Development of an algorithm for experimental data analysis involving small laboratory animals in the Open Field test system

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MATHEMATICAL MODELING AND COMPUTATIONAL PHYSICS 2026

JINR MLIT 1966 - 2026

Dubna, 2026

Basic behavior patterns in the Open Field test system

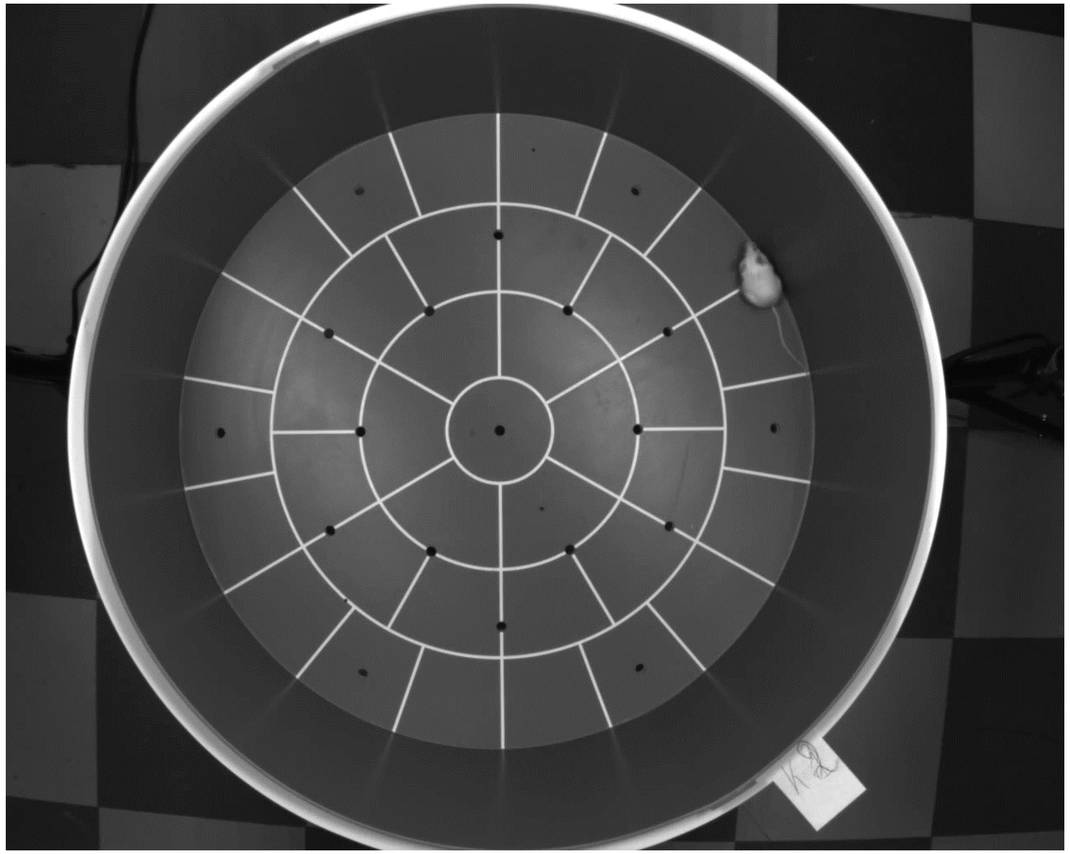
BEHAVIOR PATTERN	PATTERN DESCRIPTION	RECOGNITION METHOD
PORT EXPLORATION	detection, location and basic analysis of ports in the laboratory setup	recognition of specific movements and positions near the ports, video analysis
SUPPORT VERTICAL STAND	the animal is located in a vertical position and leans on external objects (for example, on the wall of a laboratory setup)	analysis of static positions of the body and upper body, fixation of immobility near supporting elements
FREE VERTICAL STAND	the animal is located in an upright position and does not rely on any external objects	posture and balance analysis, fixation of the vertical position without any contact with fixed supports
FREEZING	prolonged absence of movement	monitoring movement speed, detecting long periods with minimal or no activity
GROOMING	self-cleaning	localized movements, especially in the head, paws, or body area, specific repeated movement patterns



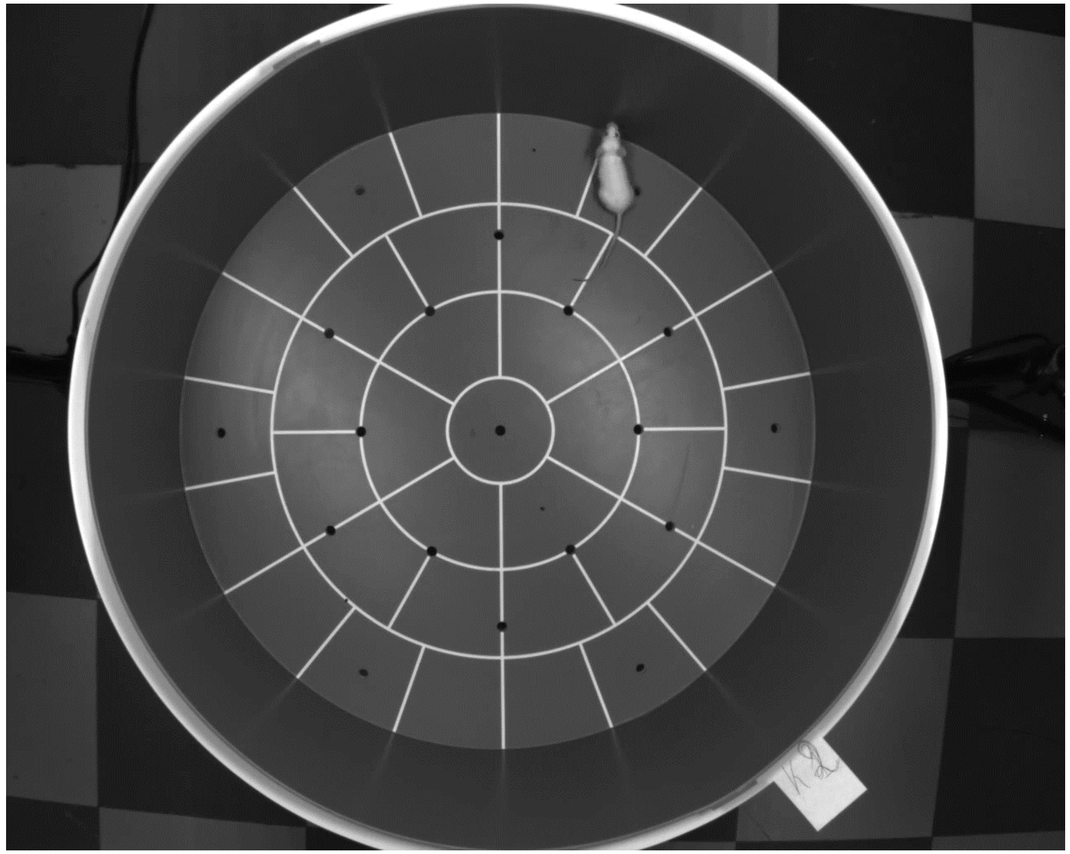


It is also necessary to conduct a study of the animal's behavior in the area of the center and perimeter of the test system, when the animal moves (or stops) in the corresponding part or moves along the edges of the area.

Basic behavior patterns in the Open Field test system

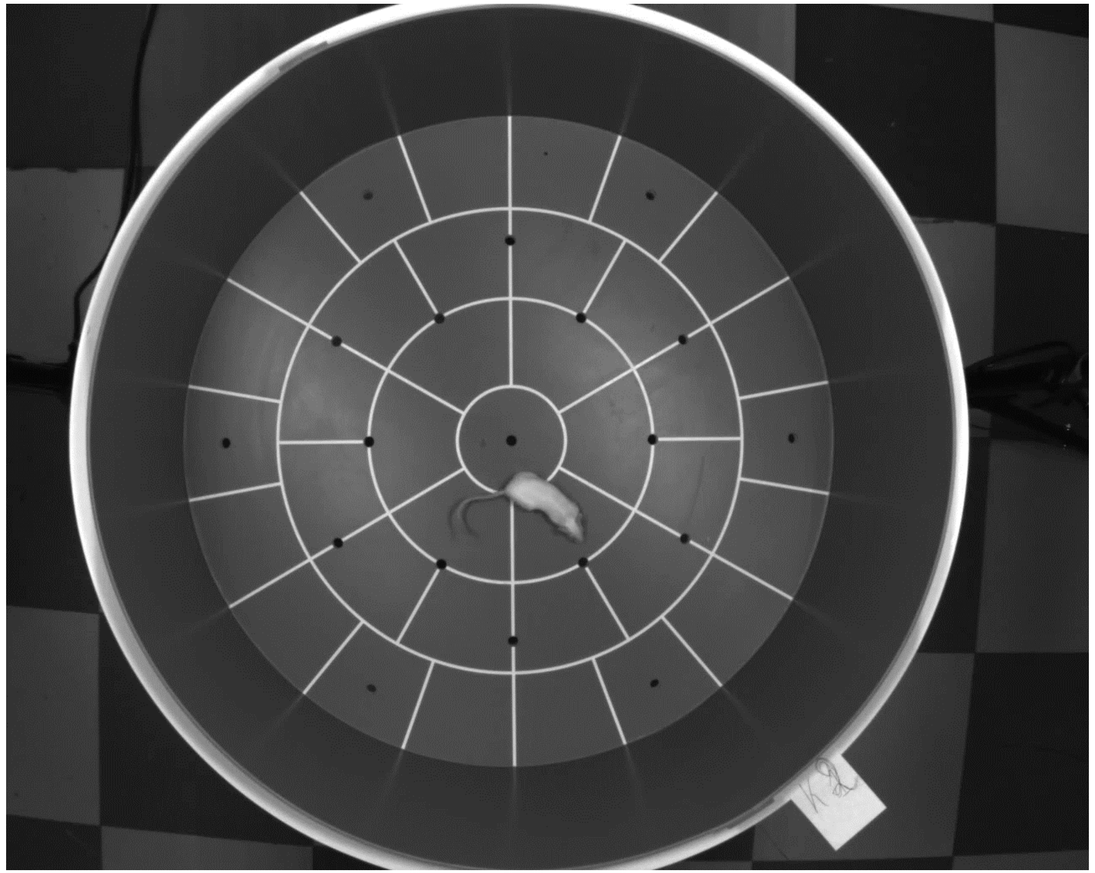


Grooming

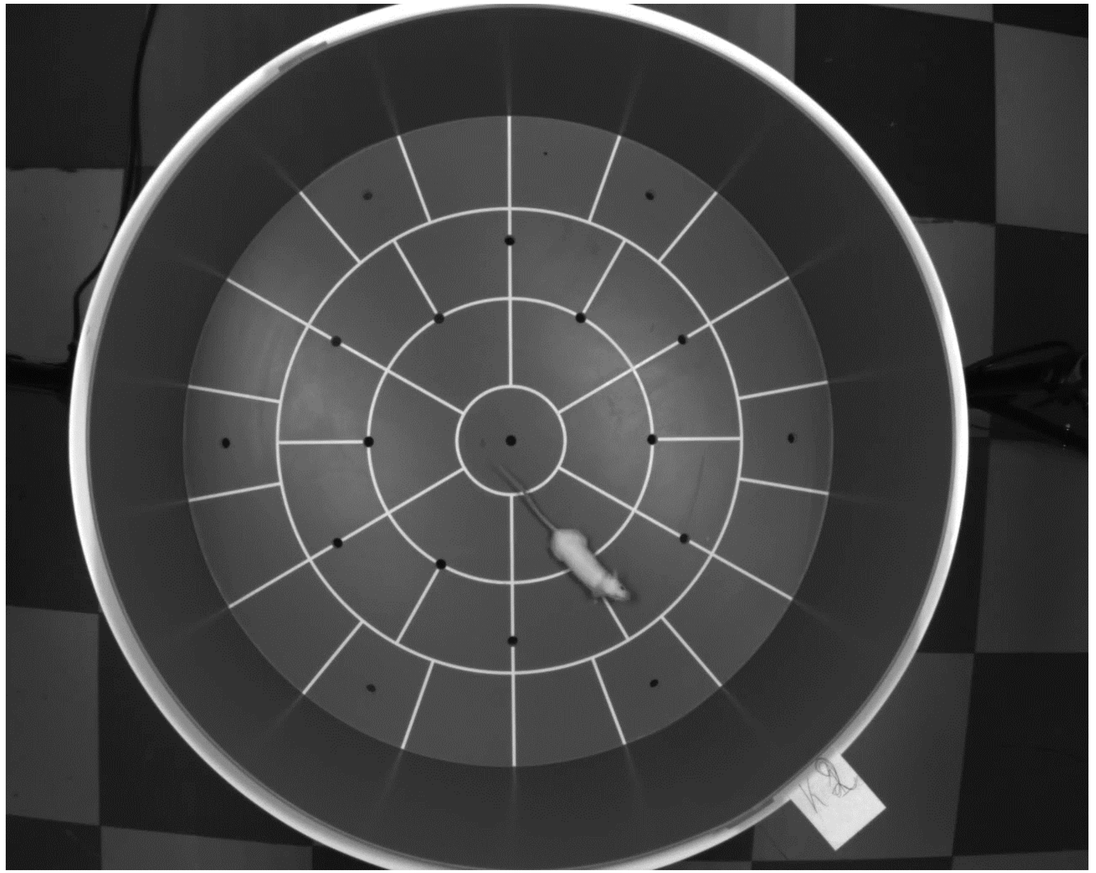


Support vertical stand

Basic behavior patterns in the Open Field test system

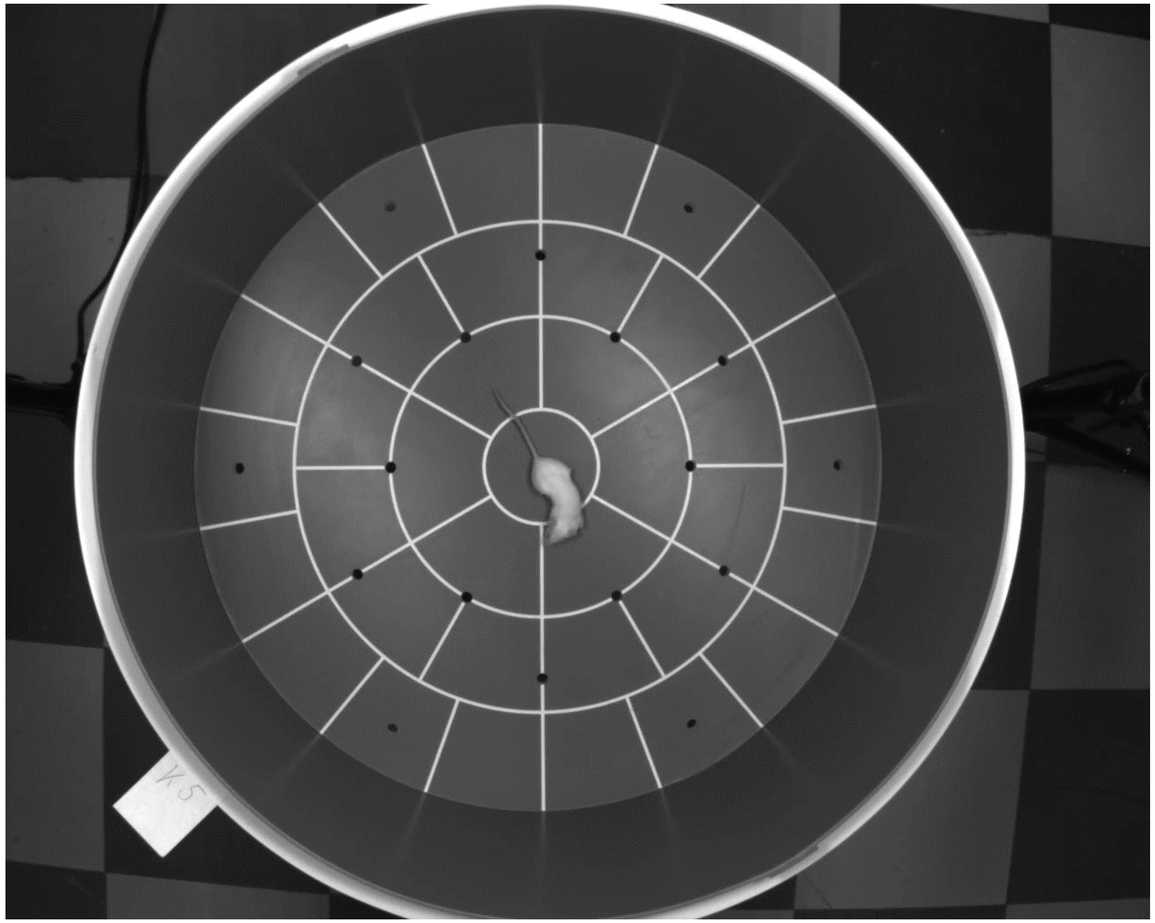


Port exploration



Free vertical stand

Basic behavior patterns in the Open Field test system

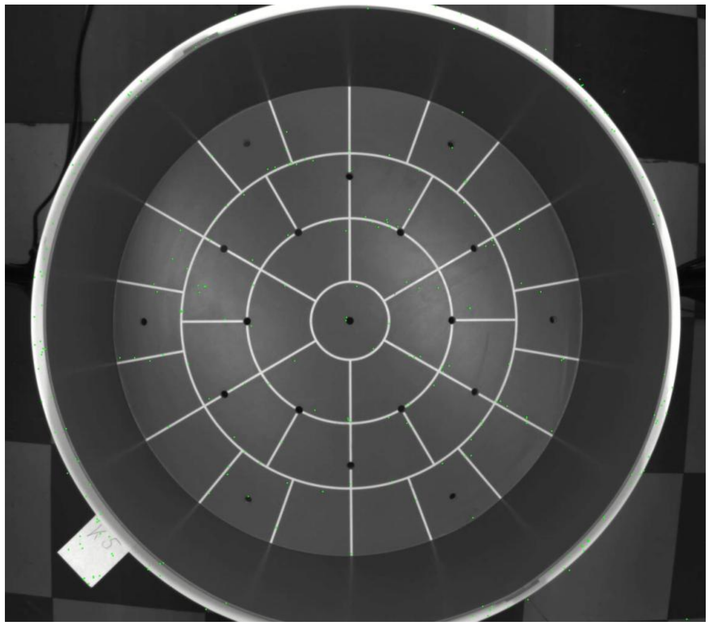


Freezing

Purpose and objectives of the work

Purpose of the work:

Development of software for the rodent experimental data analysis in the Open Field test system[1].



Open Field test system

Objectives of the work:

- ✓ Creating an annotated dataset (data annotation) for object detection
- ✓ Analysis of existing approaches and neural network models
- ✓ Training neural network models and analyzing their effectiveness
- ✓ Development of an algorithm for recording time intervals of behavior patterns

[1] OpenScience. (n.d.). Open Field test. Retrieved June 22, 2026, from https://www.openscience.ru/index.php?page=ts&item=001

Relevance of the work

Experiments conducted using the Open Field behavioral test system are a measurement tool of exploratory locomotor activity (eLMA), which is one of the most important numerical characteristics of animal behavior[2].

Another critical metric assessed in the Open Field test is center time — the total duration an animal spends in the central zone of the arena. While rodents naturally exhibit thigmotaxis (a preference for the periphery) and avoid the exposed center, center time serves as a primary behavioral index of anxiety-like behavior[3]. Increased center time is widely interpreted as a reduction in anxiety, whereas decreased center time reflects heightened emotionality and stress.

The level of exploratory motor activity allows us to assess the mental health, presence of diseases and stress level of animals, in particular, to assess the impact of various external factors, such as radiation, on behavior and physical condition.

The problem of altering behavior patterns of living organisms while exposed to radiation is critically important when planning long-term space missions involving humans.



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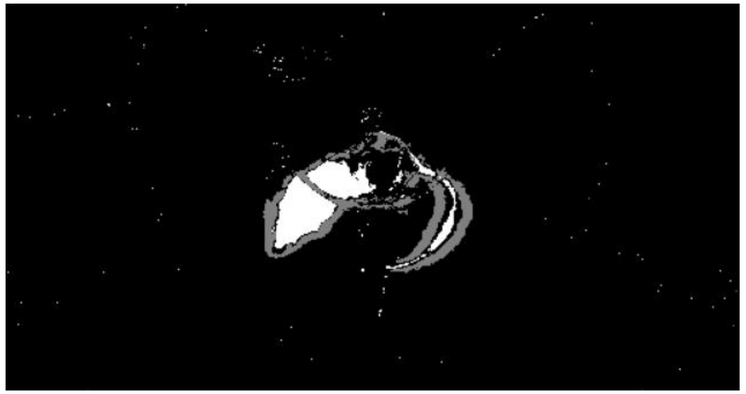
[2] Klinck , E. A. (1978). " Behavioral analysis of exploratory locomotor activity in rodents " . // Journal of Comparative and Physiological Psychology, 92(4), 850–857. DOI: 10.1037/h0077634

[3] Gould, T. D., Dao, D. T., & Kovacsics, C. E. (2009). The Open Field Test. Neuromethods. DOI: 10.1007/978-1-60761-303-9_1

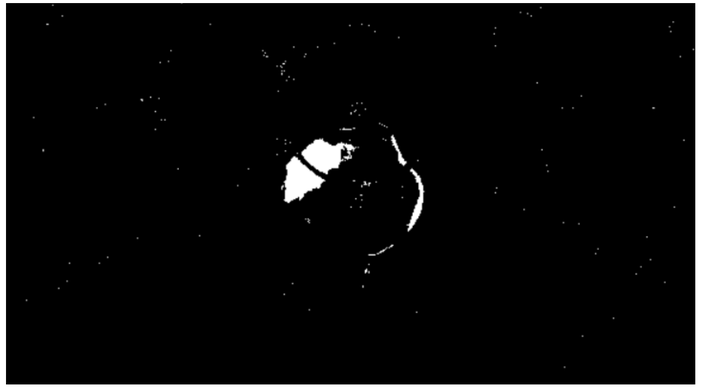
Application of classical CV algorithms to the task of object detection



Original video



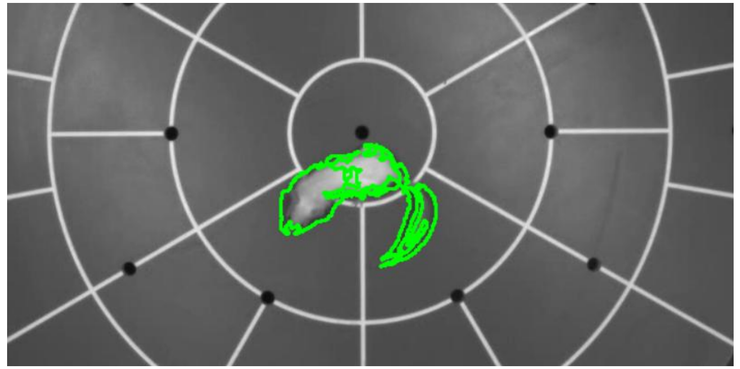
Background Subtraction



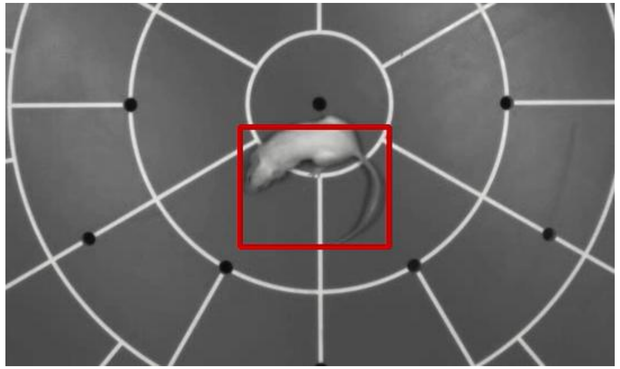
Global Thresholding



Erotion and Dilation

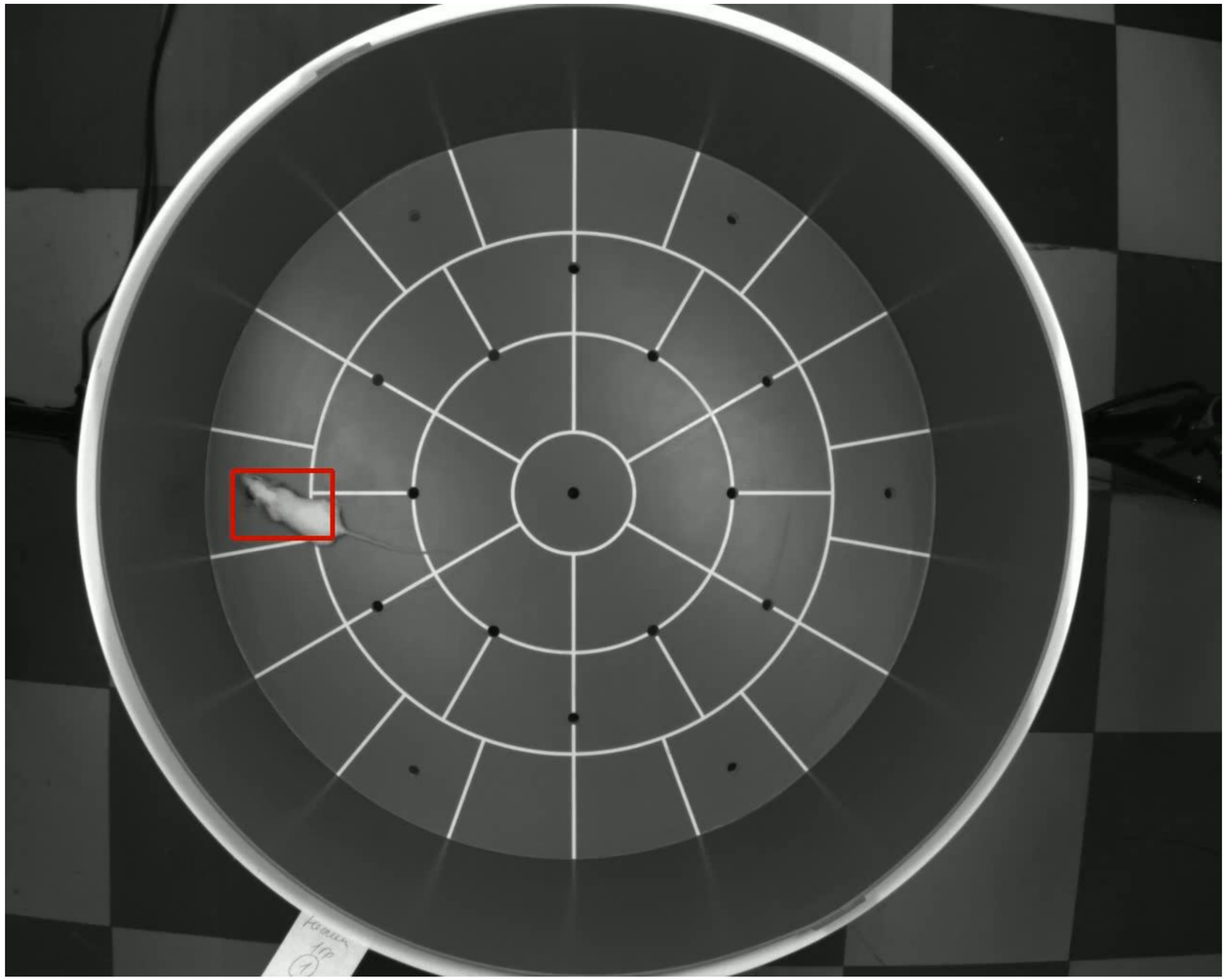


Countour Detection and Filtering



Bounding Box

Application of classical CV algorithms to the task of object detection



A brief review of the YOLO11 model

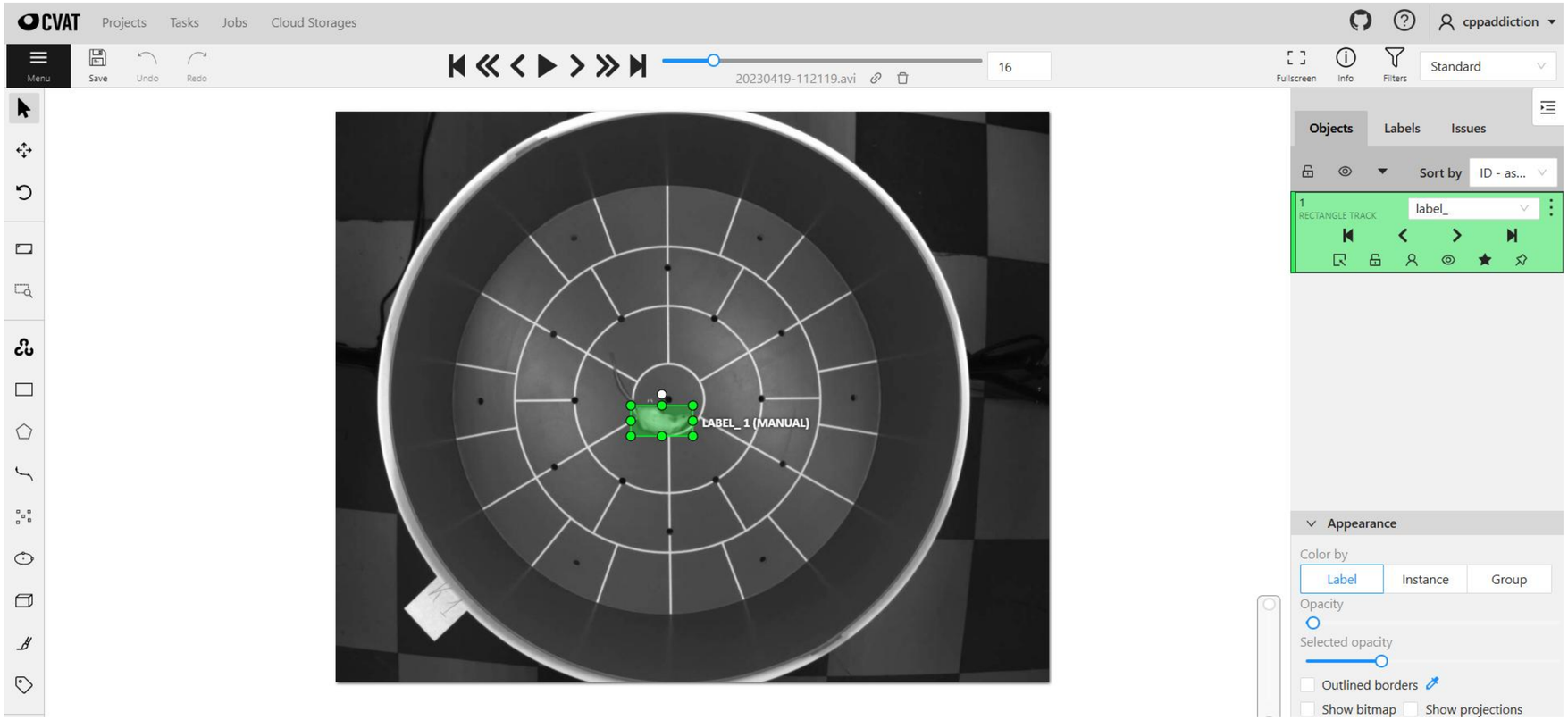
YOLOv11 (You Only Look Once) is a modern computer vision model for solving a wide range of problems , developed by the American company Ultralytics as a continuation of the YOLO model line.

YOLOv11 solves the following computer vision problems :

- ✓ Object Detection
- ✓ Instance Segmentation
- ✓ Classification
- ✓ Object tracking
- ✓ Pose Estimation

MODEL TYPE	APPLICATION
YOLO v11n	lightweight local testing/annotation validation
YOLO v11s	real-time applications
YOLO v11m	speed/accuracy balance
YOLO v11l	high precision
YOLO v11x	maximum accuracy

CVAT – Computer Vision Annotation Tool



For annotated dataset creation a version of CVAT on HybriLIT heterogeneous digital environment[4] was used.

The total number of 100 video frames has been annotated.

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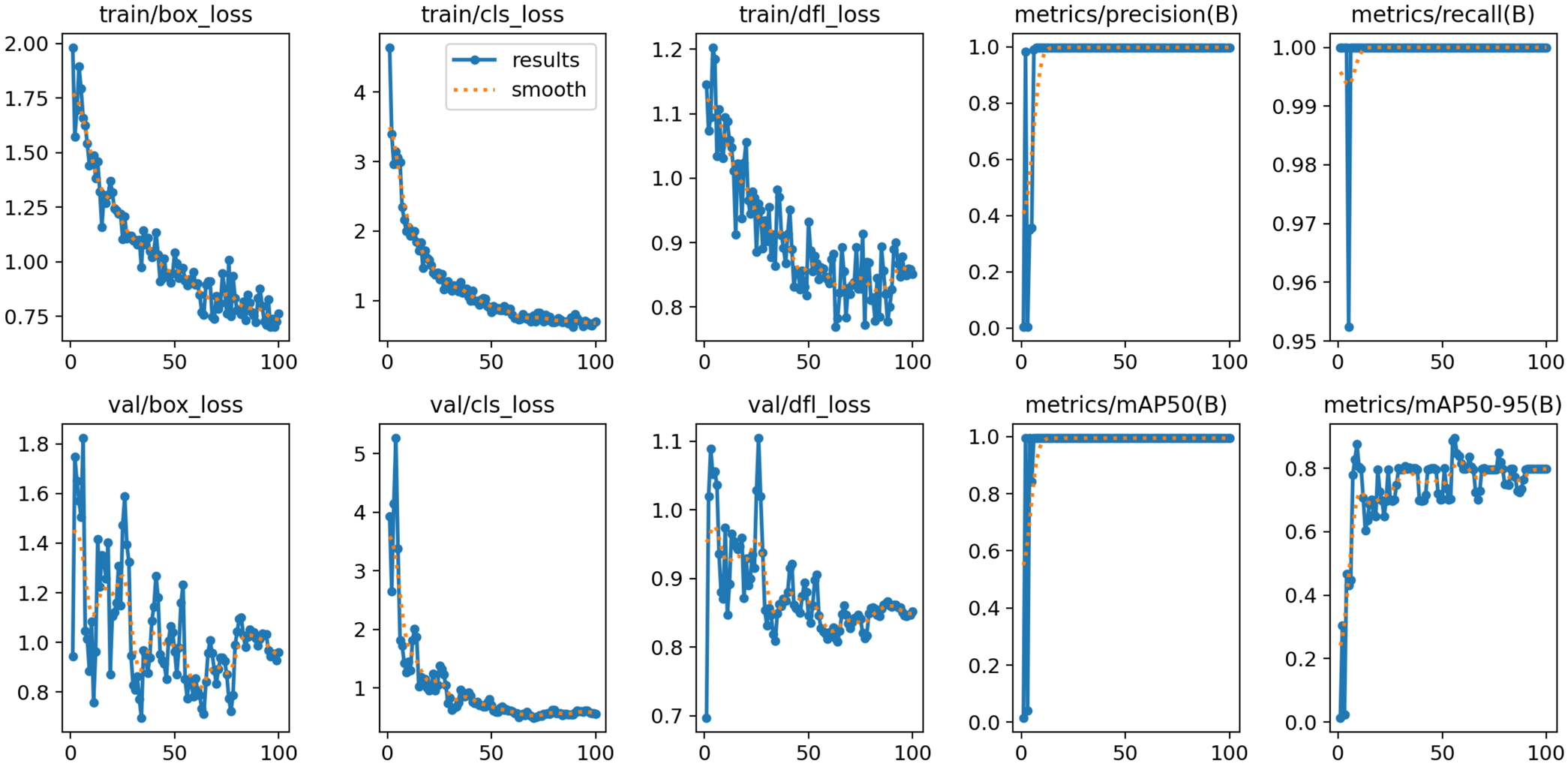
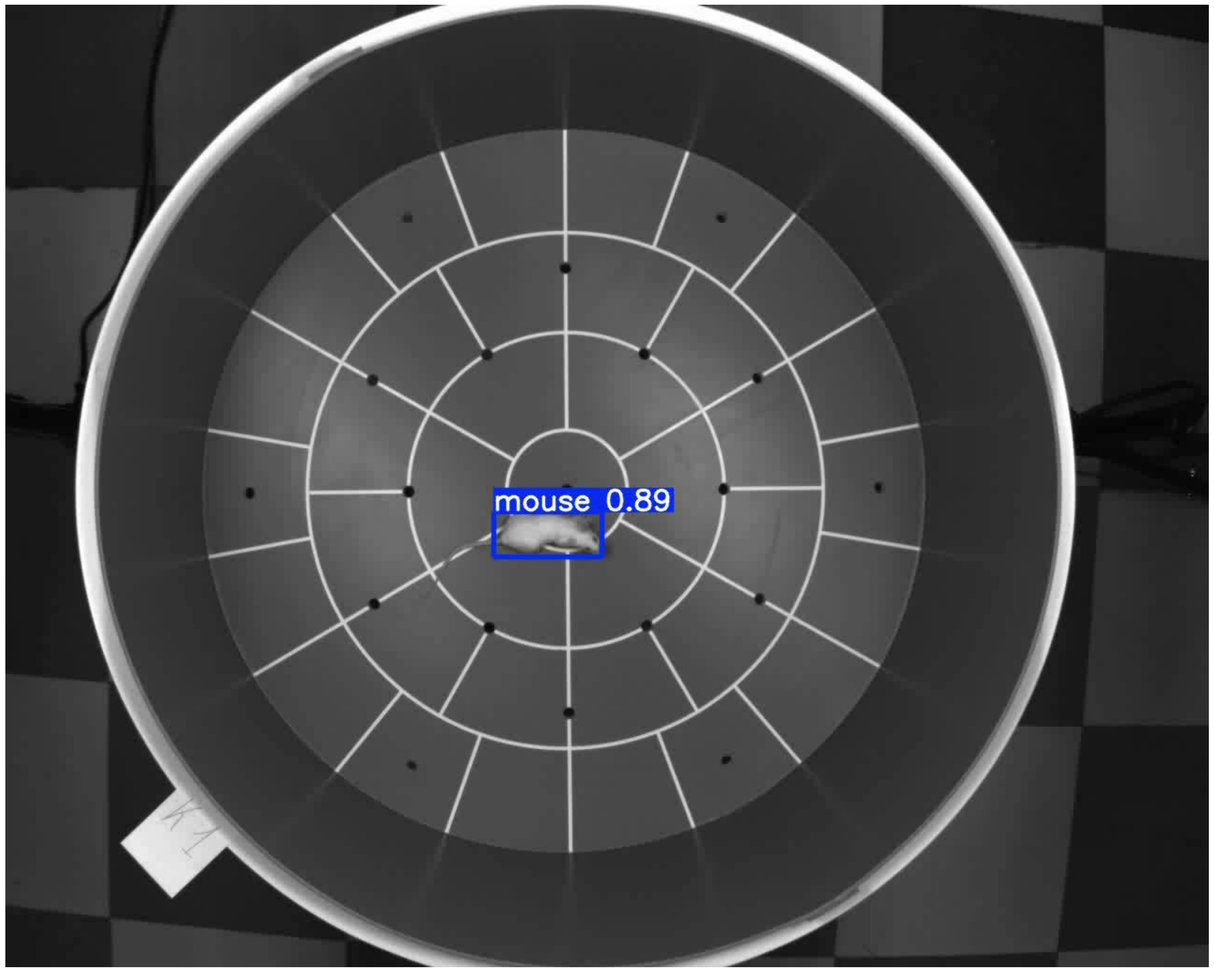
[4] HybriLIT. (n.d.). HybriLIT heterogeneous digital environment. Retrieved June 22, 2026, from http://hlit.jinr.ru/

YOLO11 training results



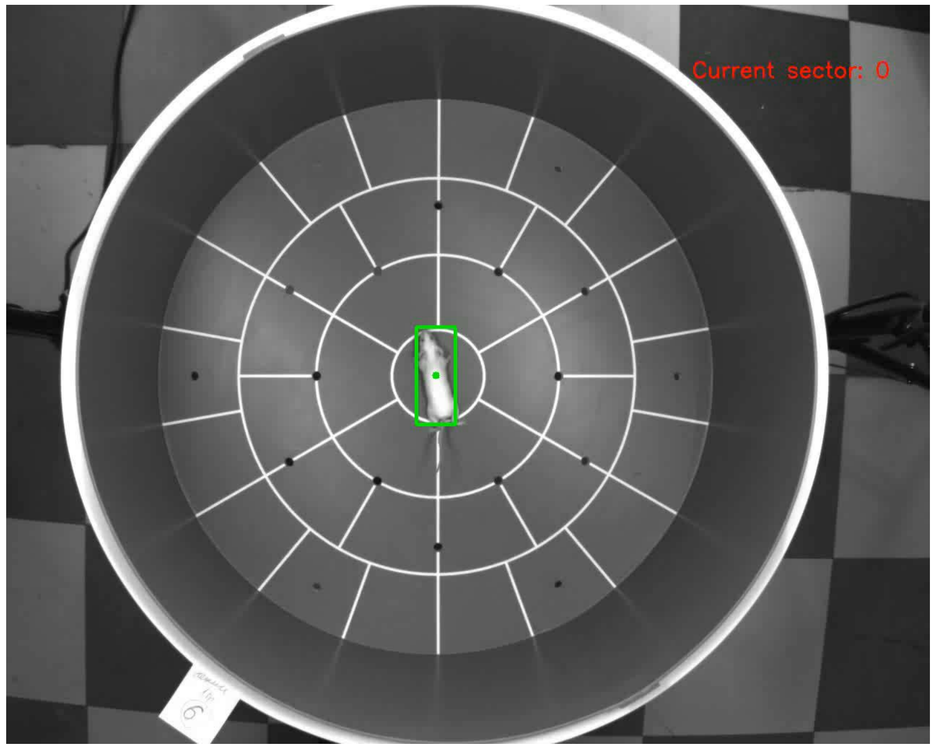
Results of applying the YOLO11 model to the task of object detection

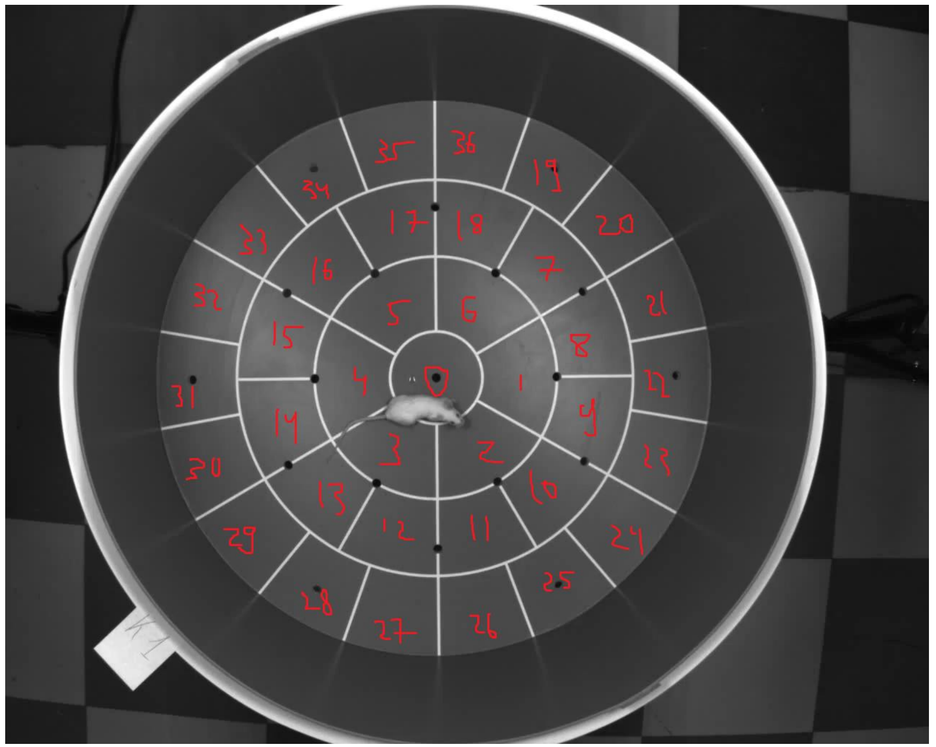


The confidence score displayed alongside the bounding box is a dynamic computational output of the YOLOv11 model, derived in real time during forward propagation. It quantifies the model's overall certainty regarding a given prediction. Specifically, this score represents the combined probability that (1) the proposed bounding box encloses a meaningful object, and (2) said object belongs to the target class (in my case, "mouse"). The resulting confidence value is the product of:

1. Objectness score – how likely the box contains any object.
2. Class probability – given an object, how likely it is the specific class.

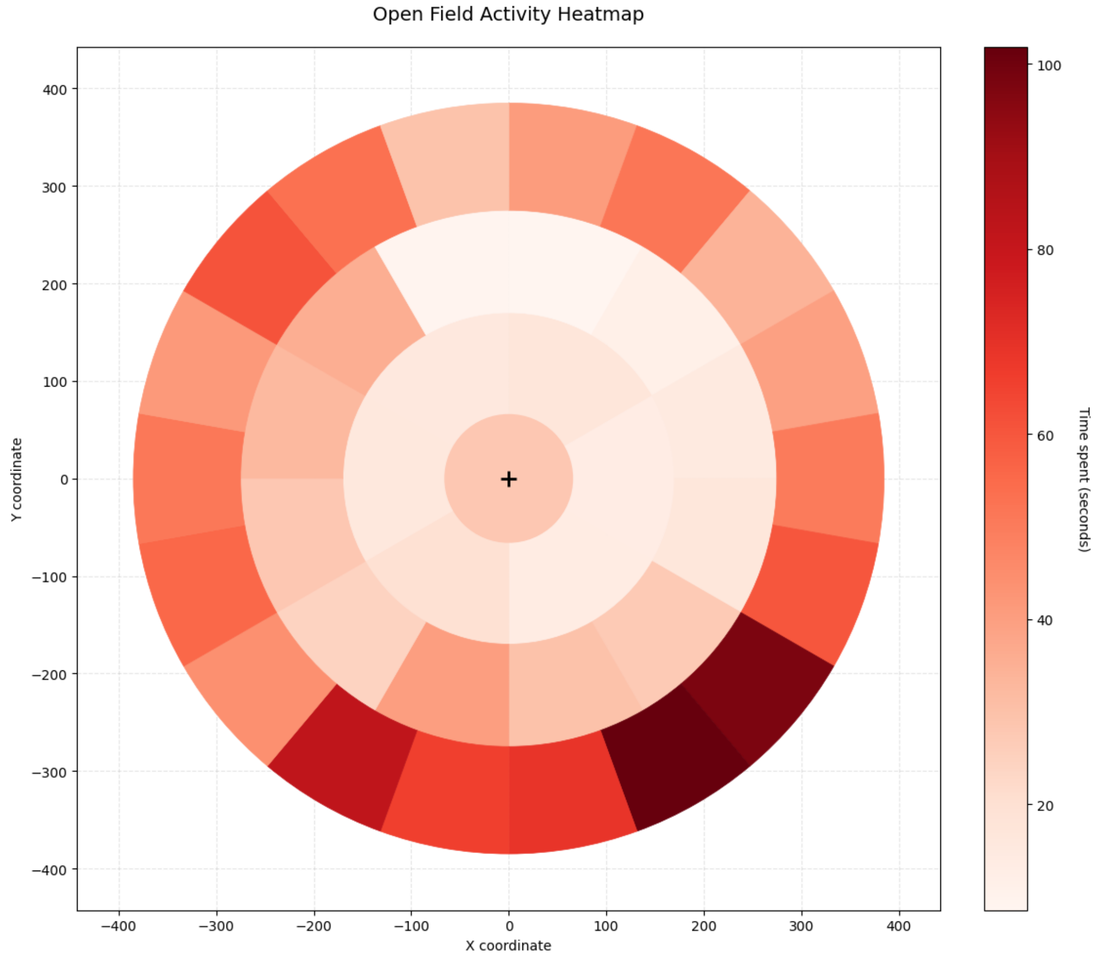
Results of applying the YOLO11 model to the task of object detection



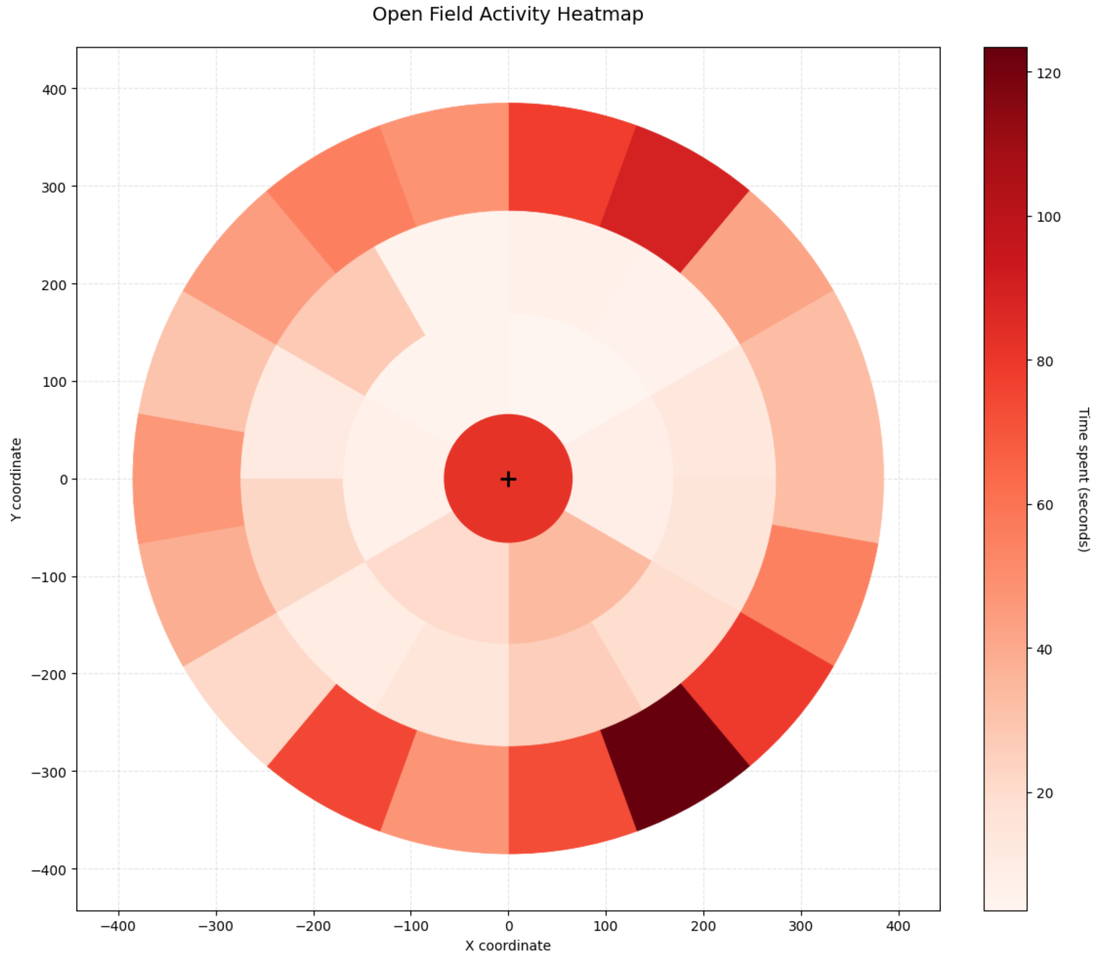


Developed YOLO11-based algorithm allows us to preform an accurate sector-based detection of the laboratory animal along with building visualization of the total time spent by an animal in the central, peripheral and border area respectively.

Rodent Open Field Activity Heatmap

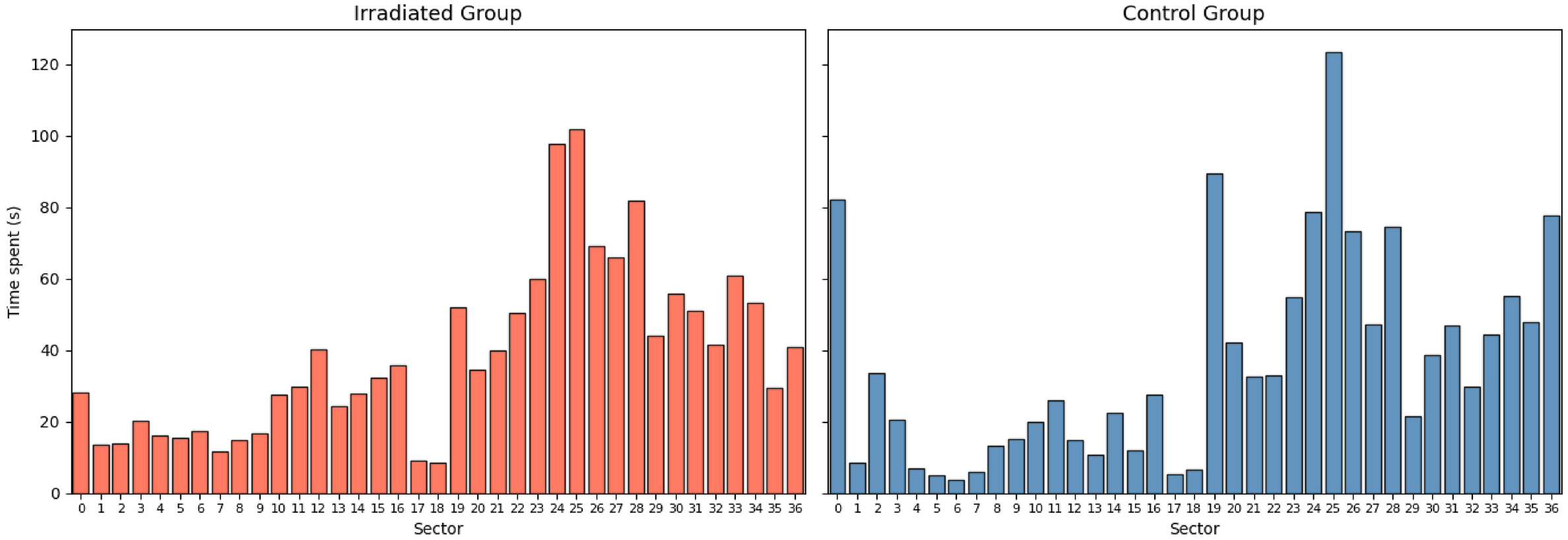


Irradiated group, heatmap visualization of total time spent in each sector for 6 different animals



Control group, heatmap visualization of total time spent in each sector for 6 different animals

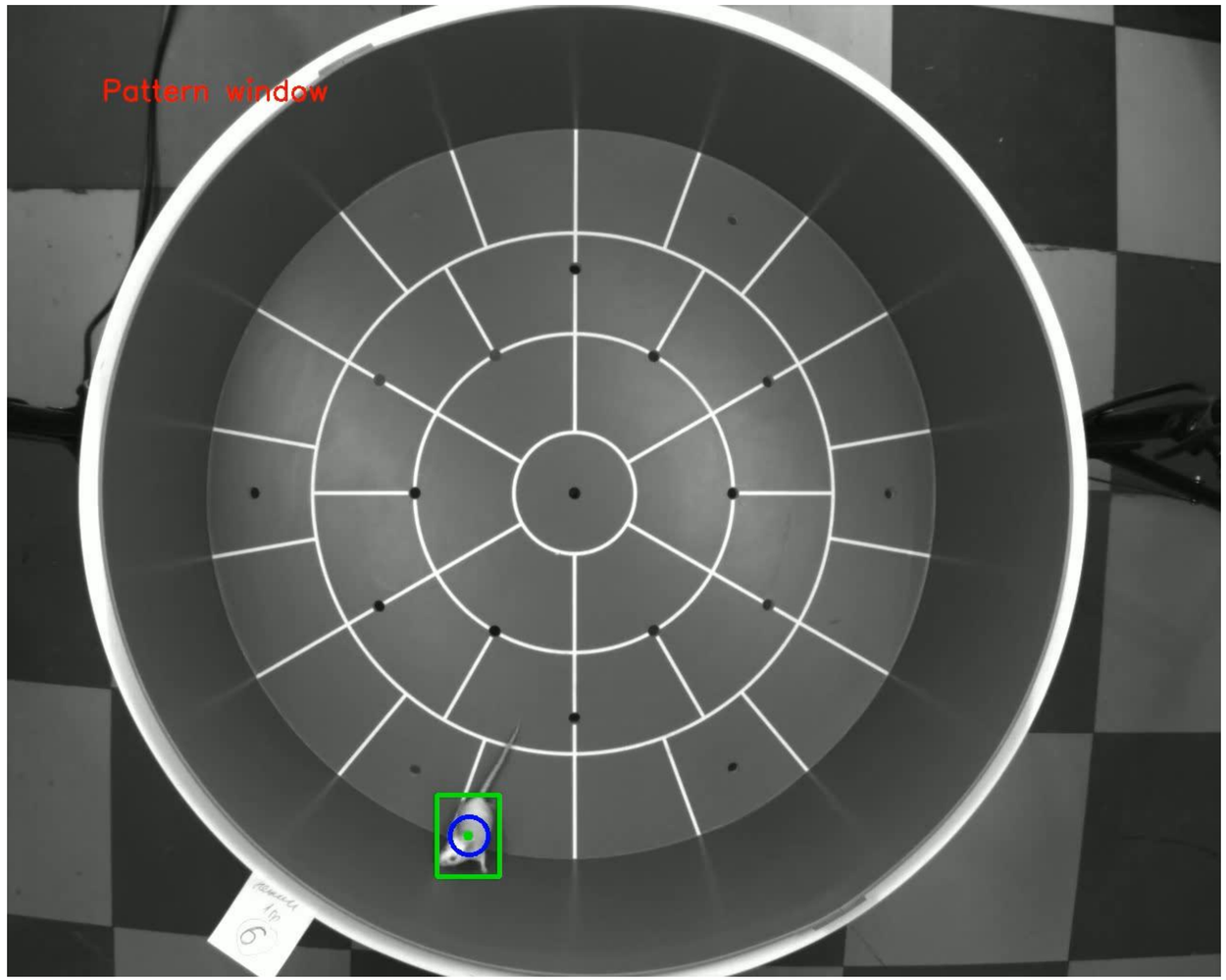
Rodent Open Field Activity Distribution



Irradiated group, distribution visualization of total time spent in each sector for 6 different animals

Control group, distribution visualization of total time spent in each sector for 6 different animals

Identifying «Pattern window»

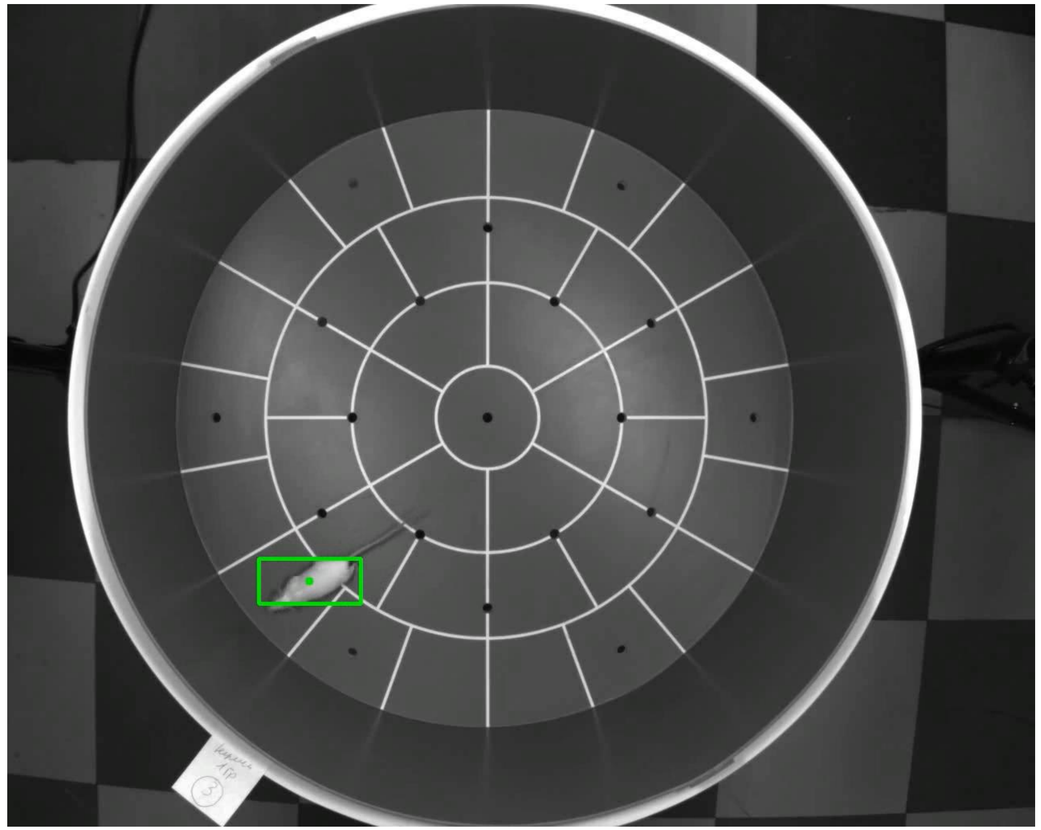


«Pattern window» is a **time interval** in the original video where potential behavior pattern can occur. In order to correctly identify them, 2 control parameters were adjusted:

- **R** - neighborhood radius. Geometric center of a bounding box is embedded into a neighborhood with a fixed radius R.
- **D** – delay. Tells us whether we should mark this interval as a potential behavior pattern or not based on how much time geometric center was fully covered by the neighborhood without crossing the border (blue line). If the border was crossed, neighborhood area moves accordingly, changing its center to the intersection point.

Results of deriving «Pattern window» time intervals from the original video

Based on neighborhood-delay technique 6 different videos from irradiated group have been analyzed. The following table contains % of correct «Pattern window» detections for each video respectively, where time intervals corresponding to specific behavior patterns have been found.



VIDEO	% OF CORRECT «PATTERN WINDOW» DETECTIONS (R=20, D=15)	% OF CORRECT «PATTERN WINDOW» DETECTIONS (R=30, D=20)
1	10/14 (71%)	**11/14 (79%)**
2	14/18 (78%)	**10/12 (83%)**
3	15/18 (83%)	**16/19 (84%)**
4	18/20 (90%)	**10/12 (83%)**
5	17/20 (85%)	**14/16 (88%)**
6	6/9 (67%)	**4/7 (57%)**

Conclusion

Classical CV algorithms and deep learning models were applied for rodent experimental data analysis in the Open Field laboratory setup. The following key steps have been achieved:

- Classical CV algorithms have shown capacity to preform basic detection and tracking of an animal using the MOG2 background subtraction algorithm, filtering, and countour detection.
- In order to achieve higher detection accuracy for future behavioral pattern recognition and eliminate the problem of vanishing bounding box while using MOG2 due to the absence of movement of a laboratory animal, an annotated dataset was created and a deep learning model (YOLO11) was applied. This approach has significantly improved tracking of a laboratory animal.
- The system under development is currently capable of accurately identifying the sector in the Open Field test system corresponding to the automatic bounding-box-center-based detection of a laboratory animal and measuring the time spent by an animal in each sector, followed by the construction of the Open Field activity heatmaps/distributions and identifying time intervals in the original video corresponding to the «Pattern window».

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