ms
::  #   5 - ClassicalLeftMotor: called 388 time(s), total 060 ms, avg < 1
ms
::  #   6 - ClassicalPushButton: called 388 time(s), total 025 ms, avg < 1
ms
::  #   7 - ClassicalSetPoint: called 388 time(s), total 005 ms, avg < 1 ms
```

loop frequency (Hz): 7

▶ yaml

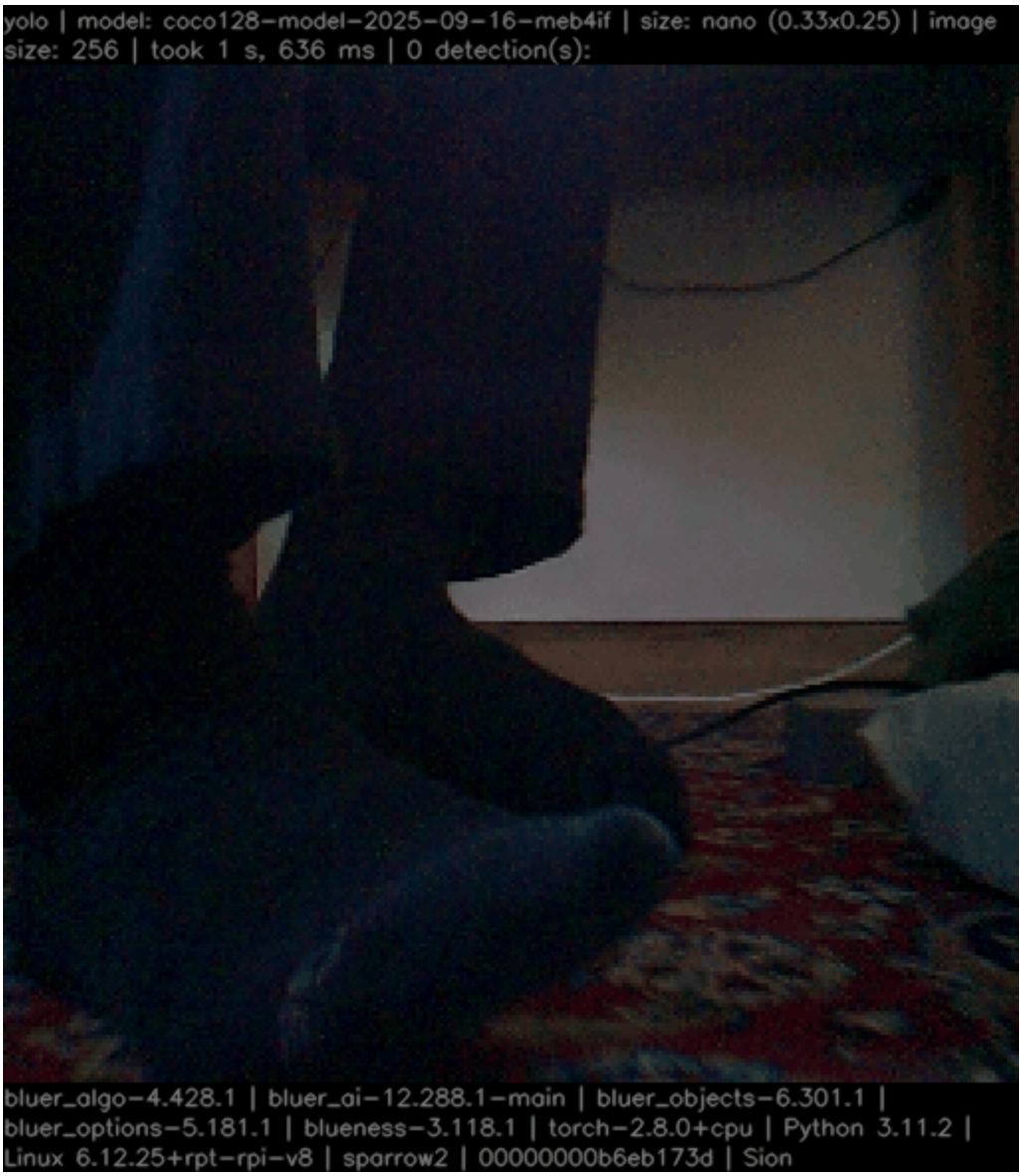
multi-threaded

yolo and ultrasonic run on individual threads.

```
::  in 5 min called 8 function(s):
::  #   0 - session.update: called 5,881 time(s), total 10 s, avg 002 ms
::  #   1 - ClassicalKeyboard: called 5,881 time(s), total 5 s, avg 001 ms
::  #   2 - ClassicalRightMotor: called 5,881 time(s), total 1 s, avg < 1
ms
::  #   3 - ClassicalLeds: called 5,881 time(s), total 1 s, avg < 1 ms
::  #   4 - ClassicalLeftMotor: called 5,881 time(s), total 888 ms, avg < 1
ms
::  #   5 - ClassicalPushButton: called 5,881 time(s), total 417 ms, avg <
1 ms
::  #   6 - ClassicalSetPoint: called 5,881 time(s), total 061 ms, avg < 1
ms
::  #   7 - ClassicalYoloCamera: called 5,881 time(s), total 033 ms, avg <
1 ms
```

loop frequency (Hz): 570.76

▶ yaml


yolo | model: coco128-model-2025-09-16-meb4if | size: nano (0.33x0.25) | image size: 256 | took 1 s, 636 ms | 0 detection(s):
bluer_algo-4.428.1 | bluer_ai-12.288.1-main | bluer_objects-6.301.1 | bluer_options-5.181.1 | blueness-3.118.1 | torch-2.8.0+cpu | Python 3.11.2 | Linux 6.12.25+rpt-rpi-v8 | sparrow2 | 00000000b6eb173d | Sion

image

validations: village-1

UGV(s): 🐬 arzhang

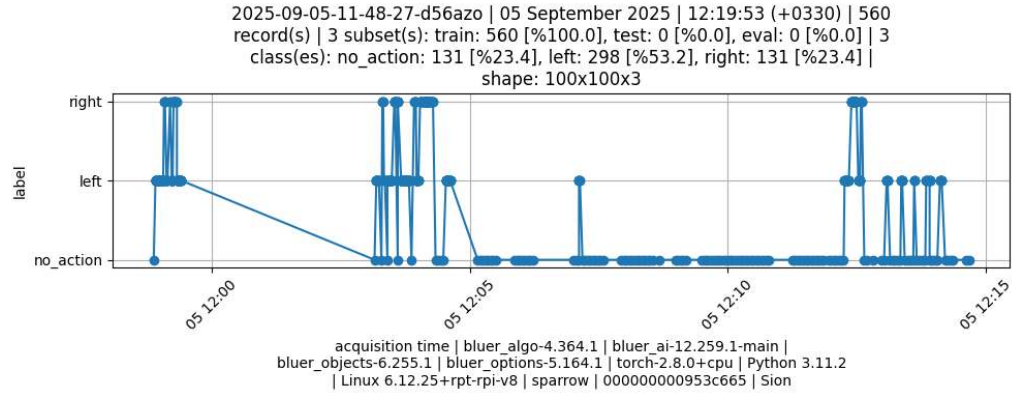
@select 2025-09-05-11-48-27-d56azo

@download policy=doesnt_exist

@upload public,zip

2025-09-05-11-48-27-d56azo

image



image

```
dataset:
  class_count: 3
  classes:
    0: no_action
    1: left
    2: right
  count: 560
  shape:
  - 100
  - 100
  - 3
  source: 000000000953c665
  subsets:
    eval: 0
    test: 0
    train: 560
```

image

observations

- image-classifier is validated. ✅

validations: village-2

UGV(s): 🐬 arzhang






debug objects

▶ collection

swallow-debug-2025-09-22-09-47-32-85hag3

swallow-debug-2025-09-22-09-59-29-emj29v

swallow-debug-2025-09-22-10-01-01-uzray6

swallow-debug-2025-09-22-10-06-19-hcyl1v

swallow-debug-2025-09-22-10-09-44-z6q9kn

swallow-debug-2025-09-22-10-19-35-mobajm



observations

- two wheel nuts loosened every few minutes. ⚠️
- one wheel nut tightened every few minutes. ⚠️

-> fixed in [village-3]

image

validations: village-3

UGV(s): 🐬 arzhang




debug object

▶ collection

swallow-debug-2025-09-25-13-16-59-rnm7jd

image

session object

```
dataset:
  count: 0
names:
  0: target
source: 000000000953c665
train: images/train
val: images/val
```

observations

- no wheel nuts loosened or tightened (: village-2) ✅
- bottom cover broke. -> 📜

validations: village-4

UGV(s): 🐬 arzhang2

debug object

```
runme() {
    @select $1

    @upload public,zip

    @assets publish extensions=gif,push
}

runme swallow-debug-2025-09-26-17-44-51-6pb87y
```

observations

- wheels functioned as expected. ✅
- robot rebooted after a minute of operation and again. ⚠️ loose power connections on shield found and fixed, subsequent testing validated the fix. ✅
- camera is upside down - fixed. ✅

```
runme swallow-debug-2025-09-27-19-15-31-6iq5vz
```

swallow-debug-2025-09-26-17-44-51-6pb87y	swallow-debug-2025-09-27-19-15-31-6iq5vz
	

validations: village-5

UGV(s): 🐬 arzhang, 🐬 arzhang2

script

```
runme() {
    @select $1

    @upload public,zip

    @assets publish extensions=gif,push

    # ---

    @select $2

    @swallow ultrasonic review \
        upload .

    @assets publish extensions=gif+png,push
}
```

objects

arzhang

```
runme \
    swallow-debug-2025-10-10-08-49-45-yk18ei \
    2025-10-10-08-52-35-6jjnzn
```

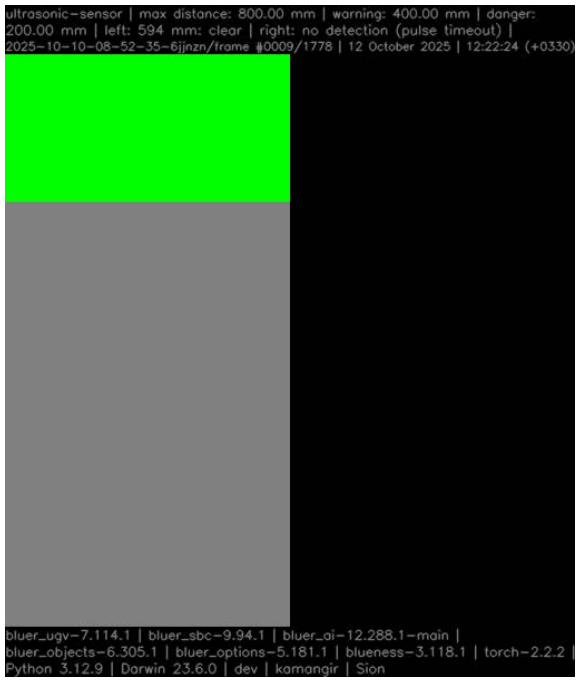
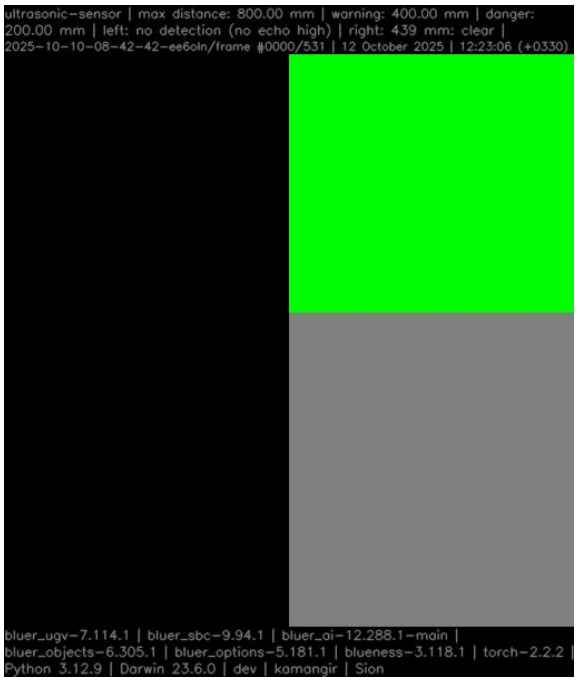
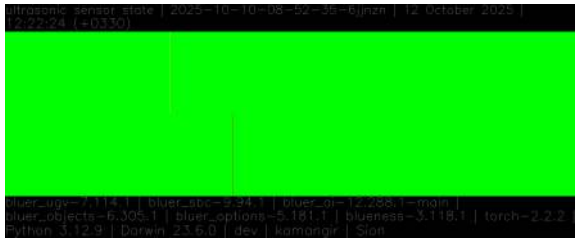
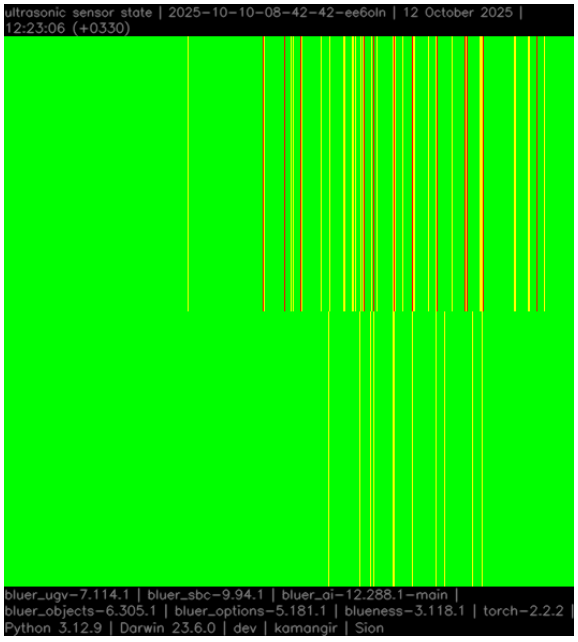
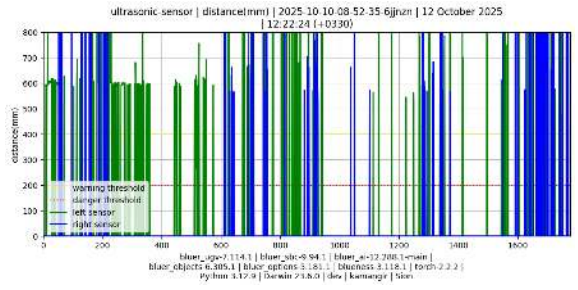
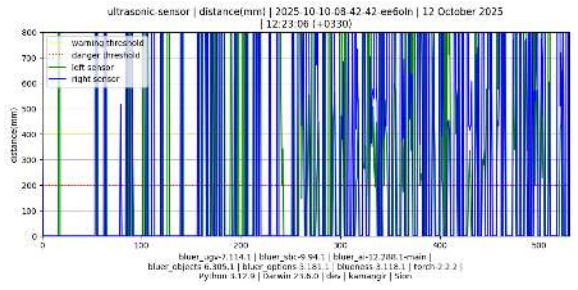
loop frequency (Hz): 310.87

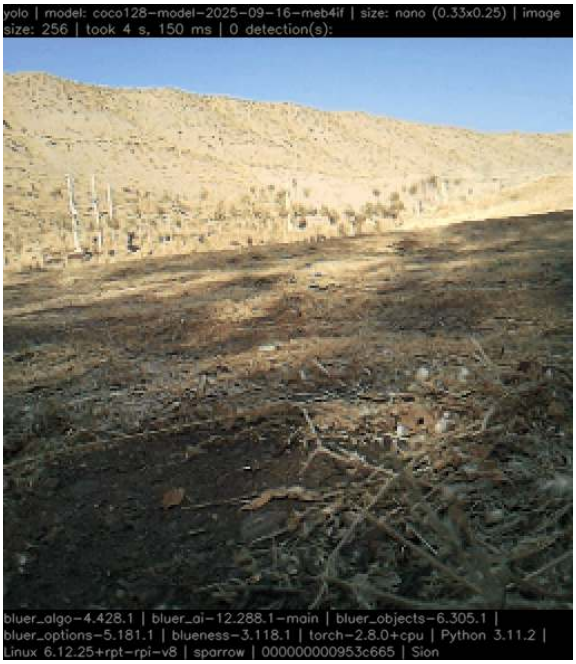
arzhang2

```
runme \
    swallow-debug-2025-10-10-08-40-38-k8oc2p \
    2025-10-10-08-42-42-ee6oln
```

loop frequency (Hz): 408.95

---

arzhang	arzhang2
	
	
	

arzhang	arzhang2
	

observations

- ultrasonic sensor is activated when the surface is uneven - will adjust the sensor.
- yolo may not have time to perform the action. -> 🪵

validations: village-6

UGV(s): 🐬 arzhang, 🐬 arzhang2

scripts

```
@select swallow-debug-2025-10-19-14-14-23-ectn97

@upload public,zip

@assets publish extensions=gif,push

runme() {
    @select $1

    @swallow ultrasonic review \
        upload .

    @assets publish extensions=gif+png,push
}

runme 2025-10-19-14-16-36-tunrlm
runme 2025-10-19-14-16-07-75yxbw
```

objects

arzhang

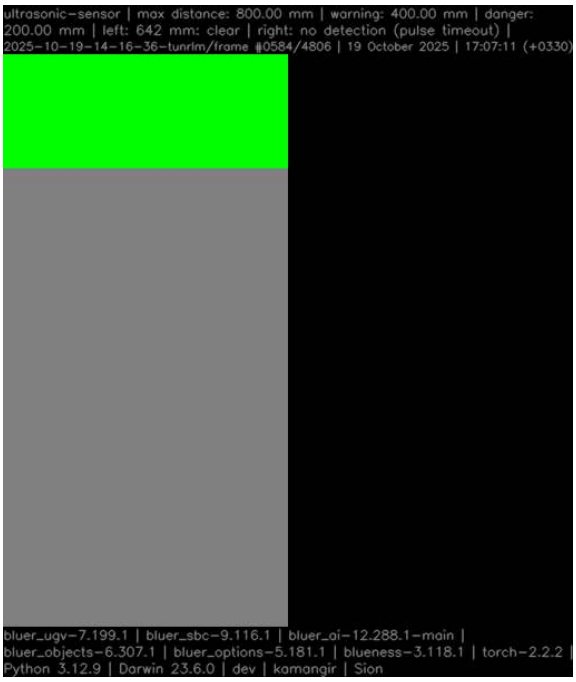
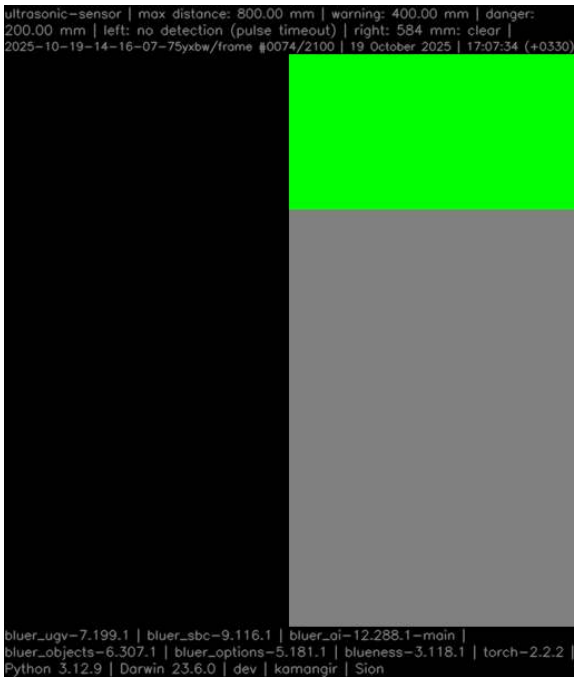
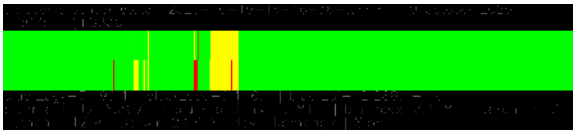
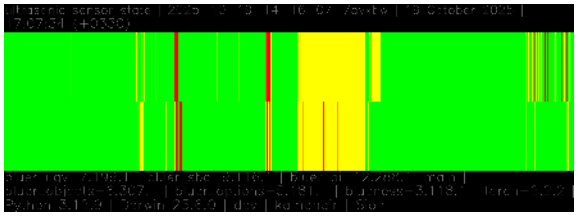
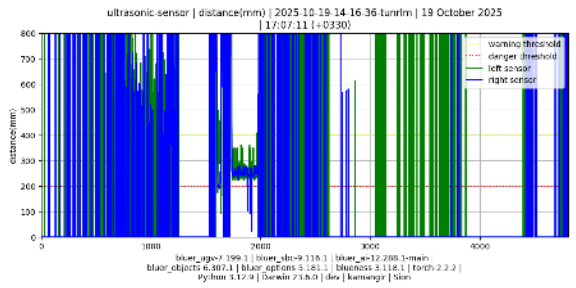
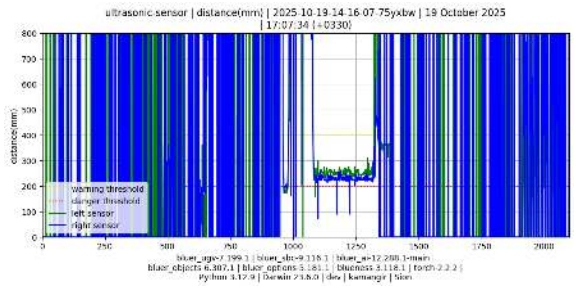
loop frequency (Hz): 321.78

arzhang2

loop frequency (Hz): 242.58

---

arzhang	arzhang2
2025-10-19-14-16-36-tunrlm	2025-10-19-14-16-07-75yxbw

[arzhang](#)	[arzhang2](#)
	
	
	

image

observations

- the range of numpad is ~10-20 m, noticeably lower than that of the full keyboard, which is ~50 m.



validations: village-7

UGV(s): 🐬 arzhang, 🐬 arzhang2, ⚓ arzhang3

▶ publication

arzhang

loop frequency (Hz): 185.88

2025-11-06-10-50-35-myadvn

arzhang2

loop frequency (Hz): 190.13

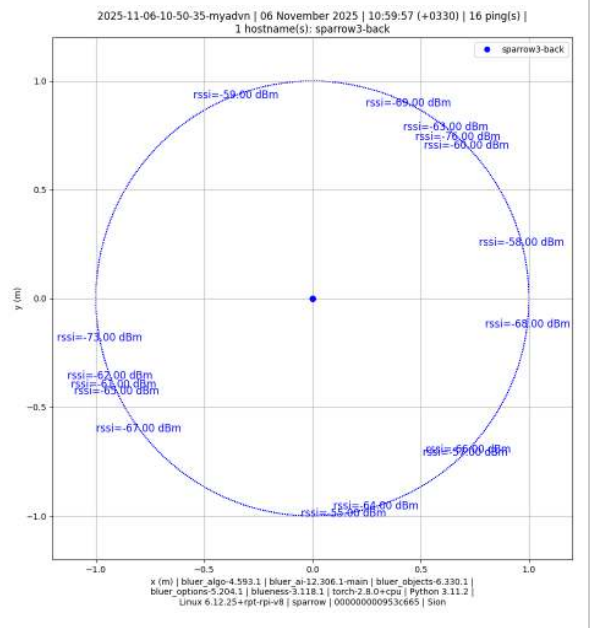
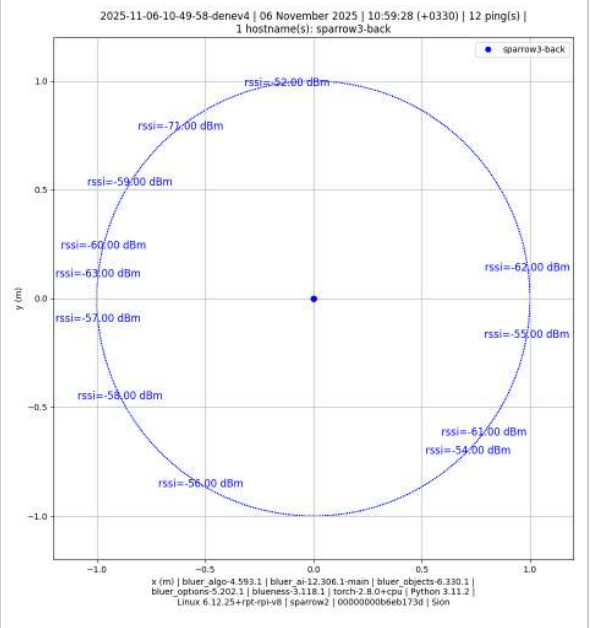
2025-11-06-10-49-58-denev4

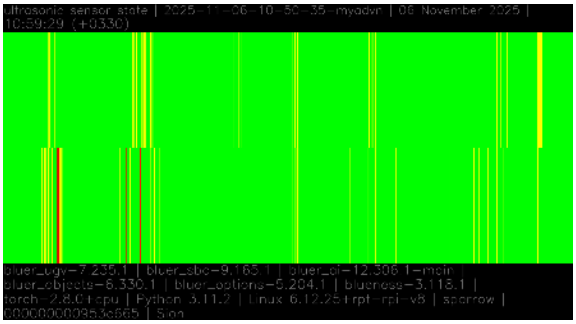
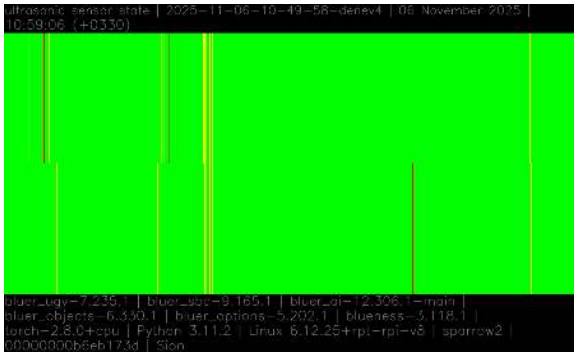
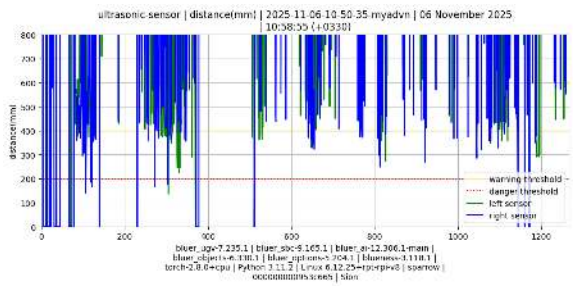
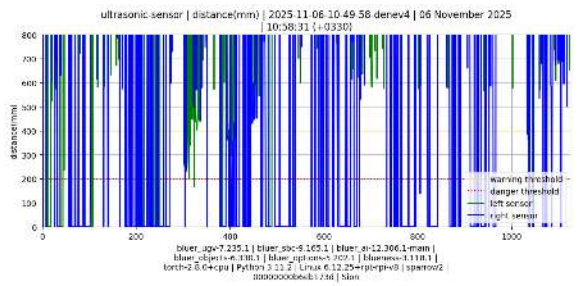
arzhang3

loop frequency (Hz): 183.64

2025-11-06-10-49-36-koxzf3

---

arzhang	arzhang2
	

arzhang	arzhang2
	
	

observations

- one of the back wheels on arzhang broke. -> 🪵
- the on/off switch on arzhang broke -> 🪵
- the two arzhangs did not receive each other's advertisements. they both received advertisements from arzhang3. ⚠️ - will review in the next validation.