Approaches to the analysis of experimental data on small laboratory animals

Inna Kolesnikova [2,3]

Yu.S. Severiukhin[2,3], Kr.N. Golikova[2], D.M. Utina[2],

O.I. Streltsova[1,3], A.I. Anikina[1], A.V. Nechaevsky [1,3], M.I. Zuev [1], T. Bezhanyan[1,3], S.Shadmehri[1]
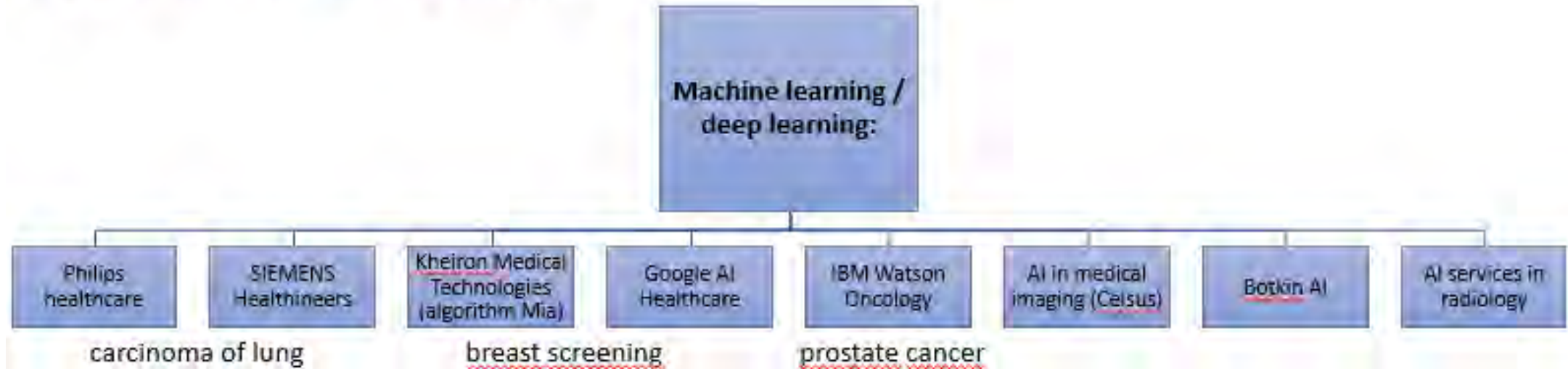
[1] *Meshcheryakov Laboratory of Information Technologies, JINR*

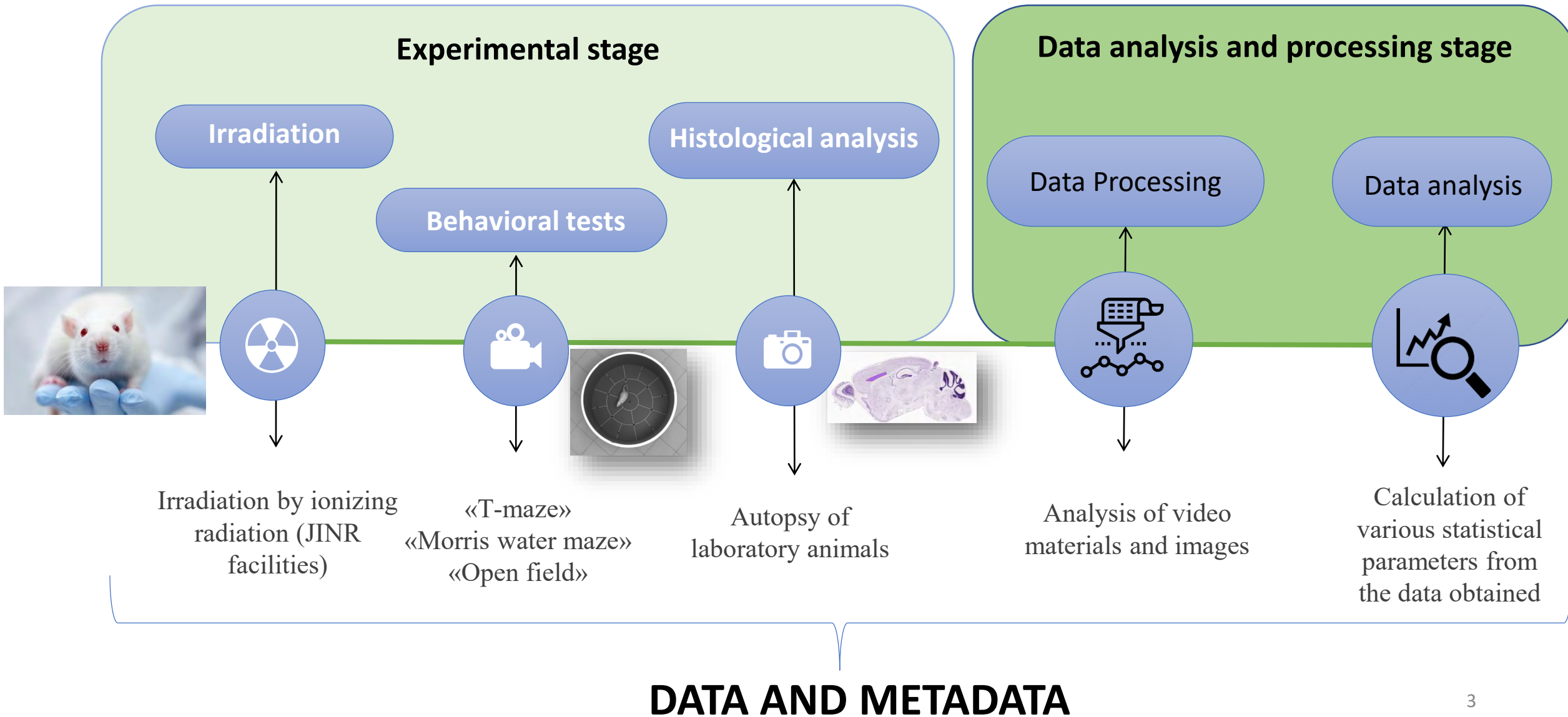[2] *Laboratory of radiation biology, JINR*

[3] *Dubna State University*

RELEVANCE

IT for biological tasks

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                          │ Machine learning /│
                          │  deep learning:   │
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| Philips healthcare | SIEMENS Healthineers | Kheiron Medical Technologies (algorithm Mia) | Google AI Healthcare | IBM Watson Oncology | AI in medical imaging (Celsus) | Botkin AI | AI services in radiology |

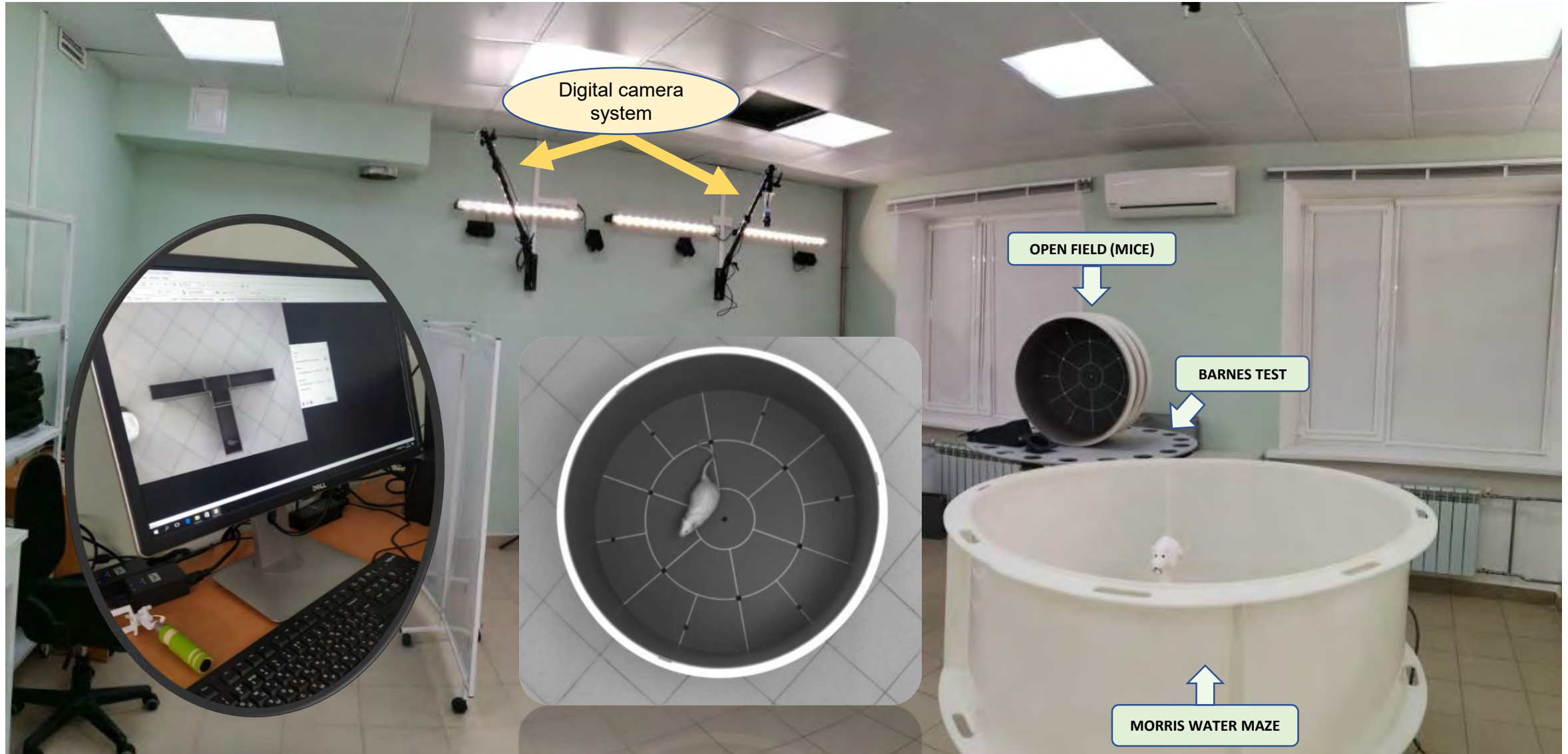carcinoma of lung   breast screening   prostate cancer

- Now the accuracy is >93% (mammography, fluography)
- The use of ML systems accelerates the description of mammographic examination by 30-40%.
- ML provides a significant (by 15-25%) increase in the accuracy of predicting cancer predisposition, relapses and mortality.
- According to the results of AI testing to detect breast cancer, the time to describe the study is reduced by 15-50%.
- DL can not only accurately distinguish between the two most common subtypes of lung cancer, adenocarcinoma and squamous cell carcinoma, but also predict mutated genes from images.
- etc.

General scheme of our experiments

Experimental stage

Data analysis and processing stage

Irradiation

Behavioral tests

Histological analysis

Data Processing

Data analysis

Irradiation by ionizing radiation (JINR facilities)

«T-maze»
«Morris water maze»
«Open field»

Autopsy of laboratory animals

Analysis of video materials and images
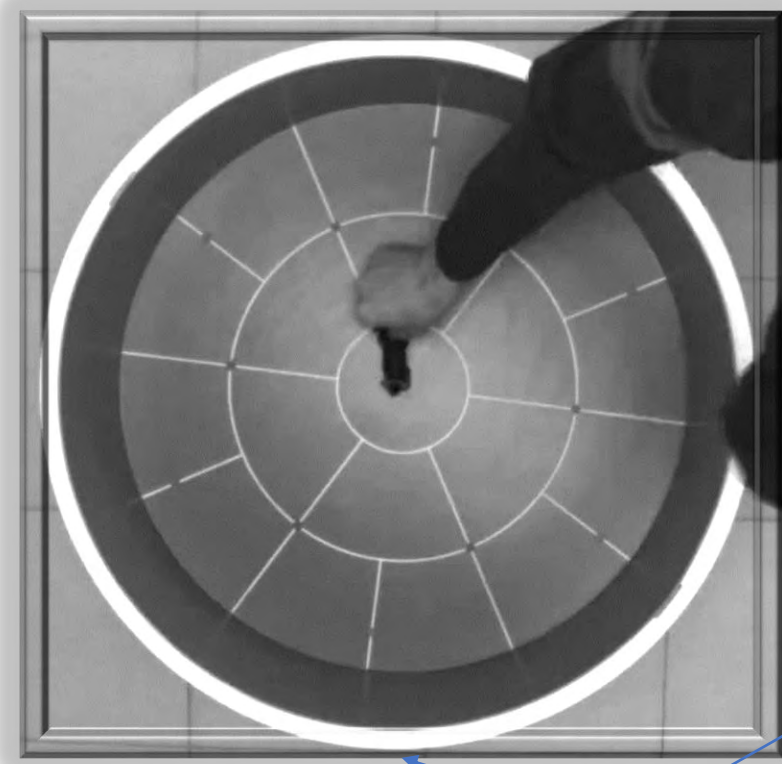
Calculation of various statistical parameters from the data obtained
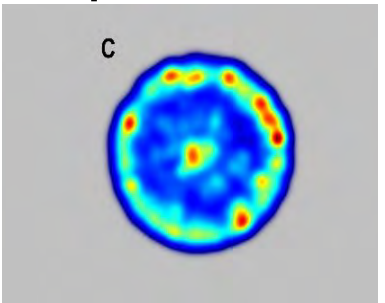
DATA AND METADATA

Behavioral laboratory room

Behavioral analysis

3 min	Grooming	Sectors crossings	Center entrance	Stand ups	Hole dipping	Freezing
Control	8		7		5	
Irradiated	5	4	6	3	4	0
6 min						
control	5	1	4			1
Irradiated	2	5	4		7	1

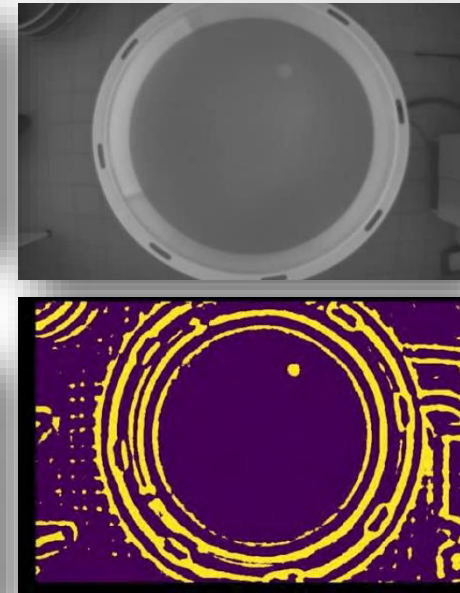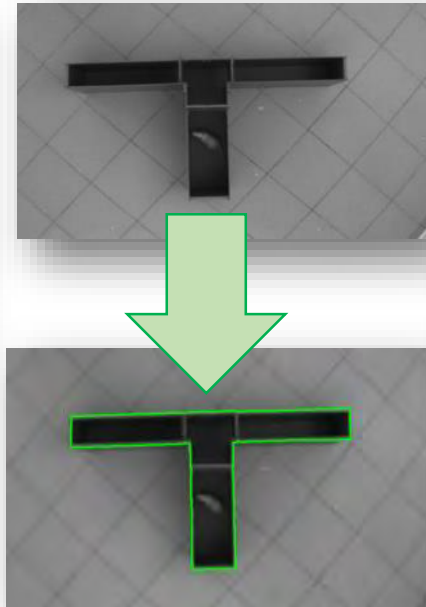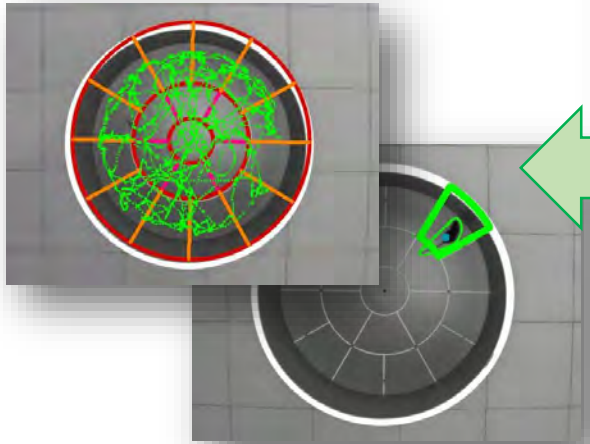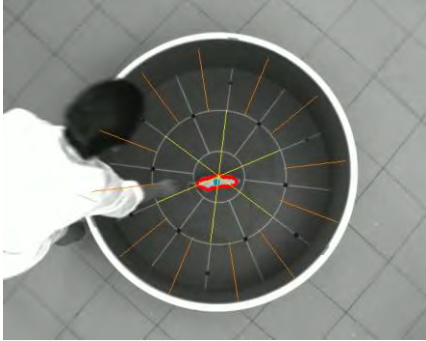EthoVision XT

Distance moved - Total
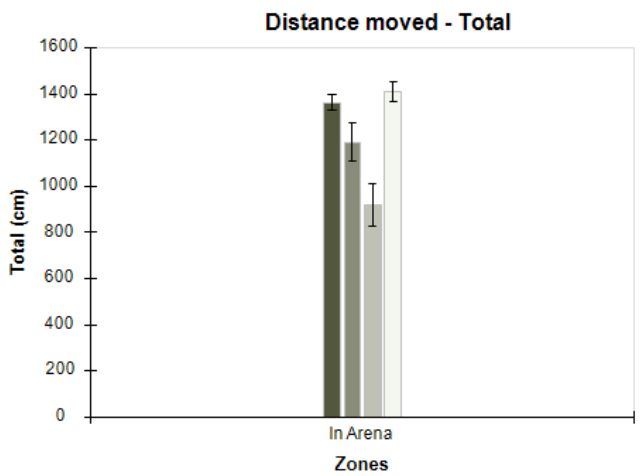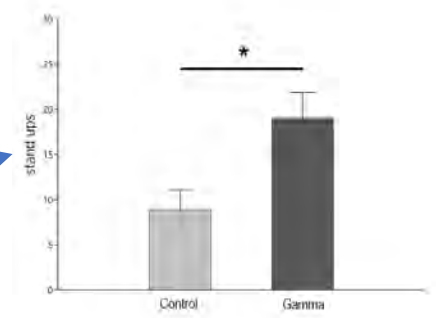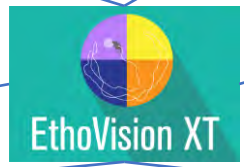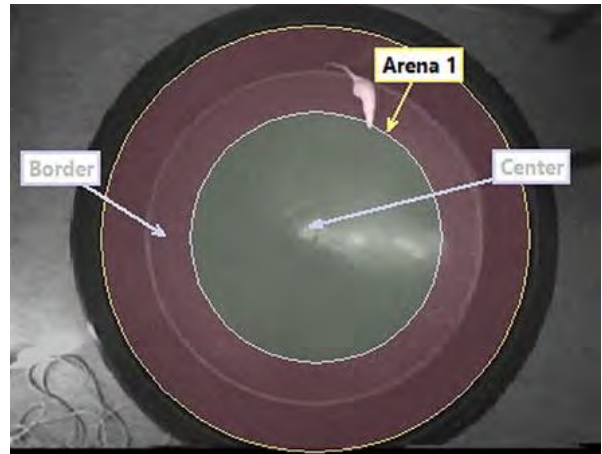
Tracking

Heatmap
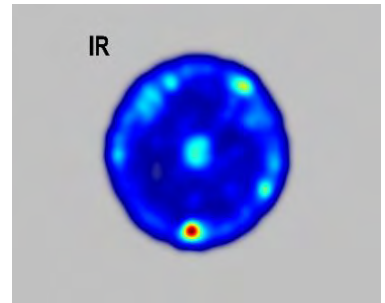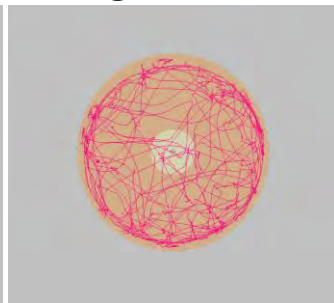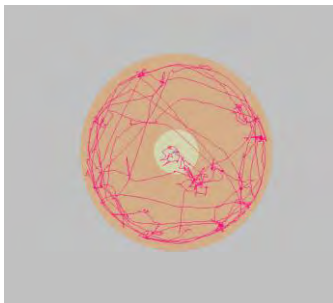
Tasks of the algorithmic block of the Information System
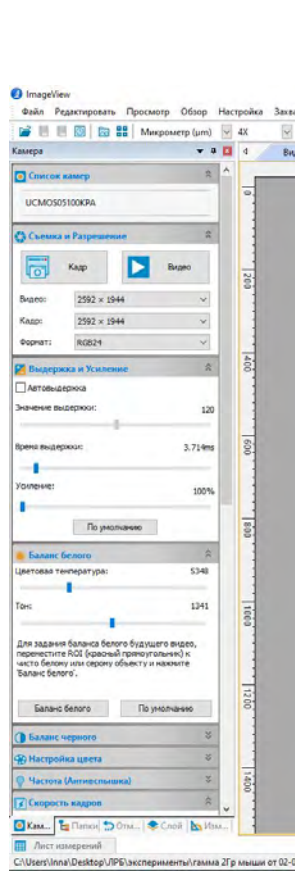

Behavioral part:

- Analysis of the experimental field markup
- Tracking the position of the animal as part of the experiment
- Classification and determination of the type of animal activity
- Etc.
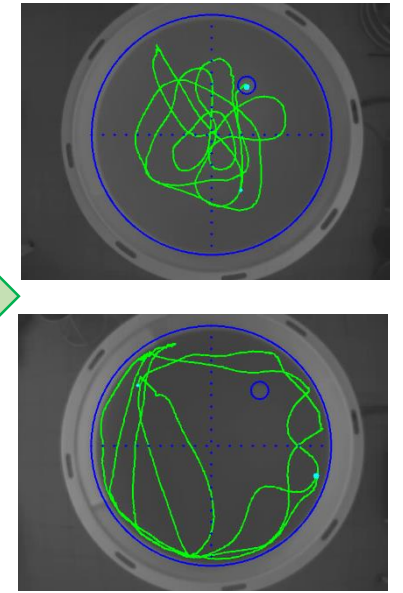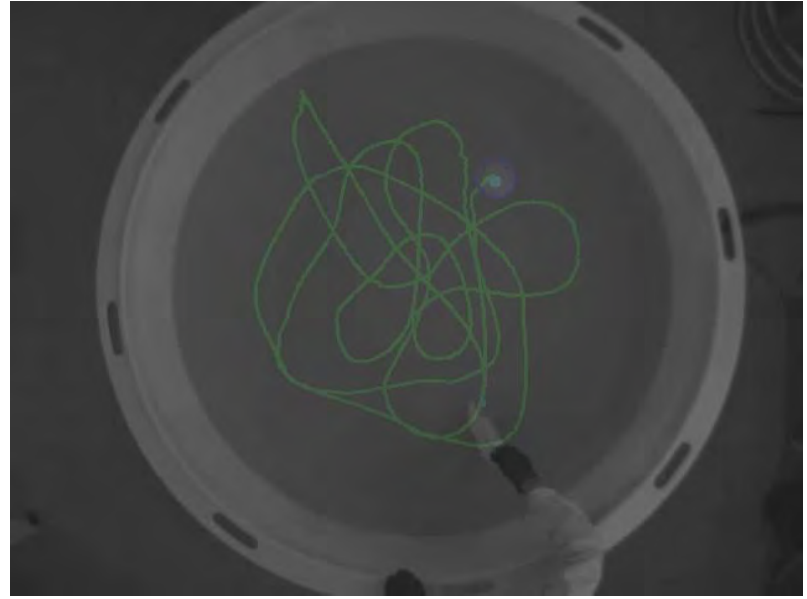
Tools for histological analysis

Camera

Microscope

ImageJ

Software Tou

Pictures of m
~10 pics of h

Comprehensive analysis of biological data + IT
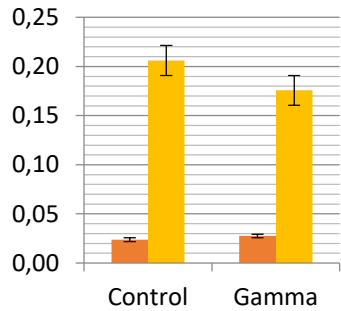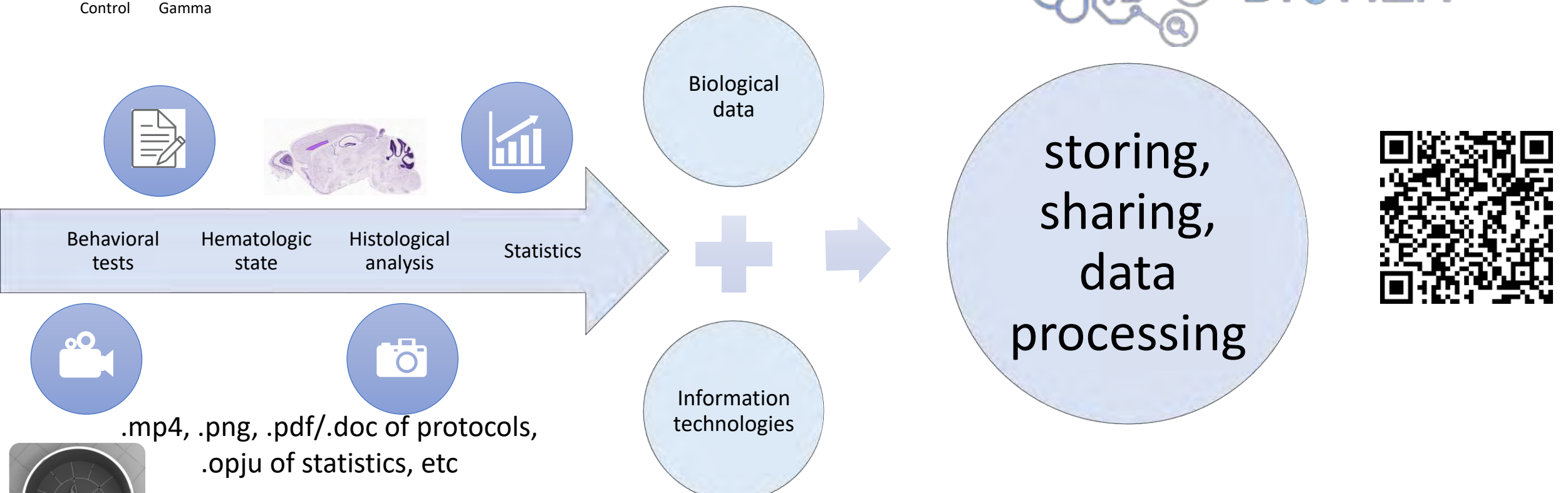
Artificial intelligence cannot replace specialists. But it can become an excellent tool for data mining.

Webapp

Metadata DB

BIOHLIT
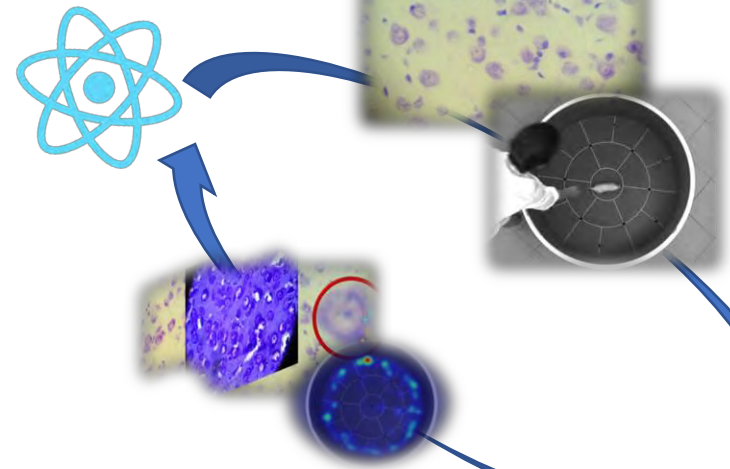
Supercomputer "Govorun"

metadata

Train,
Inference,
Results

Jobs,
resource
allocation

Images,
Videos, data

API-Server

Auth data,
credentials

Train,
Inference,
Dev

HLIT-storage, JINR EOS

Auth

Batch-system

ML\DL ecosystem

Approaches to solve the issues

Histological part:

№		healthy	altered	degenerated
1	control	20.4±8.85	66.9±12.0	10.1±3.97
2	irradiated	14.8±4.62	68.2±3.91	15.7±4.57*

Deep learning

Computer view

Computer vision & deep learning

Behavioral part

Computer vision & data analisis

3 min	Grooming	Center entrance	Stand ups	Hole dipping
Control	1.1±0.5	3.8±2.5	7.2±5.9	4.1±2.0
Irradiated	1.3±0.6	3.4±1.9	11±5.9	**6.1±2.2***
6 min				
Control	1.3±0.6	3.6±2.3	8.9±4.7	3.0±1.3
Irradiated	0.8±0.5	4.3±2.9	**19±6.5***	4.6±3.1
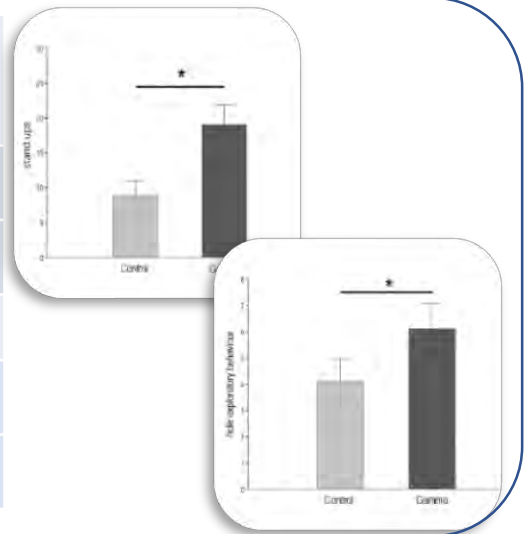
Algorithmic block
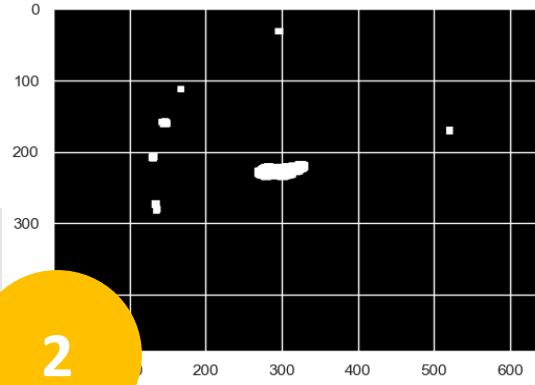## for analyzing video data from experiments on the Morris Water Maze
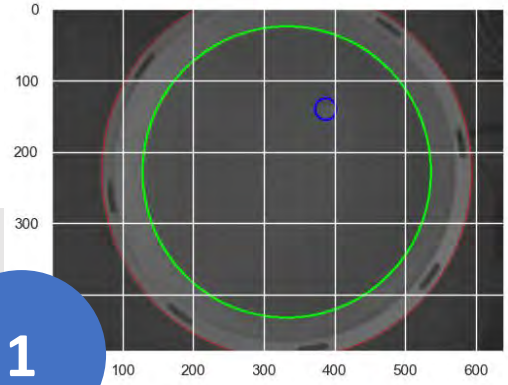
1

Setup field marking
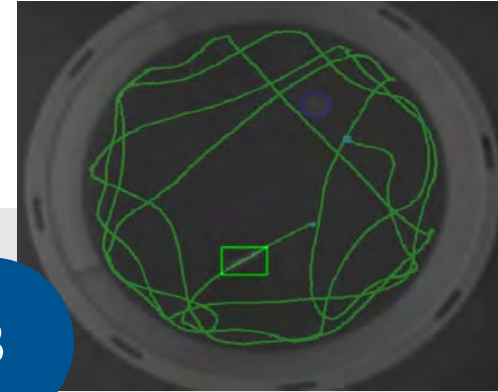- External and internal boundaries of the pool
- Platform Area Detection

CV: Filtering and Hough transformation
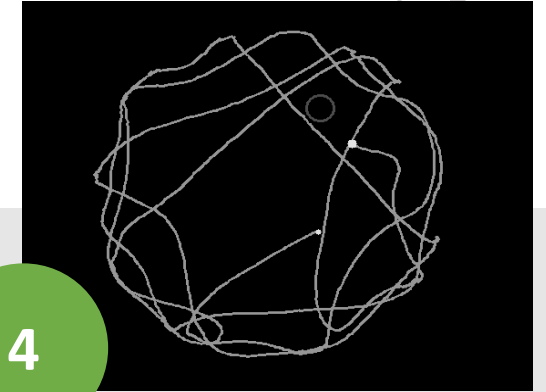
2

Object detection
CV: background subtraction,
Filtering
Binarization
edge extraction

3

Local tracking
- Detect an object on the first frame
- Determine local area centered on the point of the object`s CM
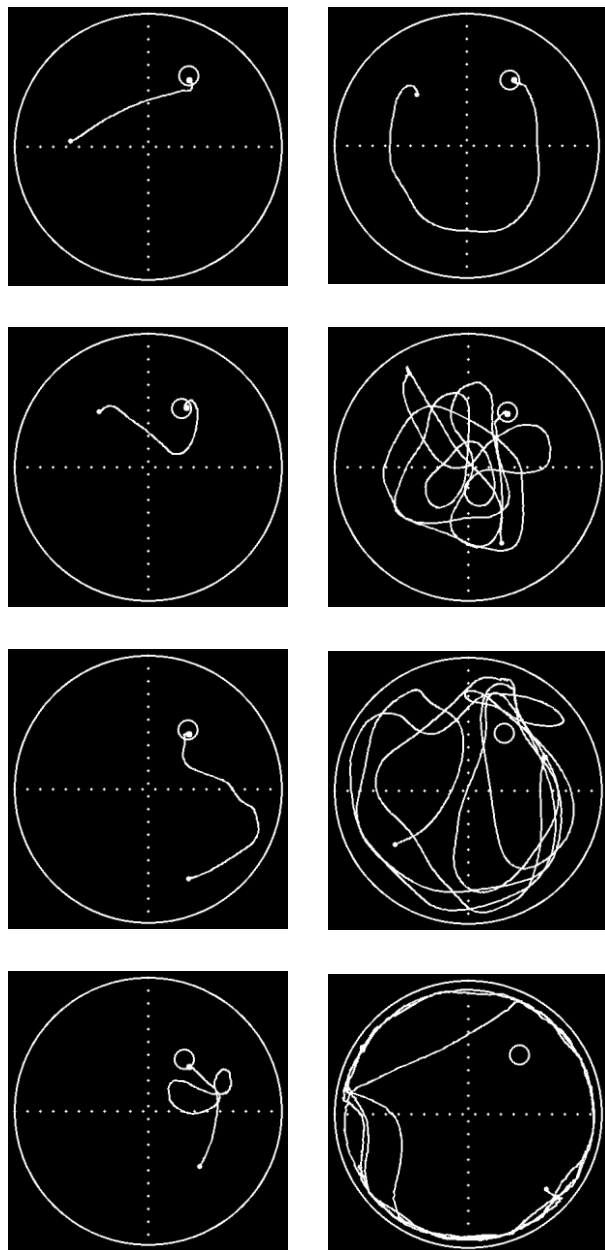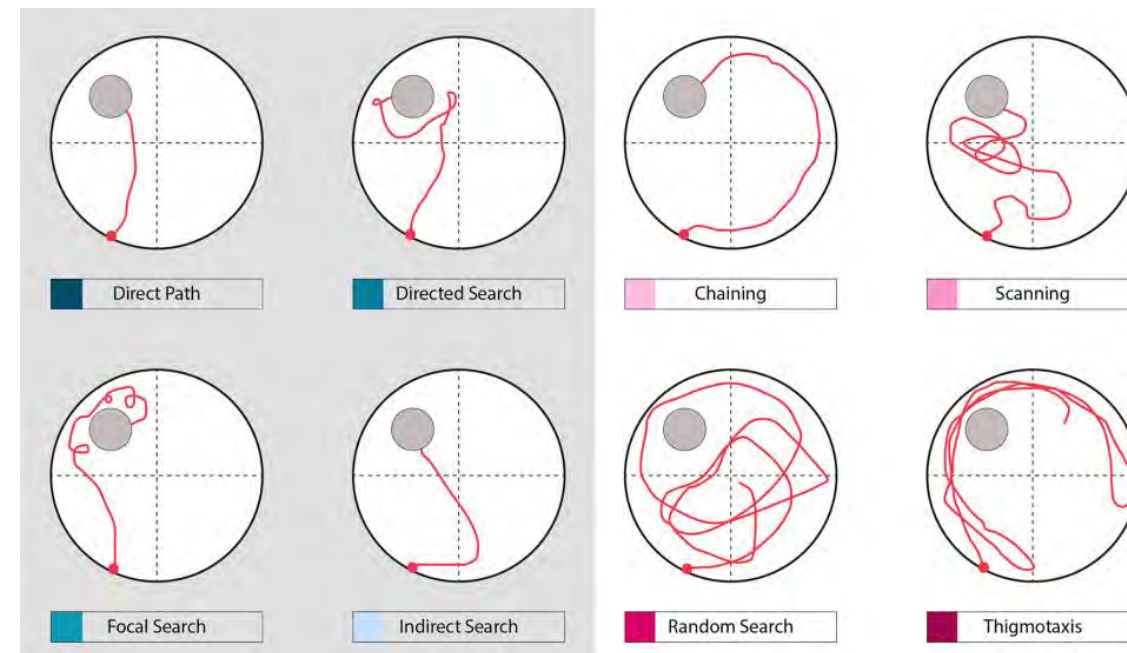- Detect the object in the next frame

4

Dataset: Trajectories For classification tasks
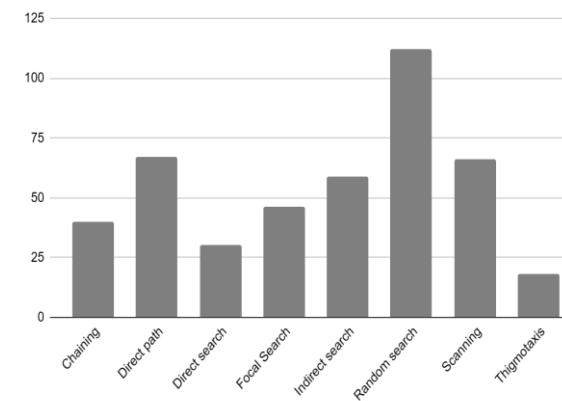Marking the pool border, mouse, start and finish points, the mouse and its trajectory
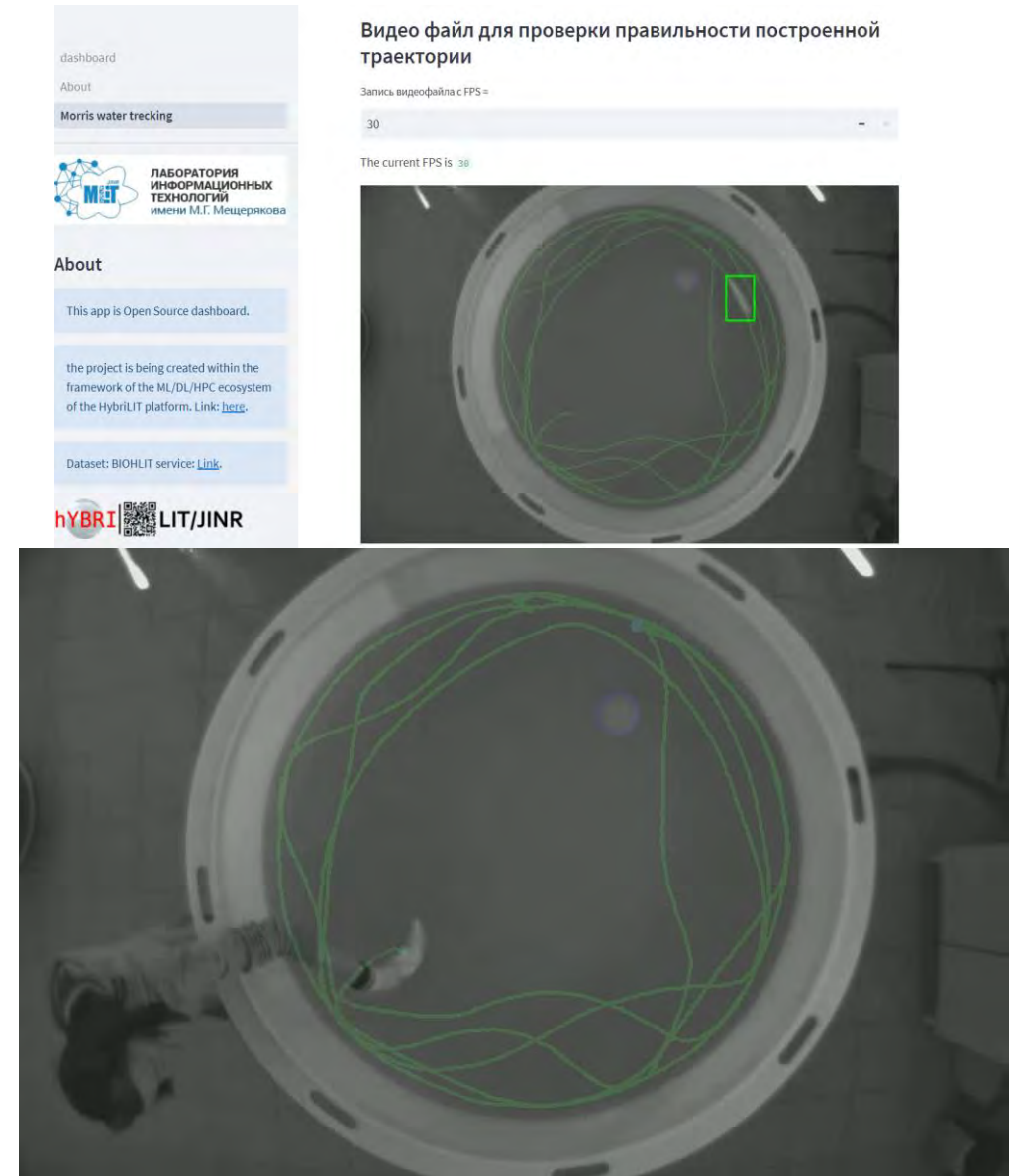
Algorithmic block: 8-class classification problem
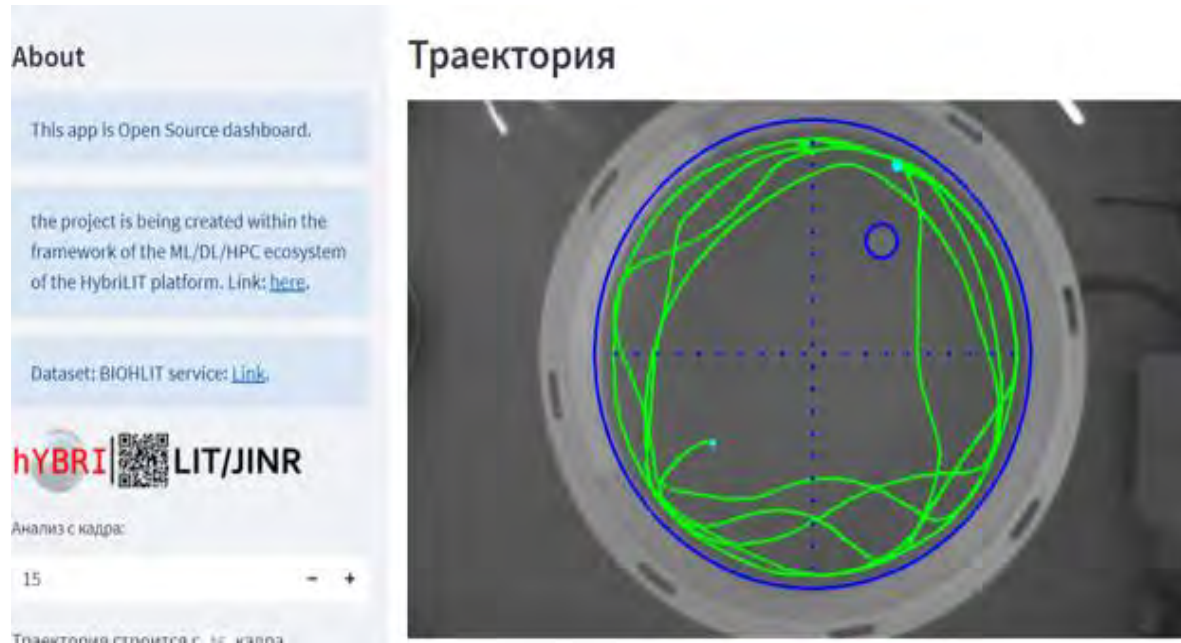

Convolutional Neural Network

- Direct Path
- Directed Search
- Chaining
- Scanning
- Focal Search
- Indirect Search
- Random Search
- Thigmotaxis

➤ Now: **Significant imbalance
(8 classes)**
(~ 475 images)
**Conduct more experiments**

Web service for «Morris Water Maze» behavioral test

We are developing a Web service for the trajectory analysis of laboratory animals in the «Morris Water Maze» behavioral test

- ✓ Developed and tested algorithm for trajectory construction
- ✓ Received trajectories are annotated
- ✓ Created a dataset for classification
- ✓ Currently improving our Web service to classify the trajectories

Histological part: Algorithmic block
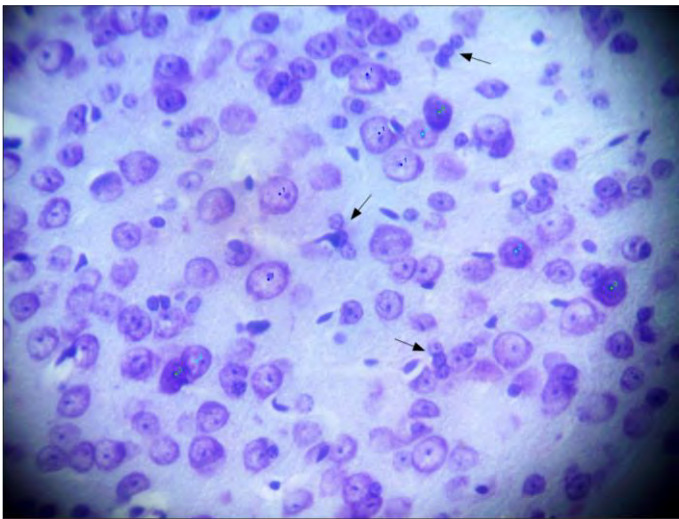
I. Whole image analysis approach:
For the instance segmentation task **U-net** neural network architecture is well suited. However, the required accuracy was not achieved.
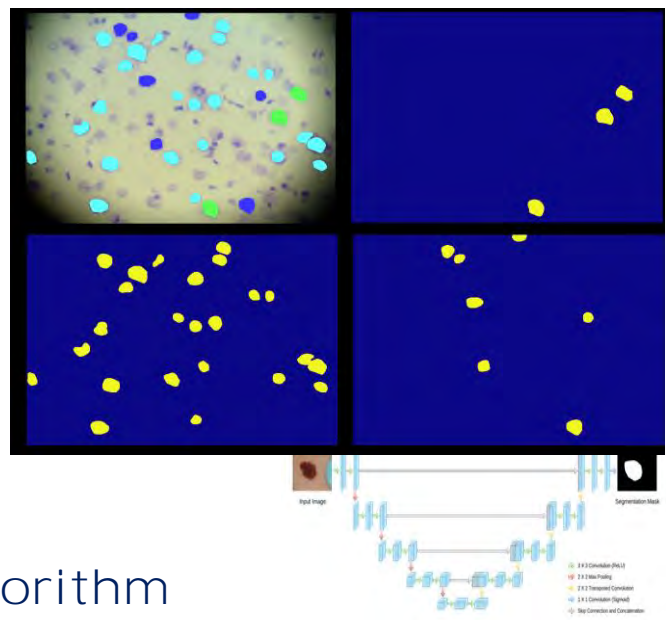
II. Approach is based on a two-stage algorithm

Stage 1. The problem of segmentation is solved for further cutting out the object: NN: cell detection (Contour Proposal Networks); SAM 2 (Segment Anything Model 2)
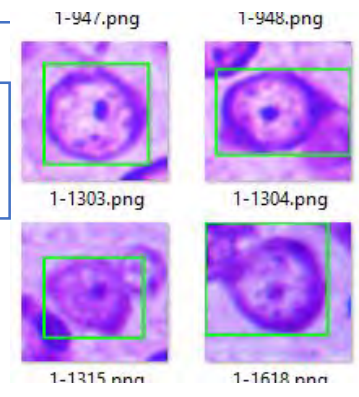
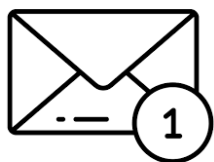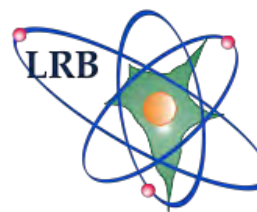Stage 2. Solving the classification problem for cut-out cell images

Classification of brain cells:
- normal
- altered
- degenerative
- glia
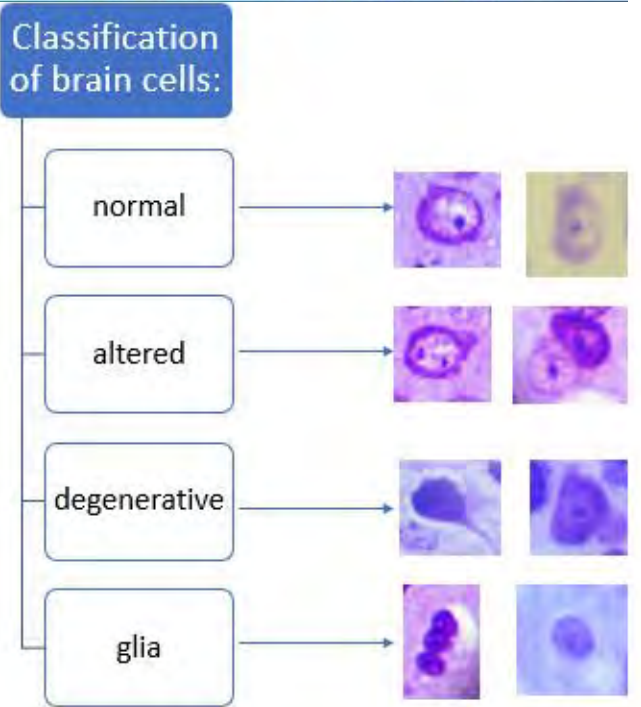
Machine learning:
features: area, roundness index and structural complexity of its core

Deep learning:
CNN

88%

Thanks for your attention!

innakolesnikova@jinr.ru

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