Automated Behaviour Analysis of Rats

TUAN PHAM
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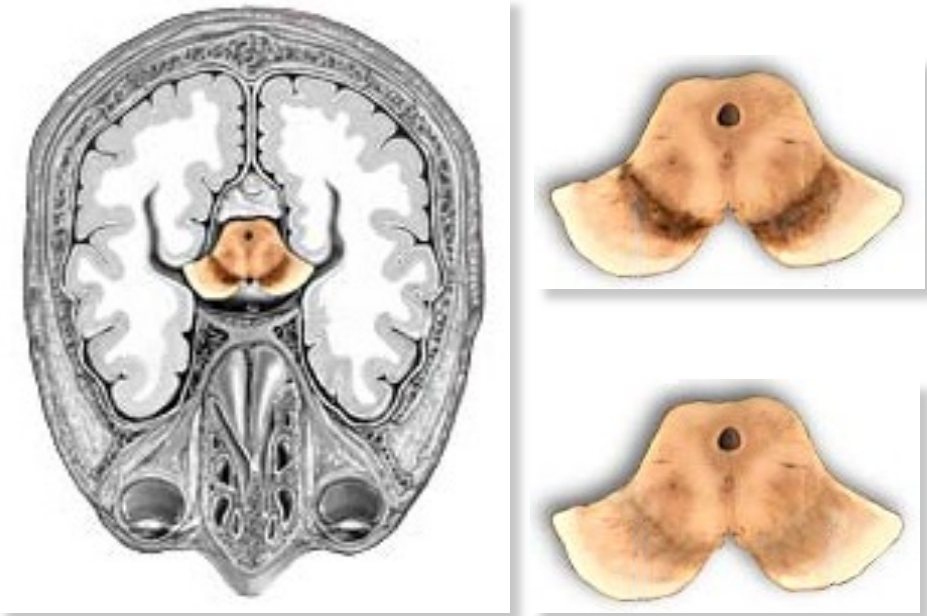
Parkinson's Disease

Motor Symptoms

- Tremor

- Muscle rigidity

- Impairments in movement initiation, posture and balance

Core Symptom

- Dopamine deficiency

Assessment of Therapeutic Interventions

- Modelling Parkinson's disease in **rats**

- Brain has **two hemispheres**, each is controlling one side of the body

- Selectively killing off the dopamine cells on **one hemisphere**, leading to **one-sided behavioural impairments**

- Use **behavioural tests** to assess the effects of therapeutic interventions

Good side   Bad side

Corridor Test

- **Lids with sugar pellets** are placed along a corridor

- Counting the number of **retrievals**

- Distinguishing between retrievals from the **left side or the right side**

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BRAIN RESEARCH BULLETIN

ELSEVIER

(B) 7cm

240cm 13cm

34cm
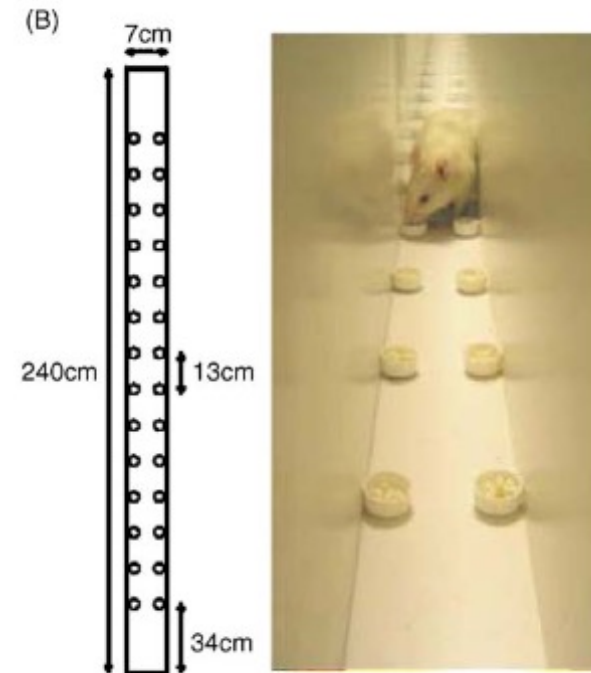
Limitations of Testing Approaches

- Traditional behaviour tests are **laborious and time consuming**
  - Corridor test: Each test lasts five minutes and there could be 50+ rats to be analysed
- They are **constrained by human limitations**
  - Corridor test: Only based on counts
- **Robustness**
  - Corridor test: Disagreement between humans, influence of fatigue, …

→ **Task**: Automate the corridor test!

Data

Modelling

- How to frame the corridor test as a ML problem?
  - Input:
    Single frame vs. entire video?
  - Output:
    Counts vs. intermediate values?
- Minimize resource requirements
  - Number of samples
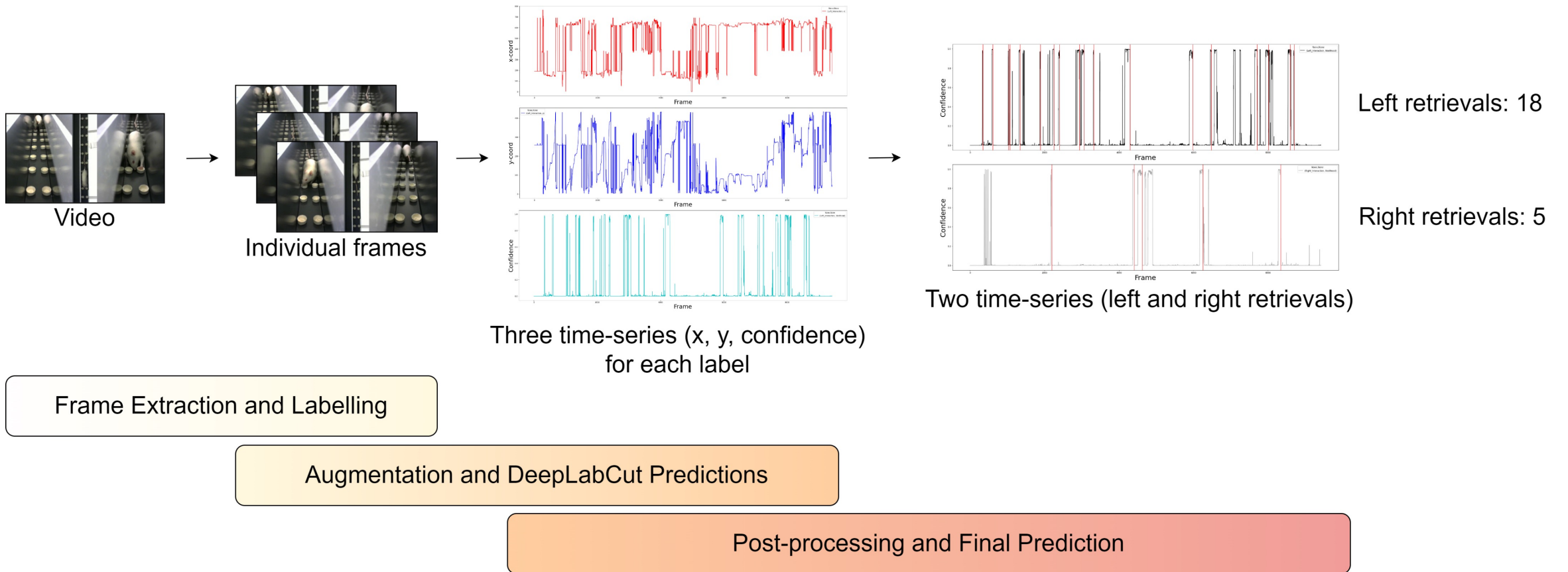 - Label complexity
  - System complexity
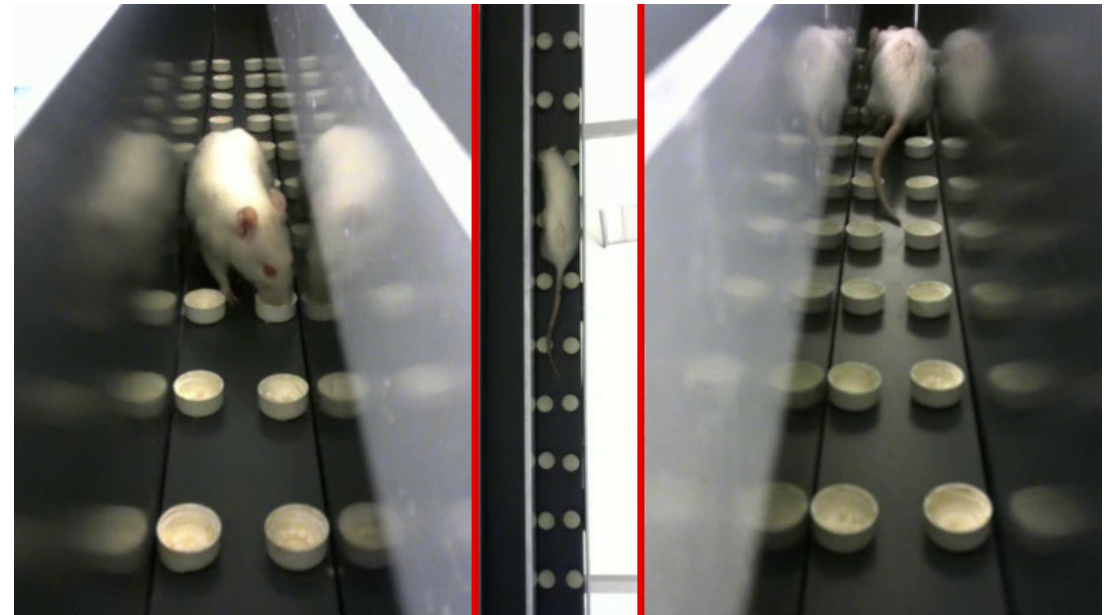
DeepLabCut

- DeepLabCut is a popular tool for **marker-less pose estimation**

- Based on **pre-trained models** such as **ResNet** and others

- Makes a prediction for **each frame**

- Output: **Probability distribution** over the image

Pipeline

Video

Individual frames

Three time-series (x, y, confidence)
for each label

Two time-series (left and right retrievals)

Left retrievals: 18

Right retrievals: 5

Frame Extraction and Labelling

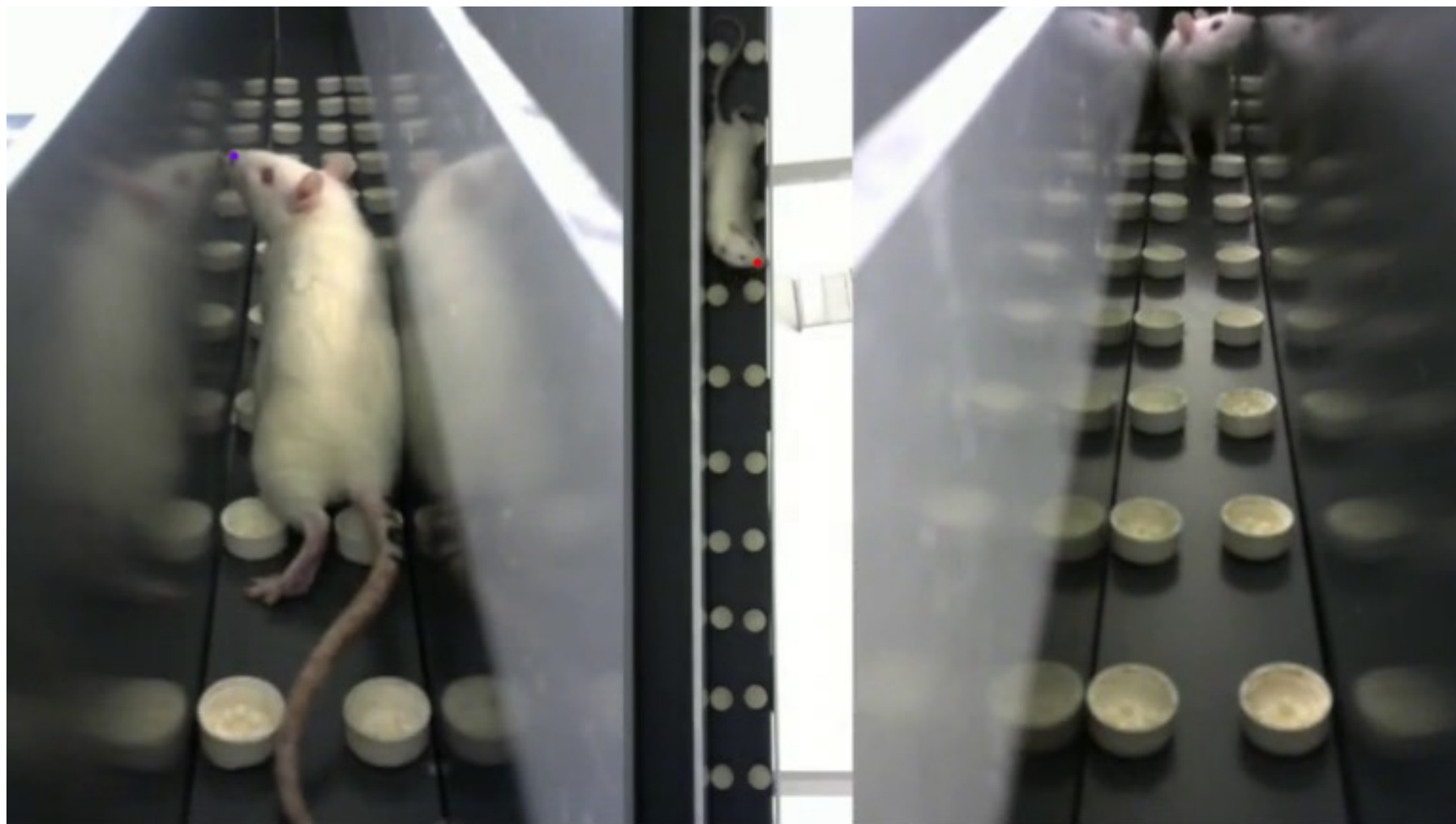Augmentation and DeepLabCut Predictions
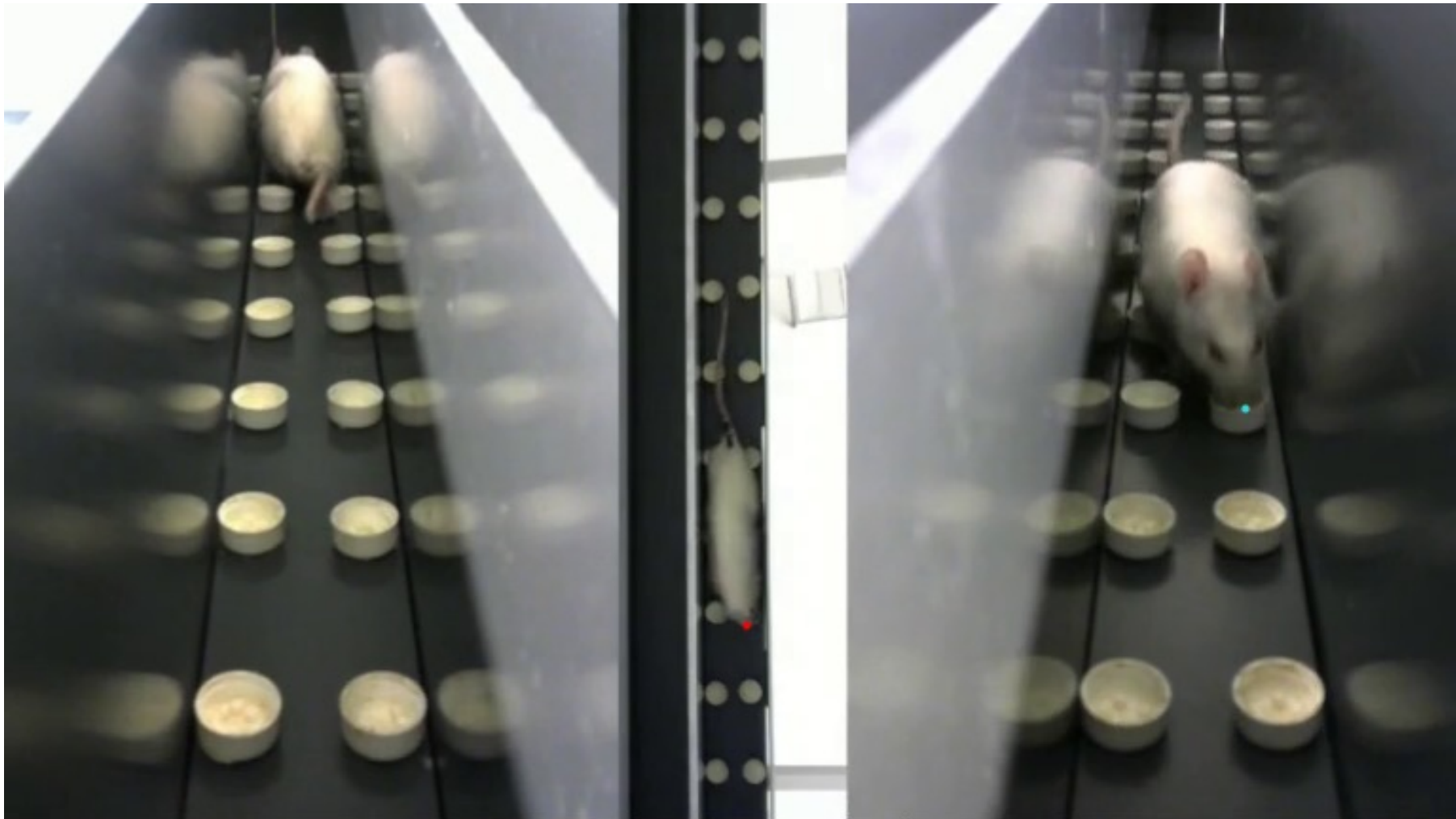
Post-processing and Final Prediction

Frame Extraction and Labels

- Sample a **set of frames** from each training video
  - K-means to obtain a diverse set
- Three labels to capture **retrieval status** (none/left/right)
- One label to capture **head position in the bird view**
- For each frame, only **two labels are present**

No Retrieval

Left Retrieval

Right Retrieval

Data Augmentation

- Contrast, brightness, saturation, and colour augmentations to simulate **changing lighting conditions**

- Cropping, scaling, translation, and rotation to simulate **different recording setups**

- Label-preserving mirroring to deal with **potential label imbalance**

Visualised DeepLabCut Output

Post-processing

- Transforms DeepLabCut output to **retrieval counts**
- Requires input with regards to desired
  - Minimum confidence level
  - Minimum retrieval duration
  - Minimum movement after a retrieval

Evaluation

- So far, we only evaluated the model's performance on an unseen test set of 6 videos. The minimum retrieval duration was set to 0.25 sec.

Counter	Febe		Irene		Model	
Rat	L	R	L	R	L	R
59	19	6	13	3	18	5
60	7	17	6	14	6	20
61	10	7	6	6	11	6
62	6	19	5	13	4	18
63	2	5	1	2	2	6
64	8	14	7	10	7	14

Conclusion

- **Label design** is extremely important
- **Transfer learning approach** enables a very robust performance despite very small dataset
- **Data augmentation** is crucial to obtain a robust result on different corridor setups
- A more rigorous **evaluation** is needed

Questions?