2024-1

Team 5

Capstone
Final Report

이준희, 양예찬, 김승민, 이유빈, 김다은, 양정현

Automated table cleaning system

Problem

뉴스투데이 이은수 리포터

[스마트 리빙] 젖은 행주로 식탁 닦으면 식중독균 '득실'

입력 2020-05-04 06:53 | 수정 2020-05-04 06:53

교내 식당이 변기보다 6만배 더럽다…심각한 美

방제일 기자

입력 2023.10.26 13:47 수정 2023.10.26 13:55 읽는 시간 36초

HOME > 건강정보 > 건강일반

깨끗해지려고 쓰는 행주, 알고 보니 '세균덩어리'

유대형 기자 (ubig23@k-health.com) | 승인 2018.07.11 09:48 | 댓글 0

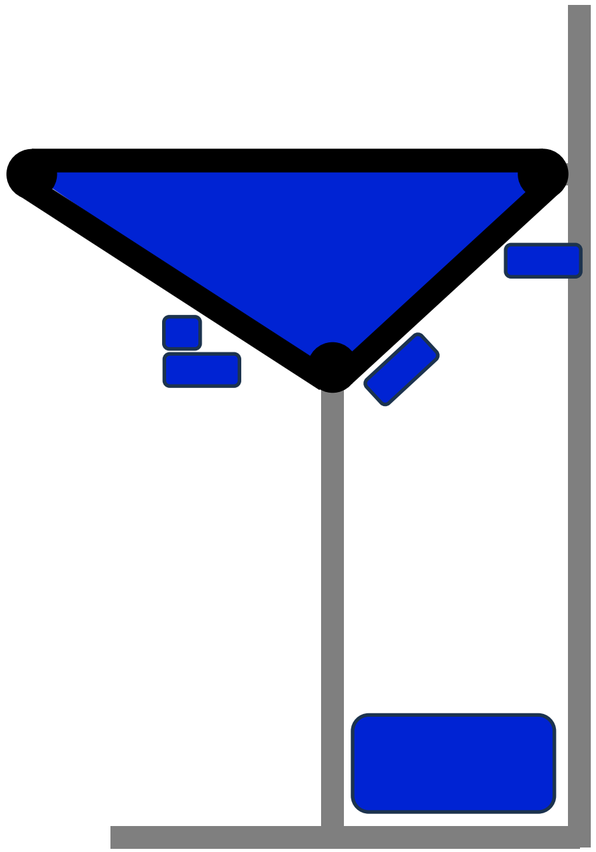
A bar table used by small business establishment

Table cleanliness problem

A labor cost problem

Small businesses are struggling with keeping a clean table & increasing labor cost

Features



Water jet

UV lamp & Circulator

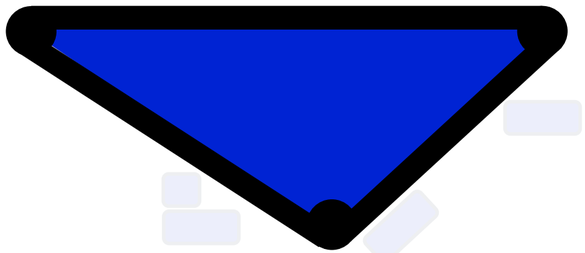
Waste

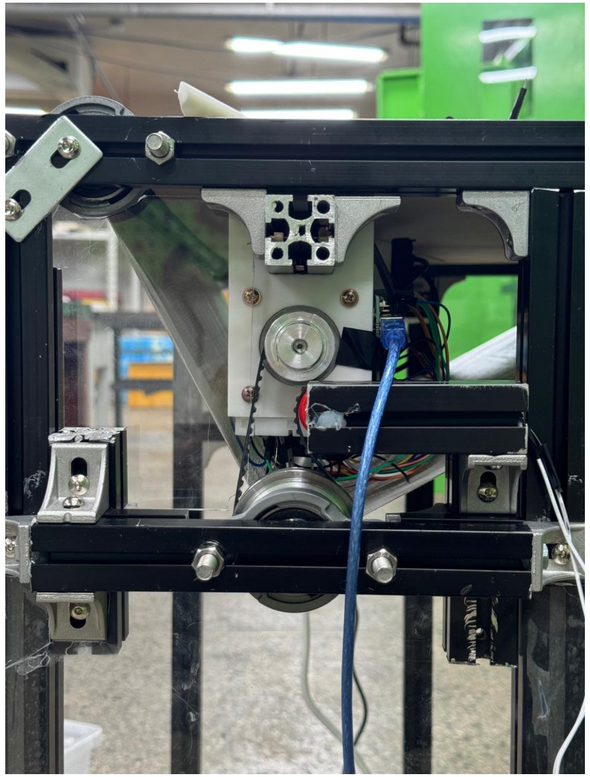
Water & Detergent

HW layer

Module Explanation

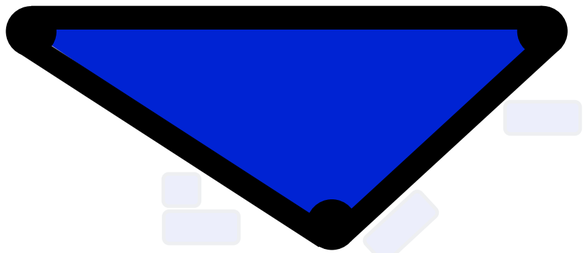
Belt System

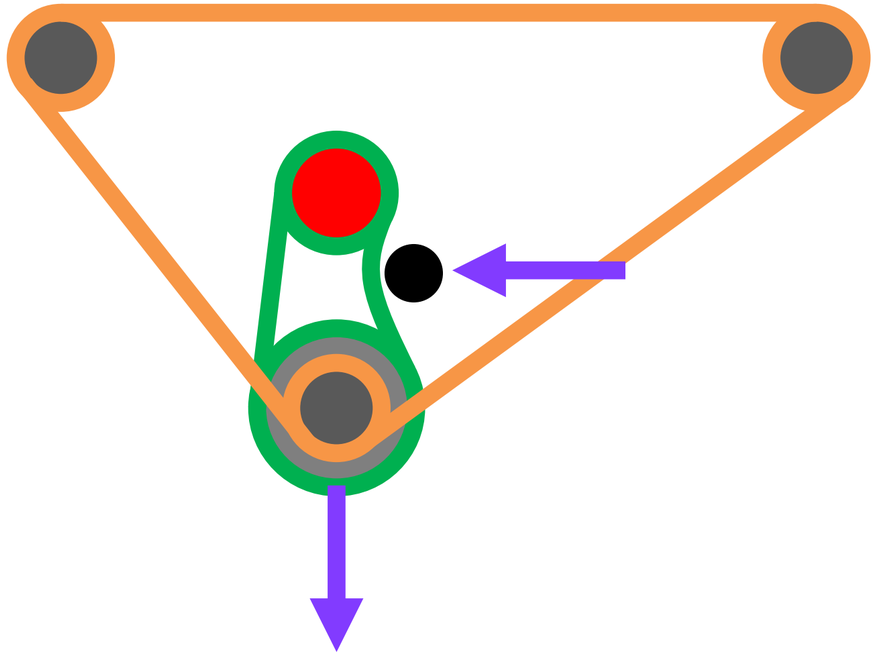


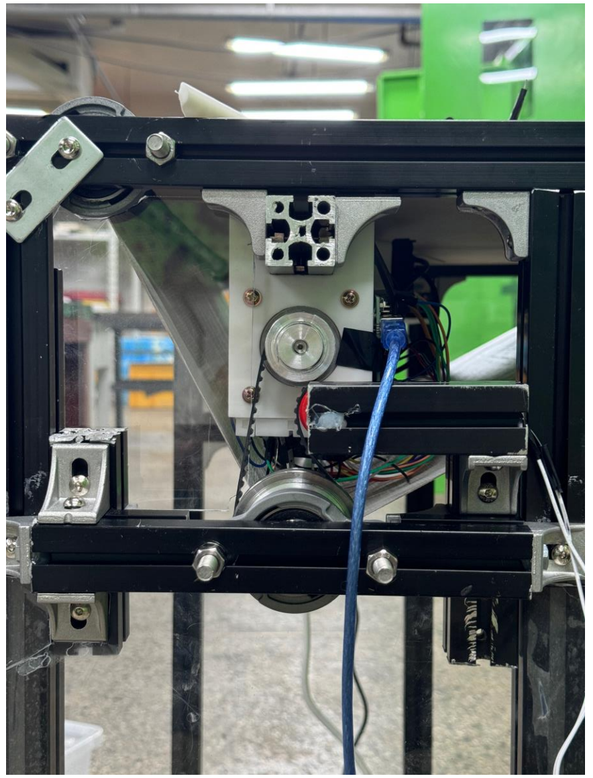


Module Explanation

Belt System

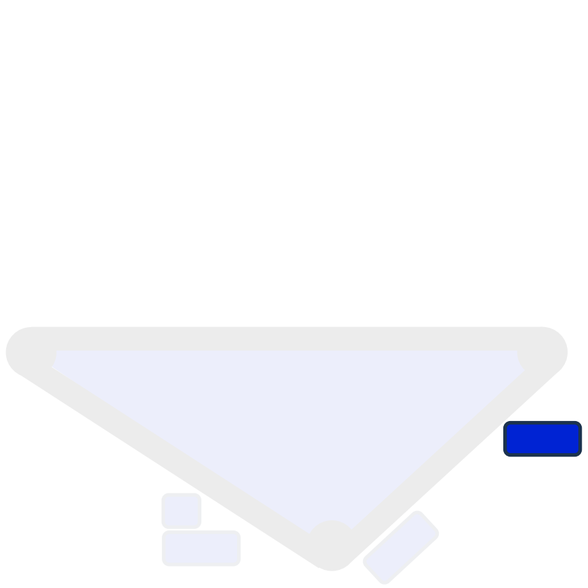


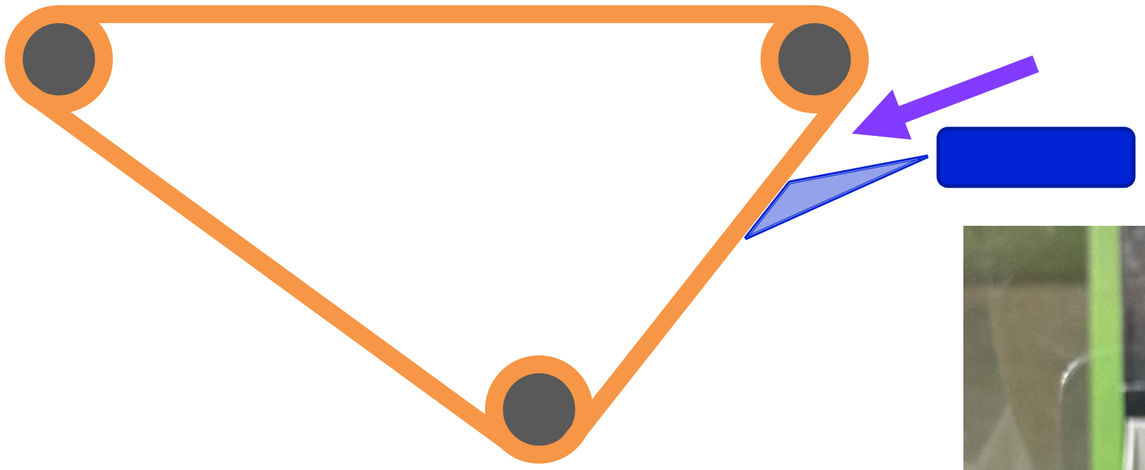




Module Explanation

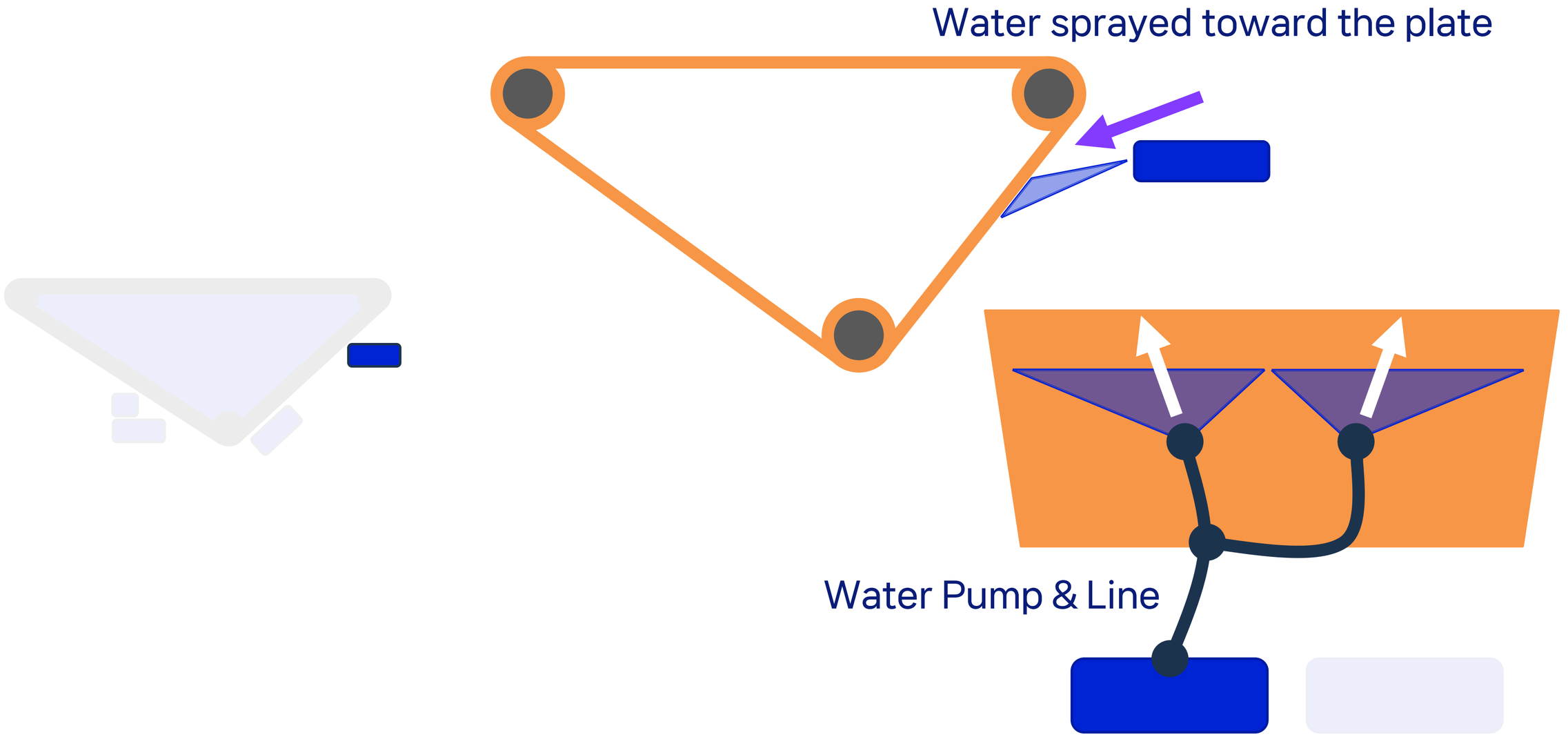
Water jet





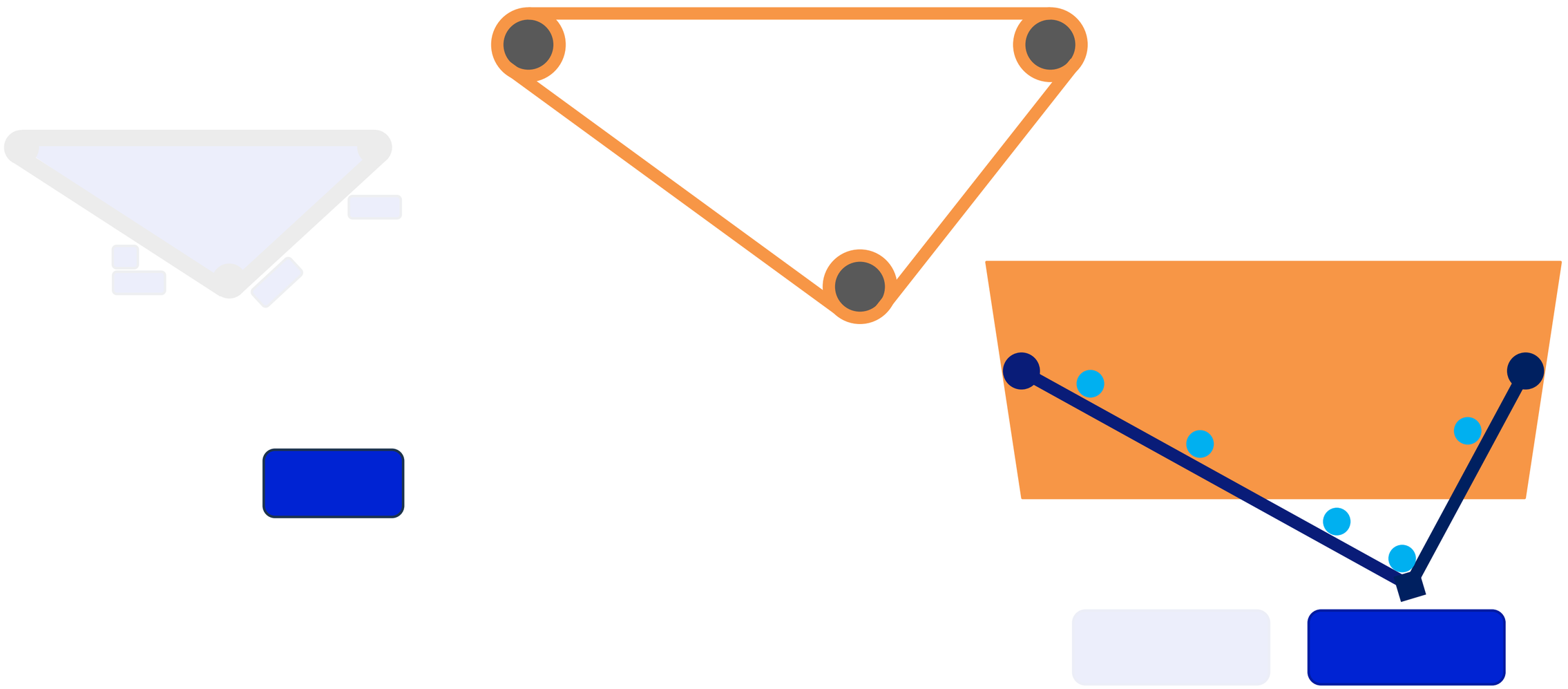
Module Explanation

Water jet



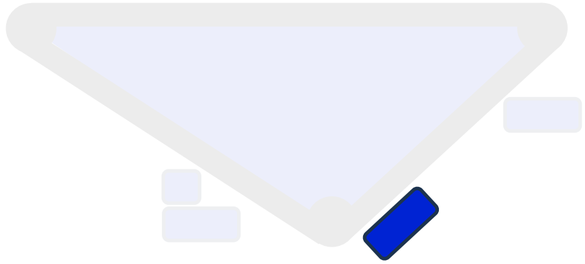
Module Explanation

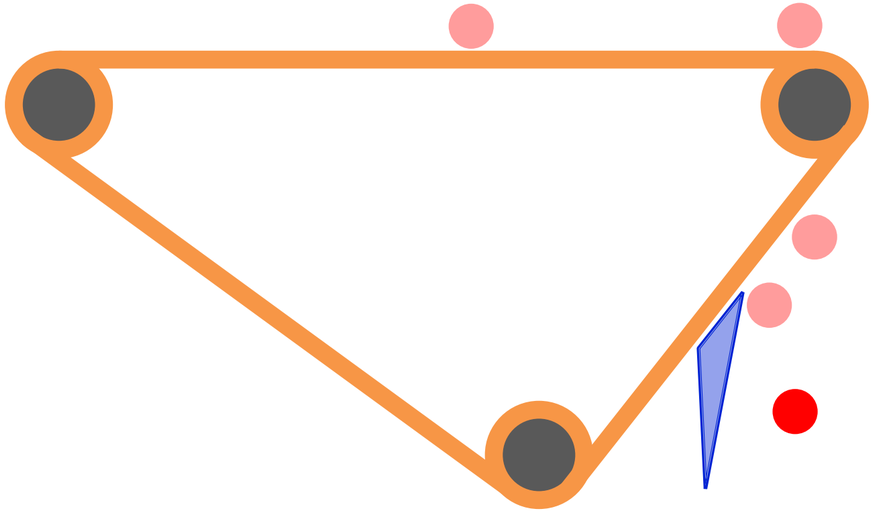
Drain System

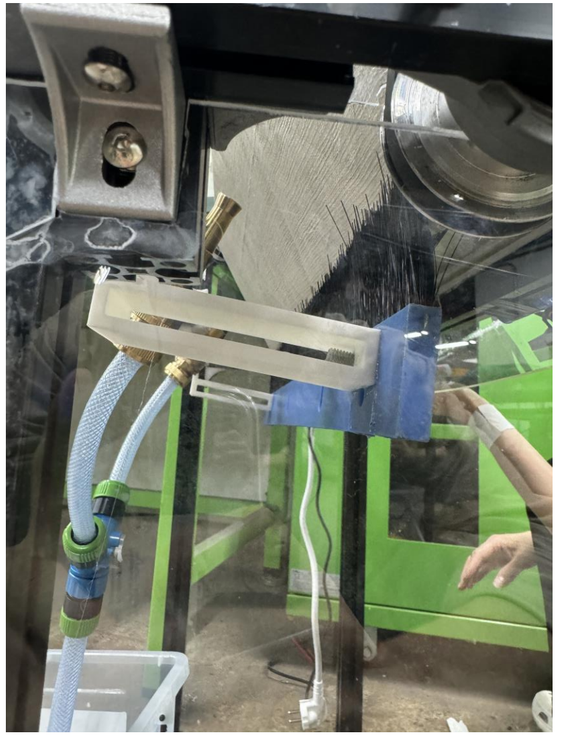


Module Explanation

Brush

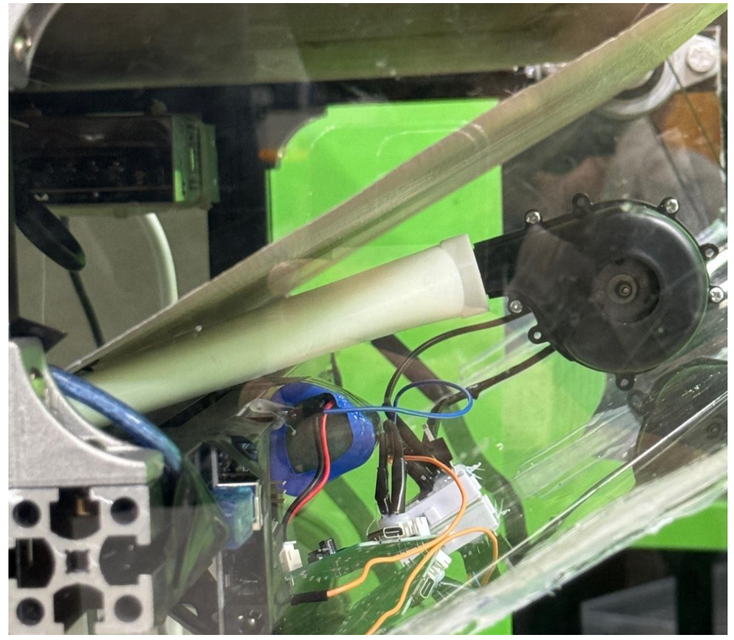


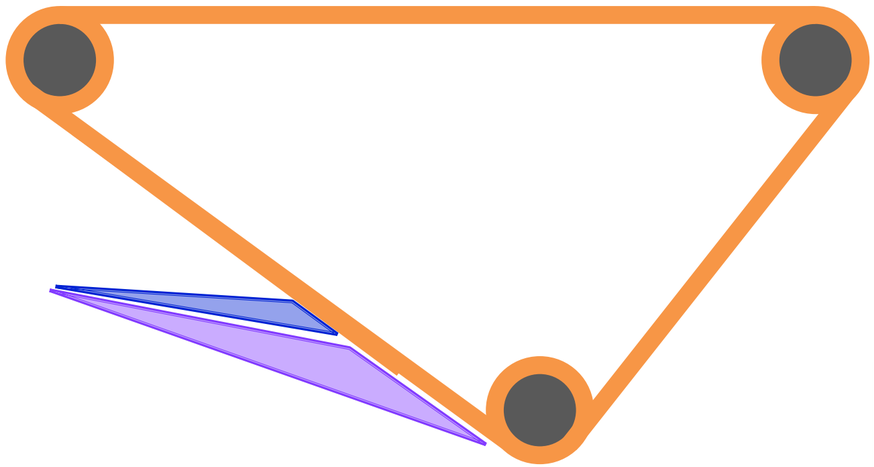




Module Explanation

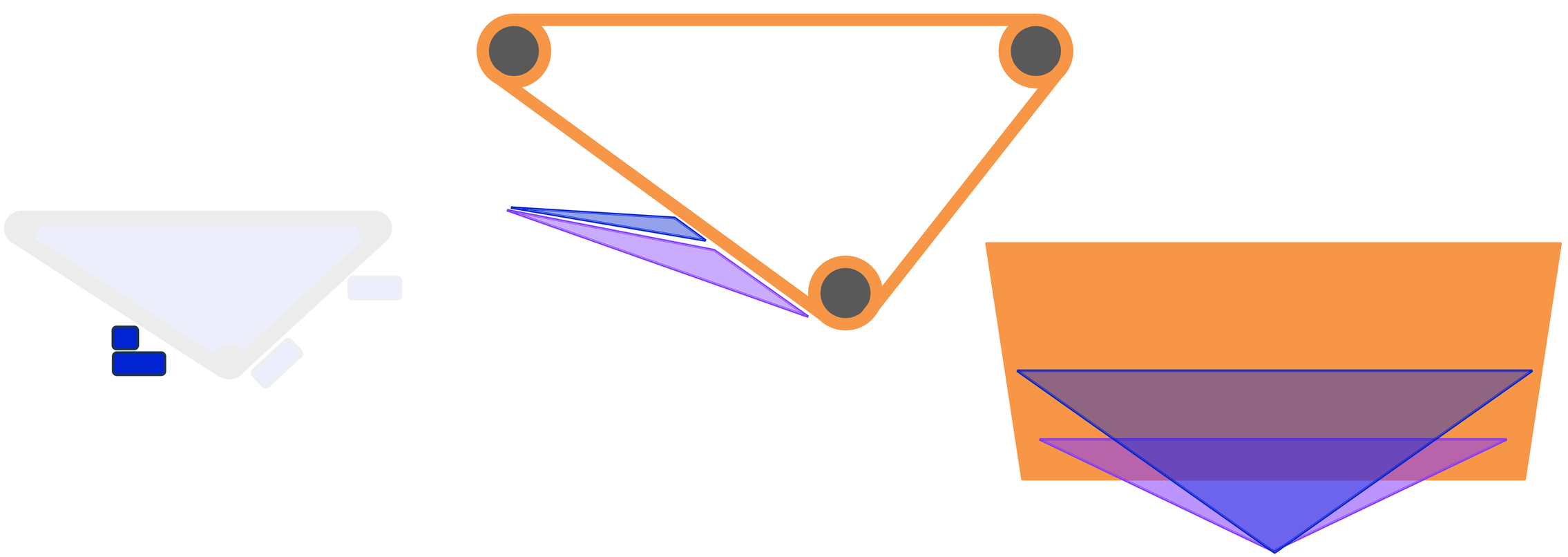
Blow & UV System



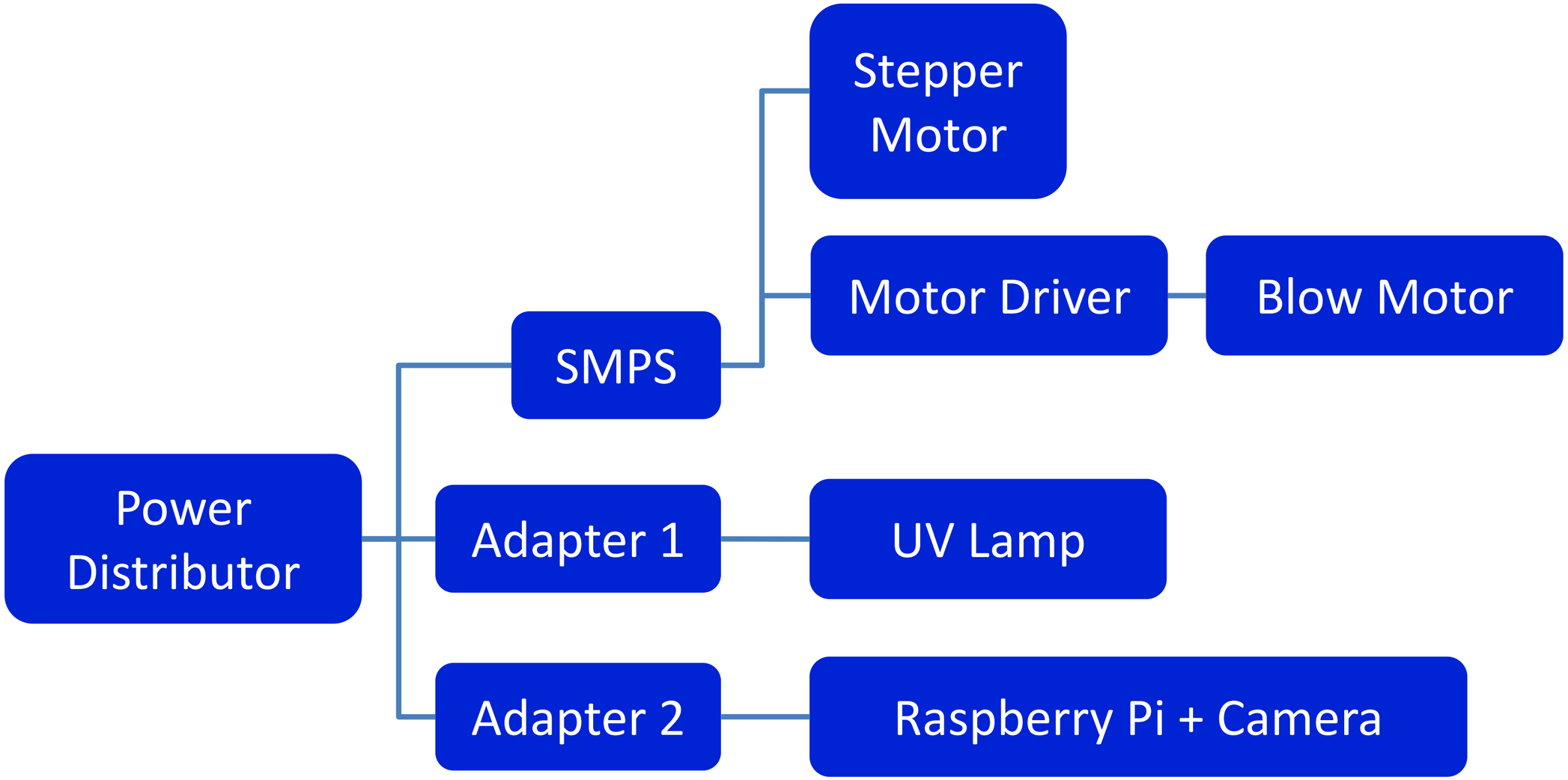


Module Explanation

Blow & UV System

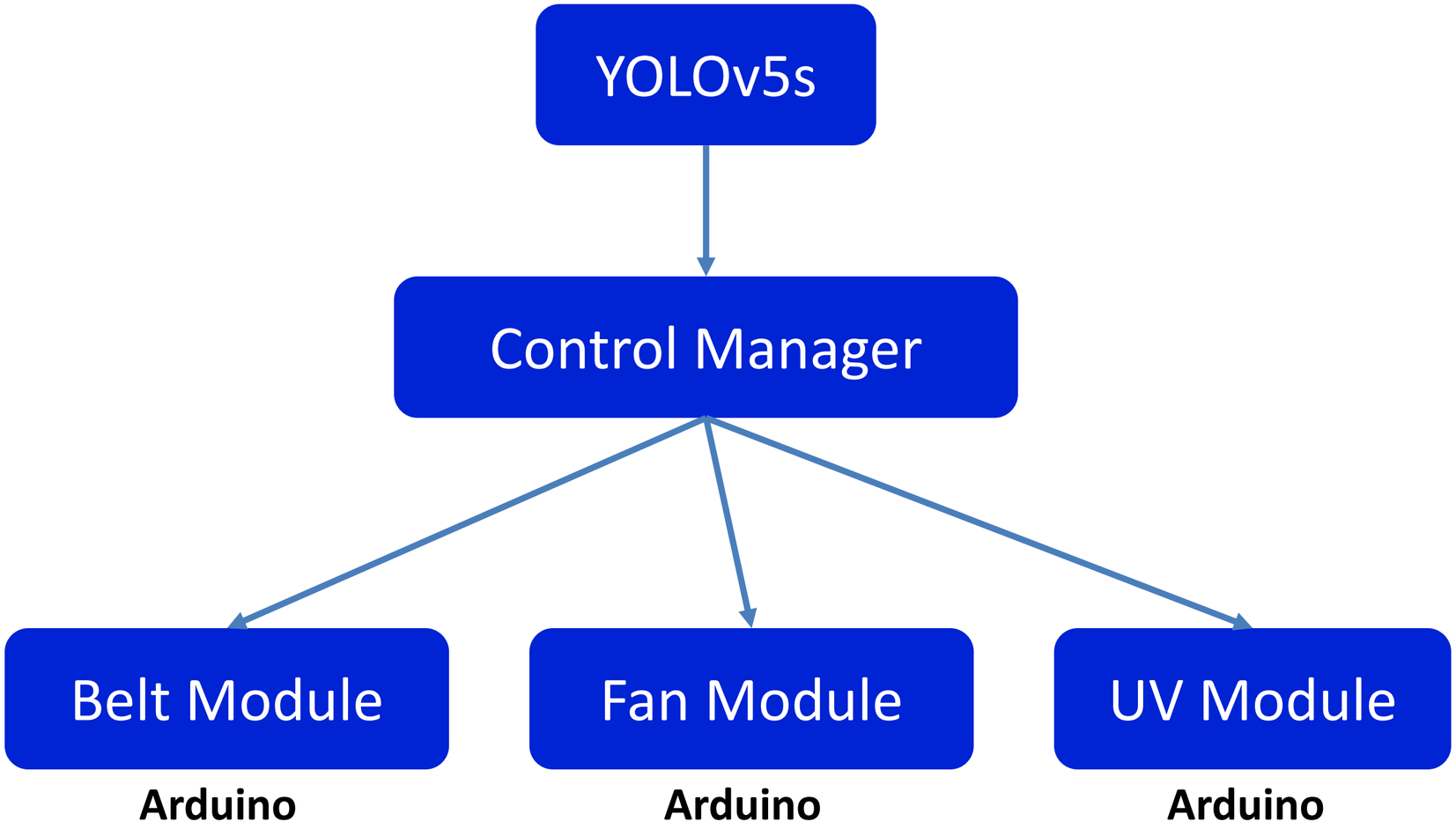


Power grid

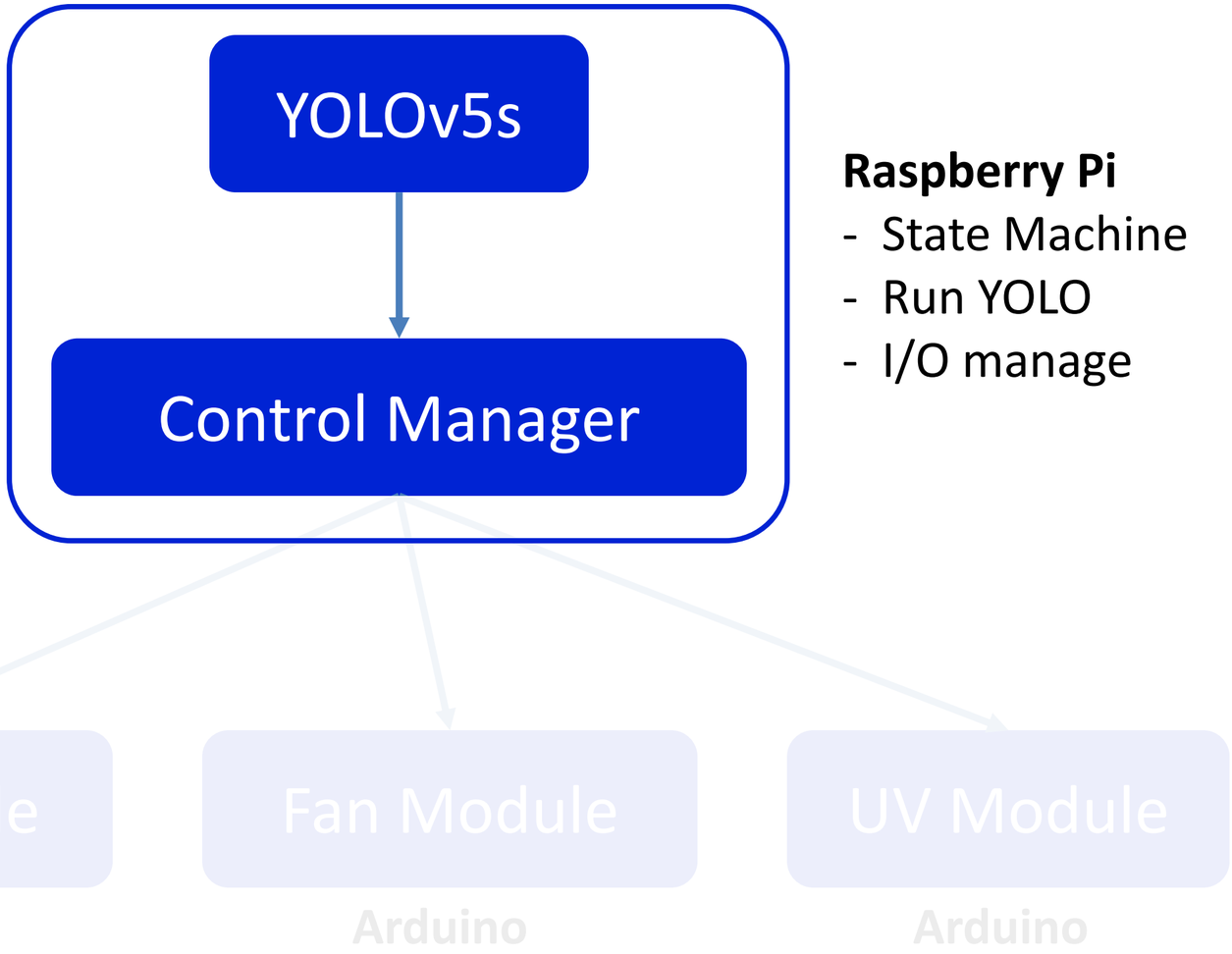


Power Grid

SW Explanation



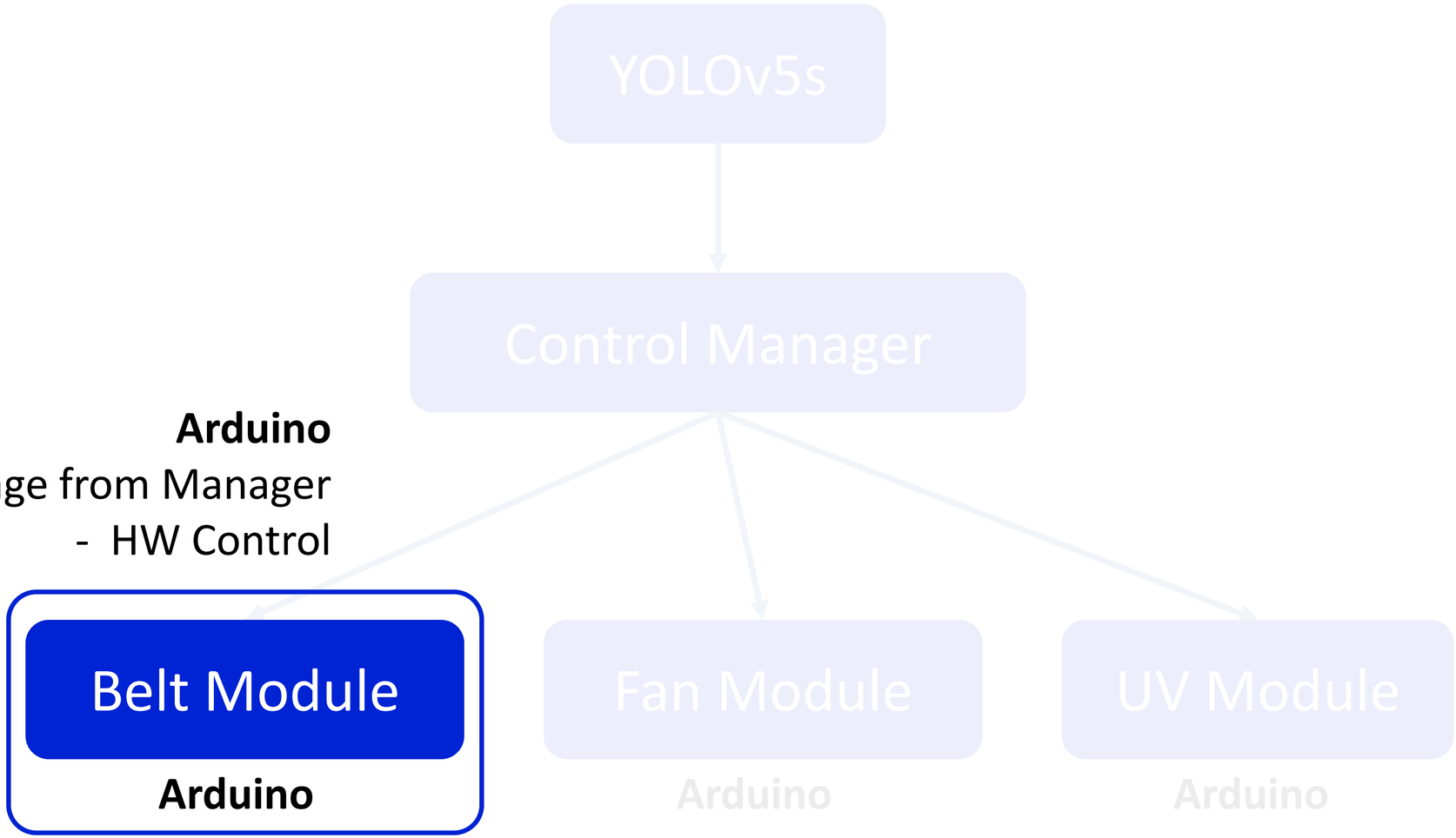
SW Explanation



Raspberry Pi

- State Machine
- Run YOLO
- I/O manage

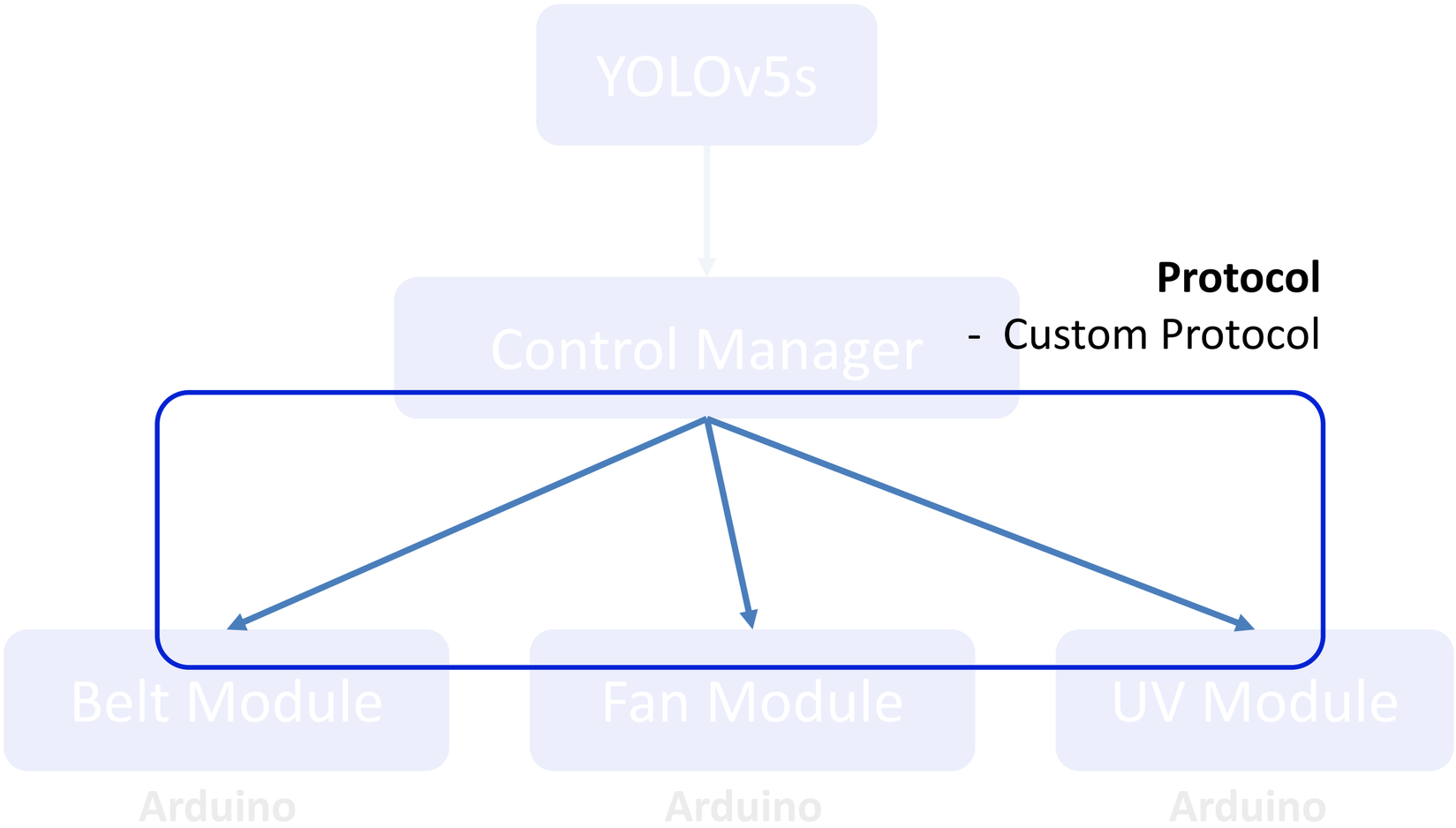
SW Explanation



Arduino

- Receive Message from Manager
  - HW Control

SW Explanation

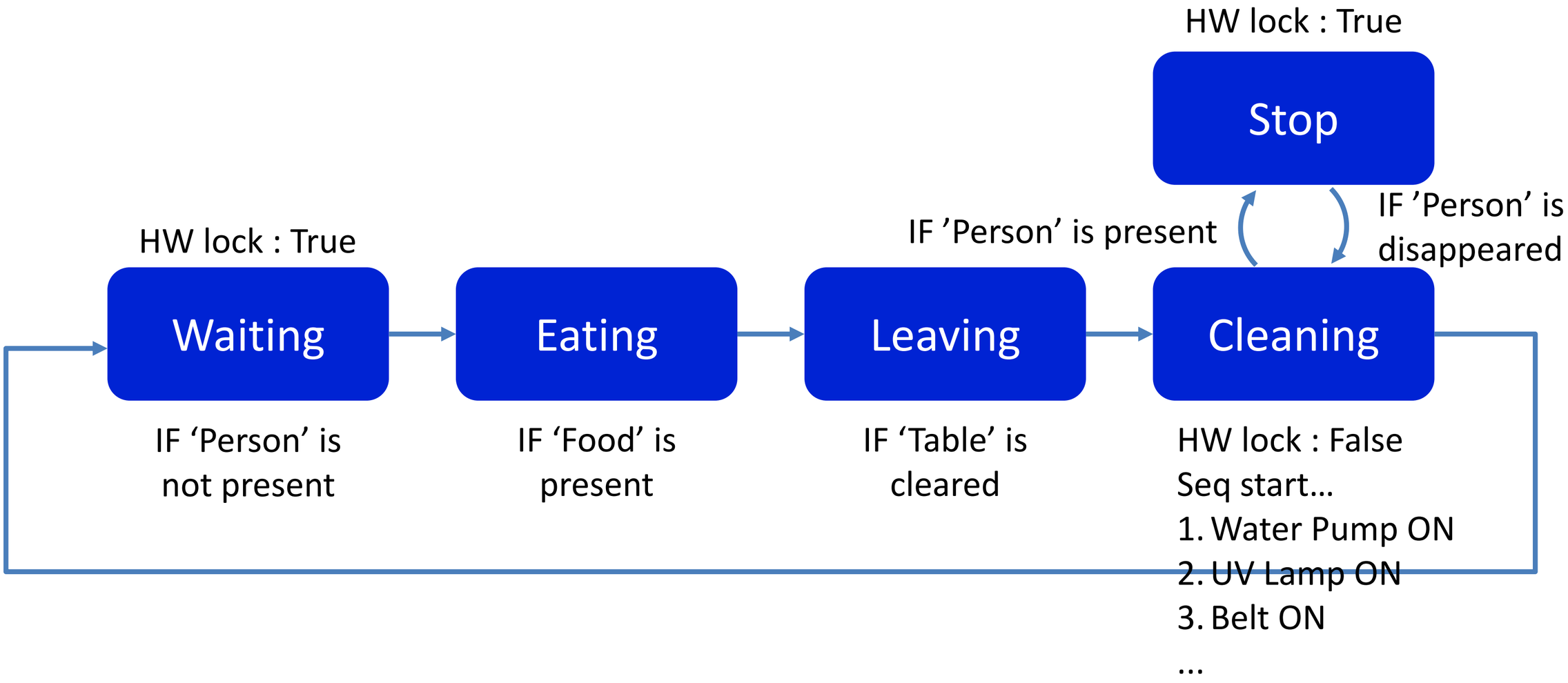


Protocol

- Custom Protocol

SW Explanation

HW I/O always look for ‘HW lock’ variable

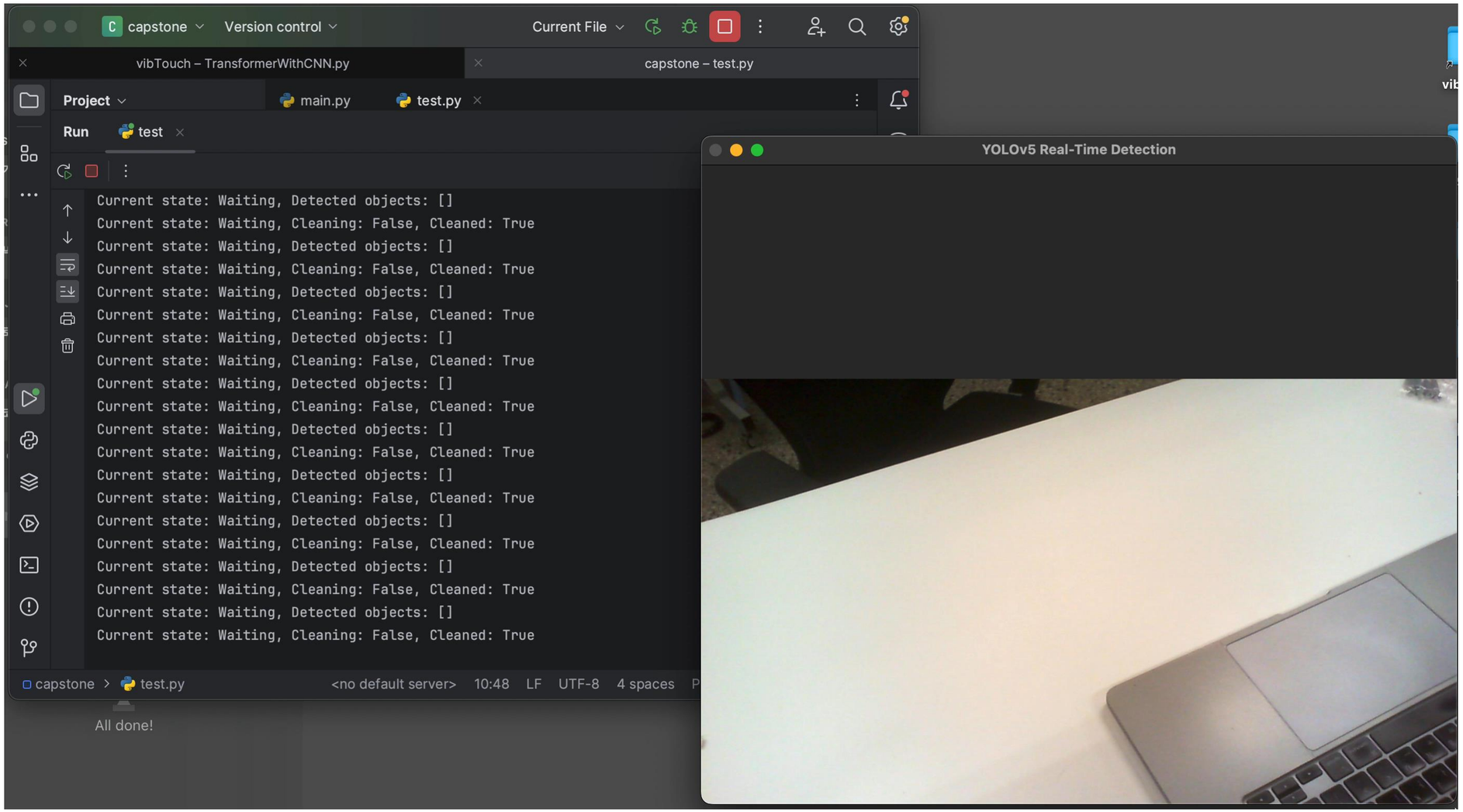


State depend architecture

SW Explanation

Working Demo

SW Explanation



Waiting

Eating

Leaving

Cleaning

Stop

Yolo detection Demo

Thank you
Q&A

이준희, 양예찬, 김승민, 이유빈, 김다은, 양정현

How effective the solution is ?

w/o our solution

- 10,000won/h
- Working 11 – 21
- 100,000 per day
- **24days -> 2,400,000 won**

w/ our solution

- Price : 700,000won/machine
- Maintenance cost : 10,000won/month

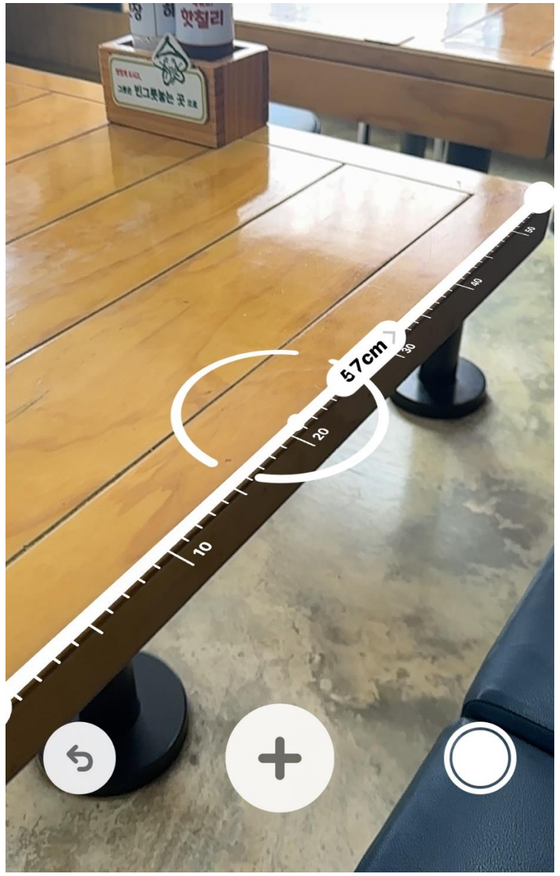
How effective is the solution?

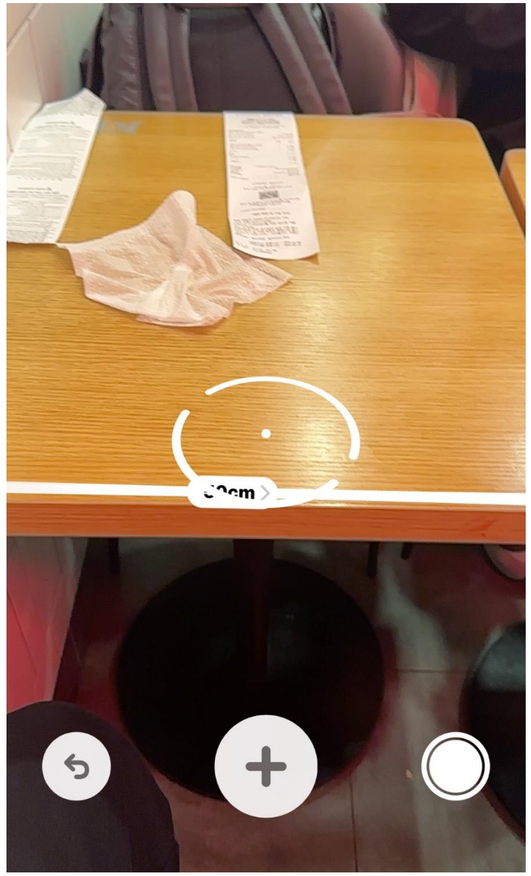
- 10 seats
- Initial investment 7,000,000won + a
- 100,000won for maintenance

- **3 ~ 4 months to pass break-even point**

Food court in stores could be our customer

Pre-investigation





Pre-investigation to find a right table size

[HW] Shaft

Material -AL 2014 T6, $S_{ut} = 400\ MPa$, $S_y\,(0.2\%\ offset) = 360\ MPa$
-Check to Fatigue Failure stability

$$D = 25mm\ \ d = 6\ mm \qquad K_{ts} = 2.97,\ \ K_t = 1.97\ \ (q_s = q = 1)$$

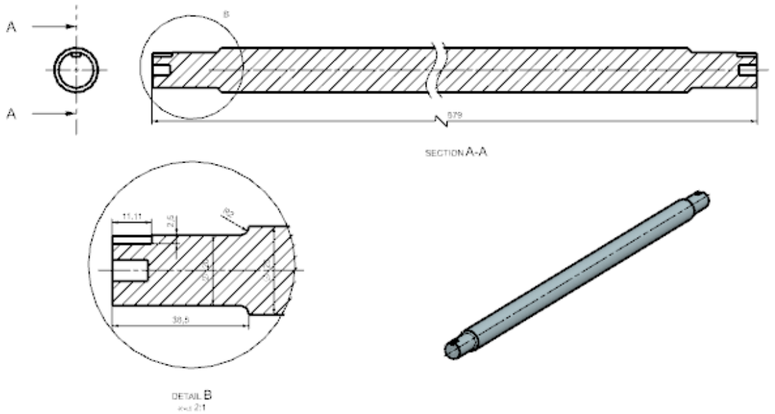
$$Marin\ Factor\ [k_a = 4.51 \cdot (S_{ut})^{-0.265} = 0.9217,\ k_b = 1.24 \cdot D^{-0.107} = 0.902,$$
$$k_c = 1, k_d = 1\ , k_e = 0.814(99\%\ \text{Reliability})] \qquad \therefore S_e = 197.76\ MPa$$

$$T_m = \frac{max(T)+\min(T)}{2} = 46.11\ N.m\ ,\ \ T_a = \frac{max(T)-\min(T)}{2} = 7.14\ N.m\ ,$$

$$M_m = \frac{max(M)+\min(M)}{2} = 265.72\ N \cdot m\ , \qquad M_a = \frac{max(M)-\min(M)}{2} = 49.52\ N \cdot m$$

$$A = \sqrt{4\left(K_f M_a\right)^2 + 3\left(K_{fs} T_a\right)^2} = 191.88\ \ N \cdot m\ , B = \sqrt{4\left(K_f M_m\right)^2 + 3\left(K_{fs} T_m\right)^2} = 875.51\ N \cdot m$$

$$n = \frac{\pi d^3}{16}\left(\frac{A}{S_e} + \frac{B}{S_{ut}}\right)^{-1} = 1.34 \rightarrow \text{Select Diameter Fit}$$



-Check to Bending Moment, Torsion Moment stability

$$\sigma = \ K_t \frac{M \cdot c}{I} = \frac{261.7 \times 32}{\pi D^3}\ \ (D = 25\ mm)$$

$$\sigma_{max} = 290.02\ MPa < S_y \rightarrow \text{Fit}$$

$$\tau = \ K_{ts} \frac{T \cdot c}{J} = \frac{106.4 \times 16}{\pi D^3}\ \ (D = 25\ mm)$$
$$\tau_{max} = 43.35\ MPa < S_{sy} \rightarrow \text{Fit}$$

HW layer

[HW] Bearing

The Load on the bearing → $F_R = \sqrt{{F_r}^2 + {F_B}^2} = 1088$ N

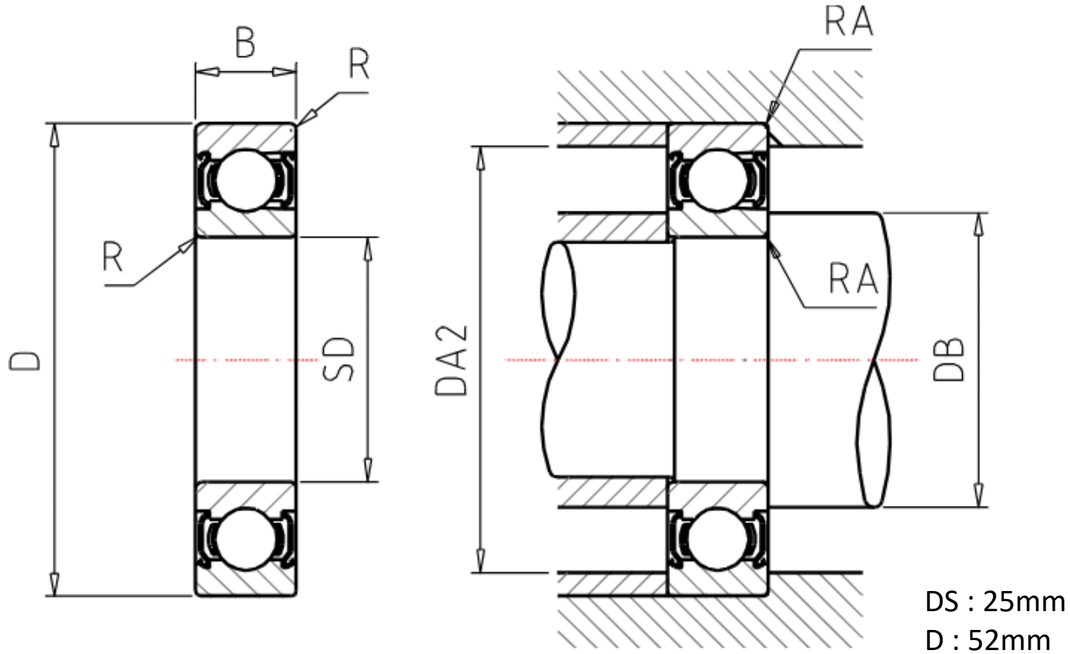
Bearing Design Conditions → $L_d = 10000\ hours,\ \ n_d = 5\ rev/min$

$\sqrt[4]{R} = 0.9$, $R = 0.974$ ($Reliability$ 97.4%)

$$C_{10} = a_f * F_r * \left(\frac{X_D}{x_0 + (\theta - x_0)(1 - R_D)^{\frac{1}{1.483}}}\right)^{\frac{1}{3}} = 12.7\ kN$$

(02-25mm Bearing , a_f = 1.2)

$L \geq 10^6$ (infinite life) → Fit



DS : 25mm
D : 52mm
B : 15mm
R : 1mm

[HW] Progress so far...

Final rendering

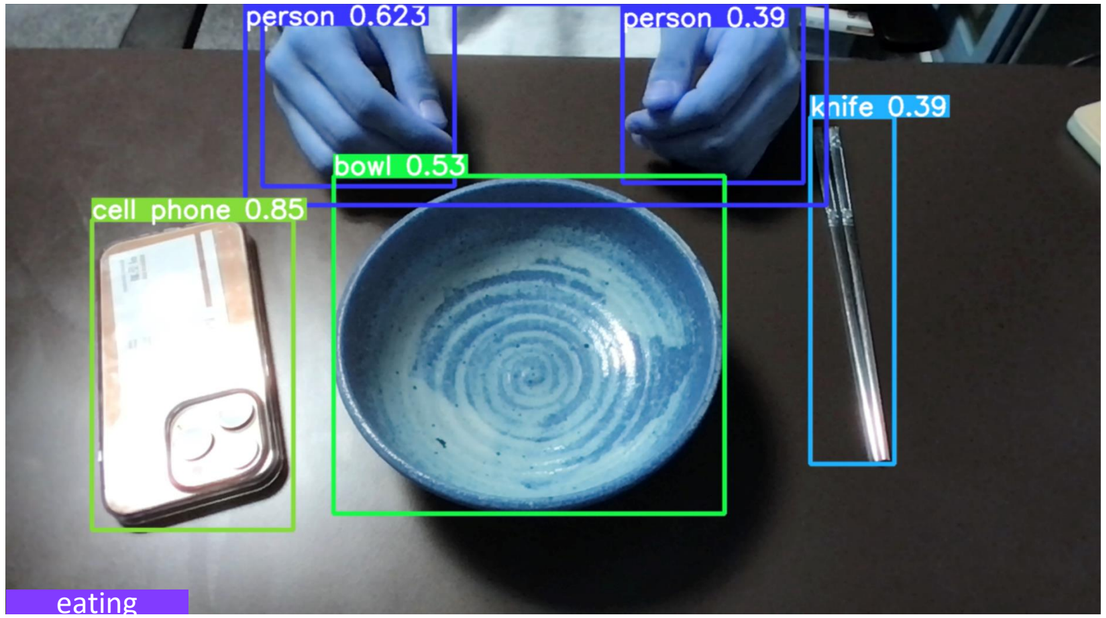
[HW] Progress so far...

Module table

SW

- Automatic status cognition for safety
- Protocol

Challenges
- Small OD(Object detection) model using TinyML
  - Is customer present / leaving?
  - Did customer left something?



Yolov8s model, raspberry pi 4b+

Yolov8s wasn't trained our preference
need additional train for
hand, chapstick, and a bowl(certain angle)

Model itself needs to be lighter

SW

Challenges

- Small OD(Object detection) model using TinyML
  - Small and fast enough to run on limited resource

Re-train model
to achieve lighter model size

Implement new(smaller) model struct
to run on limited resource env

TinyissimoYOLO: A Quantized, Low-Memory Footprint, TinyML Object Detection Network for Low Power Microcontrollers

Julian Moosmann, Marco Giordano, Christian Vogt, Michele Magno
Center for Project Based Learning - ETH Zürich
julian.moosmann, marco.giordano, christian.vogt, michele.magno@pbl.ee.ethz.ch

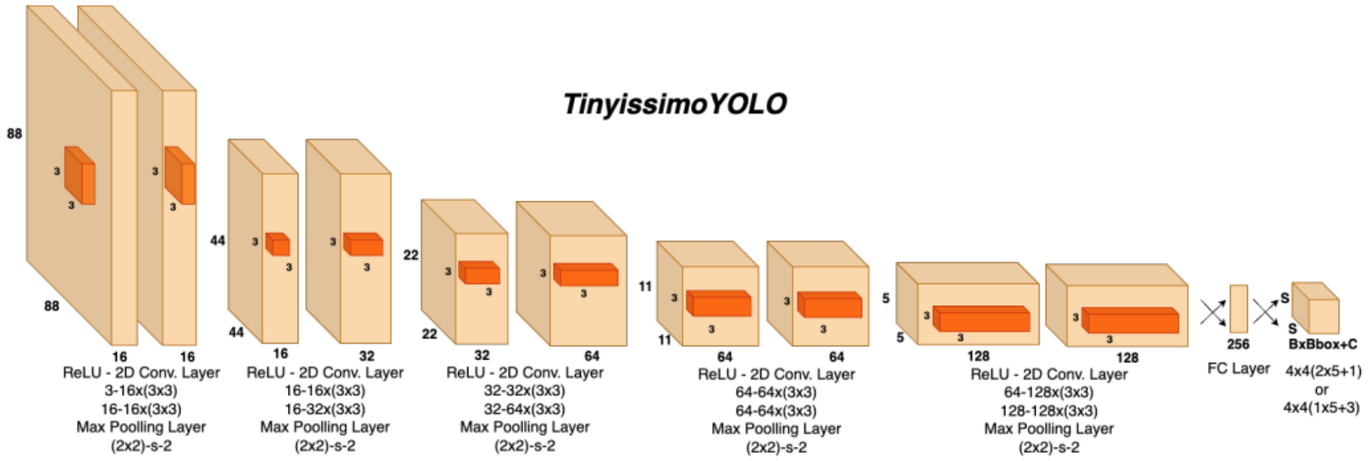


Fig. 1. TinyissimoYOLO proposed by this paper.