1st ADAPT workshop

Advanced Agile Production

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Agenda

1:00 PM – Introduction and schedule; Roel Pieters, TAU

1:10 PM – METRICS introduction; Guillaume Avrin, LNE

1:30 PM – ADAPT Competition; Roel Pieters, TAU

1:50 PM – ADAPT Field campaign; Max Pfingsthorn, OFFIS

2:10 PM – ADAPT Cascade campaign; Farzam Ranjbaran, CEA

2:30 PM – Stakeholder discussion

3:00 PM - Closing

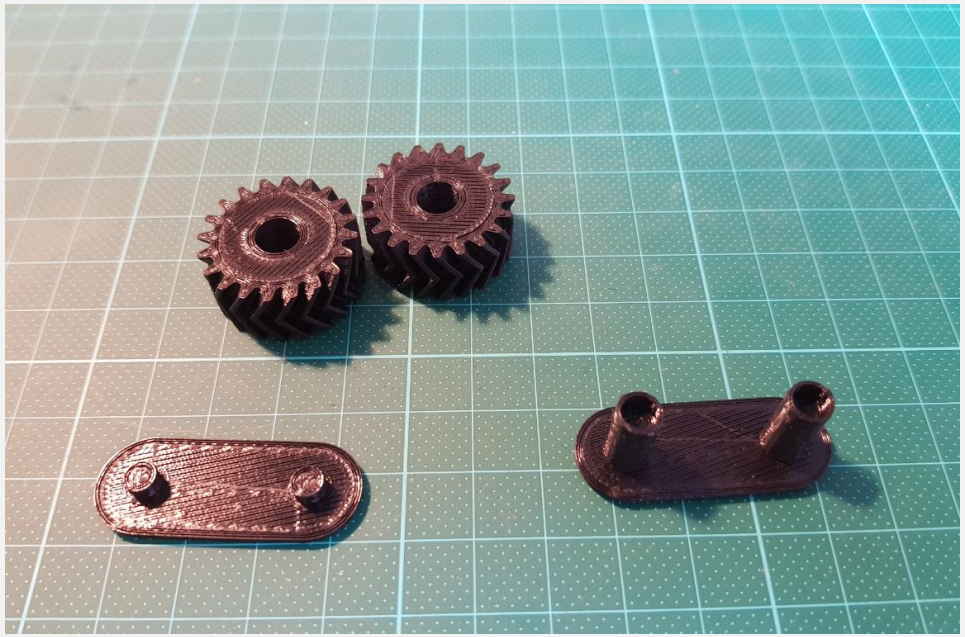
ADAPT Cascade Campaign

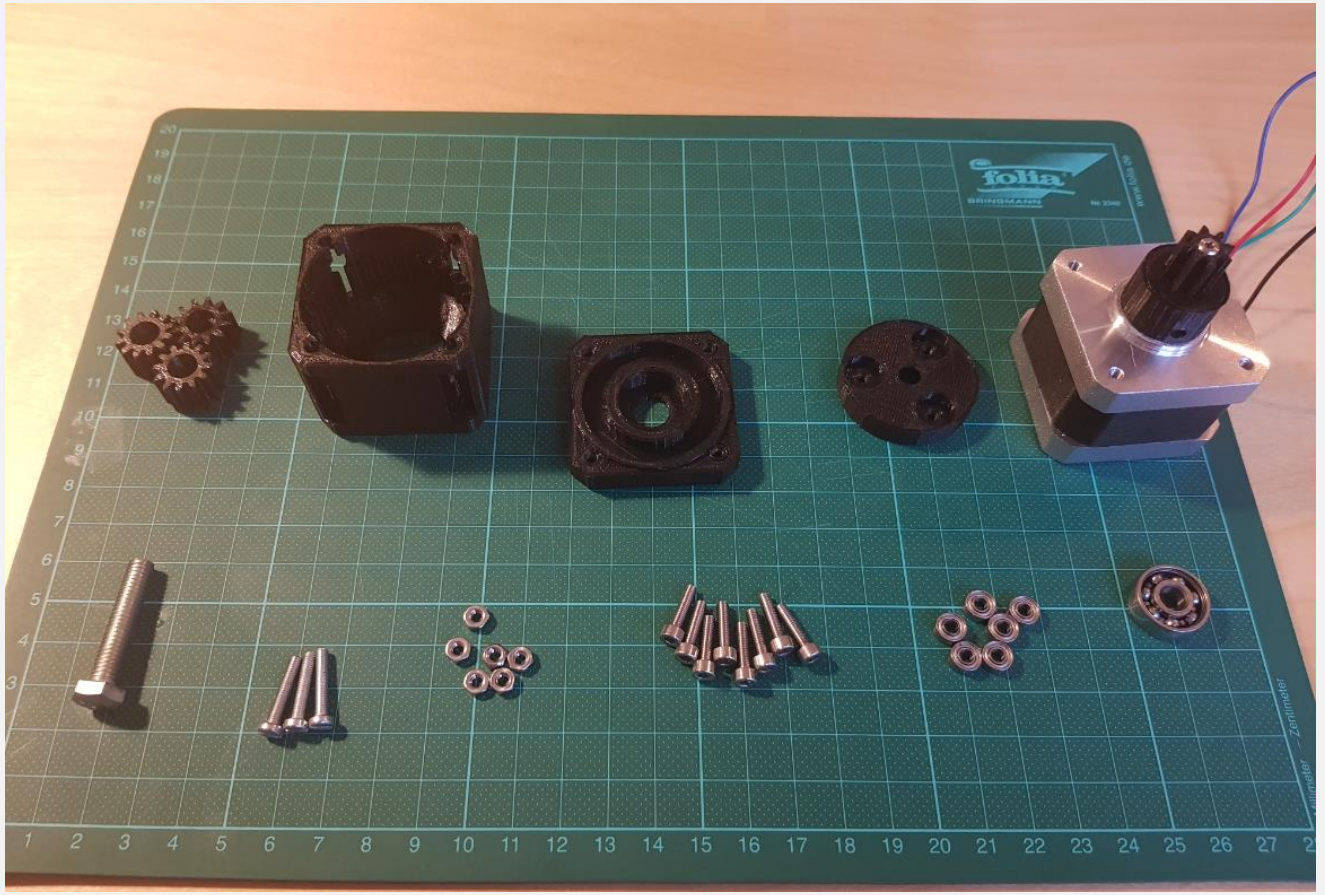
- **Main features (based on D6.1 ADAPT evaluation plan):**
  - Cascade evaluation campaigns were meant to be organized after the field evaluation campaigns, with the first cascade competition to serve as a dry run (mainly to test and validate the evaluation tools)
  - In the current situation the first field campaign has been turned into a virtual one
  - Focus on the ability of the competitors to quickly solve new tasks in a low data regime. Only *small* sets of sample training data will be made available for each new assembly
  - Evaluated robots annotate a detected objects with bounding box, to be compared to the ground truth
  - Evaluation is to be done offline based on collected datasets: while ensuring reproducibility and fairness

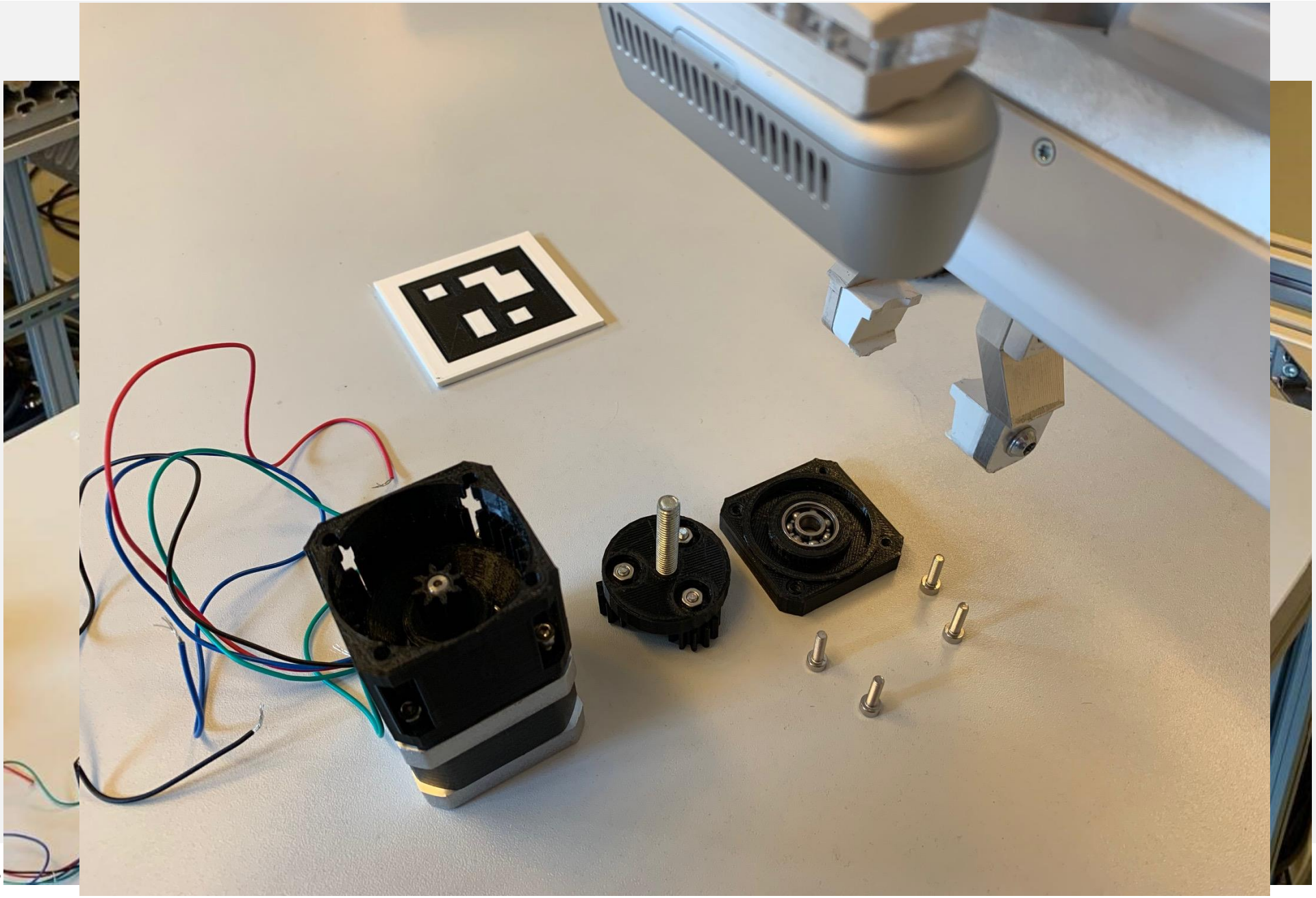
- **Main goal:**
  - To evaluate the competing systems' performance based on 3 main functional benchmarks:
    - FBM1: Object detection and classification (typical industrial components)
    - FBM2: Object pose estimation
    - FBM3: Quality control for representative assembly operations

- **Two important Questions to be answered very soon:**
  - Hosting of the competition, e.g., on Codalab (similar to the 1st ACRE Cascade Competition)
  - Nature/content of datasets (annotation, types/description of example images, etc.)

Parts and assemblies







FBM1: Detection and Classification of Parts

- **Task:** Given a set of test images, predict the location and the class of each part

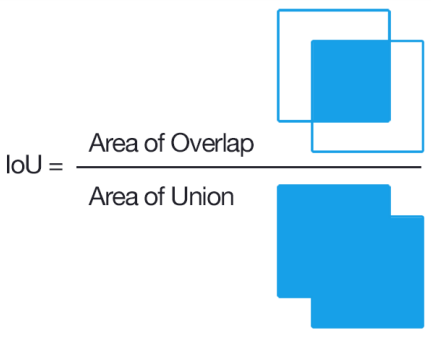
Typical example of Metrics (not yet finalised):

- **mean Average Precision (mAP)** which is the average precision averaged over all part classes

$$AP = \int p(r)dr$$ where p(r) is the PR-curve

- **Intersection over Union (IoU)**: True or false detection is detemined based on overlap between ground truth and predicted bounding boxes

$$IoU(A,B) = \frac{area(A \cap B)}{area(A \cup B)} > \tau$$



FBM1: Detection and Classification of Parts

- **Input:** Set of objects/classes to be detected: instance names, description, CAD models, Images RGB(-D)
- **Output**:{class_id, confidence, x, y, w, h};

maximum time allowed per trial is one minute with ten trials per team

- **Data Collection:** The online benchmarking data to be logged:
  1. Video stream of sensor data, at the rate of acquisition/processing (e.g. RGB: 30 fps at 720p, D: 15 fps at 48
  2. Detected parts in the scene (2D location + bounding box, instance estimates), at the rate of processing
- **Performance evaluation, in order of importance:**
  1. Number/percentage of correct part detections
  2. Number/percentage of correct part classifications
  3. Precision/recall, F-measure of detection and classification
  4. Detection/classification time
  5. Classification confidence

FBM2: Pose Estimation

Task: Given a set of images (of stationary parts), predict the 6D pose of the detected parts

- Parts may have complex shape, symmetries, (non-)uniform structure and different surface finish

Typical Metrics under consideration (not yet finalised):

Average Distance (ADD); Average closest point distance (ADD-S); Trans. and Rot. Errors (e_{TE} and R_{TE})

Given the ground truth rotation matrix $\mathbf{R}$ and translation vector $\mathbf{t}$ and estimated rotation $\widetilde{\boldsymbol{R}}$ and translation $\tilde{\mathbf{t}}$,

Ambiguity-Invariant

$$ADD = \frac{1}{m}\sum_{x\epsilon M}\left\|(\boldsymbol{R}\boldsymbol{x}+\boldsymbol{t})-(\widetilde{\boldsymbol{R}}\boldsymbol{x}+\tilde{\boldsymbol{t}})\right\|_2$$

$$ADD_S = \frac{1}{m}\sum_{x_1\epsilon M}\min_{x_2\epsilon M}\left\|(\boldsymbol{R}\boldsymbol{x_1}+\boldsymbol{t})-(\widetilde{\boldsymbol{R}}\boldsymbol{x_2}+\tilde{\boldsymbol{t}})\right\|_2$$

Rotation and translation errors

$$e_{TE}(\boldsymbol{t},\tilde{\boldsymbol{t}}) = \|\boldsymbol{t}-\tilde{\boldsymbol{t}}\|_2$$

$$e_{RE}\left(\boldsymbol{R},\widetilde{\boldsymbol{R}}\right) = \cos^{-1}\frac{\mathrm{Tr}\left(\mathbf{R}\,\widetilde{\boldsymbol{R}}^T\right)-1}{2}$$

FBM2: Pose Estimation

❑ **Input:**

- List of objects present: instance names, description, Images (RGB-D), CAD models,
- Reference system with respect to the surface on which objects are placed

❑ **Output:**

- 3x3 Rotation matrix + 3x1 Position vector for each instance of objects present in the scene

maximum time allowed per trial is one minute with ten trials per team

- **Data Collection:** The online benchmarking data to be logged:
  1. Video stream of sensor data, at the rate of acquisition/processing (e.g. RGB: 30 fps at 720p, D: 15
  2. Estimated part pose in the scene with respect to table (6D Pose, instance estimates), at the rate o

- **Performance evaluation, in order of importance:**
  1. Pose error for correctly classified objects with respect to the ground truths
  2. Pose estimation time

FBM3: Quality Control of Final Assembly

Task: Given the image of an assembly of parts, assess the correctness and completeness of the assembly

- **Performance evaluation, in order of importance:**
  1. Number/percentage of correct assembly, correctness estimate
  2. Number/percentage of correct assembly, level of completion
  3. Precision/recall, F-measure of assembly correctness and level of completion
  4. Quality control time
- **Data Collection:** The online benchmarking data to be logged:
  1. Video stream of sensor data, at the rate of acquisition/processing (e.g. RGB: 30 fps at 720p, D: 15 fps at 480)
  2. Estimated part pose in the scene with respect to table (6D Pose, instance estimates), at the rate of processing

Inputs: The teams will be provided with:

- Set of objects/parts that are potentially included in the assembly (description, CAD models, images)
- Set of object assemblies which undergo the quality control (description, CAD models, images, annotated assembly quality)
- Quality control metrics: SUCCESS, FAULTY, INCOMPLETE. A level of completion is to be estimated as a percentage or as a ratio.

maximum time allowed per trial is one minute with ten trials per team

Schedule (tentative)

- 26/02 Formal launch
- 15/03 Challenge guidelines publications
- 01/04 Training and Validation datasets publications
- 17/05 Test data publications and opening of results submission
- 14/06 End of results submission
- 30/06 Challenge results publication

THANK YOU

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