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A framework for dataset construction including fused data from Human and Remotely Operated Vehicles (ROVs)

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Introduction

- Remotely Operated Vehicles (ROVs) → widely used in many critical missions.
- Human operator must control the ROV under stressful conditions and harsh environments → risk of unintentional movements → unwanted results.
- Need → control mechanisms embedded on the ROV to prevent accidents → easy implementation with the use of non-invasive wearable sensors.
- Monitoring the human through physiological signals along with an embedded mechanism controlling → helpful in search and rescue missions.
- **Aim: a framework for dataset construction consisting of human and ROV data**

Proposed Framework

Dataset Acquisition Setup

- 6 subjects (5 males & 1 female), 23-29 years old, 3 experienced and 3 non-experienced operators.
- 2 repetitions → stimulate the fatigue that occurs under stressful conditions.
- Pre-defined course → 4 basic simple movements (left, right, forward, backward) & pass the ROV around a sign.
- Data only from the right hand → focusing on on-air motion.
- 3-5 sec movement → 10 sec resting → flight duration: 10-12 min.
- sEMG sensor, HR Sensor & ROV - Drone

Stress Induction Technique

- 2 repetitions: 1 stress-free & 1 stress-full
- Dataset of irritating sounds¹.

State-Trait Anxiety Inventory (STAI) Evaluation

- Questionnaire with 40 questions: 20 for the state & 20 for trait anxiety².
- Filled in prior and at the end of the experiment.

Data Fusion

- Record of data = 8 sEMG values + 1 HR value + 11 values from the ROV = 20 signals.
- Annotated manually using video recordings from data collection process.



Figure 4. Setup for Data Collection

1. Wanlu Yang et al. "Affective auditory stimulus database: An expanded version of the International Affective Digitized Sounds (IADS-E)". In: *Behavior Research Methods* (2018), pp. 1415–1429.
2. Konstantinos N Fountoulakis et al. "Reliability and psychometric properties of the Greek translation of the State-Trait Anxiety Inventory form Y: preliminary data". In: *Annals of General Psychiatry* (2006), pp. 1–10.



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Data Acquisition

sEMG Signal Acquisition

- MYO Armband
- 8 active electrodes
- 200Hz sampling rate
- Bluetooth connection



Figure 1. MYO Armband

HR Signal Acquisition

- Polar OH1 Heart Sensor
- 1Hz sampling rate
- Bluetooth and ANT+ connectivity



Figure 2. Polar Sensor

ROV's Signal Acquisition

- DJI Spark Drone
- 200Hz sampling rate
- IMU's data



Figure 3. DJI Spark Drone

Data Analysis

Feature Extraction

- Window of 10 sequential time-frames
- 11 features for sEMG were evaluated → 7 were selected
- **sEMG**: VAR, WL, MAV, ZC, WAMP, RMS, SSC, MAX, MIN, SSI, IAV
- Raw HR
- **ROV**: Median, Mean, Min, Max

Data Evaluation

- Use of average values and box-plots
- Statistical t-test

Human Data					
Raw data			Features		
	Normal	Abnormal		Normal	Abnormal
S1	-0.893	-0.887	VAR	82.079	29.944
S2	-0.989	-0.975	WL	550.05	323.97
S3	-0.974	-1.005	MAV	0.476	0.272
S4	-0.9491	-0.951	ZC	9.375	4.237
S5	-1.0347	-1.027	WAMP	9.909	3.742
S6	-0.9276	-0.922	RMS	8.371	5.070
S7	-0.8817	-0.887	SSC	8.835	3.680
S8	-0.4045	-0.889	MAX	29.303	19.286
			MIN	-29.695	-16.149
HR	84.266	70.828	SSI	6676.2	2479.1
			IAV	432.677	263.97

Table 1. Average Values of human data

ROV Data					
Raw data			Features		
	Normal	Abnormal		Normal	Abnormal
AccX	0.003	0.038	Median	0.711	0.840
AccY	-1.005	0.008	Mean	925.36	898.78
AccZ	-1.03	-0.92	Max	-767.04	-725.42
GyroX	0.382	0.361	Min	31.668	41.051
GyroY	0.331	-0.492			
GyroZ	0.866	0.079			
MagX	85.430	190.434			
MagY	-741.67	-714.84			
MagZ	914.33	888.57			
Altitude	82.751	981.973			
R. Height	7.012	6.396			

Table 2. Average Values of ROV data



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Human Data – Statistical T-test				ROV Data – Statistical T-test			
Raw		Features		Raw		Features	
	p < 0.05		p < 0.05		p < 0.05		p < 0.05
S1	x	VAR	✓	AccX	✓	Median	✓
S2	x	WL	✓	AccY	✓	Mean	✓
S3	x	MAV	✓	AccZ	✓	Min	✓
S4	x	ZC	✓	GyroX	✓	Max	✓
S5	x	WAMP	✓	GyroY	✓		
S6	x	RMS	✓	GyroZ	x		
S7	x	SSC	✓	MagX	✓		
S8	✓	MAX	✓	MagY	✓		
		MIN	✓	MagZ	✓		
		SSI	✓	Altitude	✓		
		IAV	✓	Rel. Height	✓		

Table 3. Statistical T-test values for Human and ROV

Results

- STAI did not show any significant difference prior and at the end of the experiment.
- Average values after extracting the features are different between normal and abnormal movements.
- Statistical analysis between normal and abnormal movements showed that the data are statistically different between the two movements.
- The selected features for sEMG and ROV are promising when used for classification.

Conclusions

- Propose a framework for the construction of a dataset including data from human and an ROV during a mission.
- Construct a dataset including stressfree and stressful data from human and an ROV, annotated manually.
- We perform data analysis which includes extracting the average values and performing a statistical t-test to conclude to the most suitable features.

Future Work

- Construct a larger dataset with operators with different degrees of experience.
- Include more physiological signals such as Electrodermal Activity (EDA), Accelerometer, Blood Volume Pulse (BVP) and Skin Temperature (ST).
- Develop classification algorithms used especially for anomaly classifications.
- Design of a shared-control mechanism for monitoring jointly the operator and the ROV and preventing the execution of commands given by involuntary movements.

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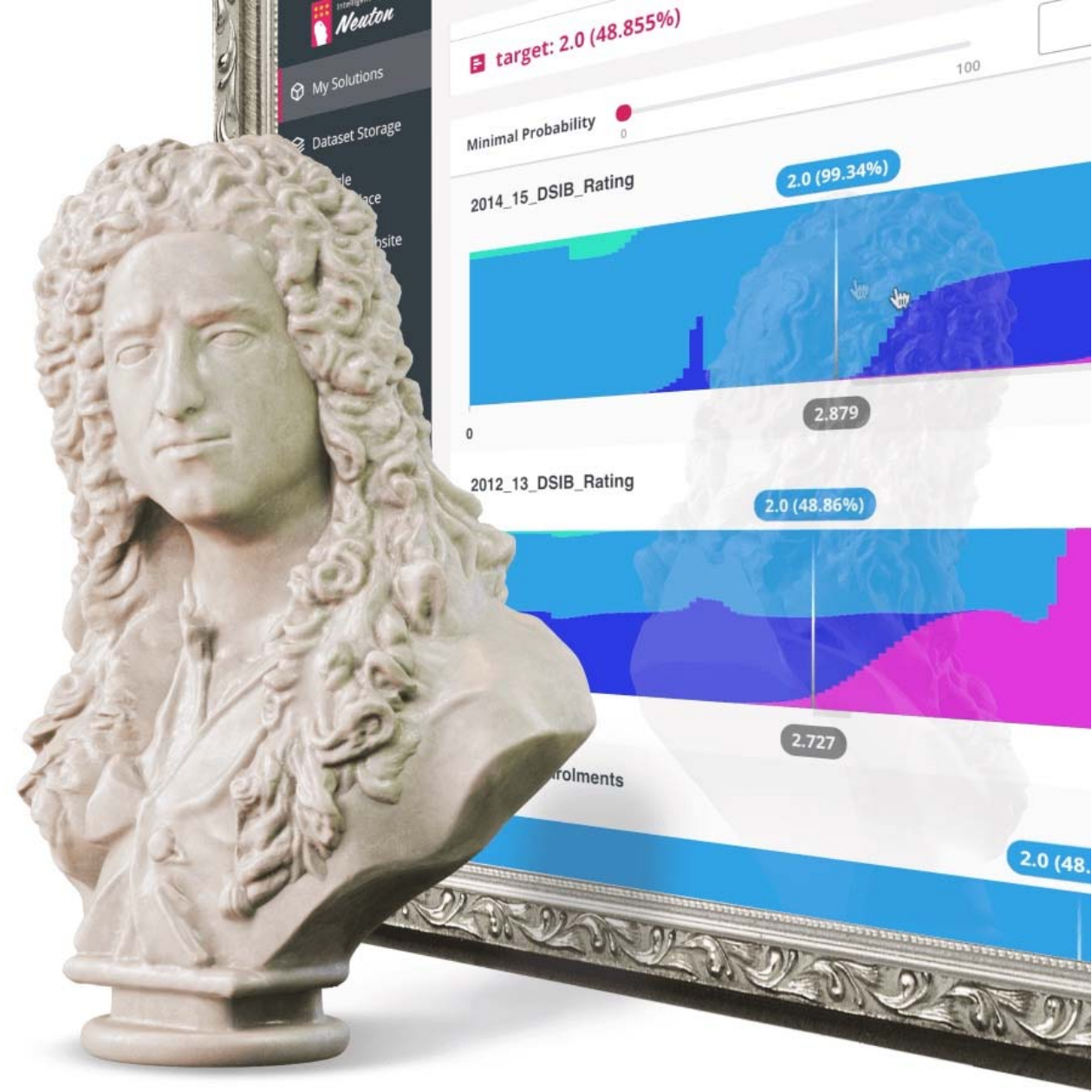
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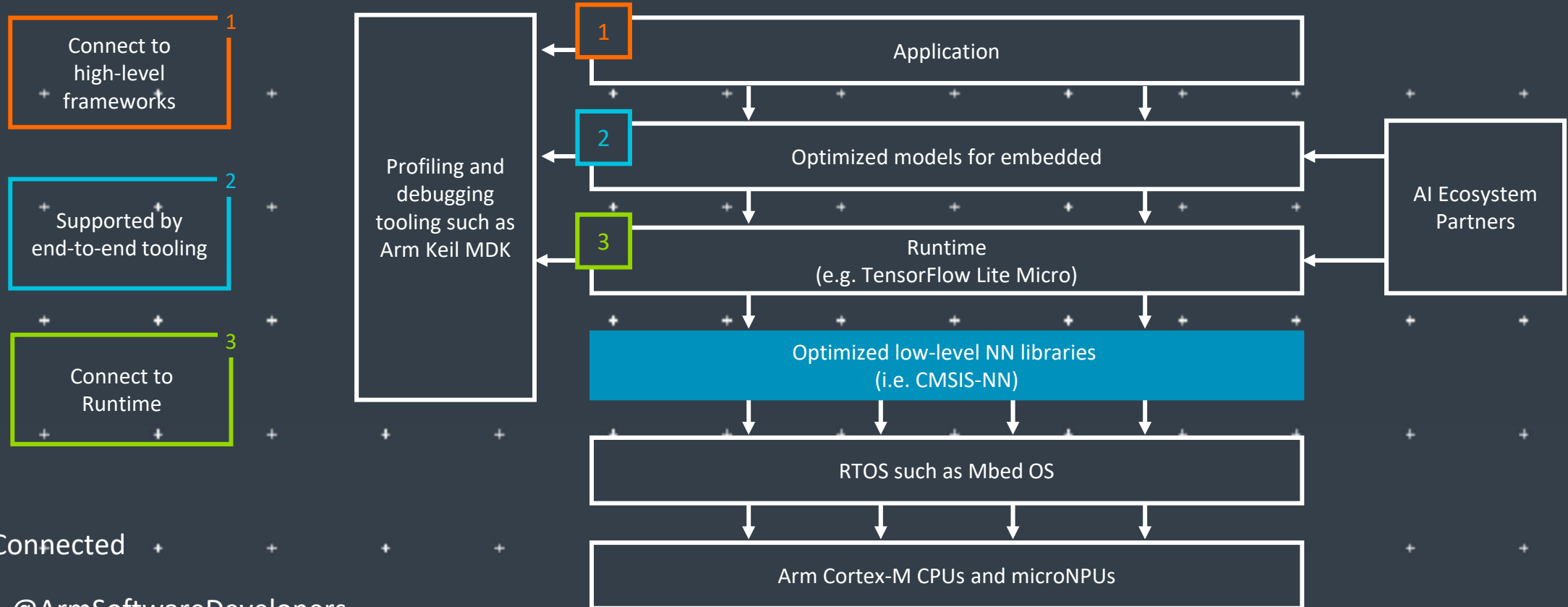
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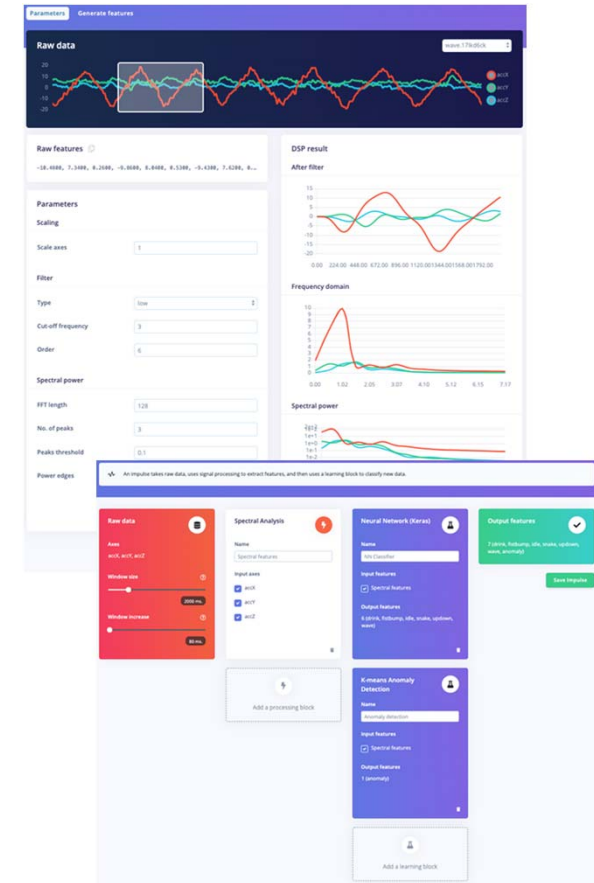
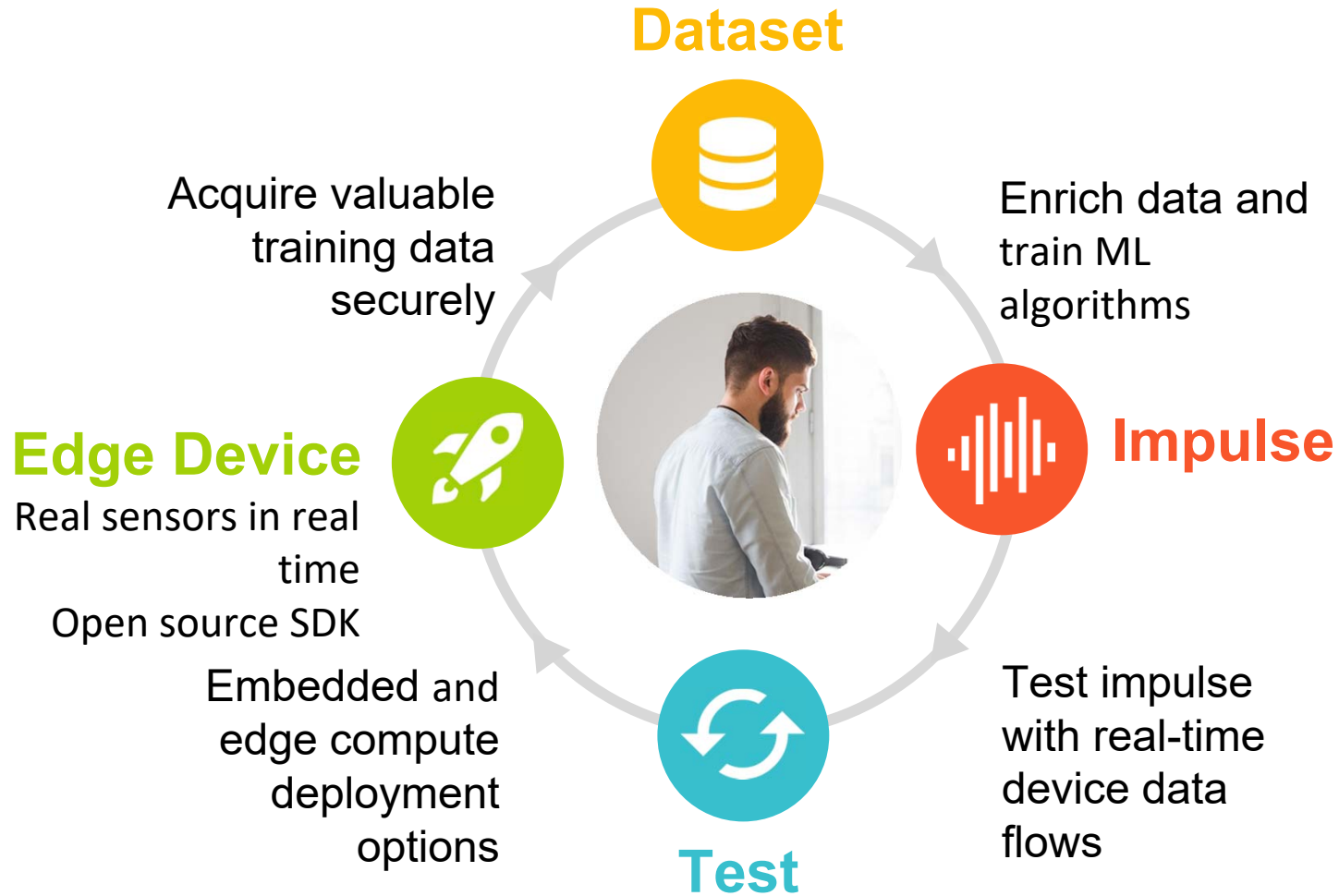
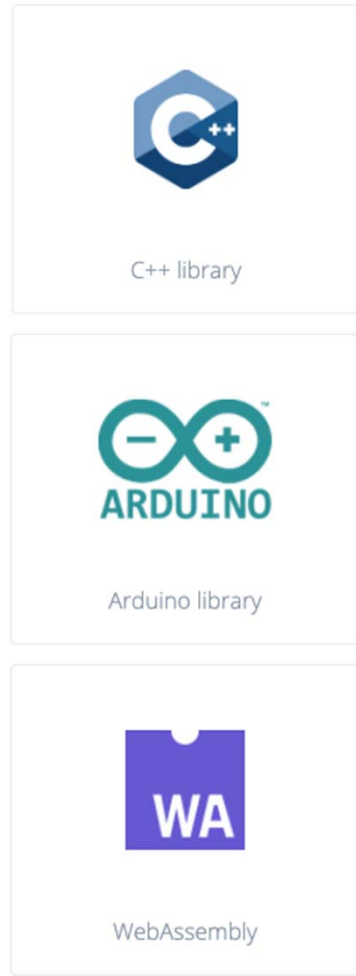
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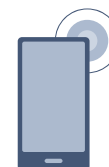
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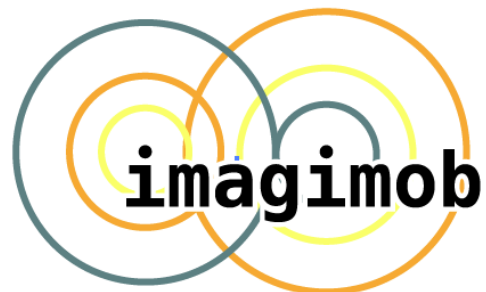
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