

"GreenGuard: Intelligent Plant Protection System"



Simone Serafini
Biagio Carpaneto



MOTIVATION

IDEA AND BENEFITS

FUNCTIONING

AN OVERVIEW OF ALL FEATURES

HARDWARE E SOFTWARE

CORE COMPONENTS

DEMO

A FINAL DEMONSTRATION OF OUR WORK

INDEX



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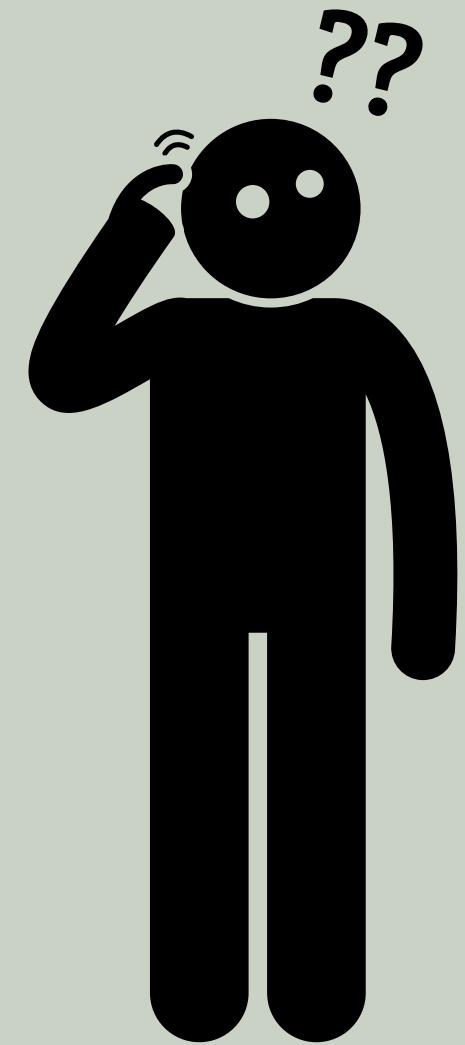
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MOTIVATIONS

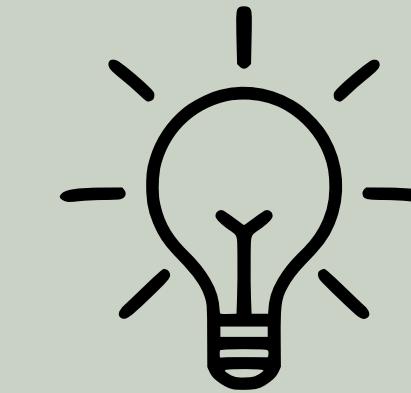


- LACK OF TIME, KNOWLEDGE, OR CONSISTENCY
- PLANTS CAN GET SICK WITHOUT SHOWING EARLY SYMPTOMS. IF NOT DETECTED PROMPTLY, LEAF DISEASES CAN DAMAGE THE PLANT AND SPREAD QUICKLY
- NO CENTRALIZED SYSTEM TO MONITOR PLANT HEALTH





OUR IDEA



AN IOT SOLUTION THAT:

- REAL-TIME MONITORING OF PLANT CONDITIONS (LIGHT, TEMPERATURE, HUMIDITY, AIR QUALITY) WITH IMMEDIATE VISUAL FEEDBACK
- AUTONOMOUS AND REAL-TIME IDENTIFICATION OF PLANT HEALTH STATUS
- THE SYSTEM ALLOWS REMOTE MONITORING OF THE PLANT AND ADJUSTMENT OF ENVIRONMENTAL PARAMETERS



BENEFICT

- WASTE REDUCTION
- AUTOMATION = LESS MANUAL LABOR
- LOWER LOSSES DUE TO DISEASES
- PREVENTION > REPAIR
- REDUCED PESTICIDE USE
- WATER SAVINGS
- LOW-COST SCALABILITY



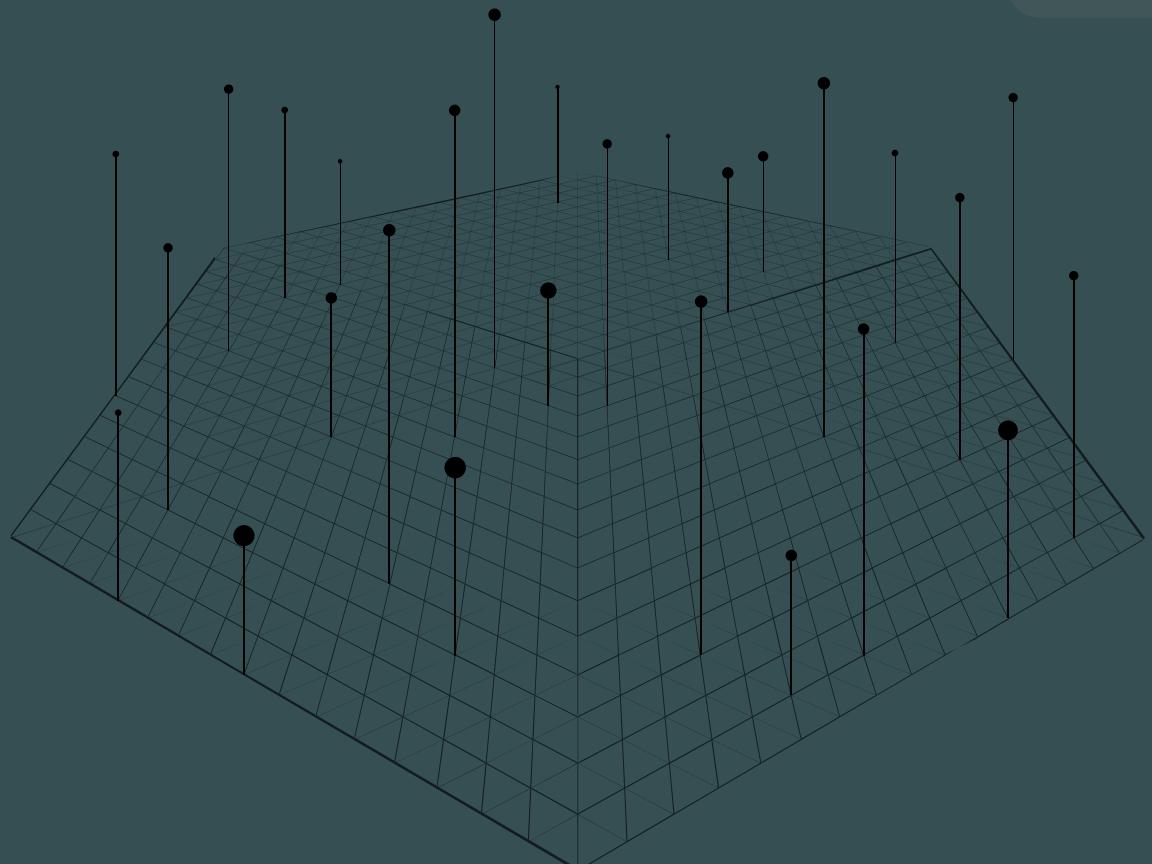
- PRIVATE USERS / HOBBYISTS
- COMMERCIAL BUSINESSES
- PROFESSIONAL FARMS AND GREENHOUSES
- MUNICIPALITIES / PUBLIC AUTHORITIES

BUSINESS TARGET



BIG DATA

BUILDING A GLOBAL
AGRICULTURAL DATA
ECOSYSTEM



INTELLIGENZA
ARTIFICIALE

CONTINUOUS TRAINING
OF LEAF AND
CLIMATE MODELS

CLIMATE CHANGE

FIGHT

MICROCLIMATE MAPPING
AND RESPONSE
TO CLIMATE CHANGE

DATA
ADVANTAGES



GREEN ECONOMY



- AVOIDING WASTE
- CENTRALIZATION
- REMOTE CONTROL
- AUTOMATED GREEN CARE
- ENVIRONMENTAL EDUCATION

MOTIVATION

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CORE COMPONENTS

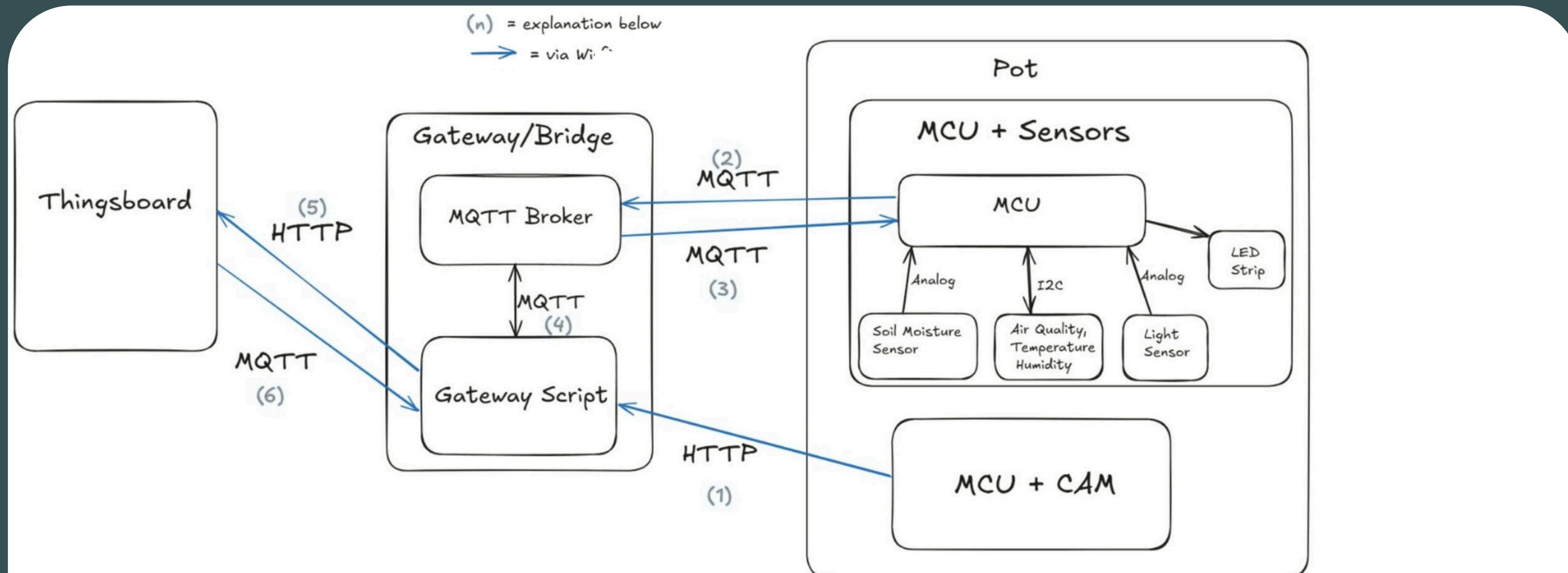
DEMO

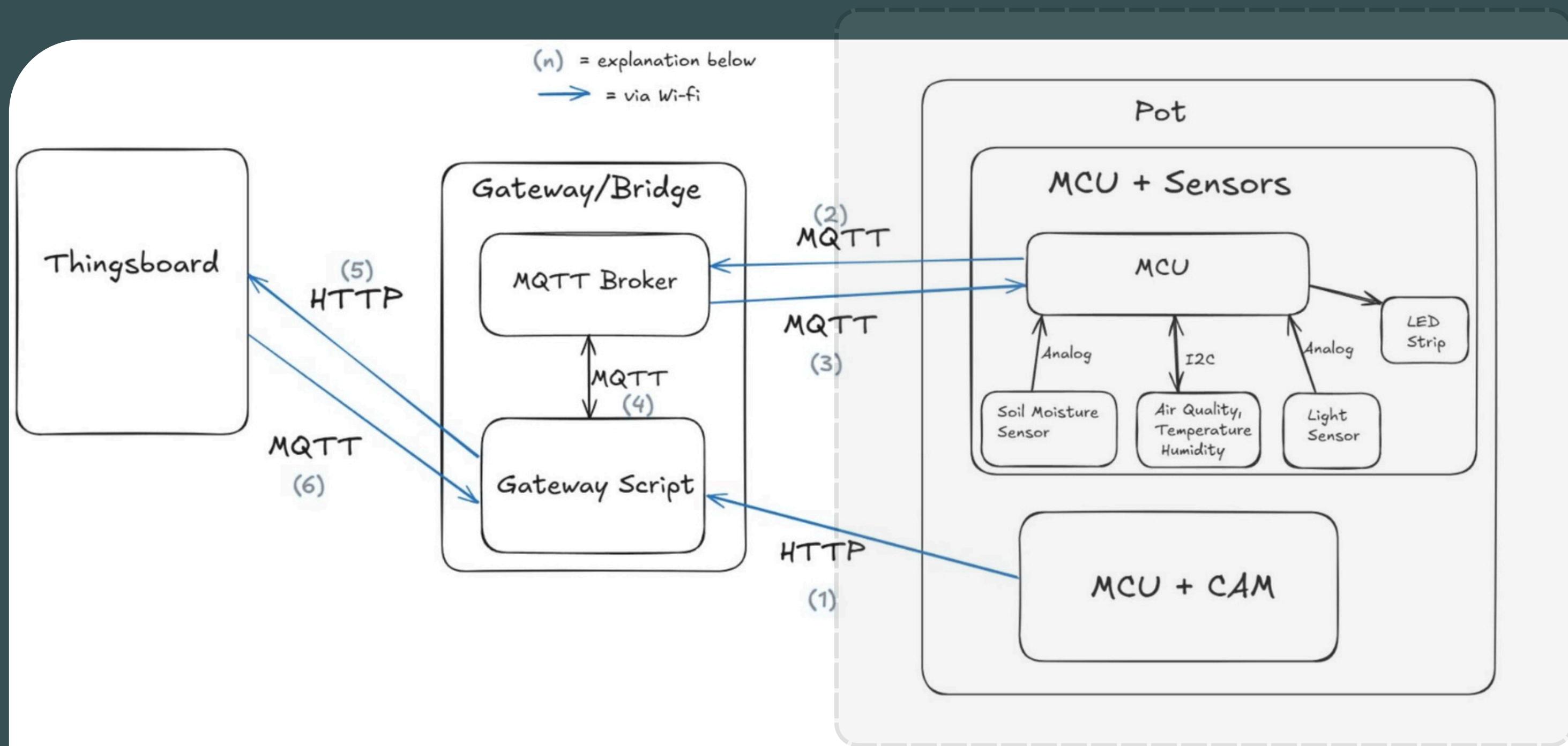
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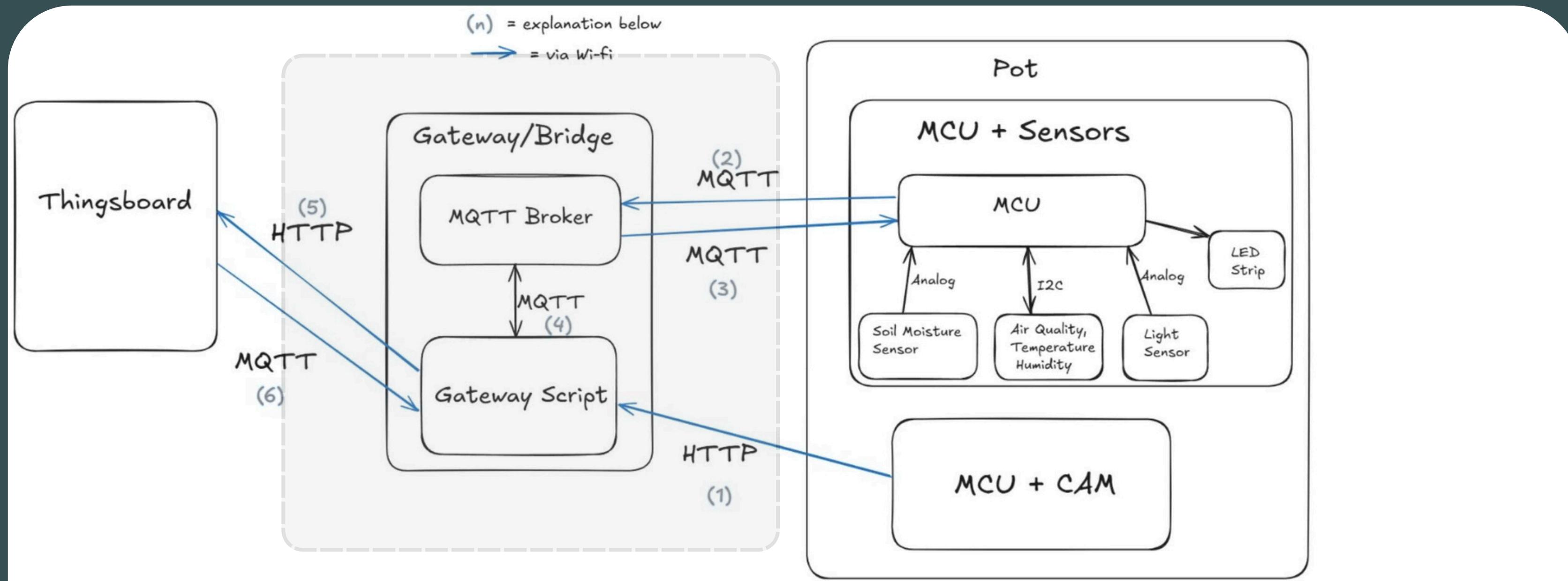
A FINAL DEMONSTRATION OF OUR WORK

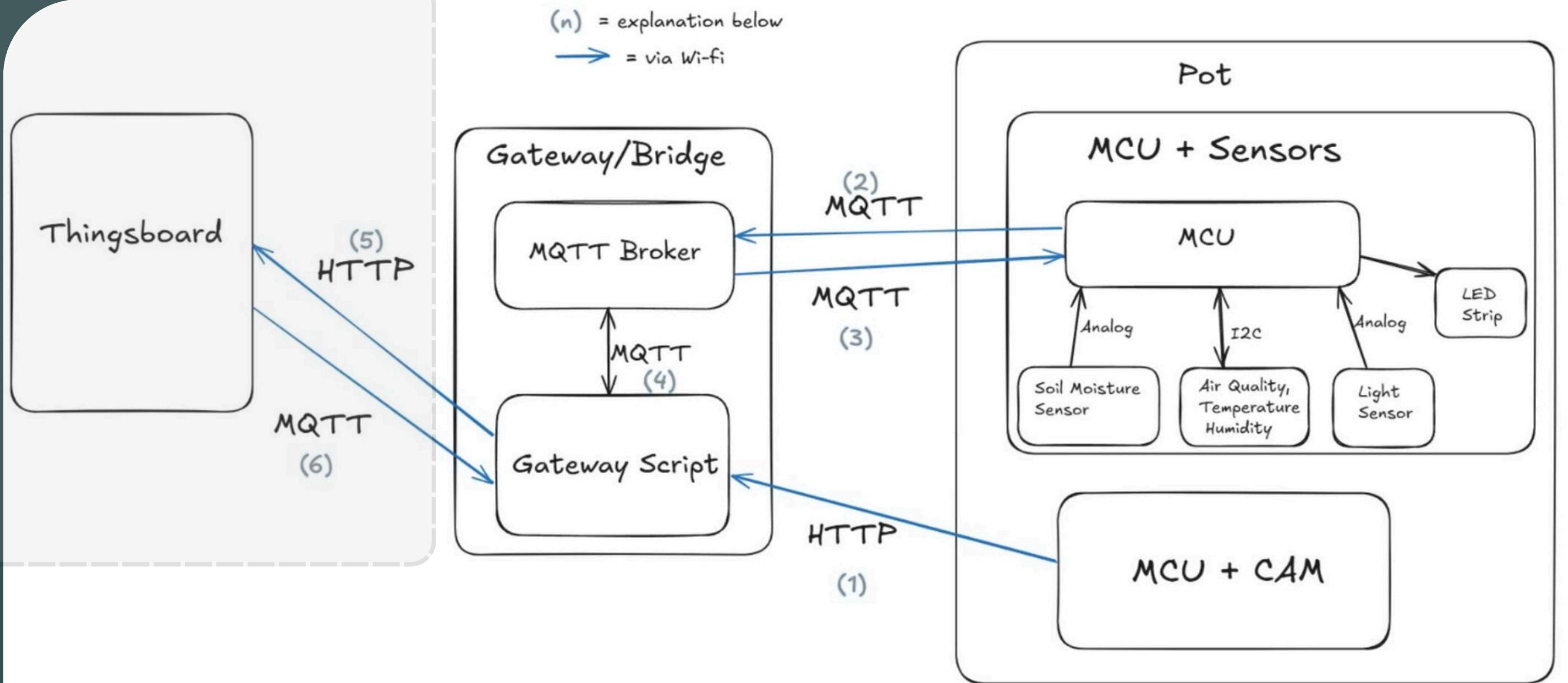
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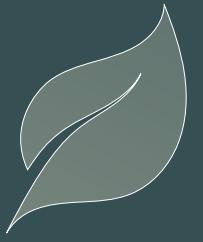


THINGSBOARD



INTRO

THINGSBOARD



DASHBOARD

THINGSBOARD



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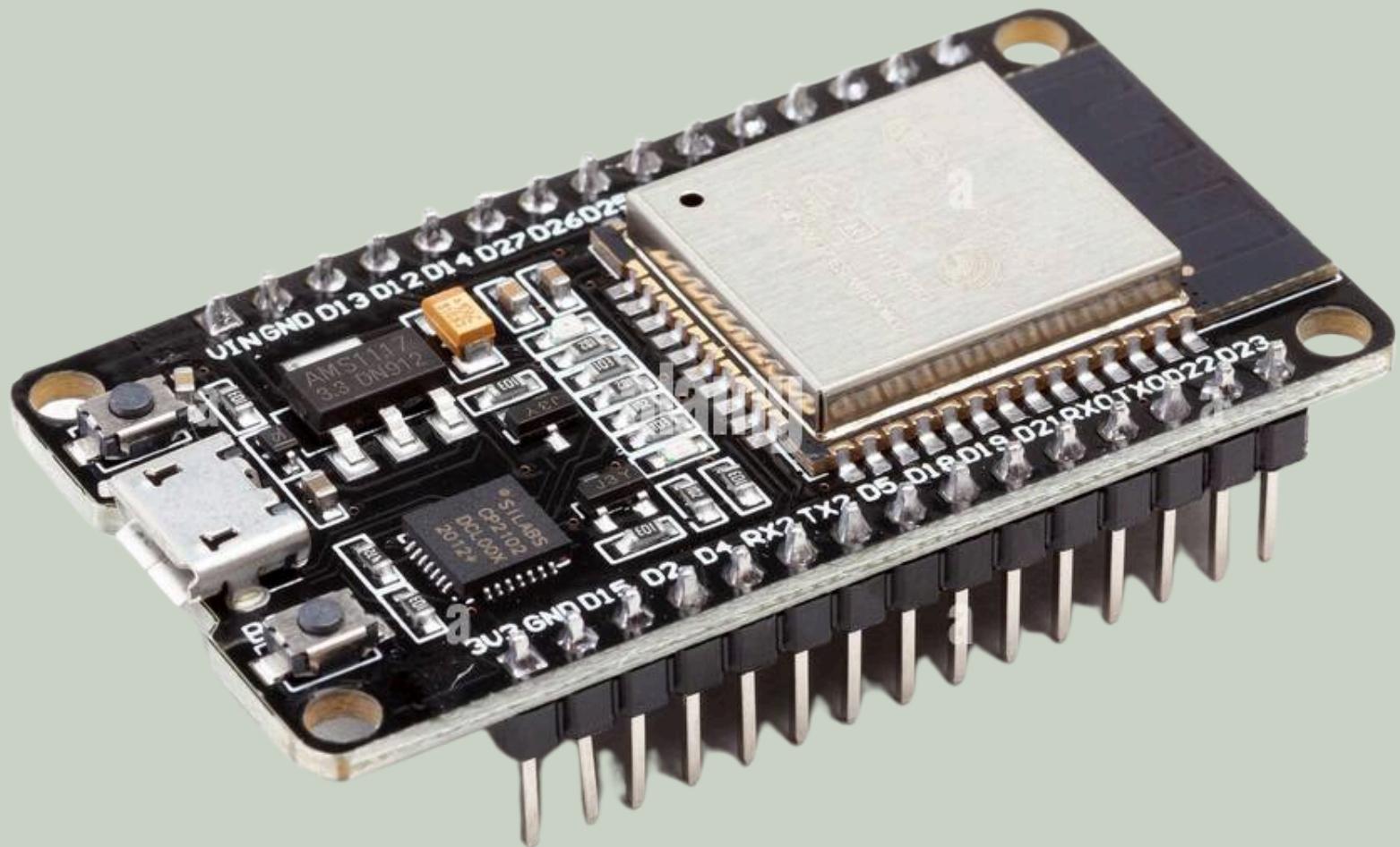


HARDWARE SCHEME





MICROCONTROLLER WITH WI-FI ESP32



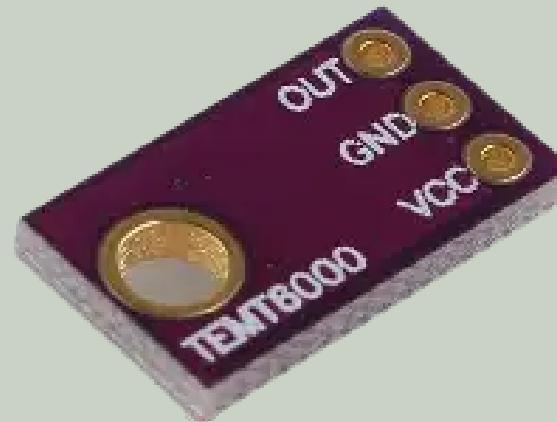
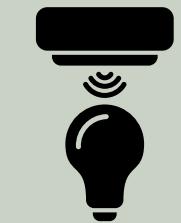
SUPPORT FOR:

- I²C connection
 - 2 Analog (ADC) connections

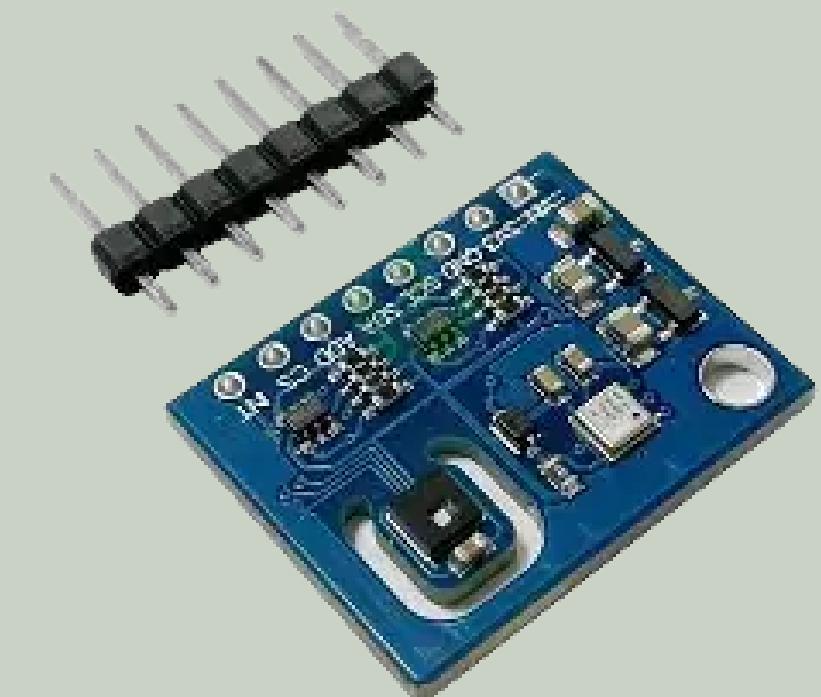
SENSORS



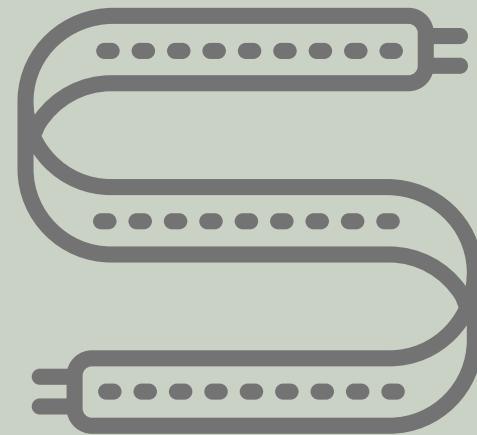
Light Sensor Module
(Analog) TEMT6000



Air Quality, Temperature
And Humidity Sensors (I2C)



Capacitive Soil Moisture
Sensor Module (Analog)



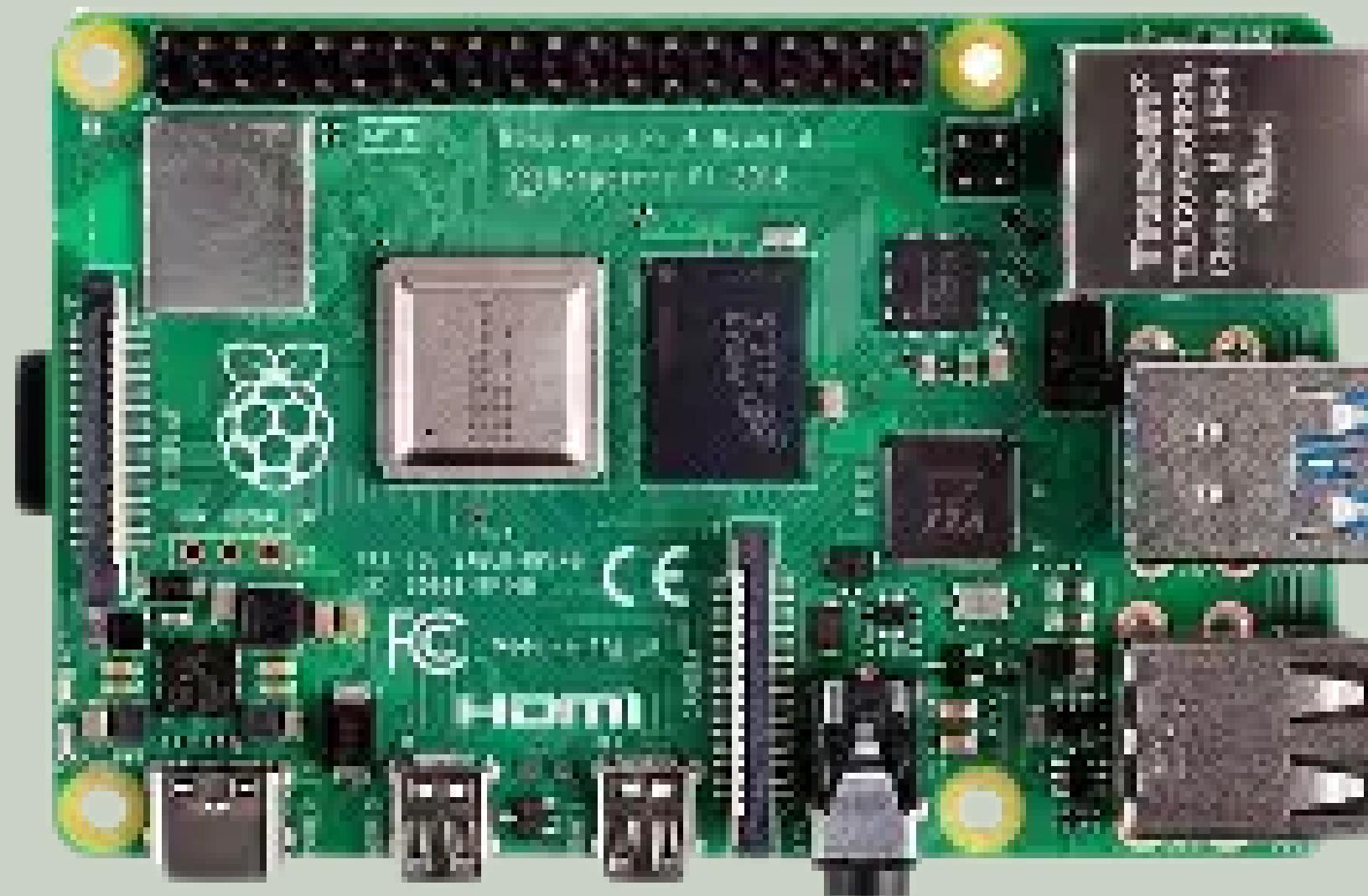
ACTUATOR: LED STRIP ADDRESSABLE RGBW (NEUTRAL WHITE), SK6812 STRIP 144LEDS/M



- STATIC
- BREATHING
- CIRCLING



SINGLE BOARD COMPUTER RASPBERRY PI 4



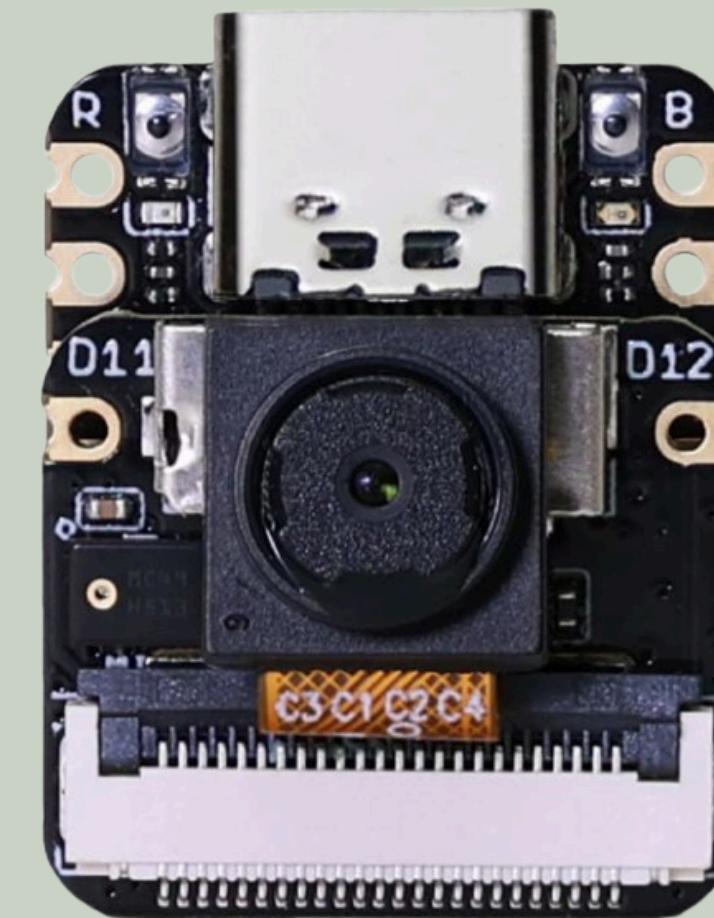
- 4GB MEMORY
- 128GB MICROSD



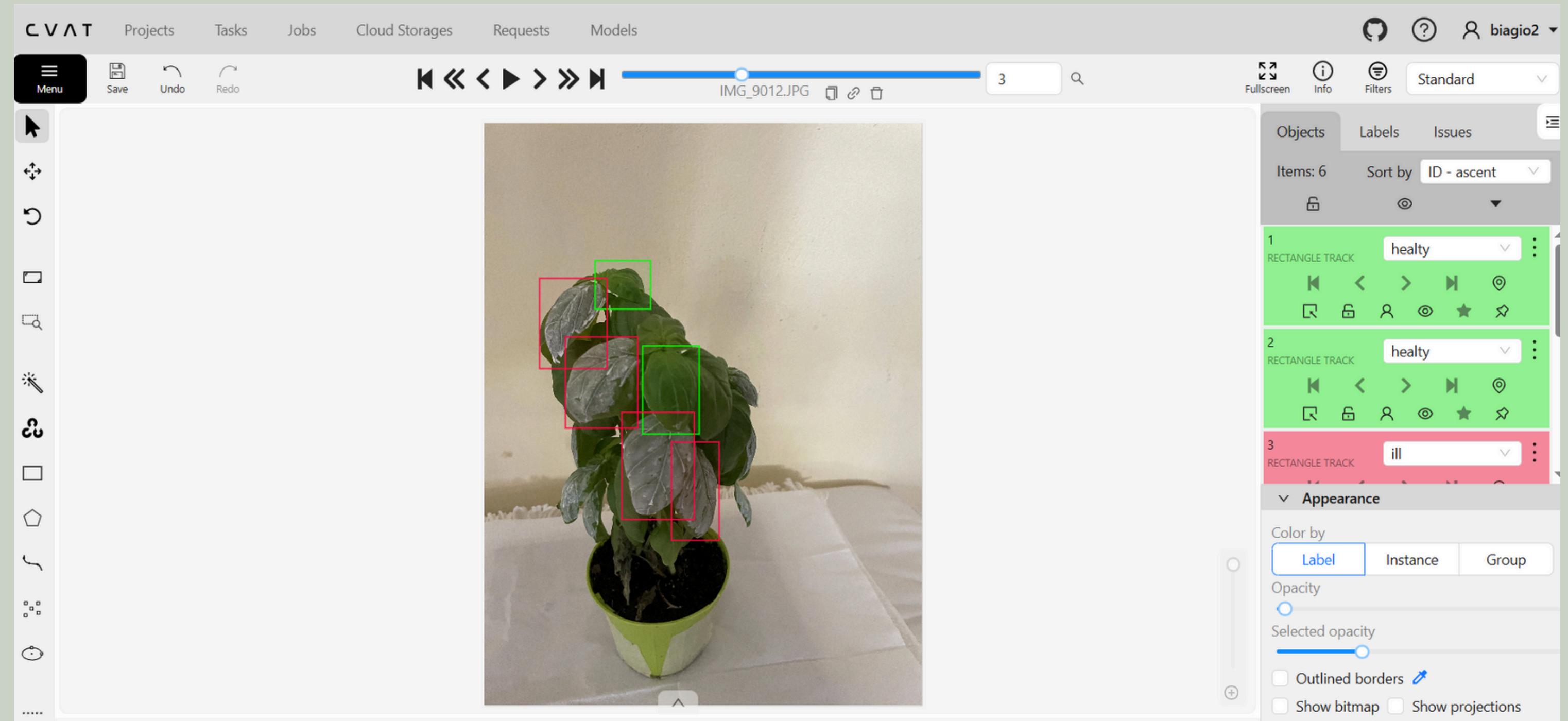
MICROCONTROLLER WITH WI-FI AND CAMERA

XIAO ESP32-S3 SENSE

- Leaf detection
- Leaf classification



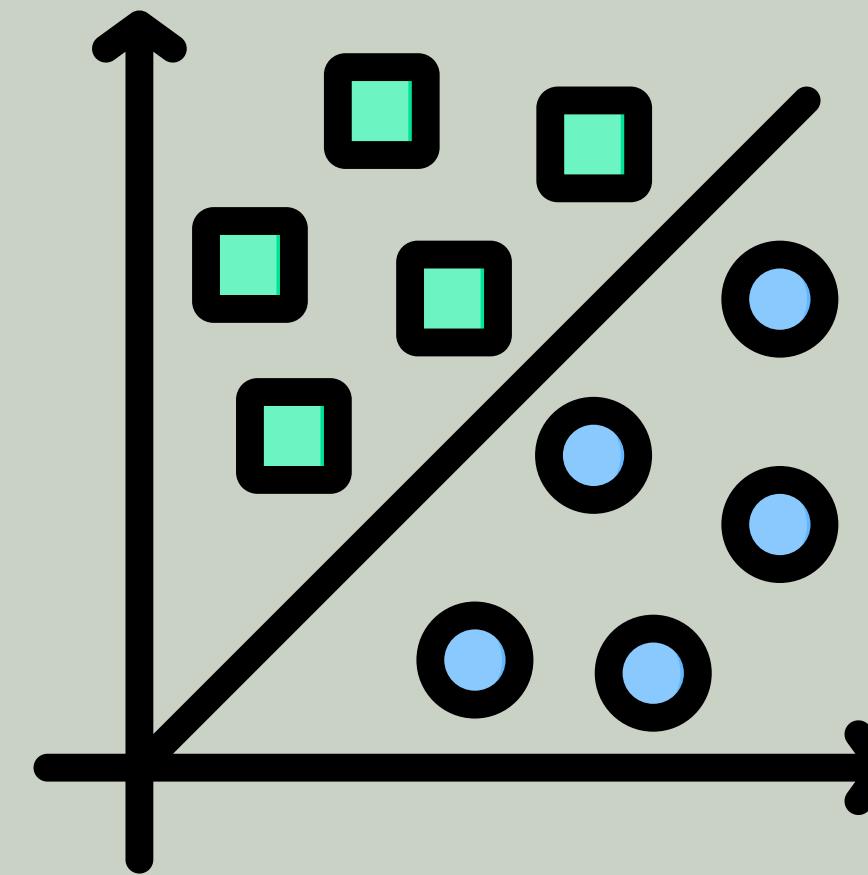
YOLOv8: labeling





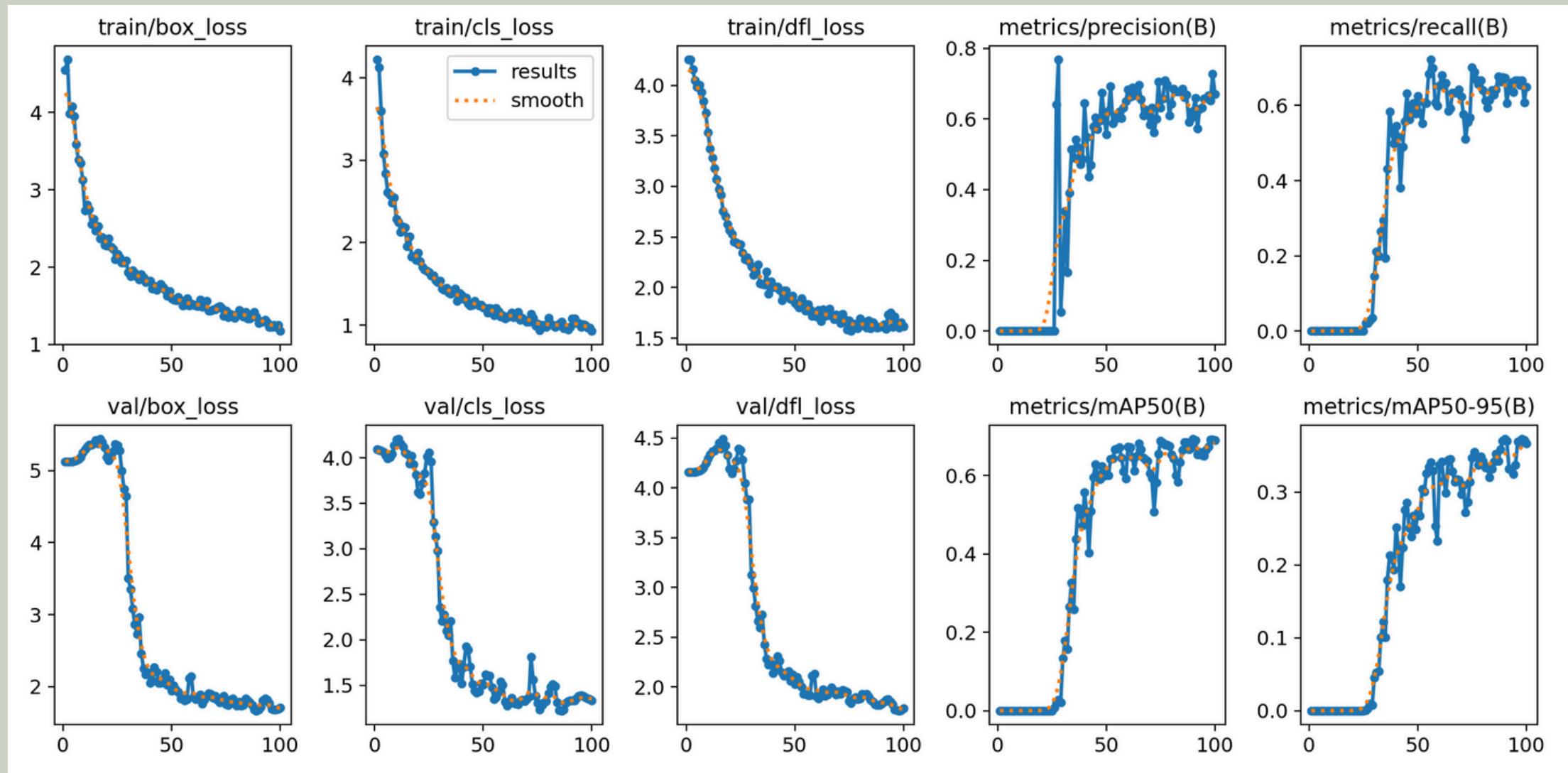
YOLOv8: training

- YOLOv8S 100 EPOCH
- YOLOv8M 100 EPOCH
- YOLOv8L 100 EPOCH

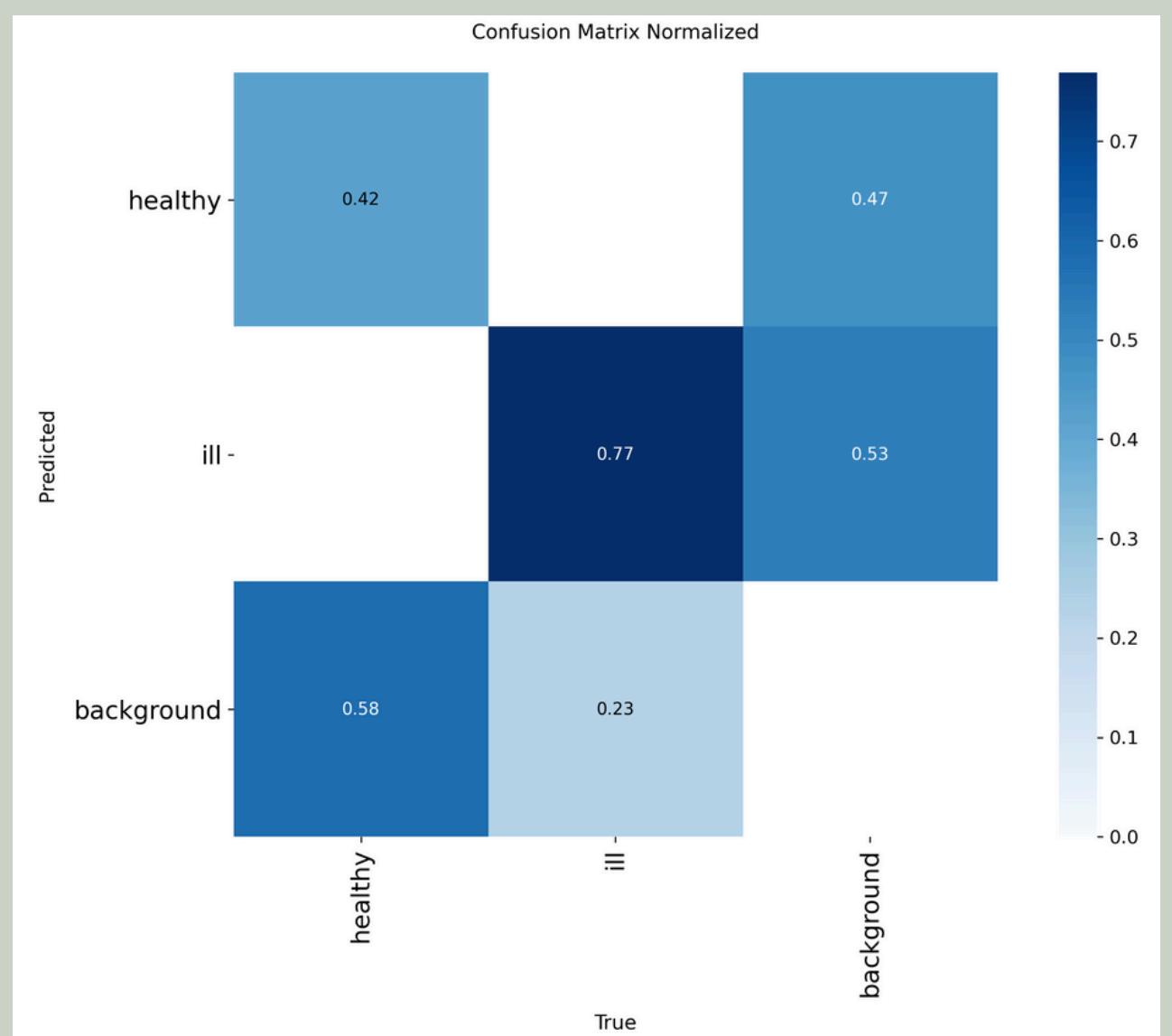




YOLOv8S



CONFUSION MATRIX NORMALIZED



YOLOv8S

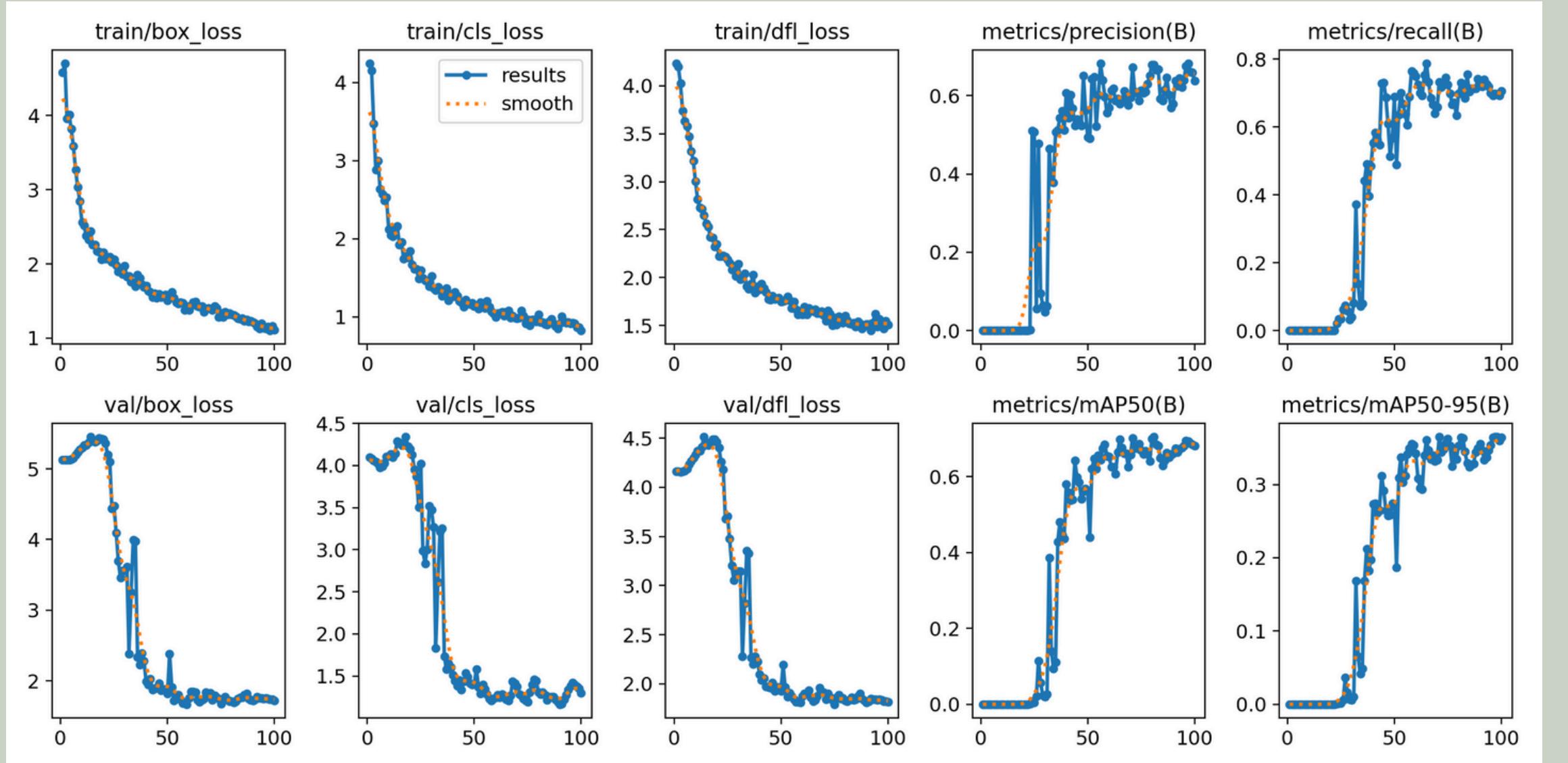


epoch	time	train/box_loss	train/cls_loss	train/dfl_loss	metrics/precision(B)	metrics/recall(B)	metrics/mAP50(B)	metrics/mAP50-95(B)	val/box_loss	val/cls_loss	val/dfl_loss
1	68.634	4.55039	4.22689	4.25501	0	0	0	0	5.12829	4.09582	4.159
2	72.8791	4.68918	4.1271	4.25745	0	0	0	0	5.12399	4.08871	4.157
3	78.9983	3.9857	3.59664	4.15591	0	0	0	0	5.12402	4.0773	4.156
4	82.6194	4.07837	3.08149	4.04974	0	0	0	0	5.12395	4.06521	4.157
5	88.0546	3.95257	2.83981	3.98291	0	0	0	0	5.13079	4.02775	4.162
6	92.3341	3.59105	2.61518	4.00474	0	0	0	0	5.1407	3.99098	4.169
7	95.9043	3.38681	2.5777	3.93565	0	0	0	0	5.16213	4.01103	4.18
8	99.2507	3.34857	2.48738	3.8395	0	0	0	0	5.18795	4.04678	4.206
9	104.29	3.12884	2.55145	3.7287	0	0	0	0	5.24733	4.13732	4.249
10	107.65	2.73674	2.28971	3.5339	0	0	0	0	5.29635	4.19967	4.294
11	110.976	2.81248	2.25192	3.3746	0	0	0	0	5.33232	4.20772	4.337
12	114.629	2.74879	2.12732	3.28234	0	0	0	0	5.3581	4.15663	4.36
13	118.968	2.55424	2.19645	3.17681	0	0	0	0	5.36258	4.12259	4.377

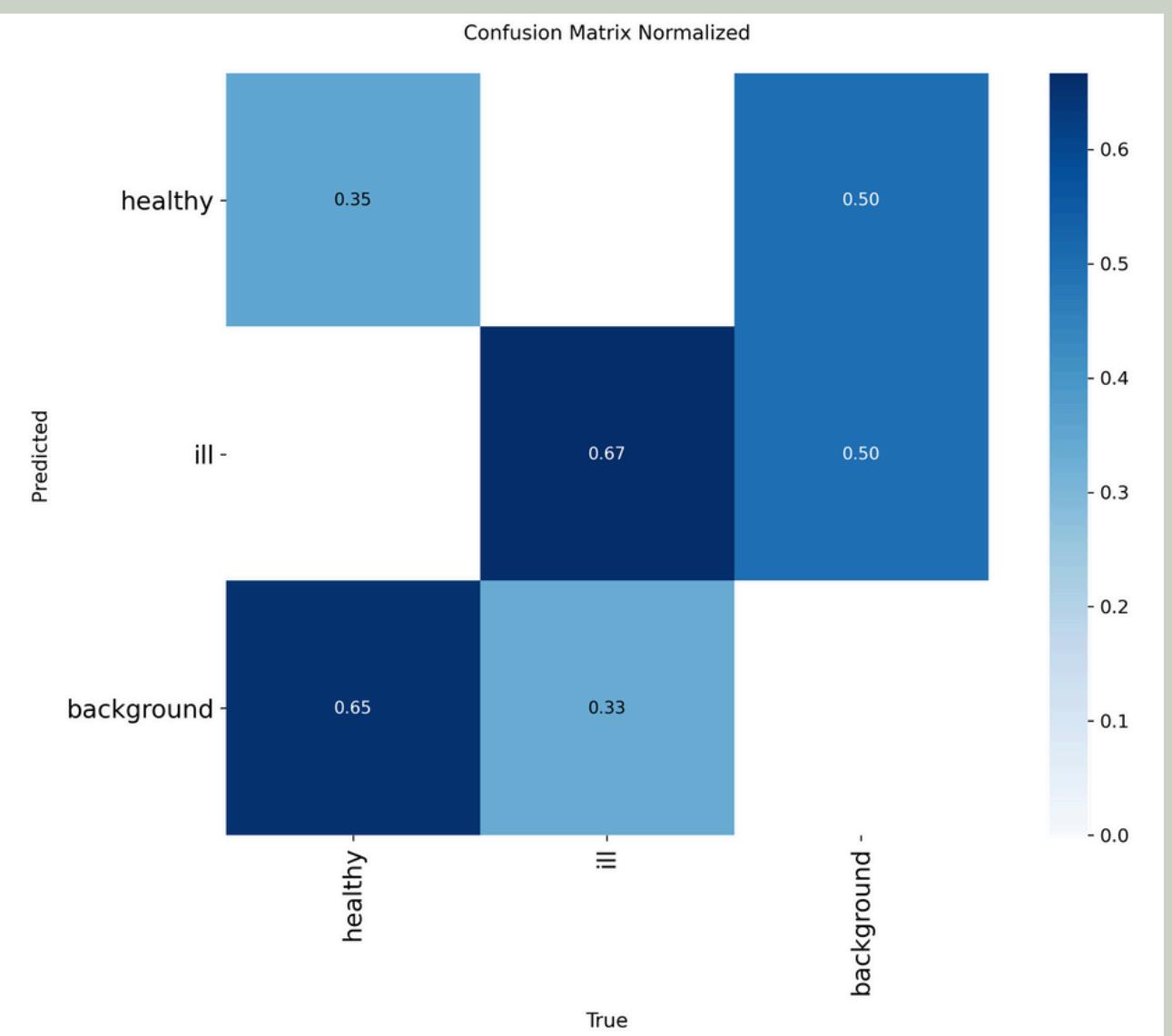
88	400.43	1.42062	0.97403	1.60116	0.59068	0.66349	0.66771	0.35849	1.68028	1.30058	1.81643
89	404.961	1.3566	0.94567	1.60837	0.60218	0.67521	0.67097	0.37063	1.66816	1.32852	1.81786
90	407.78	1.27641	0.97733	1.61449	0.62254	0.67372	0.69362	0.37285	1.68645	1.33535	1.82999
91	423.13	1.30422	1.08289	1.63273	0.65858	0.60684	0.68958	0.3708	1.72302	1.33195	1.84838
92	428.569	1.28932	1.07702	1.59288	0.57225	0.65	0.65403	0.33248	1.81212	1.33285	1.87229
93	434.667	1.31549	1.02391	1.73132	0.62855	0.66132	0.66129	0.33029	1.83645	1.36089	1.8744
94	438.872	1.2877	1.02182	1.75004	0.63088	0.63462	0.65239	0.32495	1.81771	1.38057	1.85318
95	442.208	1.22206	0.97713	1.60978	0.6576	0.6672	0.65078	0.3375	1.77009	1.39081	1.82269
96	446.584	1.22387	1.00763	1.70984	0.66005	0.6672	0.6656	0.36956	1.69654	1.38379	1.77156
97	450.149	1.25341	1.00167	1.644	0.66726	0.65511	0.67377	0.36753	1.68585	1.36694	1.76546
98	452.957	1.22559	0.97222	1.60179	0.6514	0.6672	0.69256	0.37317	1.68446	1.35457	1.76092
99	456.089	1.25503	0.96554	1.65738	0.7275	0.60813	0.69278	0.3716	1.69365	1.34351	1.76818
100	459.445	1.17393	0.92835	1.61534	0.67052	0.64975	0.69076	0.36687	1.71184	1.33222	1.78546



YOLOv8M



CONFUSION MATRIX NORMALIZED



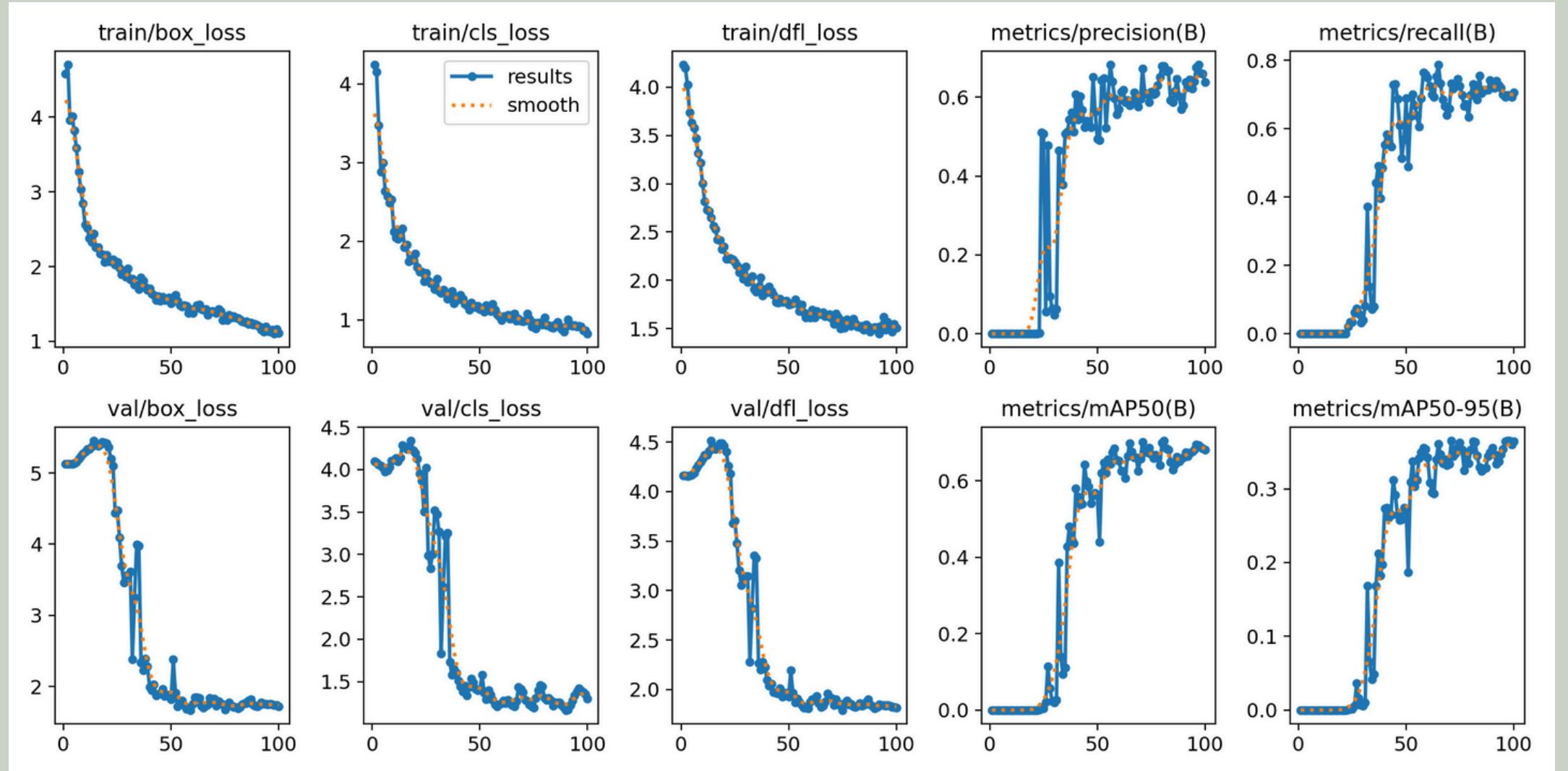


YOLOv8M

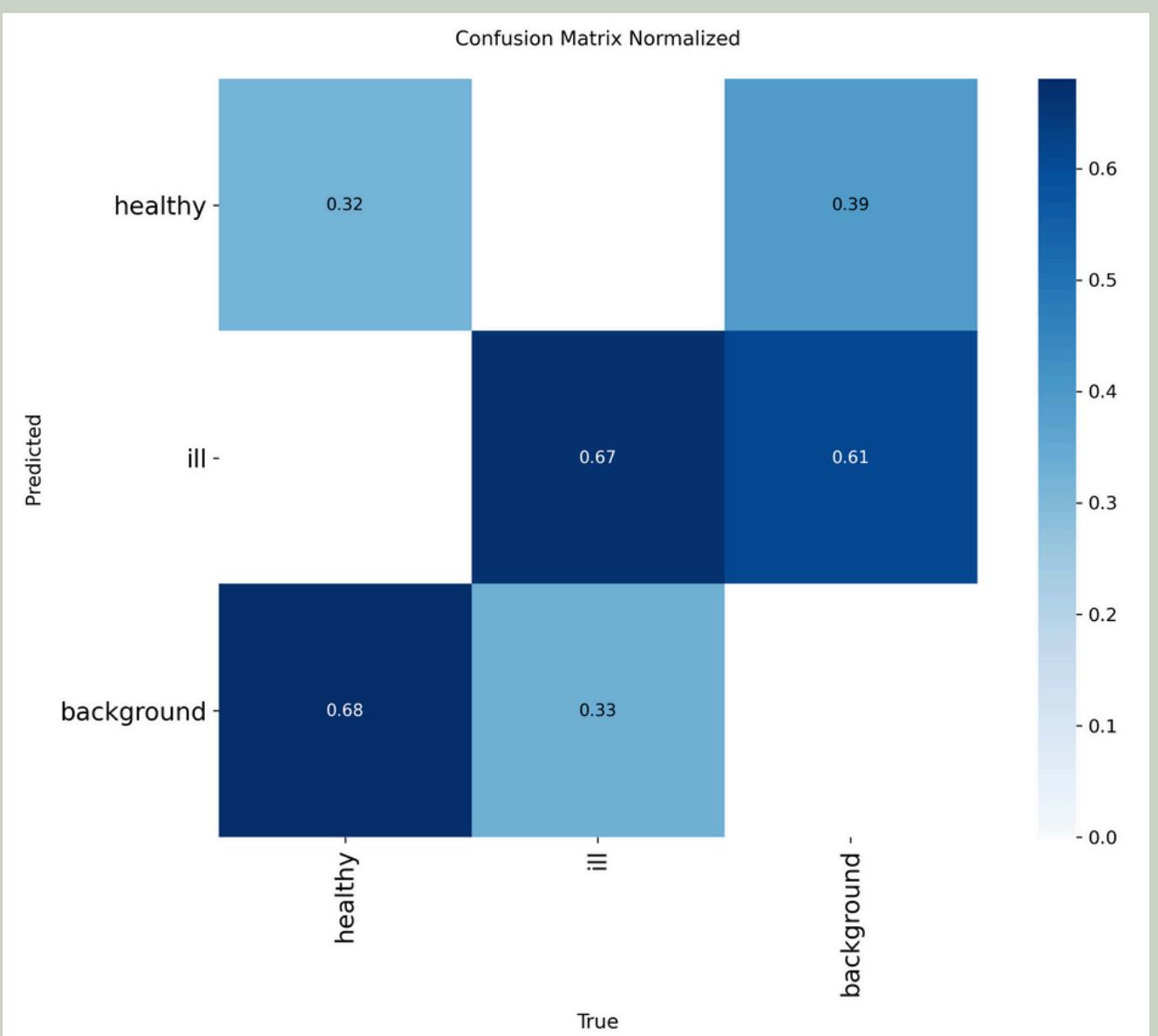
epoch	time	train/box_loss	train/cls_loss	train/dfl_loss	metrics/precision(B)	metrics/recall(B)	metrics/mAP50(B)	metrics/mAP50-95(B)	val/box_loss	val/cls_loss	val/dfl_loss
1	9.67927	4.58017	4.22915	4.24304	0	0	0	0	5.12827	4.1038	4.15874
2	16.6907	4.69588	4.10603	4.18446	0	0	0	0	5.12716	4.09809	4.15731
3	23.282	3.91534	3.34159	4.0429	0	0	0	0	5.12324	4.09551	4.15794
4	28.2119	3.9305	2.76499	3.71288	0	0	0	0	5.12899	4.06621	4.16157
5	33.3461	3.82659	2.79209	3.59059	0	0	0	0	5.14589	4.0082	4.1765
6	37.6273	3.43641	2.59623	3.45771	0	0	0	0	5.16763	4.02869	4.19963
7	45.3022	3.20822	2.62115	3.39994	0	0	0	0	5.2222	4.06838	4.24765
8	49.6986	2.87998	2.29819	3.18527	0	0	0	0	5.24324	4.06601	4.2701
9	55.6998	2.80084	2.3576	3.12997	0	0	0	0	5.26538	4.05586	4.29593
10	60.2586	2.58627	2.3048	2.98557	0	0	0	0	5.29993	4.14314	4.33498
11	65.5093	2.52801	2.10571	2.80778	0	0	0	0	5.33728	4.18645	4.38011
12	71.8219	2.43363	2.01442	2.77415	0	0	0	0	5.26715	4.14463	4.29906
91	442.145	1.28832	0.98961	1.60133	0.56655	0.72642	0.6611	0.34921	1.69285	1.25442	1.80938
92	447.838	1.16685	0.95341	1.48118	0.52867	0.70304	0.6278	0.29287	1.88185	1.28027	1.88989
93	454.683	1.18792	0.93268	1.59904	0.52685	0.68611	0.61521	0.27101	1.98421	1.35043	1.95595
94	460.068	1.24449	0.9323	1.66304	0.54132	0.66827	0.5929	0.27283	1.96464	1.41291	1.94645
95	464.952	1.19148	0.91356	1.54003	0.5727	0.68803	0.6404	0.30299	1.84318	1.42414	1.8727
96	470.056	1.15047	0.92618	1.60592	0.61896	0.7323	0.70568	0.37903	1.62346	1.37644	1.73975
97	474.133	1.17143	0.90069	1.54403	0.61743	0.74145	0.71196	0.38019	1.59274	1.33626	1.72056
98	479.084	1.15088	0.8851	1.52173	0.62398	0.74237	0.71181	0.38329	1.60198	1.28083	1.72324
99	483.871	1.20208	0.87414	1.57865	0.61927	0.74145	0.71346	0.37906	1.6247	1.24643	1.7325
100	488.066	1.14639	0.84415	1.55064	0.64366	0.75427	0.71621	0.38174	1.63463	1.20823	1.73099



YOLOv8L



CONFUSION MATRIX NORMALIZED





YOLOv8L

epoch	time	train/box_loss	train/cls_loss	train/dfl_loss	metrics/precision(B)	metrics/recall(B)	metrics/mAP50(B)	metrics/mAP50-95(B)	val/box_loss	val/cls_loss	val/dfl_loss
1	12.1545	4.57877	4.24549	4.23464	0	0	0	0	5.12826	4.09988	4.15993
2	20.6195	4.70448	4.15126	4.19914	0	0	0	0	5.12741	4.08654	4.15977
3	29.4462	3.95718	3.47236	4.02377	0	0	0	0	5.12461	4.06168	4.15874
4	37.2647	4.00795	2.87888	3.73672	0	0	0	0	5.12453	4.04788	4.16031
5	44.6587	3.81669	2.99462	3.63314	0	0	0	0	5.14106	4.01924	4.17134
6	52.2658	3.58449	2.63901	3.579	0	0	0	0	5.15802	3.97812	4.18897
7	60.273	3.27025	2.57335	3.46931	0	0	0	0	5.20348	3.9903	4.2345
8	67.2905	3.03416	2.48904	3.32	0	0	0	0	5.23864	4.02706	4.26739
9	76.1699	2.846	2.5303	3.21871	0	0	0	0	5.27516	4.10467	4.30223
10	83.424	2.55793	2.12195	3.00634	0	0	0	0	5.30078	4.11521	4.3286
11	91.1575	2.51615	2.04627	2.81924	0	0	0	0	5.33871	4.13316	4.37326

88	901.384	1.22095	0.87873	1.46713	0.60225	0.71368	0.65102	0.34418	1.74563	1.22462	1.85038
89	907.838	1.23077	0.85138	1.49538	0.56977	0.74145	0.65817	0.34916	1.72889	1.19323	1.82806
90	914.79	1.21111	0.91963	1.51655	0.57873	0.73237	0.66163	0.35551	1.71961	1.16453	1.80806
91	933.913	1.19464	1.00897	1.51209	0.63769	0.71848	0.67514	0.34659	1.73847	1.17239	1.821
92	942.139	1.15735	0.94228	1.44732	0.62559	0.74038	0.66458	0.334	1.77419	1.22318	1.85008
93	954.362	1.12796	0.92284	1.53118	0.64452	0.7265	0.67393	0.33733	1.75908	1.27453	1.8458
94	961.112	1.20078	0.93357	1.62104	0.62191	0.7196	0.67739	0.34668	1.75197	1.33903	1.84565
95	973.365	1.13752	0.9165	1.48747	0.64053	0.70077	0.682	0.35413	1.74434	1.37935	1.83449
96	985.334	1.13105	0.92292	1.56962	0.67526	0.69333	0.6958	0.36434	1.75584	1.41881	1.84535
97	992.32	1.15478	0.91682	1.52407	0.68158	0.69803	0.69411	0.36486	1.7457	1.39984	1.83439
98	1003.89	1.10132	0.86812	1.46812	0.66102	0.6958	0.68846	0.36491	1.73915	1.37146	1.82668
99	1020.07	1.16574	0.87024	1.5457	0.65941	0.69232	0.68506	0.36031	1.734	1.3518	1.82429
100	1032.45	1.10777	0.82403	1.51081	0.63836	0.70566	0.68142	0.36462	1.72178	1.30241	1.8185

YOLOv8S



YOLOv8M



YOLOv8L



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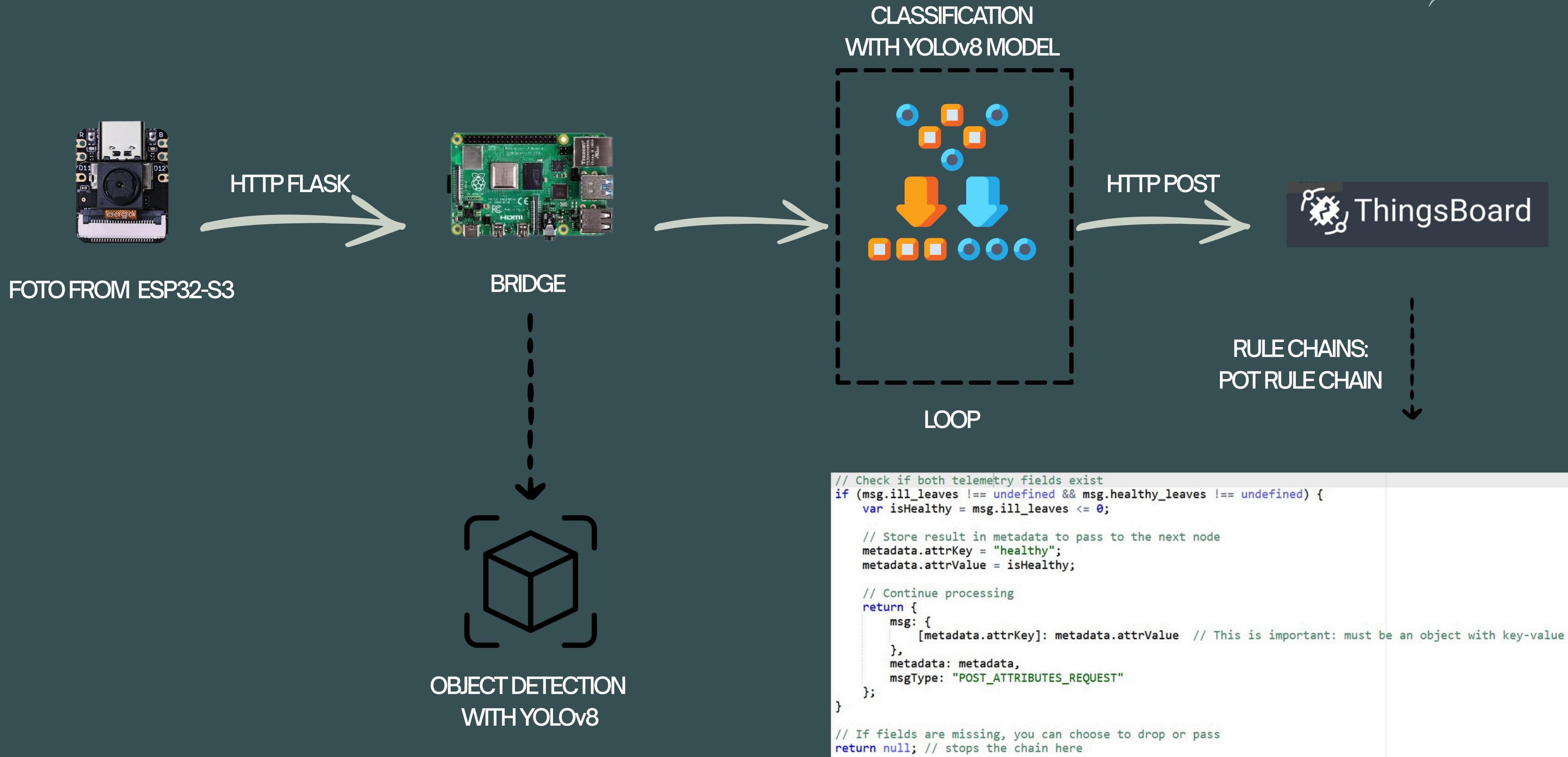
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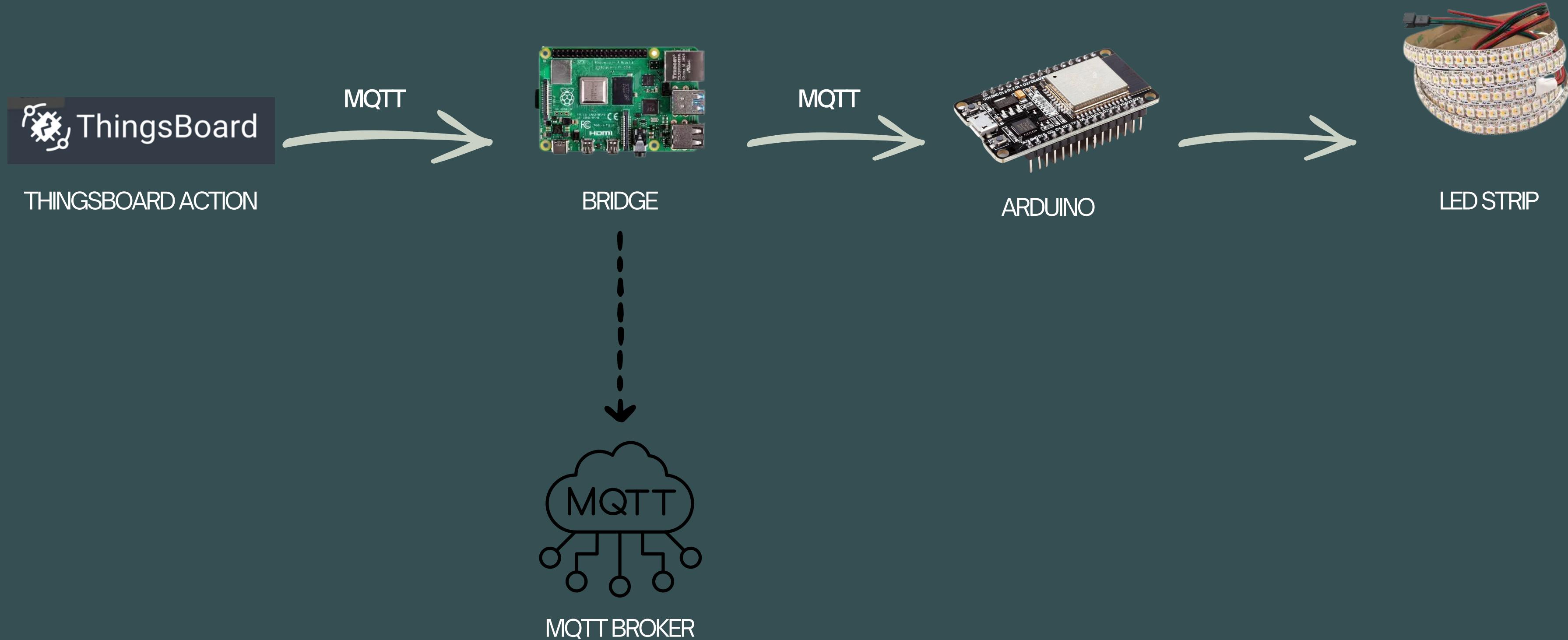
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CLASSIFICATION PIPELINE



PIPELINE SENSORISTICA





Thank You
QUESTIONS?