Animal Behavior Observation with Event Cameras
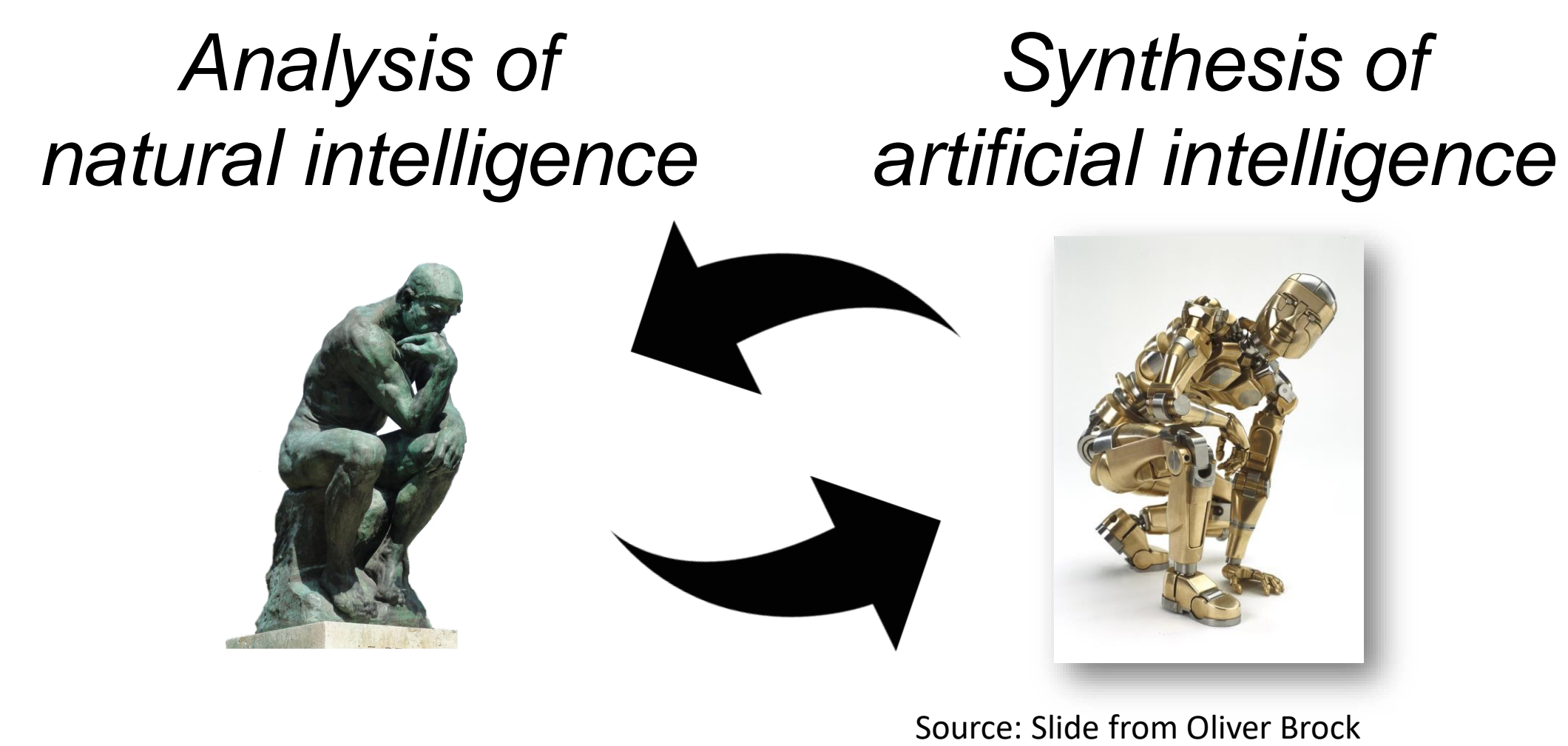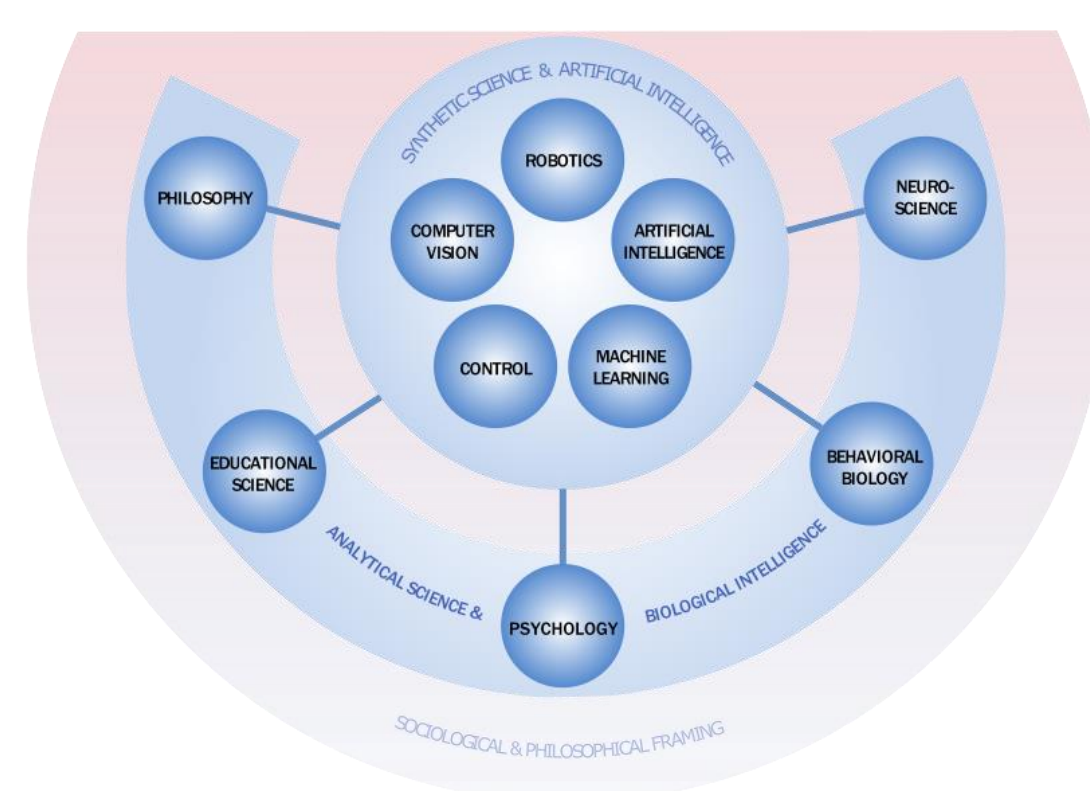## Friedhelm Hamann and Guillermo Gallego

Introduction

- DFG-funded Cluster of Excellence "Science of Intelligence": (>20PI's, 7+ years) in Germany.
- Collaboration between analytical sciences (e.g. biology, neuroscience, psychology) and engineering science.

Analysis of natural intelligence

Synthesis of artificial intelligence

Source: Slide from Oliver Brock

This Project

- **Quantification of animal behavior** is a critical part of neuro-scientific and biological research.
- Computer vision algorithms are widely used tools for automated quantification of behavior.
- Event cameras **offer potential advantages** (HDR, high temporal resolution, low power-consumption, sparsity) for this scenario.

Key Ideas

- Event cameras naturally respond to motion to capture animal movement (static camera).
- HDR allows monitoring in less controlled wild conditions.
- Event cameras do not suffer from long exposure times in low-light.
- Algorithms developed for animal behavior observation are basic research and applicable to other (e.g. industrial) use-cases.

References

Hamann, and Gallego, Stereo Co-capture System for Recording and Tracking Fish with Frame-and Event Cameras. *26th Int. Conf. Pattern Recognition (ICPR-W), Visual observation and analysis,* 2022.

Multi-Animal Tracking

- **Input:** Events + Camera calibration
- **Output:** (3D) Position of multiple (animal) instances over time
- **Method:**
  - Recording events and high-quality frames enables sensor comparison and combination.
  - Multi-step pipeline: SORT (Bewley, ICIP'16) + Triangulation
- **Advantages**:
  - HDR (lower requirements on scene lighting)
  - Capture fast movements (e.g. fleeing fish from predators)

### Mice Tracking (with Lewejohann lab, FU Berlin)

Co-capture Systems

Animal Tracks

Top view   *Front view*
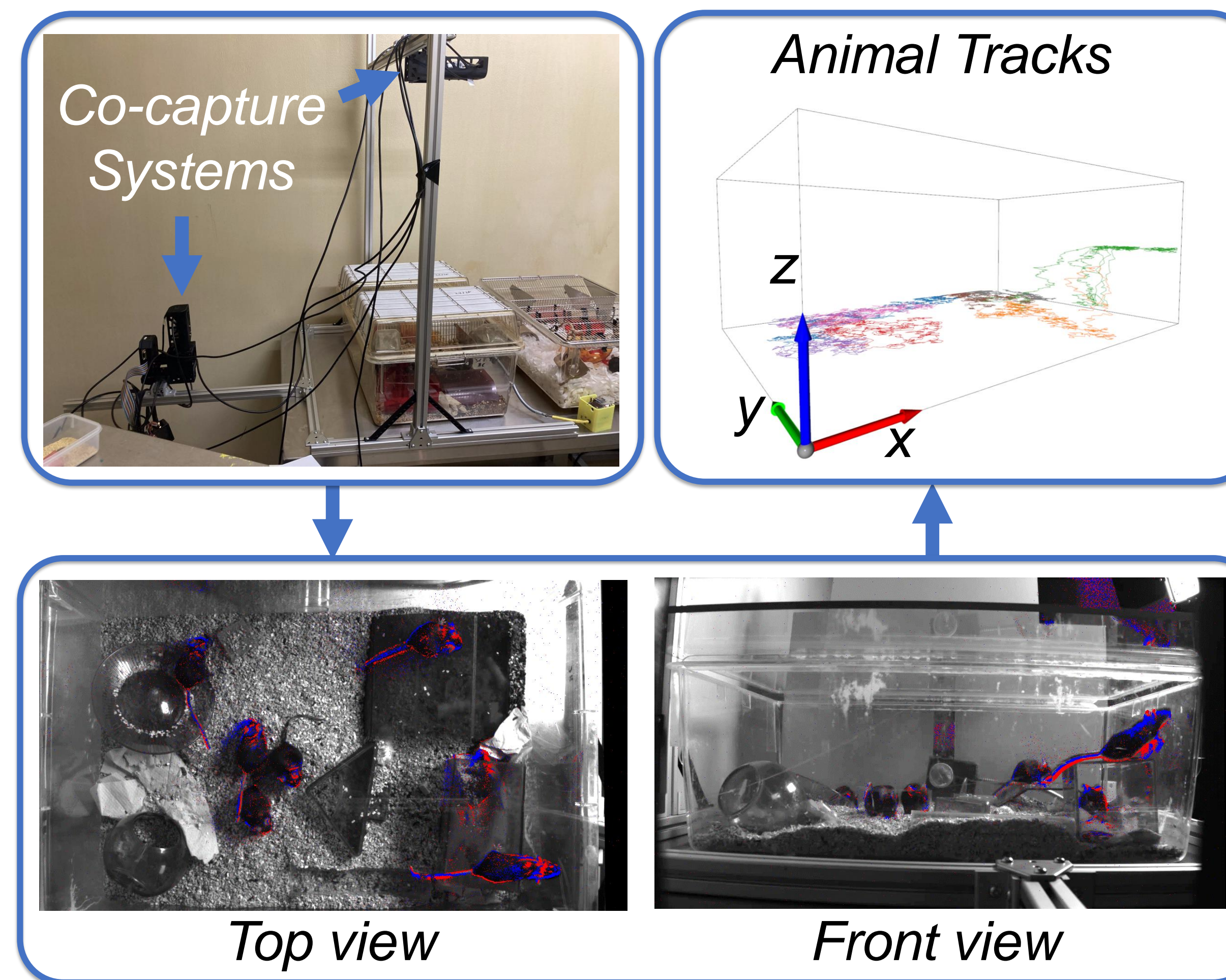
Fish Tracking (with Krause lab, HU Berlin)
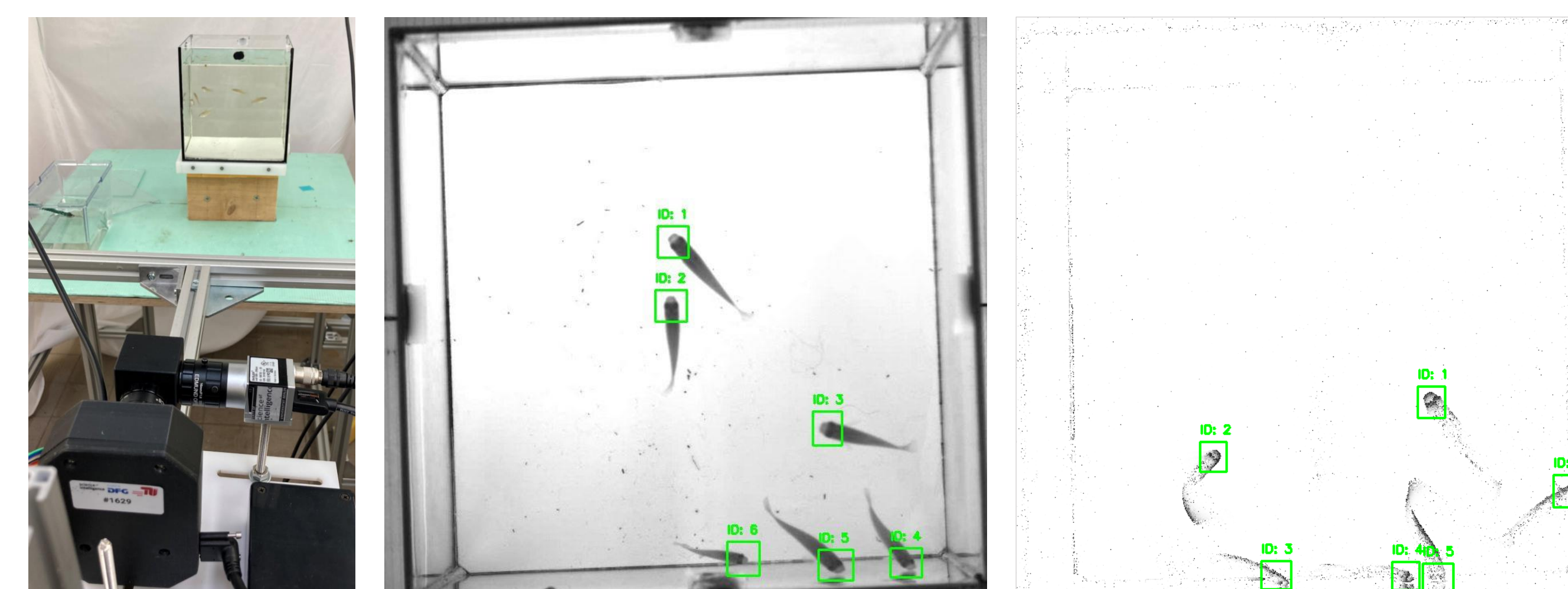
Efficient Algorithms for Wild Animal Observation

General:

- **Input:** Events in a time window
- **Output:** Predicted actions (behaviors)
- **Advantages:**
  - **Short-term:** HDR, efficiently capturing motion, algorithms applicable to systems with limited compute power.
  - **Long-term:** Low energy and storage efficiency.

Behavior 1   *Behavior 2*   *Behavior 3*   *Background*

Rate

FFT
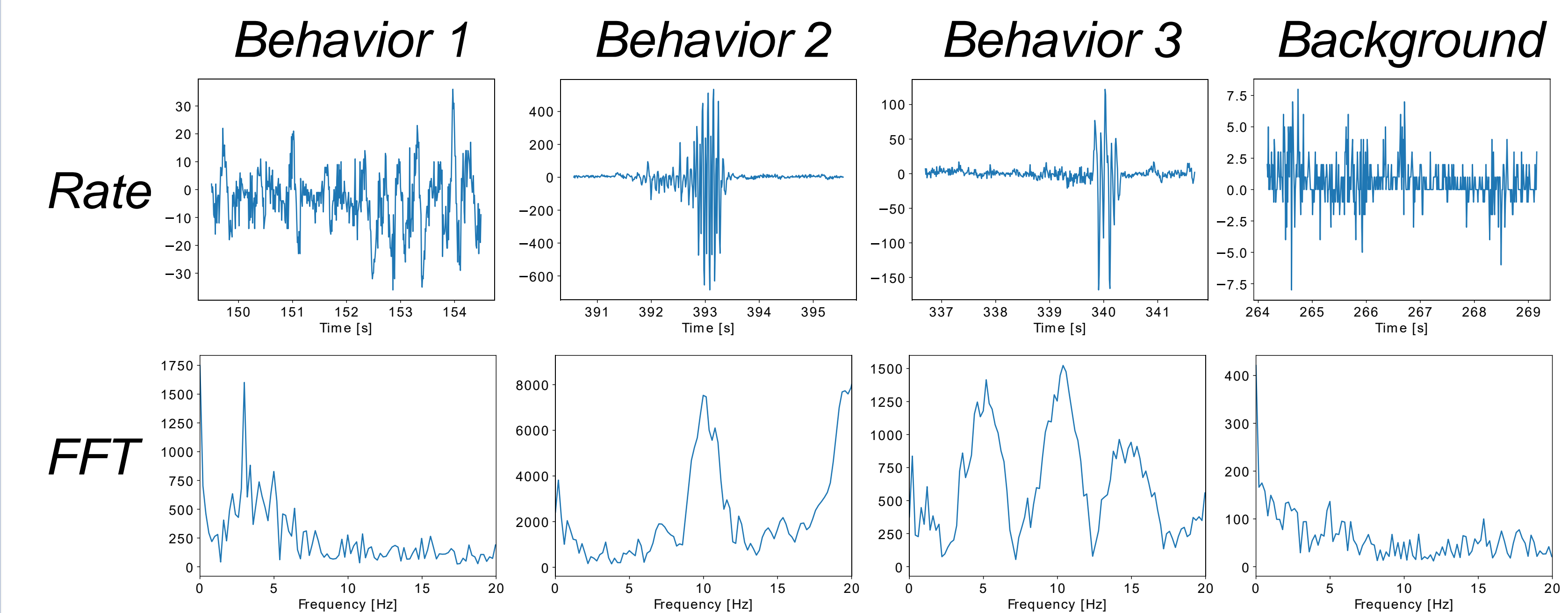
FFT-based recognition of oscillating behavior

- Distinguish different behaviors by their signature in Fourier-space.
- The method is explainable and computationally efficient.

events ε → signed event rate $r[k]$ → Spectrum R[f] → Model-based / Learned

Action classifier