Precision at Pixel Level: YOLO doing UI test automation

© Nikolaus Rieder

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A few things about me

- 7 years work experience in Quality Assurance (Testing)
- Developing test automation for integration and system testing
- Working with distributed embedded systems
  - Nurse call system

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SCHRACK SECONET

Why am I doing this?

- Reliably working user interfaces are critical in our products
- There is no margin for error when it comes to emergencies

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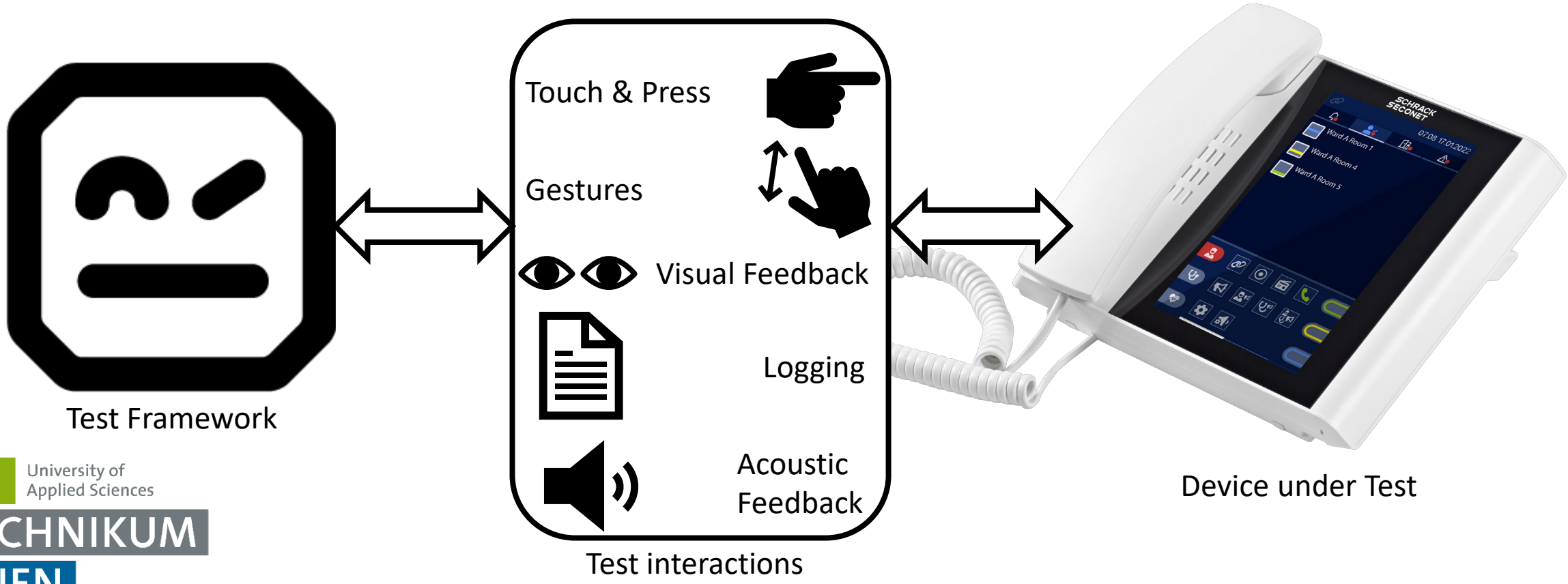
What is embedded UI test automation?

- Machine interacting with user interface of another machine
- Simulating human interactions



What are these maintenance problems?

TEST	**Unlock display lock on touch terminal with message expectation**	00:00:02.856
	Full Name: Eval.DeviceControl.Unlock display lock on touch terminal with message expectation	
	Tags: display-unlock, testdev-06	
	Start / End / Elapsed: 20240121 17:38:47.854 / 20240121 17:38:50.710 / 00:00:02.856	
	Status: PASS	
SETUP	**Single device setup** ${StTouchXYZ}, 10.64.7.93, TouchTerminal	00:00:00.055
KEYWORD	VCIP. **SET FILTER MODE ON DEVICE** ${StTouchXYZ}, Allow, Ignore	00:00:00.008
KEYWORD	VCIP. **FILTER TAG ON DEVICE** ${StTouchXYZ}, hid	00:00:00.008
KEYWORD	VCIP. **START LOGGING ON DEVICE** ${StTouchXYZ}	00:00:00.121
KEYWORD	VCIP. **TOUCH DRAG ON DEVICE** ${StTouchXYZ}, 441, 350, 191, 707, 1000	00:00:02.625
KEYWORD	VCIP. **EXPECT MESSAGE IN DEVICE LOG** ${StTouchXYZ}, X:191 Y:707	00:00:00.013
KEYWORD	VCIP. **STOP LOGGING ON DEVICE** ${StTouchXYZ}	00:00:00.009
TEARDOWN	**Single device Teardown** ${StTouchXYZ}	00:00:00.010

Our UI interactions require X,Y screen coordinates for input simulation

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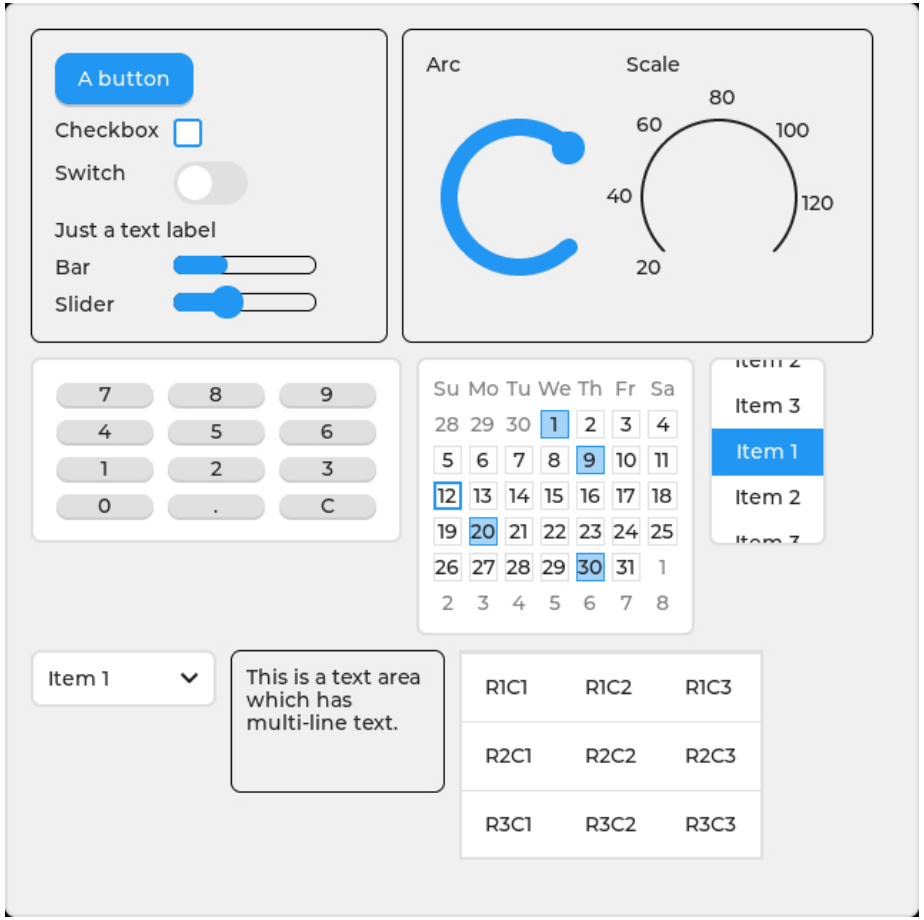
Project goals

- Address maintenance and visual challenges in UI test automation
- Automate detection of **widgets** from UI screenshots



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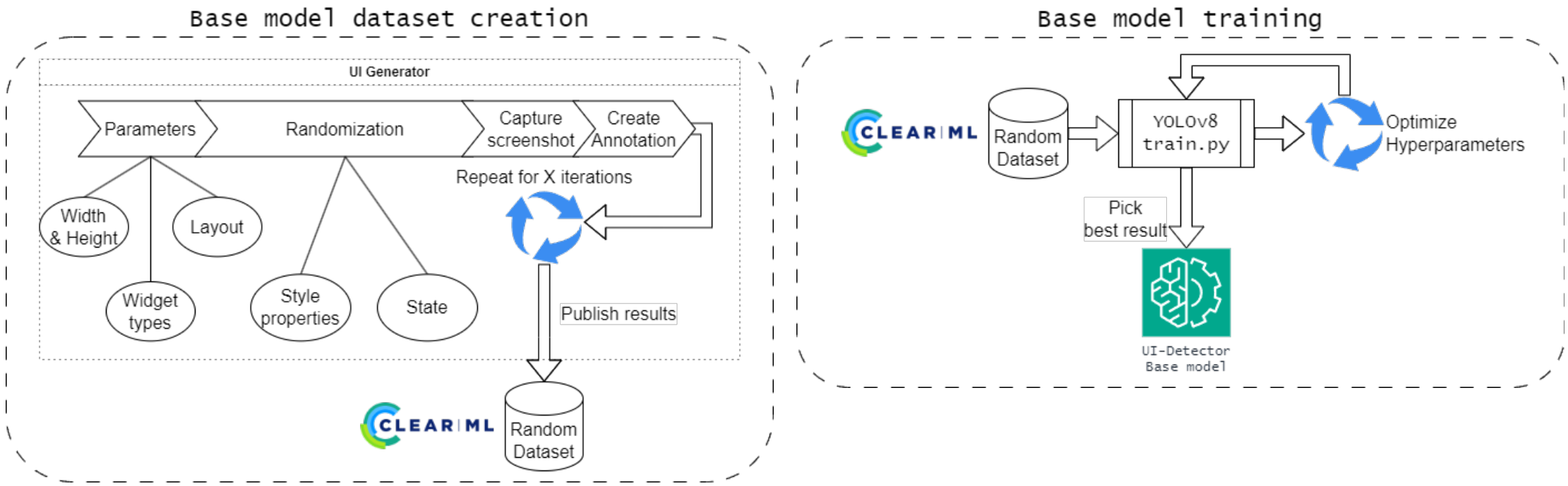
Project overview

- User interface generator using LVGL
  - … with random widgets & styles
  - … with design specification
- Base model trained on random datasets
- Improved base model trained on design specification
- YOLOv8 for object detection
- ClearML for overall experiment & dataset tracking

Training a base model



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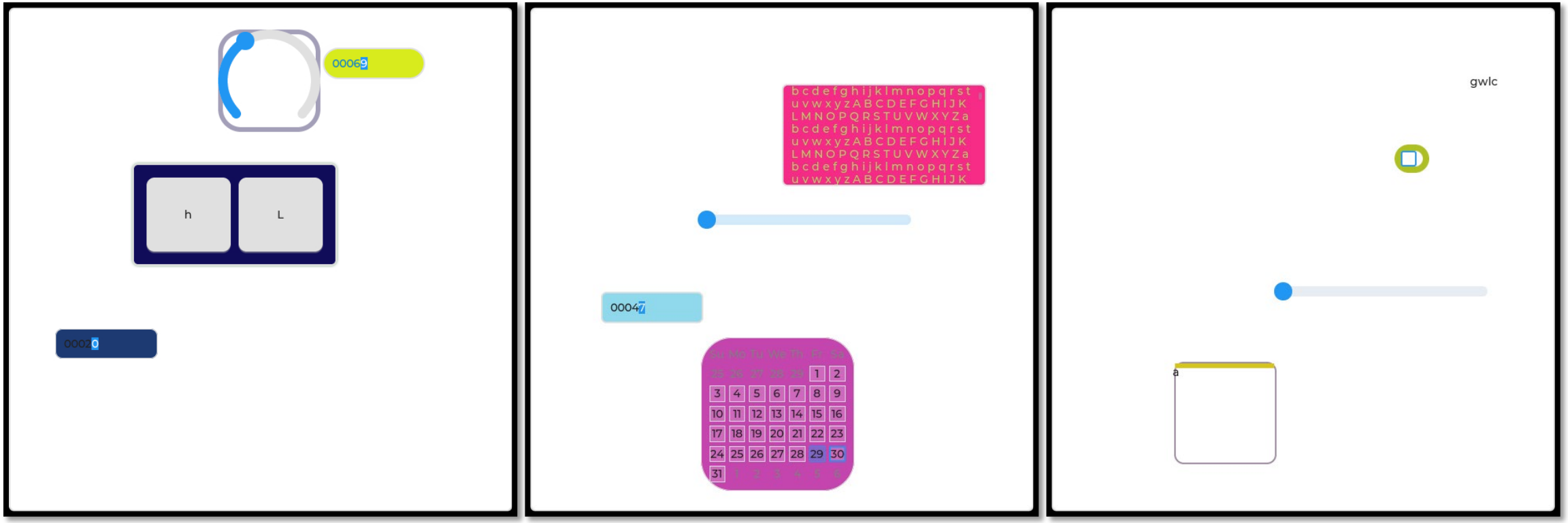
Examples from random widget dataset



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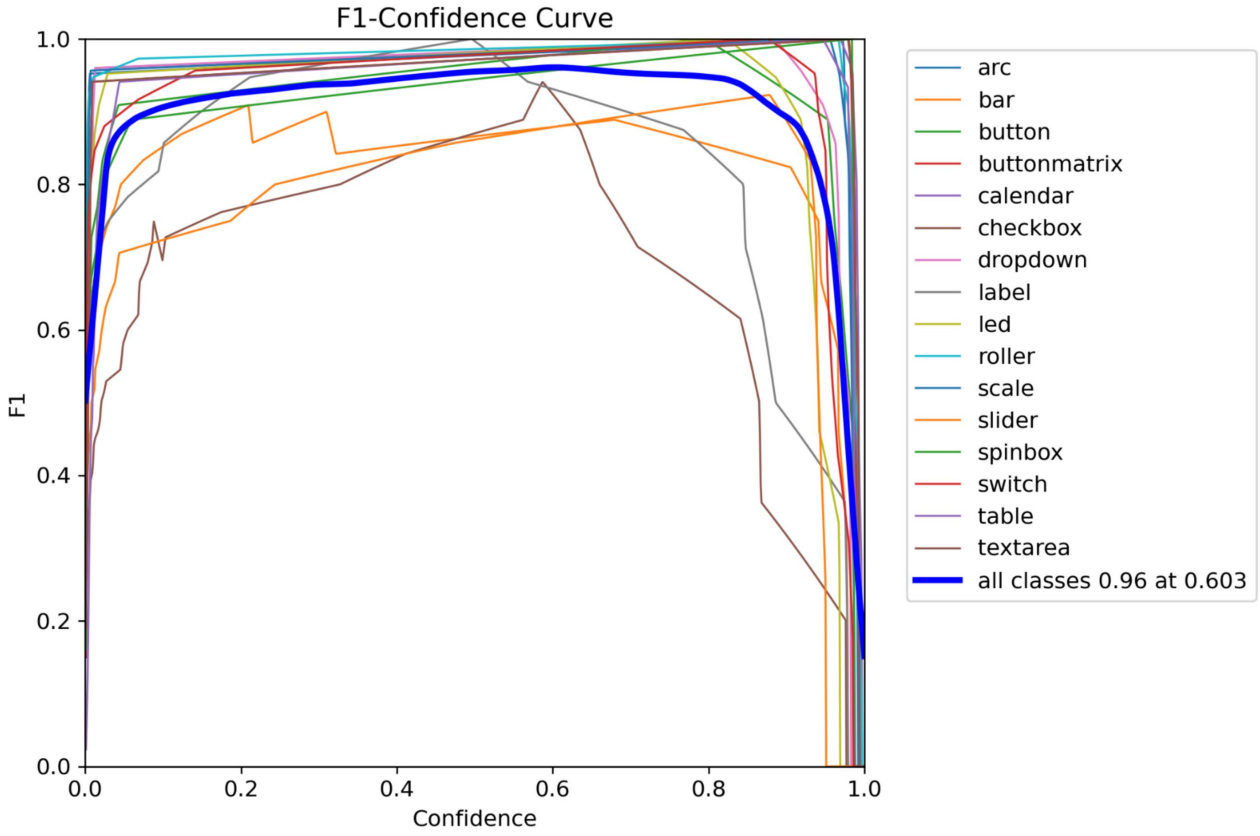
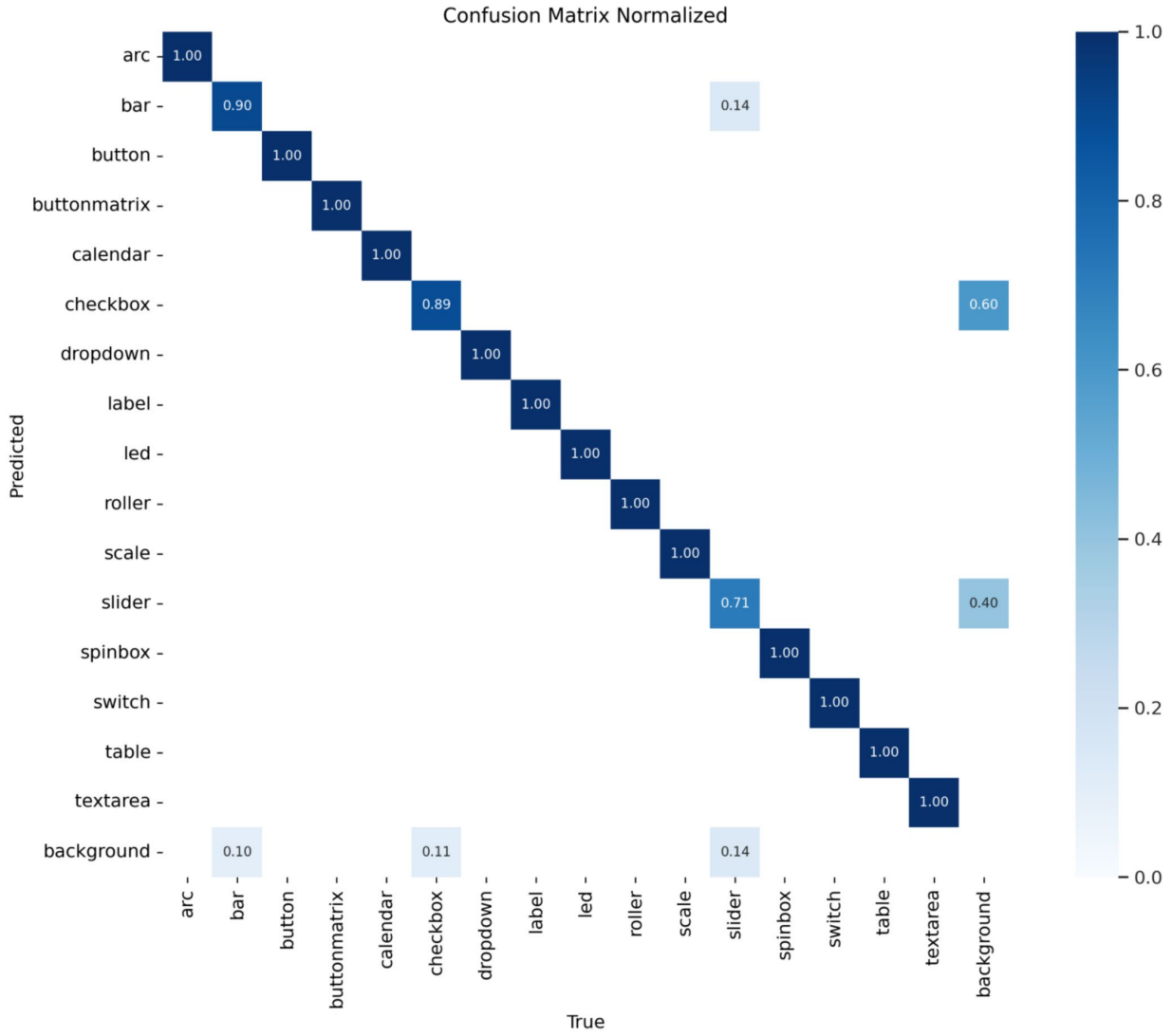
Base model: Optimized Results





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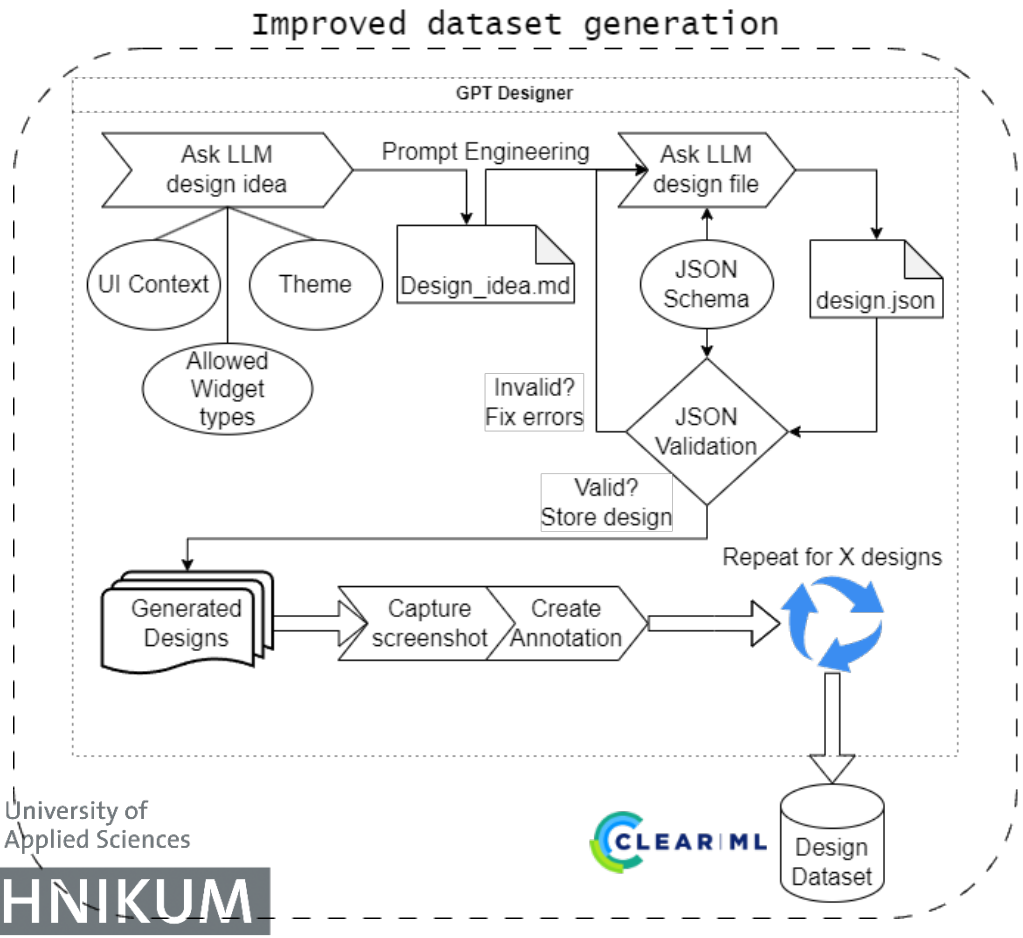
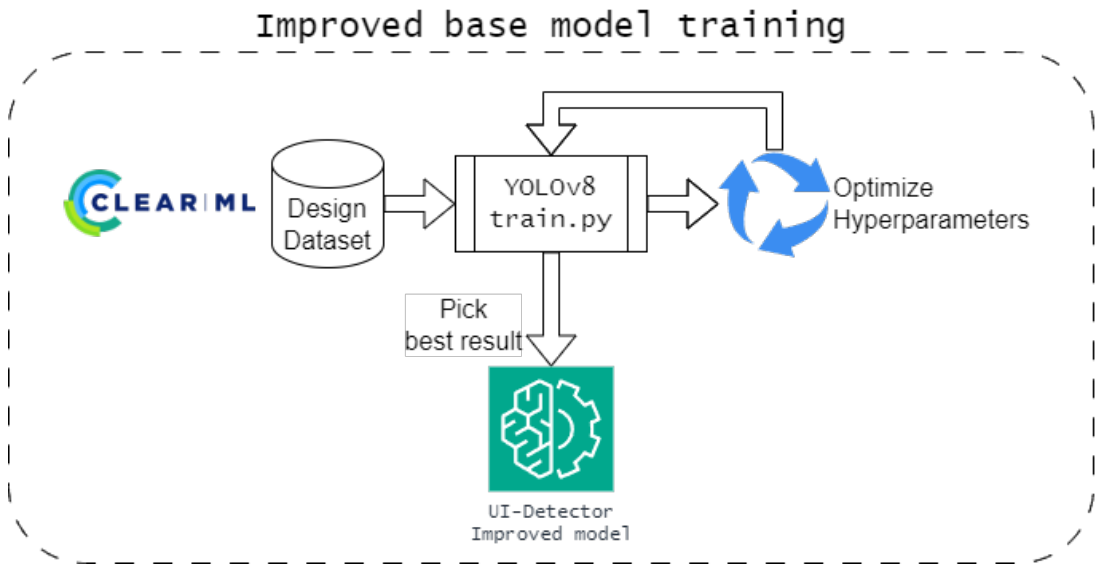
Problems with random widget creation

- Only good on paper, optimized best-case scenario
- Bad model performance with realistic UI screenshots is anticipated
  - *Bias due to white background and styles properties*
  - *Individual widgets “pop-out” from background*
  - *Widgets are absolutely positioned with distinctive distances*

Improved base model





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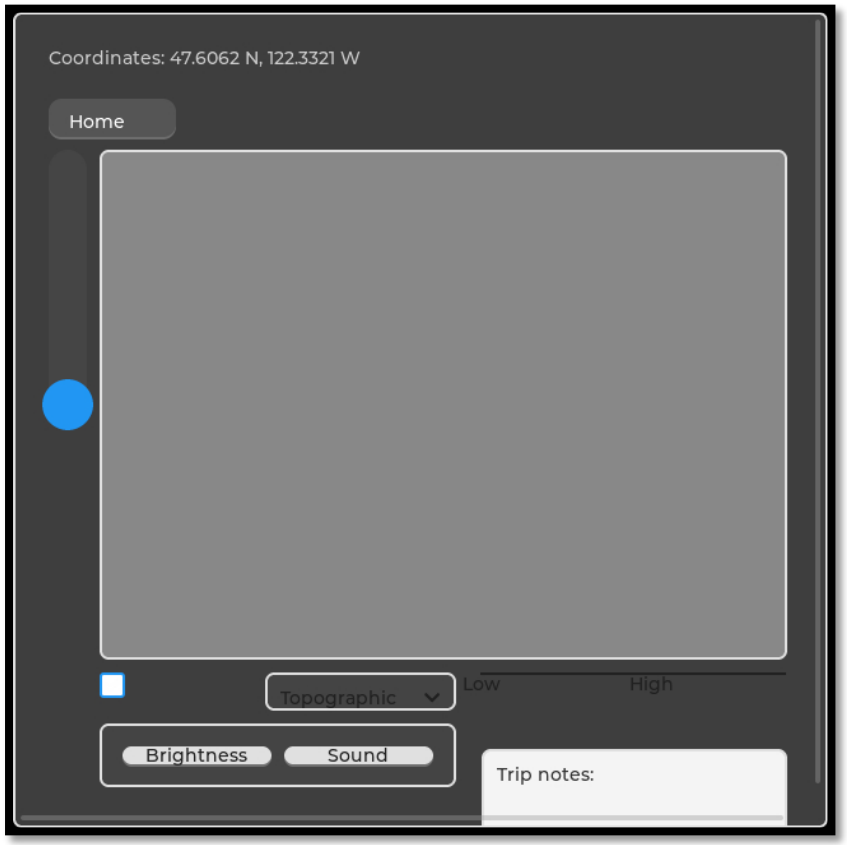
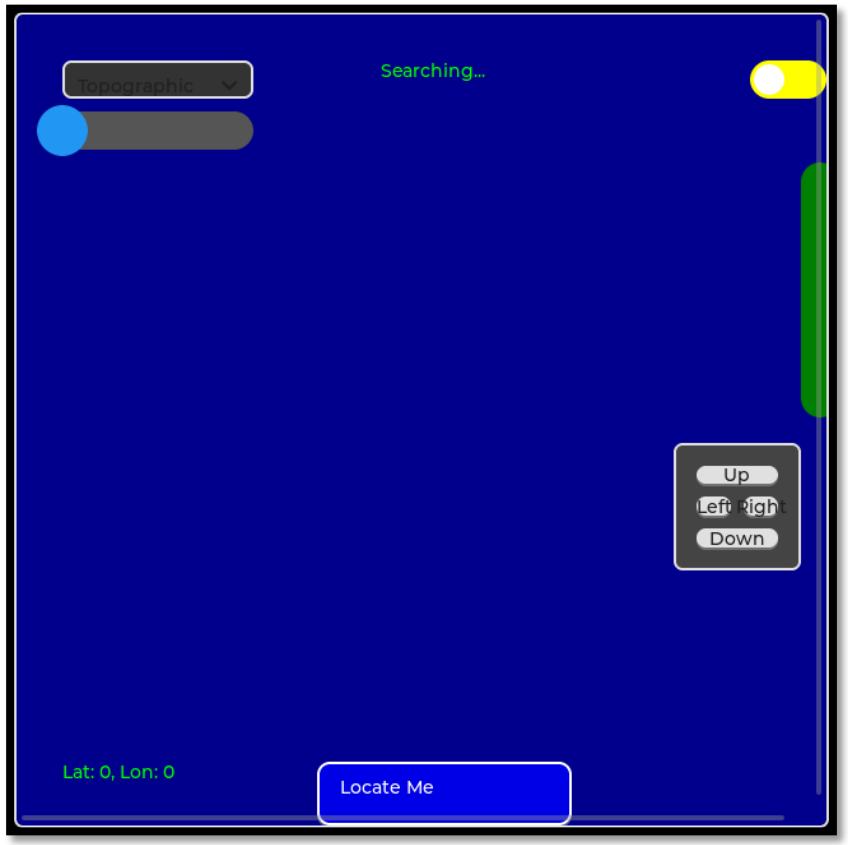
Examples from design widget dataset





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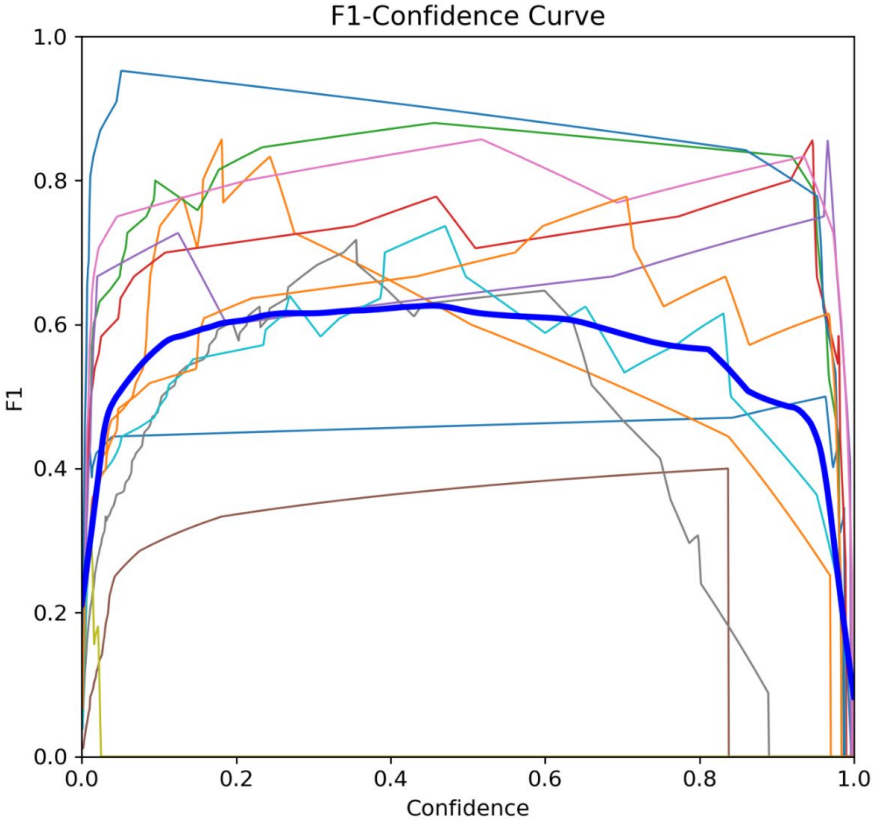
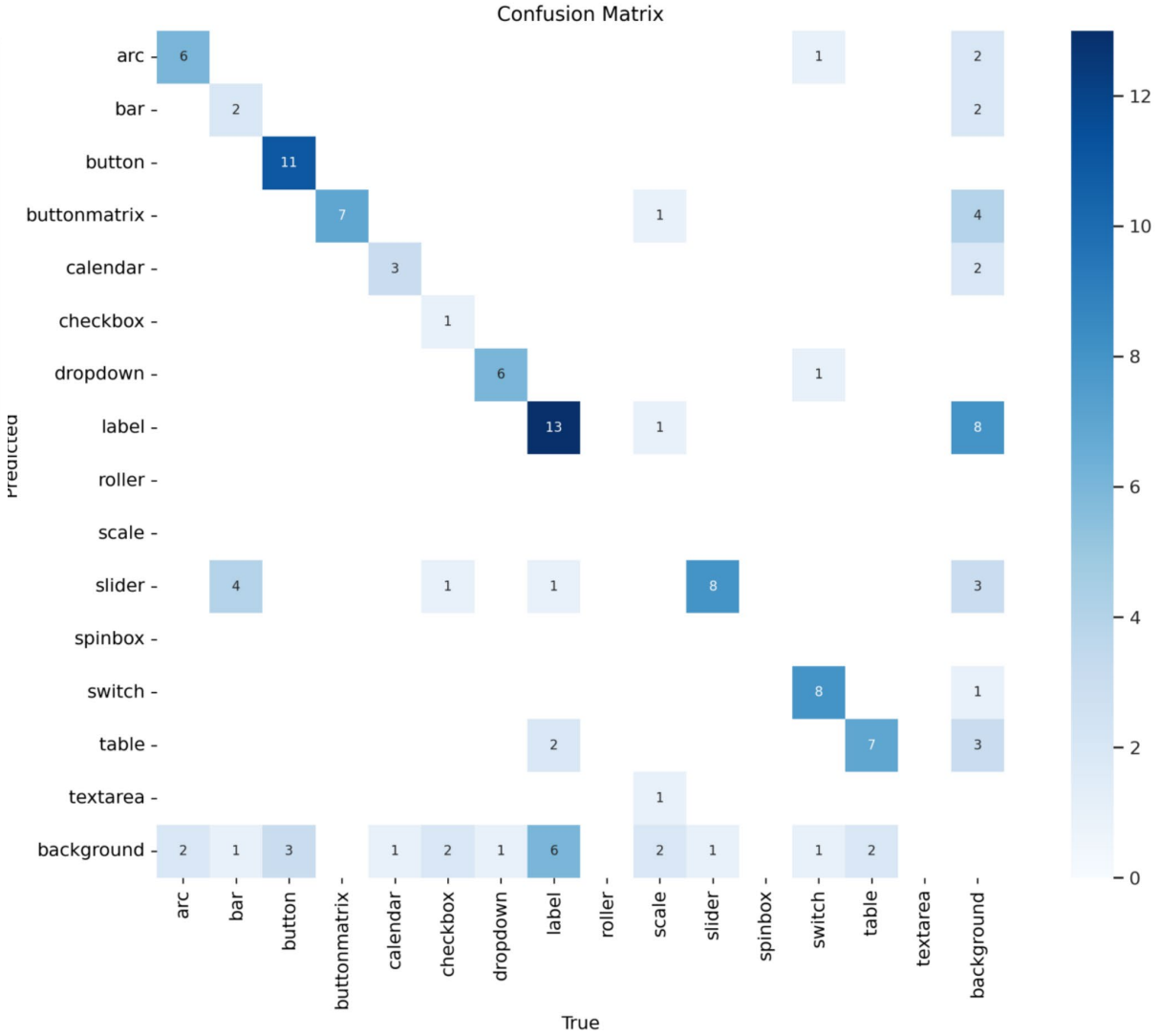
Improved base model: Tune Results





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Improved base model: Train Results

Class	Images	Instances	Box(P	R	mAP50	mAP50-95): 100%| | 1/1 [00:00<00:00, 7.83it/s]
all	13	107	0.768	0.624	0.686	0.606
arc	13	8	0.422	0.5	0.393	0.364
bar	13	7	1	0.469	0.924	0.822
button	13	14	0.994	0.786	0.861	0.706
buttonmatrix	13	7	0.627	1	0.883	0.858
calendar	13	4	0.55	0.75	0.888	0.849
checkbox	13	4	0.697	0.25	0.249	0.0991
dropdown	13	7	0.83	0.857	0.837	0.762
label	13	22	0.835	0.5	0.647	0.412
scale	13	5	1	0	0.181	0.121
slider	13	9	0.675	0.778	0.734	0.67
switch	13	11	1	0.823	0.908	0.908
table	13	9	0.586	0.778	0.726	0.703

Best results after 150 epochs.

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Final conclusions

Thoughts gathered over roughly ~450 experiments

- Synthesizing datasets for UI object detection is very error-prone
- A targeted dataset for very specific widget detection is possible
- Datasets must contain varying styles and states of widgets for realistic performance
- Styles have a significant impact on widget detection

Future work

- Designing a targeted dataset for our critical user interfaces

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Q & A

Thank you for the attention!
Feel free to ask any questions.

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BACKUP SLIDES

Further visualizations and excluded content from the presentation

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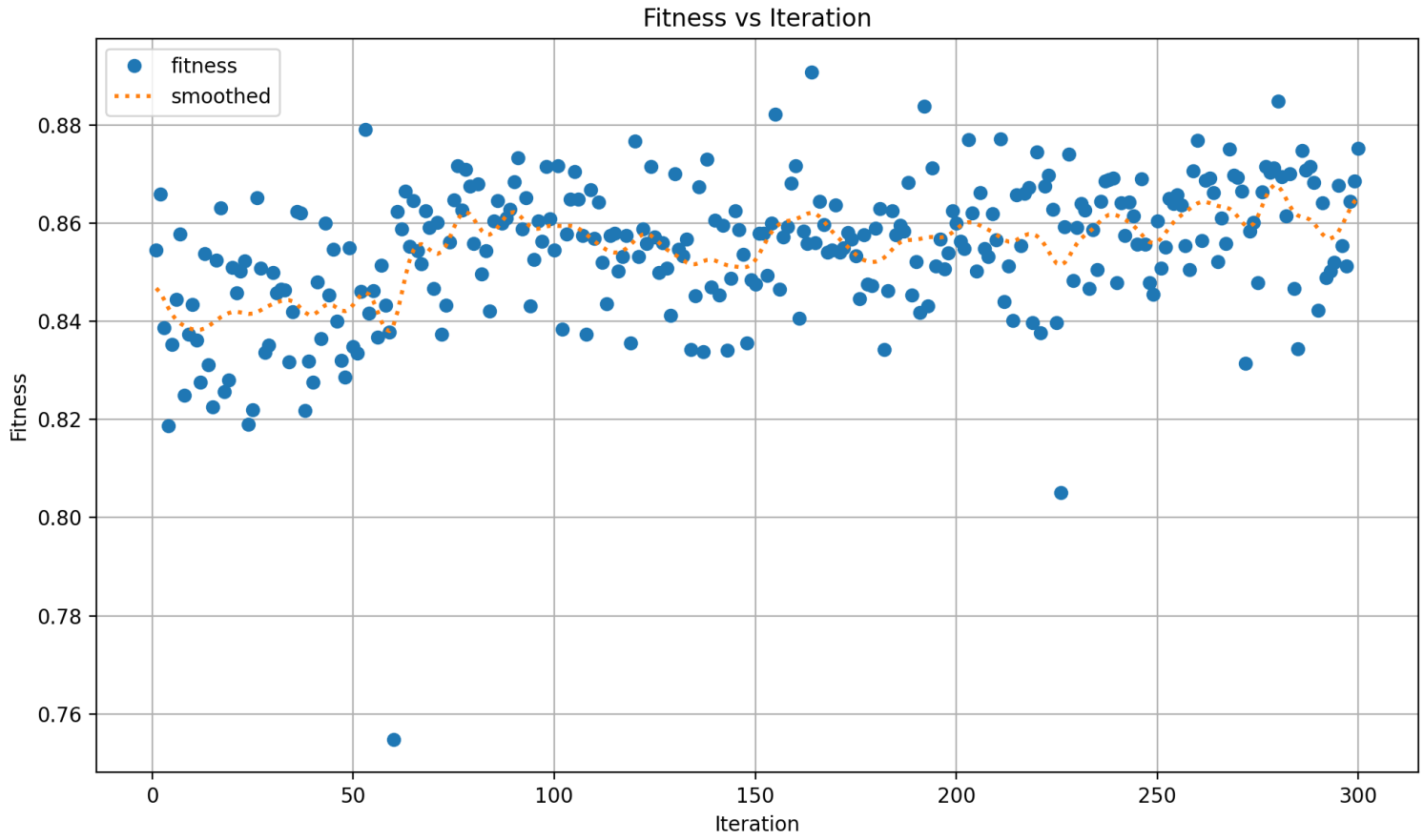
YOLOv8 Model tuning Random (1)



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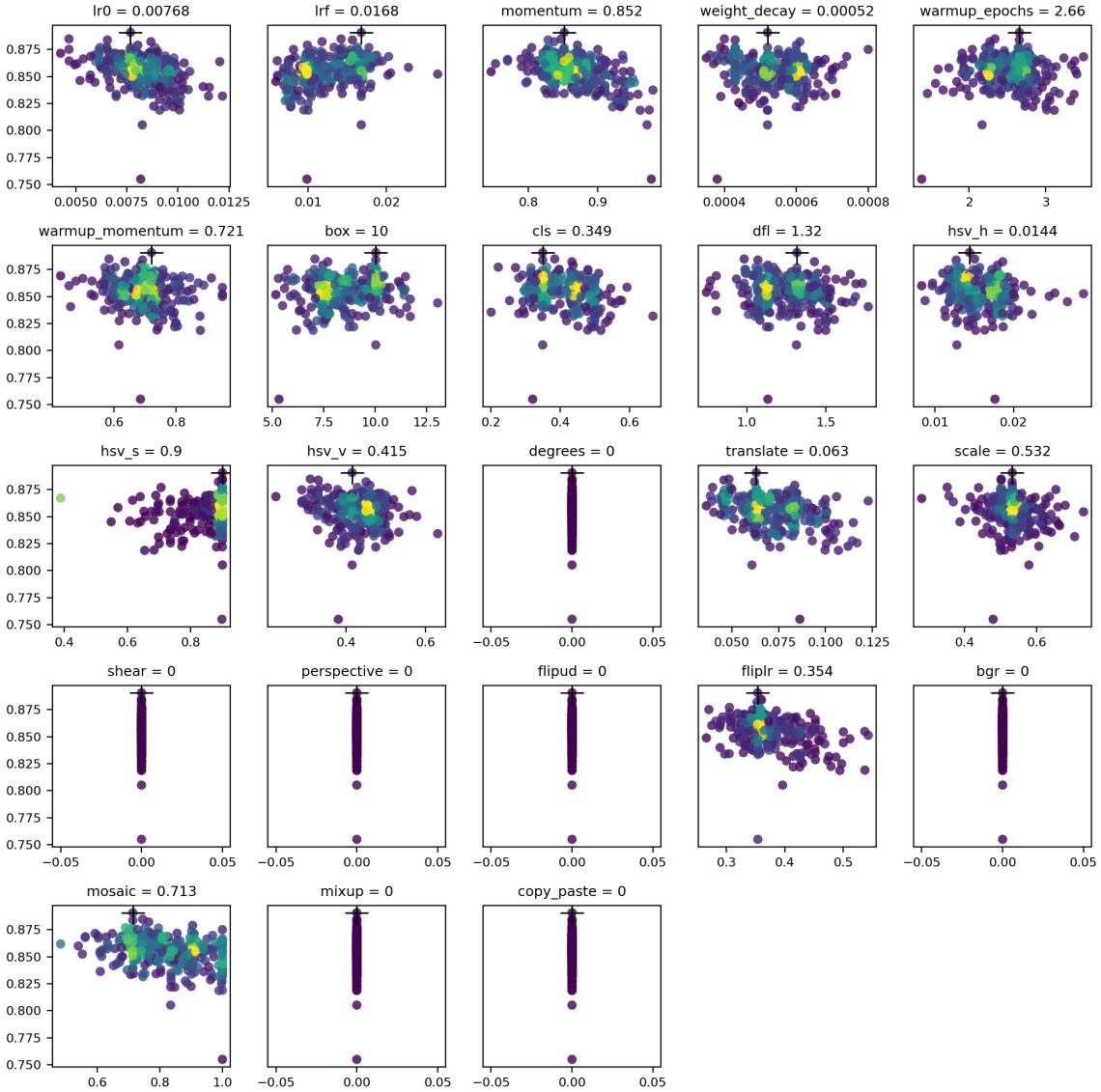
YOLOv8 Model tuning Random (2)



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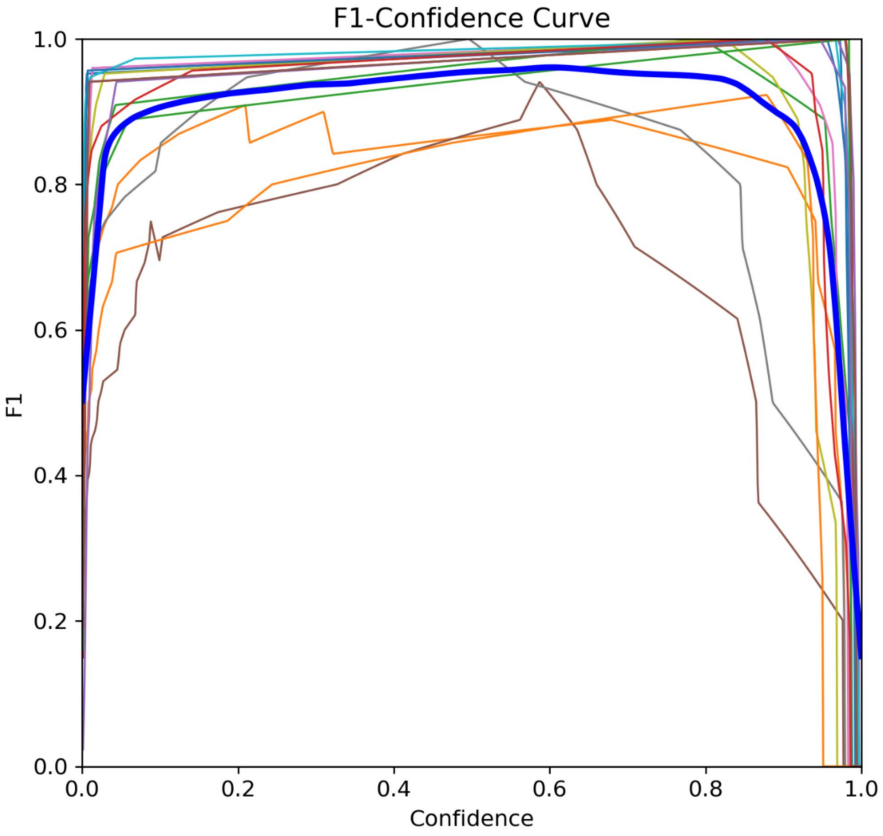
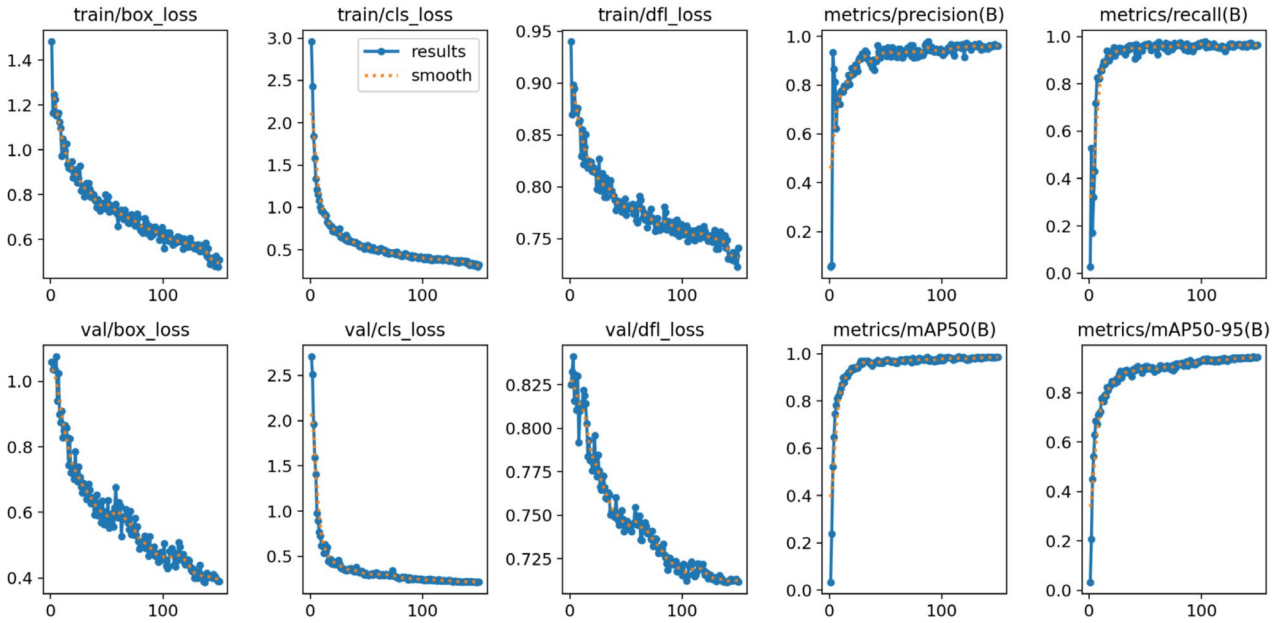
Base model: Optimized Results





Best training result:
150 epochs
mAP50-95: 0.9449

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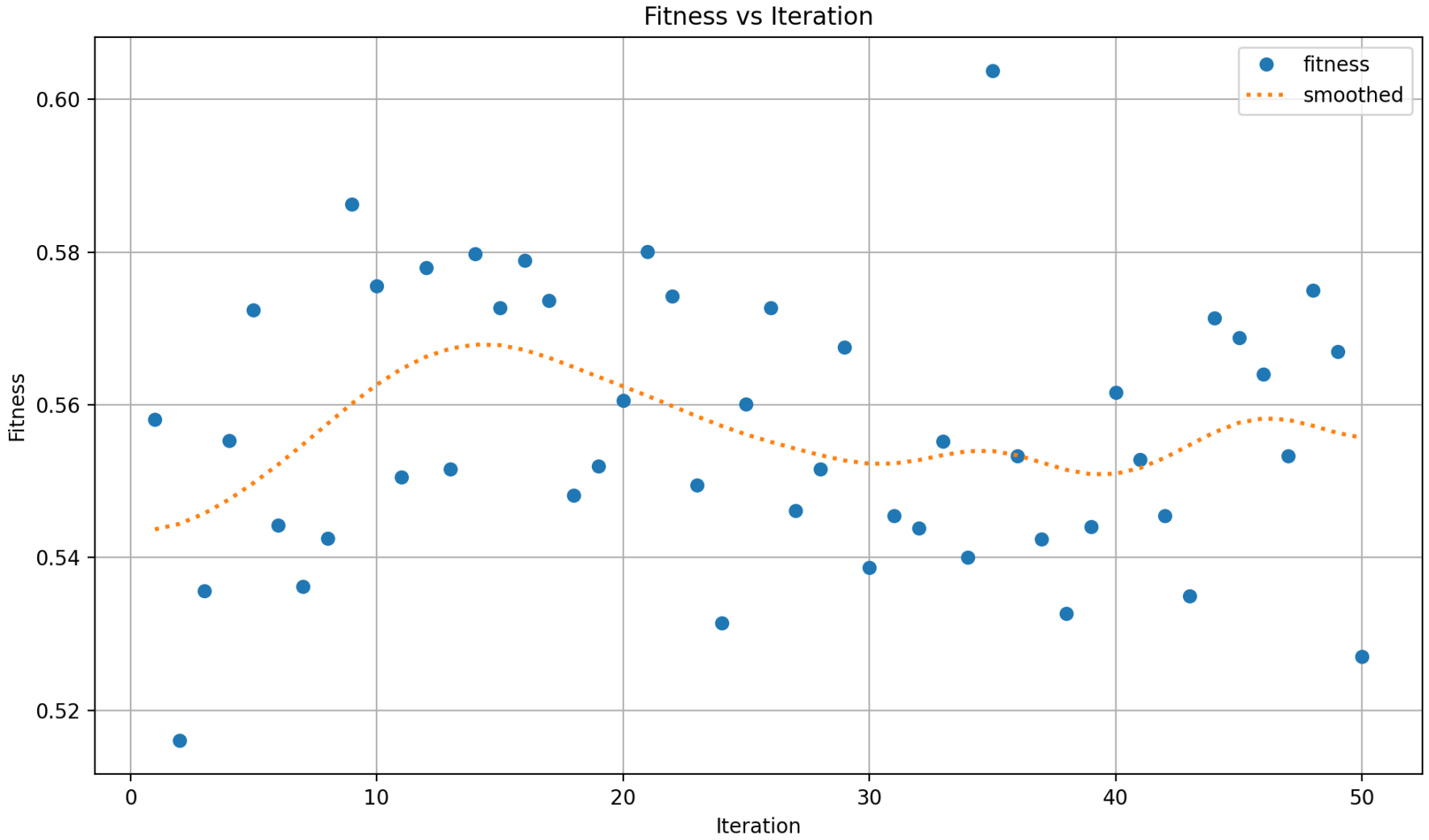
YOLOv8 Model tuning Design (1)



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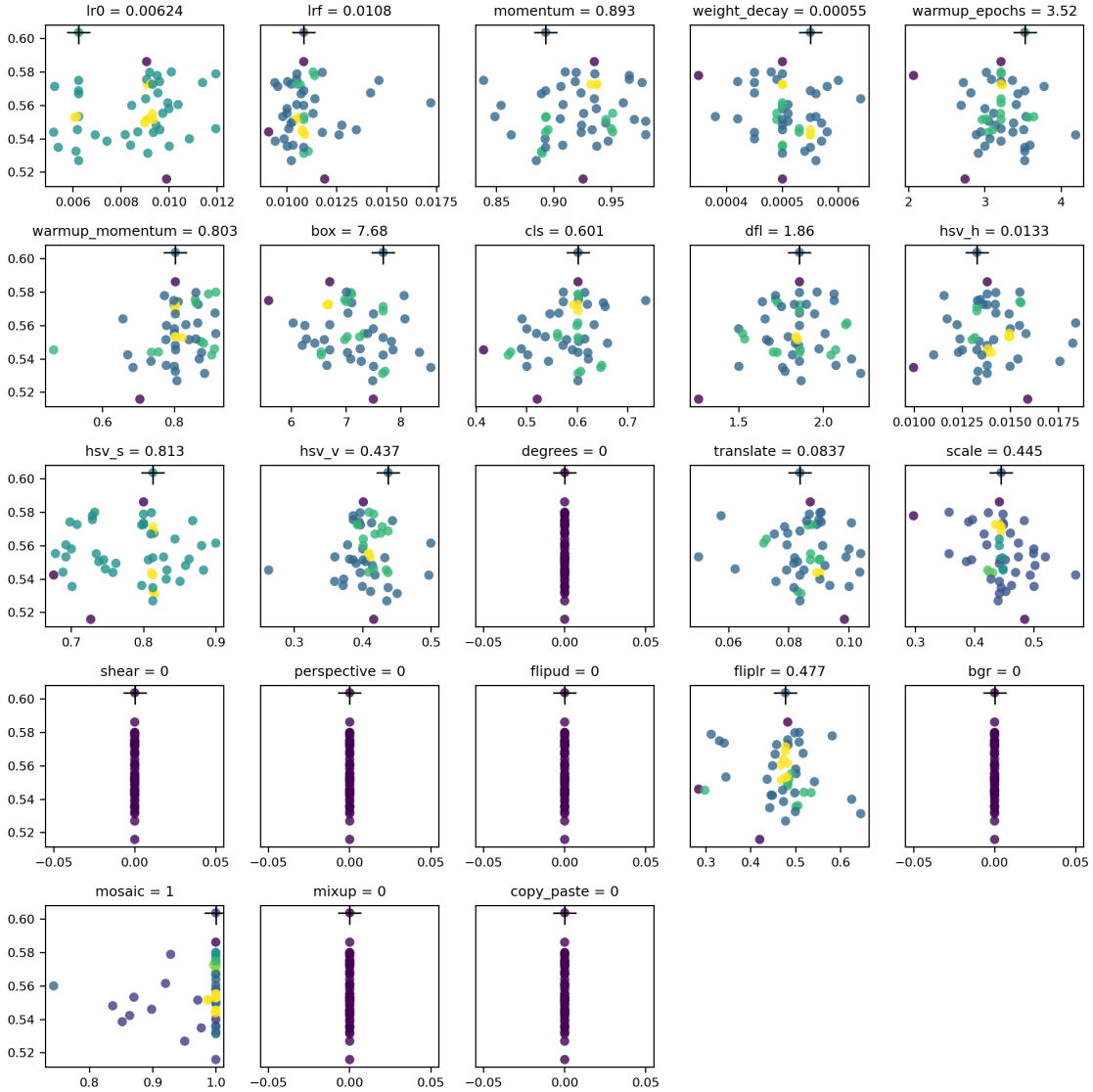
YOLOv8 Model tuning Design (2)



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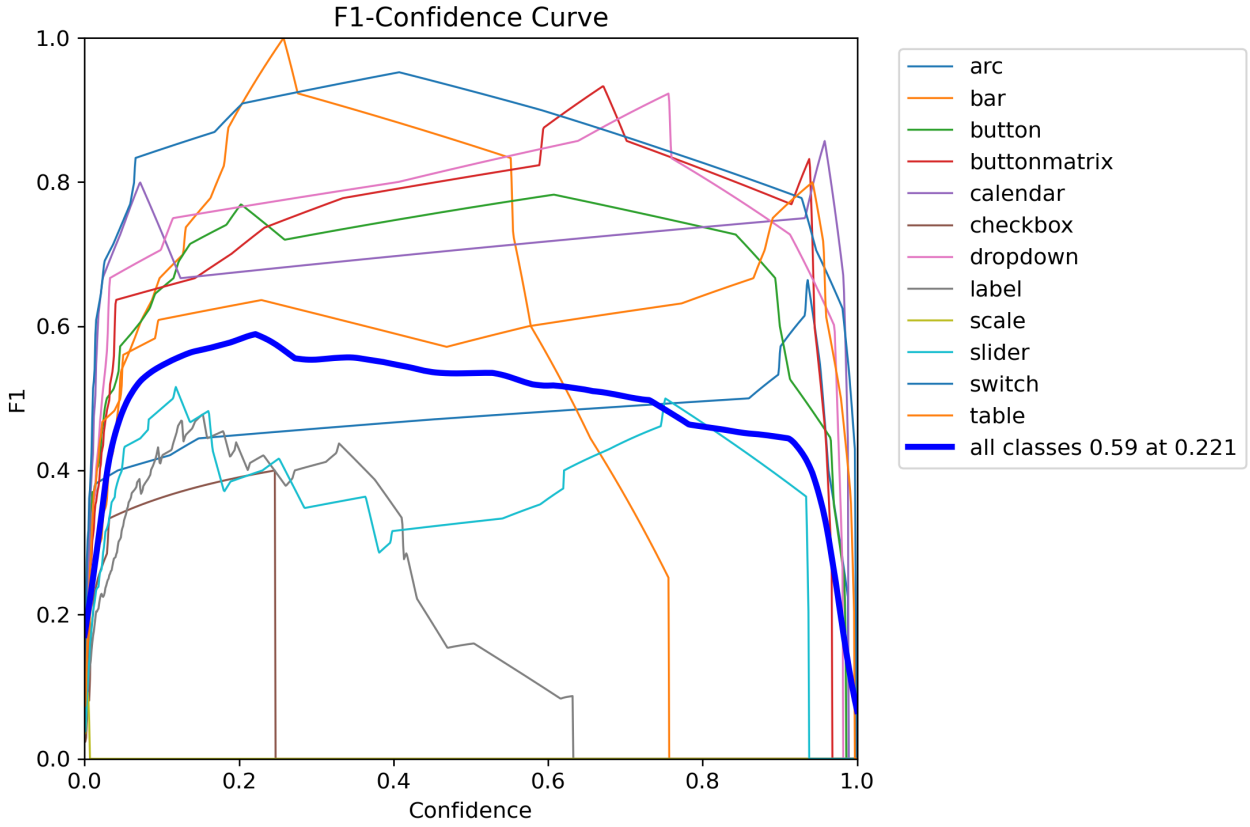
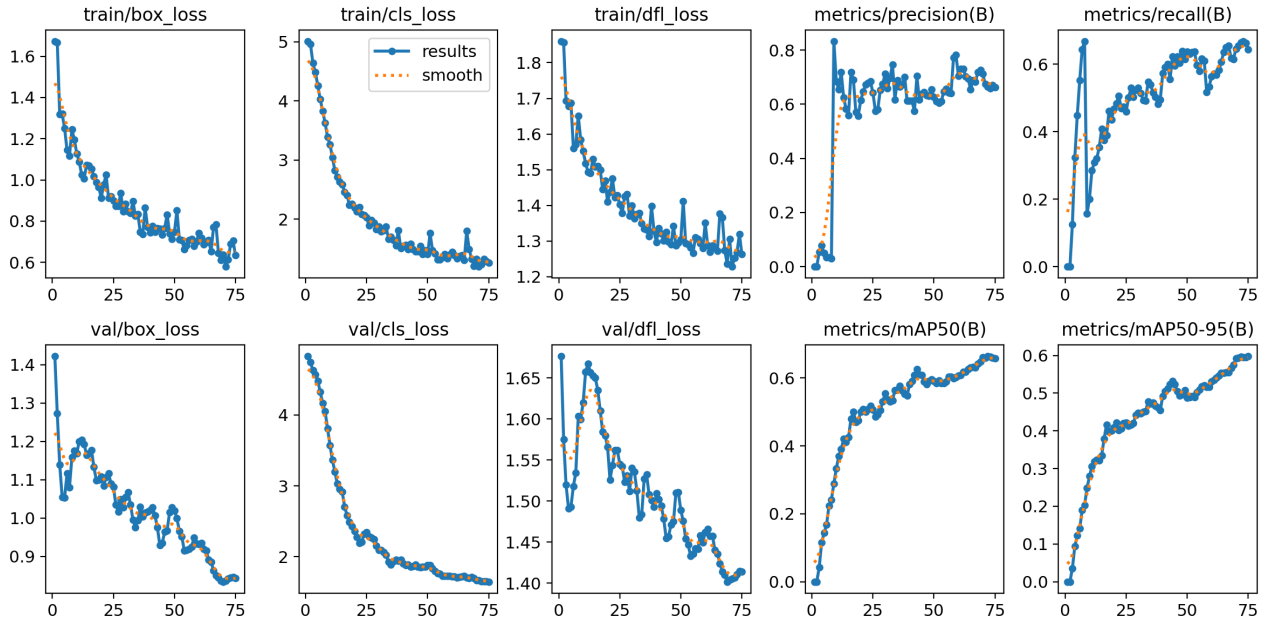
Improved base model: Tune Results





Best tune result of 50 iterations @ 75 epochs
mAP50-95: 0.59786
precision: 0.66274
recall: 0.64346

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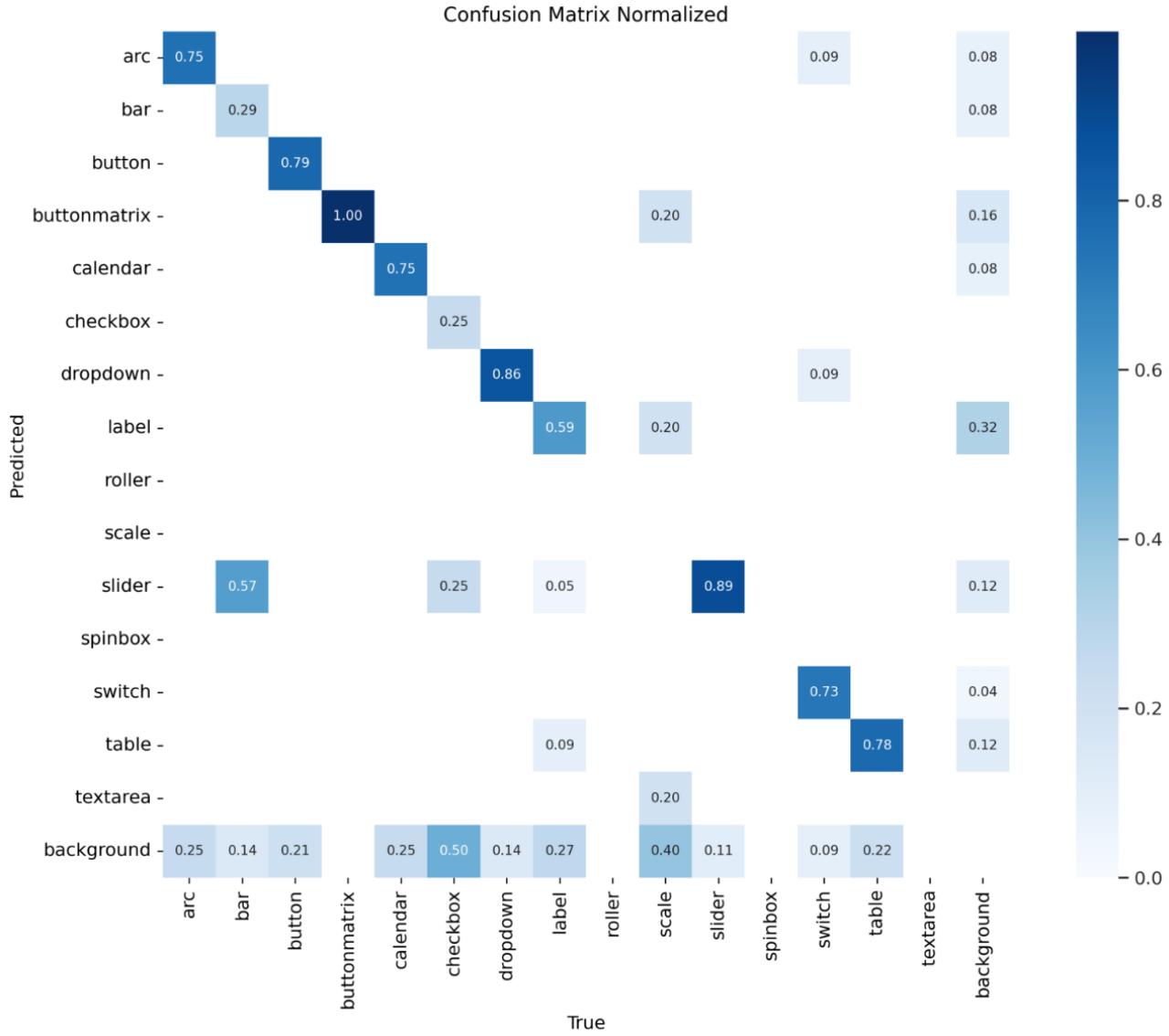
Improved base model: Train results (normalized)



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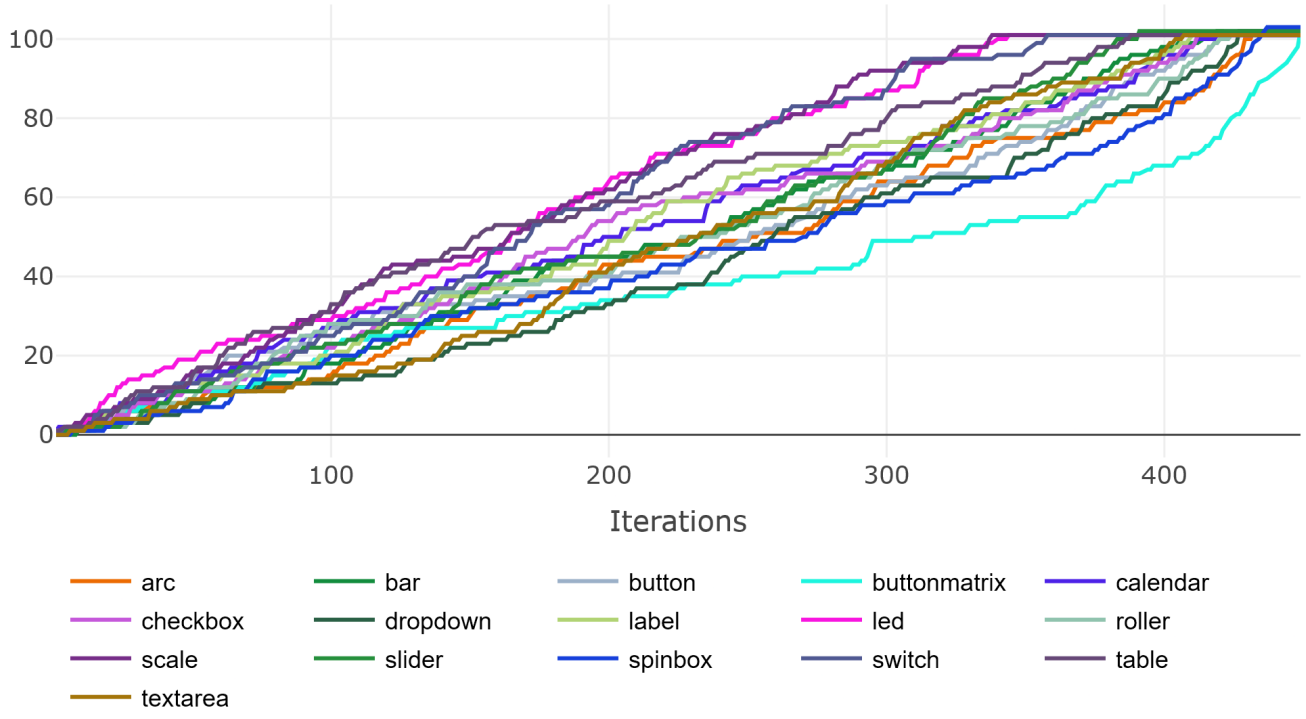
Random dataset creation (100 per widget)



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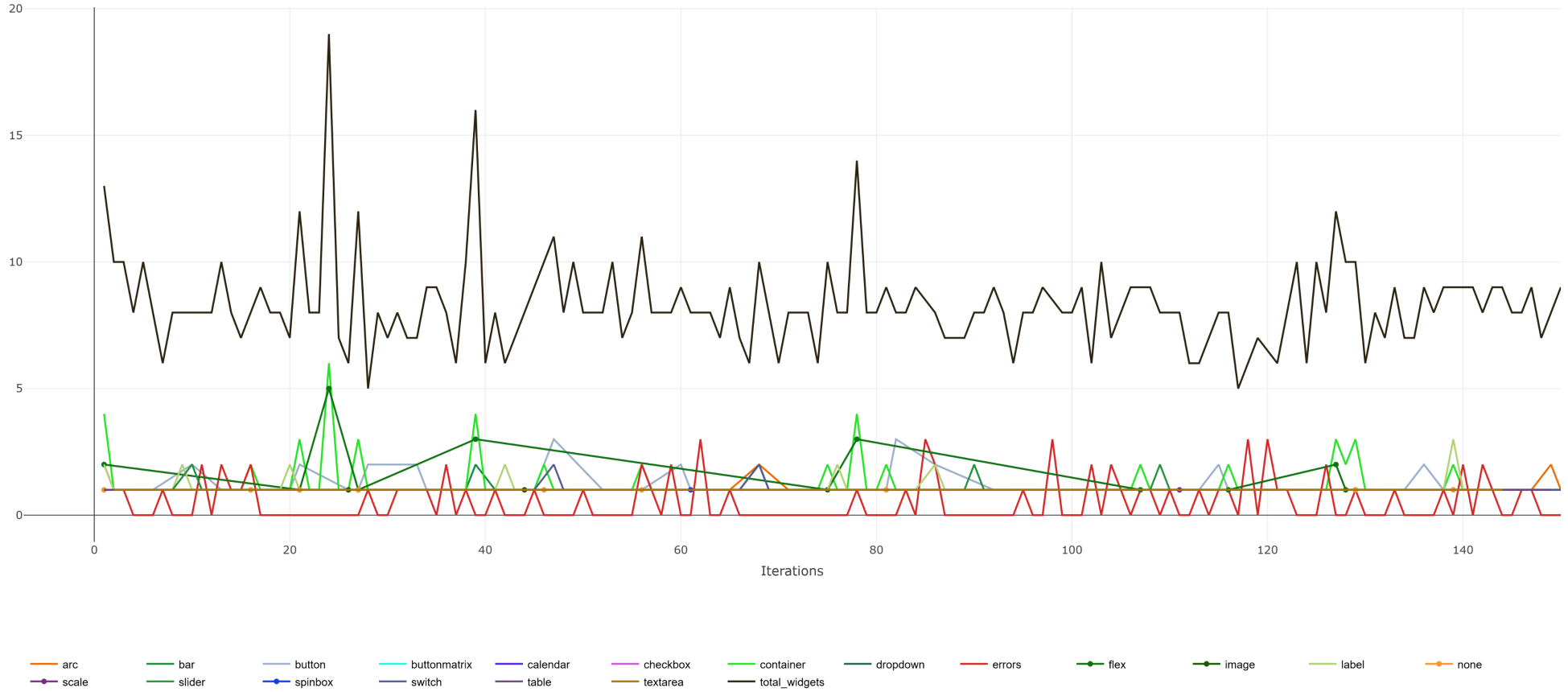
Design dataset creation (150 iterations)



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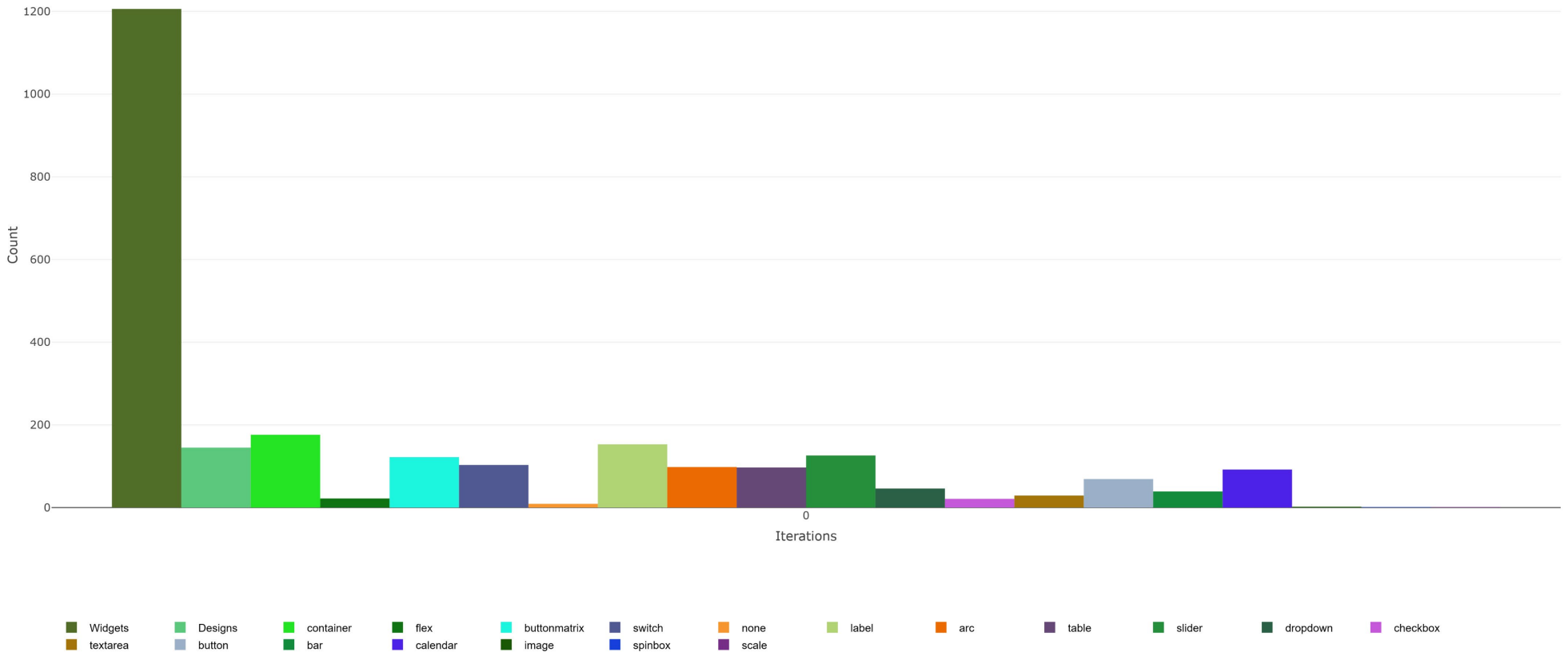
Design dataset creation (150 iterations)



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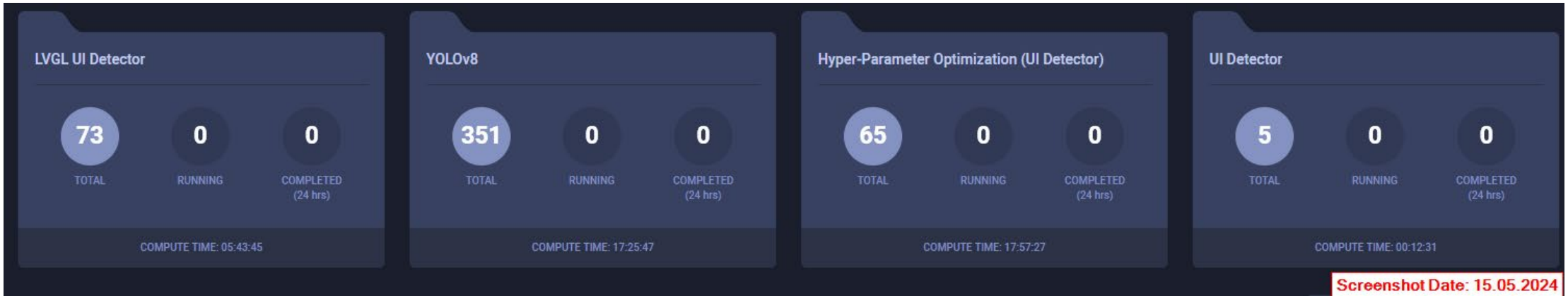
ClearML experiment tracking



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ClearML dataset versioning