Apple Fruits Monitoring Diseases on the Tree Crown Using a Convolutional Neural Network

Nikolay Kiktev, Alexey Kutyrev, Pavel Mazurchuk

Introduction

Robots in this industry are used to perform the following technological operations:

- washing transoms in greenhouses;
- harvesting vegetables, fruits and berries;
- planting seeds;

Introduction

Robots in this industry are used to perform the following technological operations:

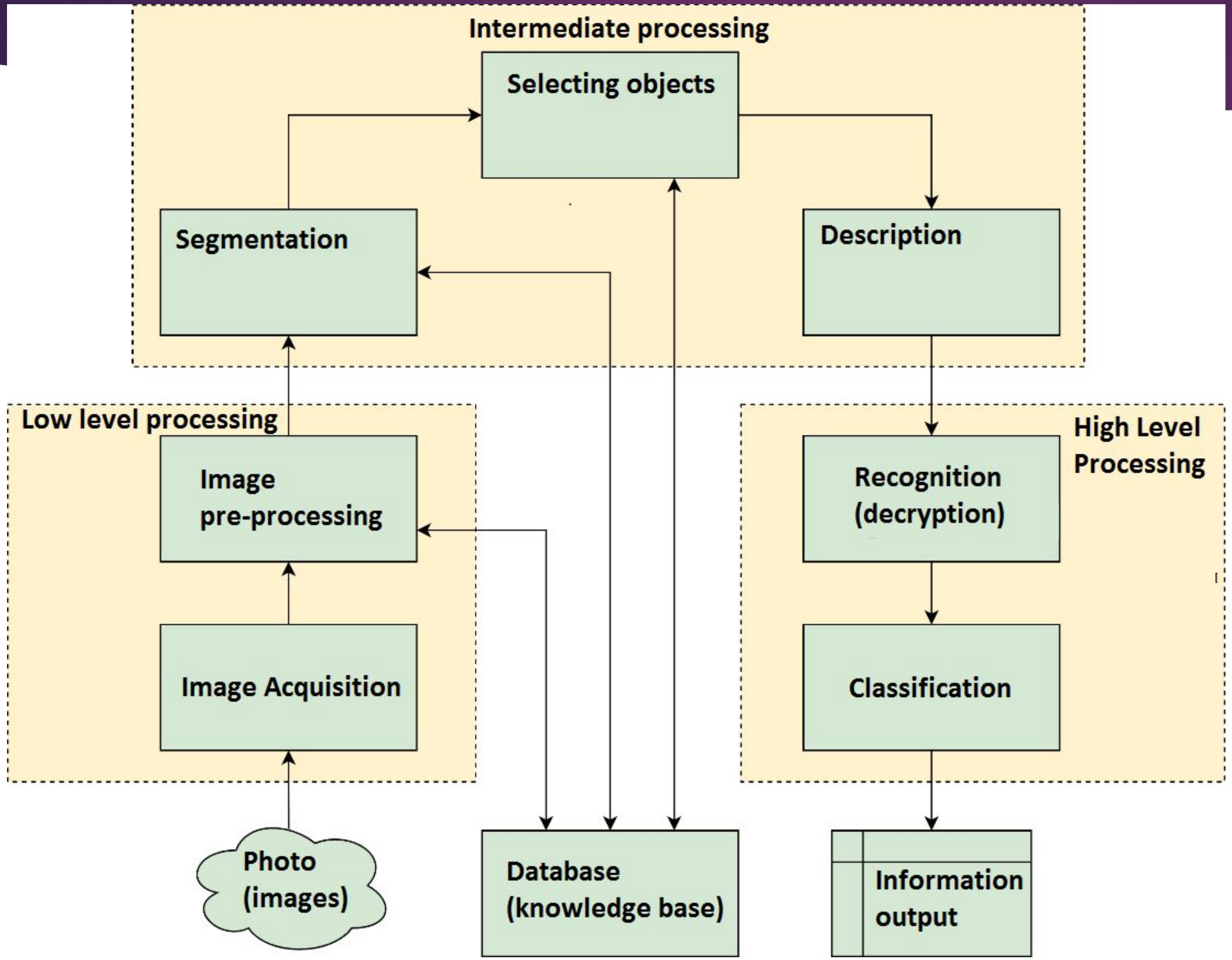
- cutting off weeds and grasses between vines;
- moving plant pots in the nursery;
- watering plants;
- determination of N_2O in the field, etc.

Problem Statement

- ***The purpose of the research*** is to improve the quality of identification of apple fruits on the crown of trees by developing a monitoring system with a mobile application based on a neural network, which will allow detecting, counting, determining diseases and ripening rates of apple fruits, as well as the yield per hectare.

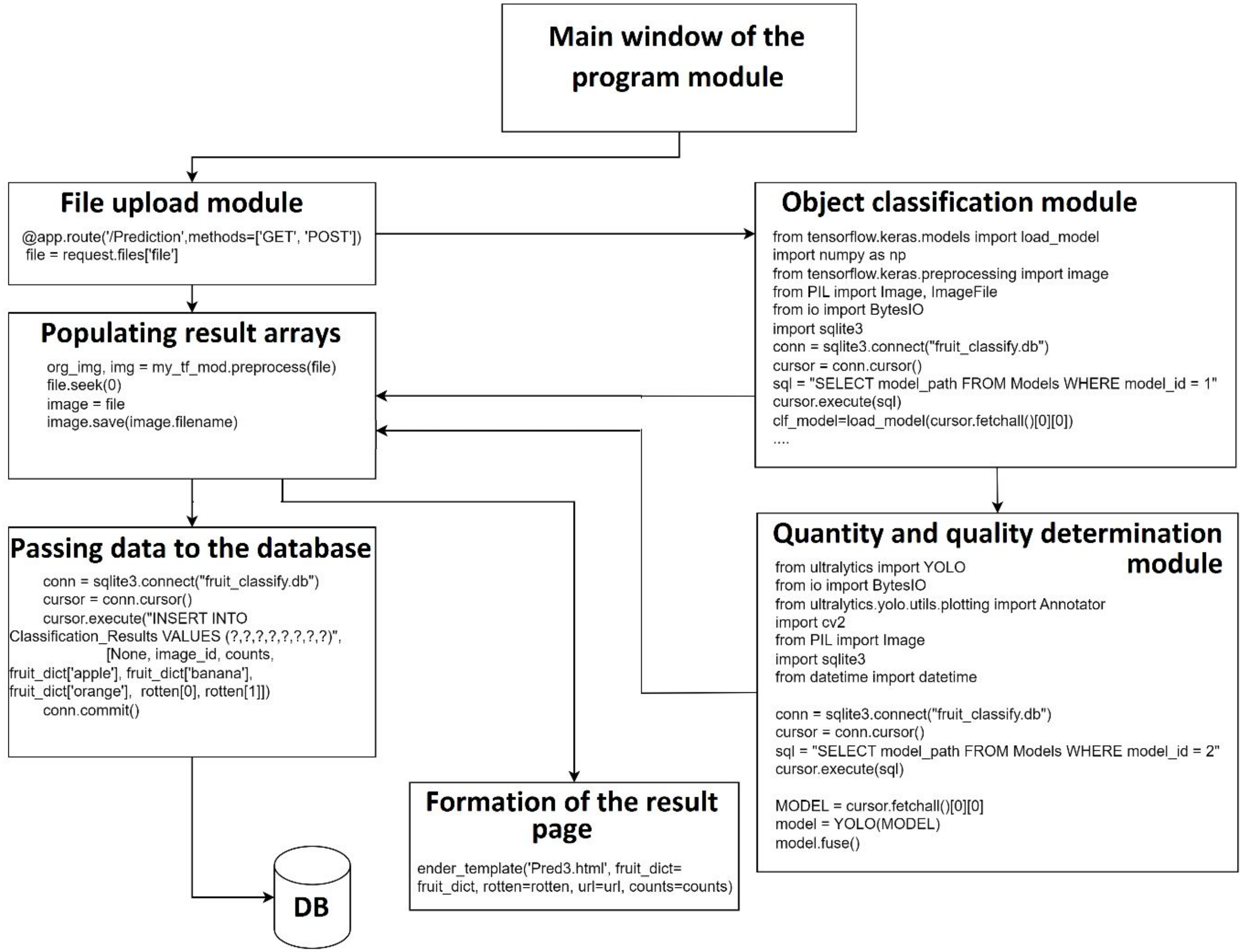
Theoretical Aspects of a Research

Scheme of foresight of the image processing process using a monitoring system



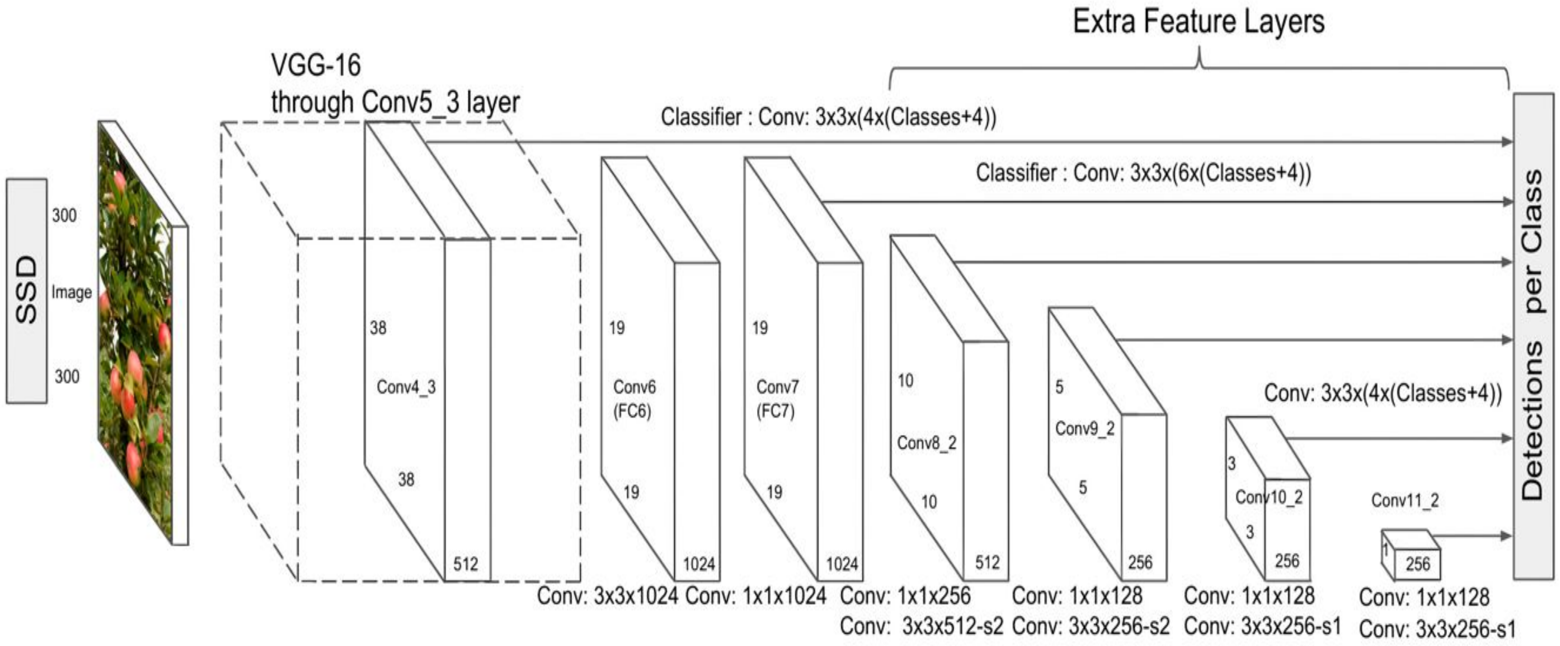
Theoretical Aspects of a Research

Scheme of foresight of the image processing process using a monitoring system



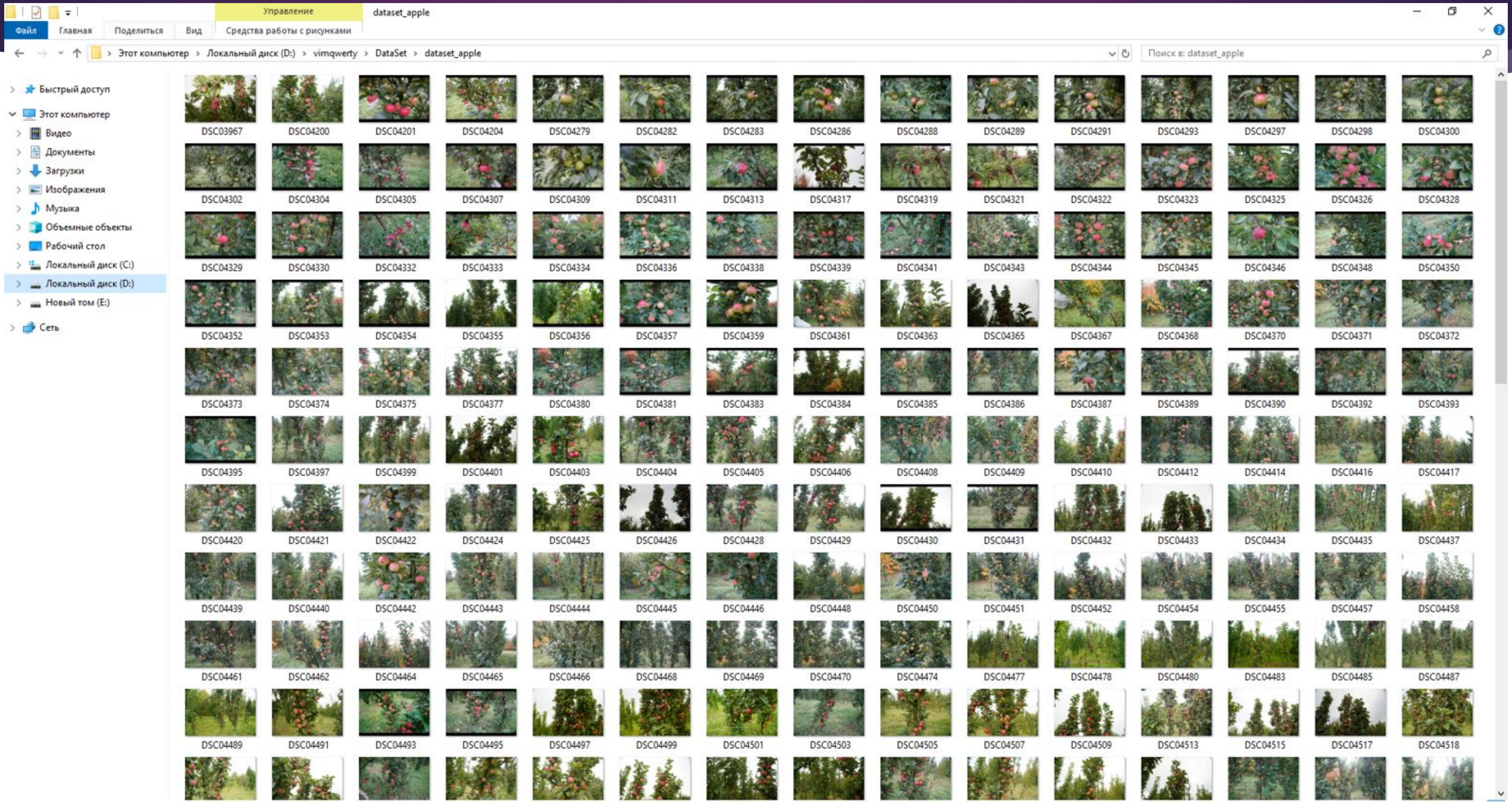
Theoretical Aspects of a Research

VGG-16 and SSD architecture



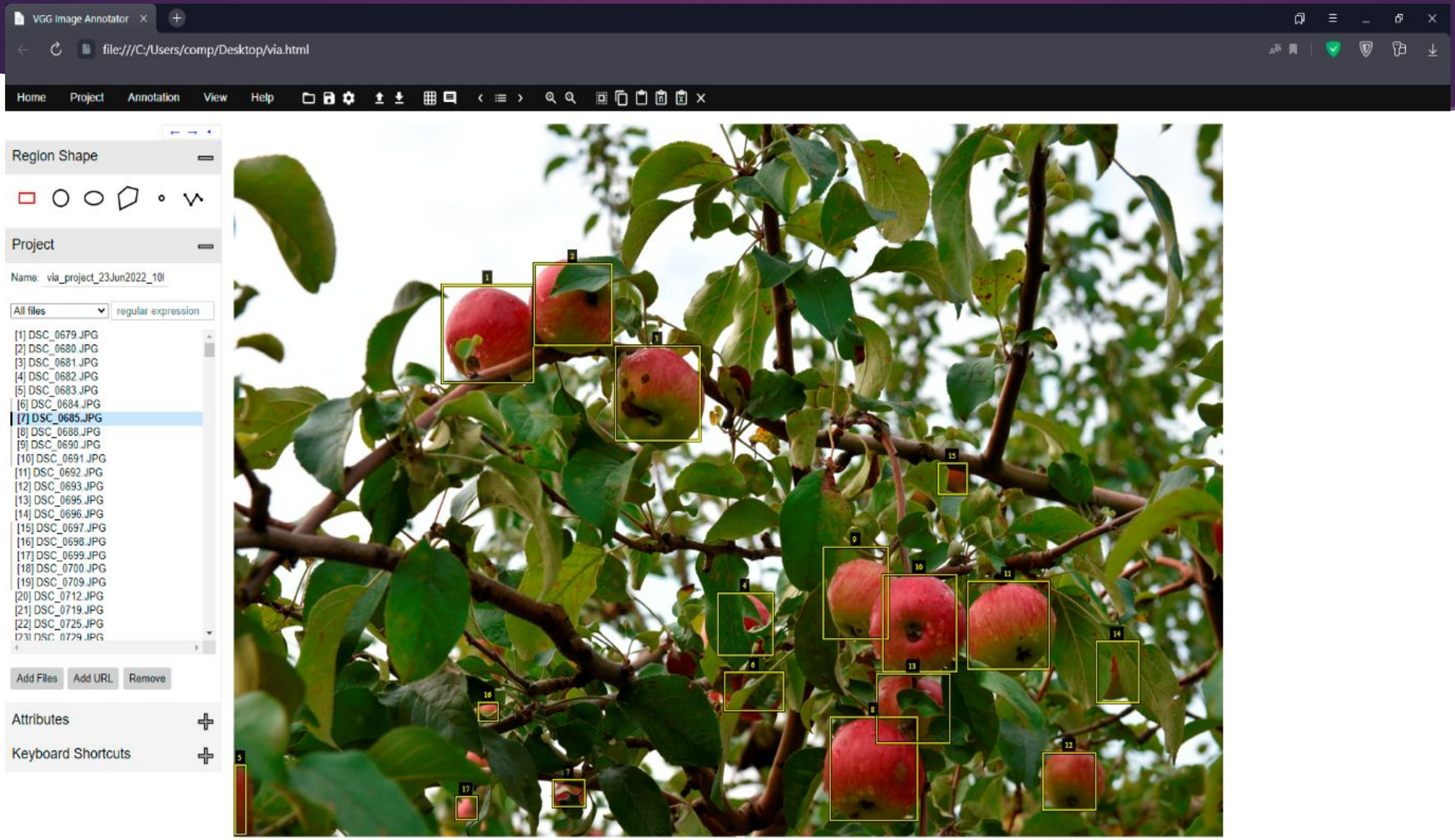
Materials and Methods

Dataset of apple fruits



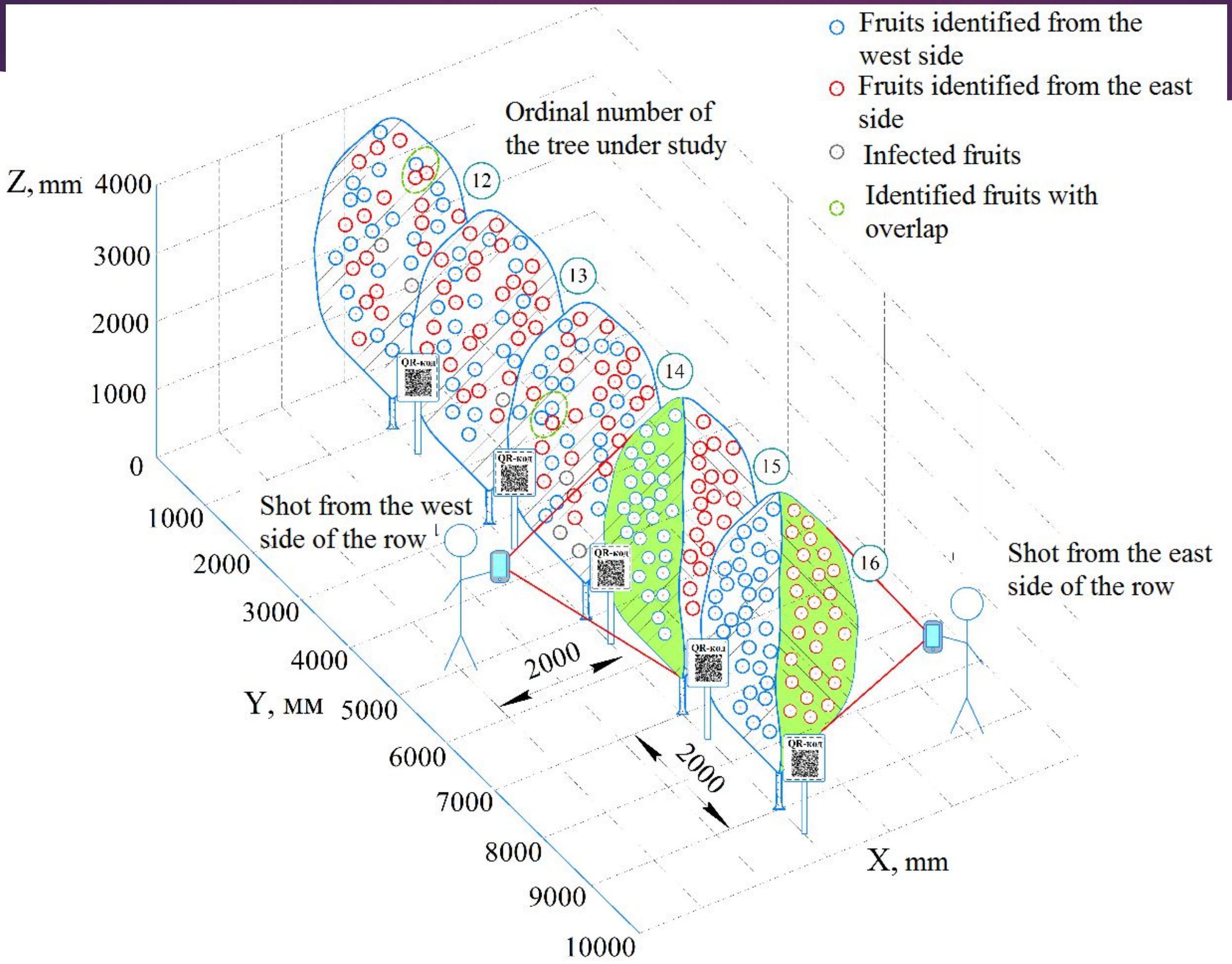
Materials and Methods

Data markup in VGG Image Annotator



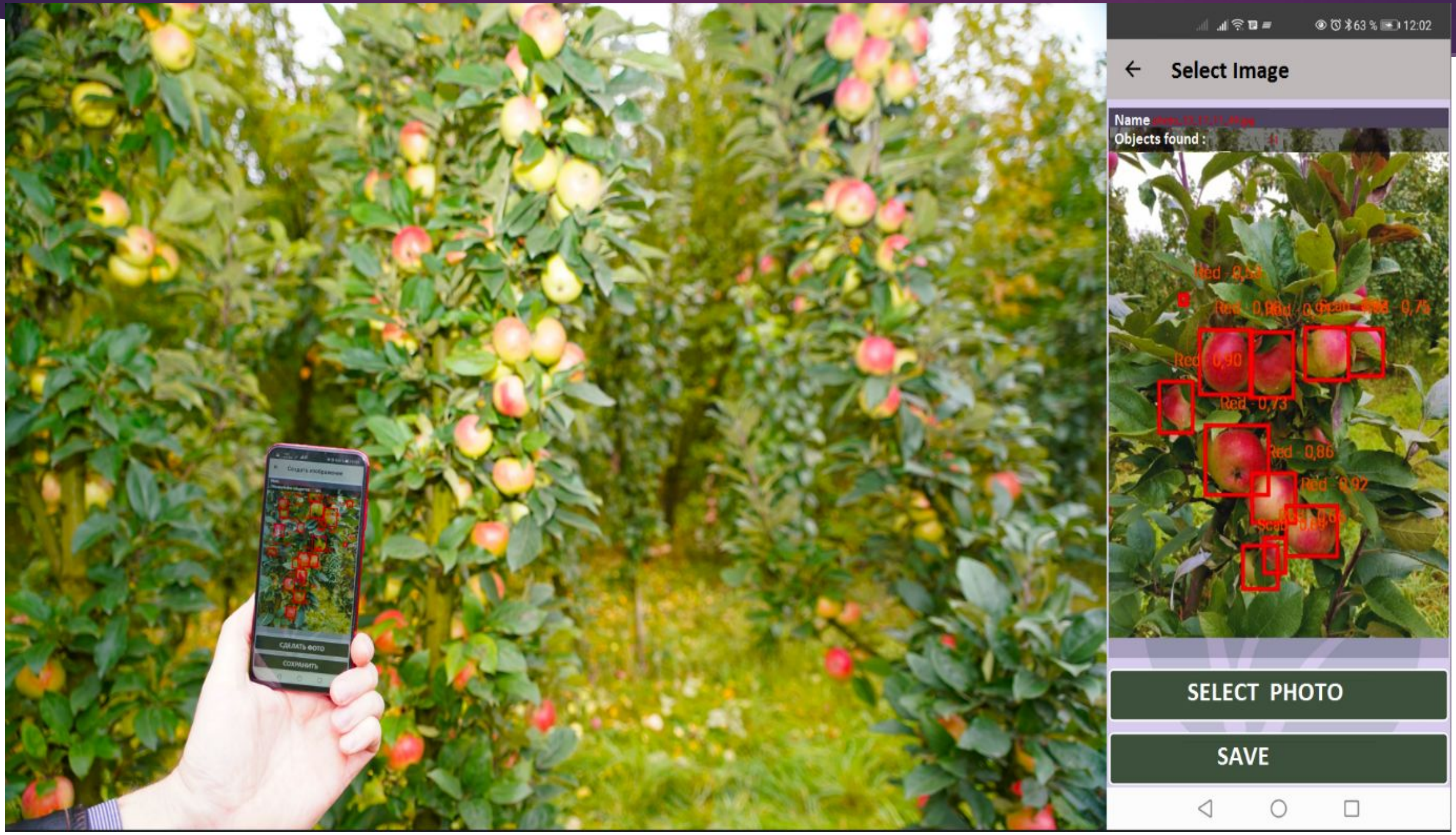
Results

Scheme of the experiment



Results

The process of identifying apple fruits using a monitoring system during the experiment



Results

Plot of an industrial plantation of an apple orchard with installed QR codes for storing and processing data

Results

Identification of diseased and healthy fruits using a neural network

Results

QR codes for storing and processing received data

QR-код	Object data	QR-код	Object data
	Intensive garden, plot: 8; Row: 2; Tree: 12; Sort: Currency; Age: 7 years; Tree coordinates: 55.567281, 37.645590; Number of fruits: 48; Infected fruits: 2;		Intensive garden, plot: 8; Row: 2; Wood: 15; Sort: Currency; Age: 7 years; Tree coordinates: 55.567254, 37.645696; Number of fruits: 46; Infected fruits: 4;
	Intensive garden, plot: 8; Row: 2; Wood: 13; Sort: Currency; Age: 7 years; Tree coordinates: 55.567268, 37.645627; Number of fruits: 44; Infected fruits: 1;		Intensive garden, plot: 8; Row: 2; Wood: 16; Sort: Currency; Age: 7 years; Tree coordinates: 55.567253, 37.645740; Number of fruits: 55; Infected fruits: 1;
	Intensive garden, plot: 8; Row: 2; Wood: 14; Sort: Currency; Age: 7 years; Tree coordinates: 55.567261, 37.645658; Number of fruits: 52; Infected fruits: 3;		

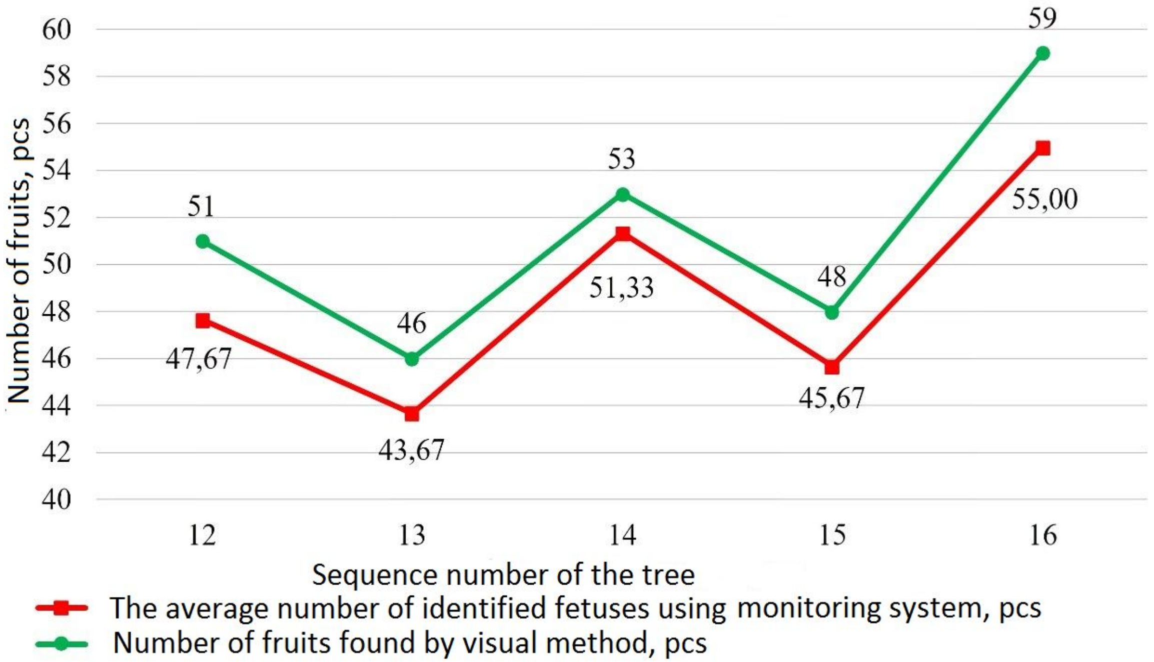
Results

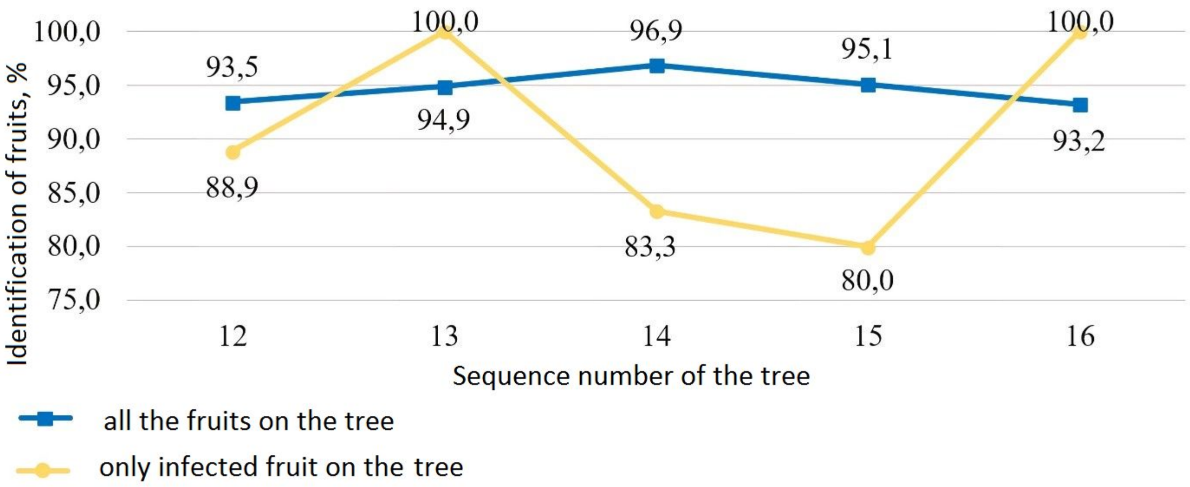
Statistical evaluation of the obtained research results

Sequence number of a tree in a row	12	13	14	15	16
Average number of identified fruits for three repetitions, pcs	47,67	43,67	51,33	45,67	55
Average number of identified infected fetuses for three repetitions, pcs	2,33	1	3	4	1
Dispersion in the general population of identified fruits, pcs2	0,22	0,22	0,89	0,22	0
Standard deviation of identified fruits, pcs	0,44	0,44	0,89	0,44	0
The number of apple fruits found on a tree by a visual method, pcs	51	46	53	48	59
The number of found infected apple fruits on a tree by a visual method, pcs	3	1	4	5	1
Percentage deviation of the number of visible fetuses to the number of fetuses identified using PAC, %	93,46	94,93	96,86	95,14	93,22
Percentage deviation of the number of visible infected fetuses to the number of identified infected fetuses using PAK, %	77,78	100	75	80	100
Absolute percentage error in identification of the total number of fruits, %	6,99	5,34	3,25	5,11	7,27
Absolute percentage error in identifying the number of infected fetuses, %	12,5	0	20	25	0

Results

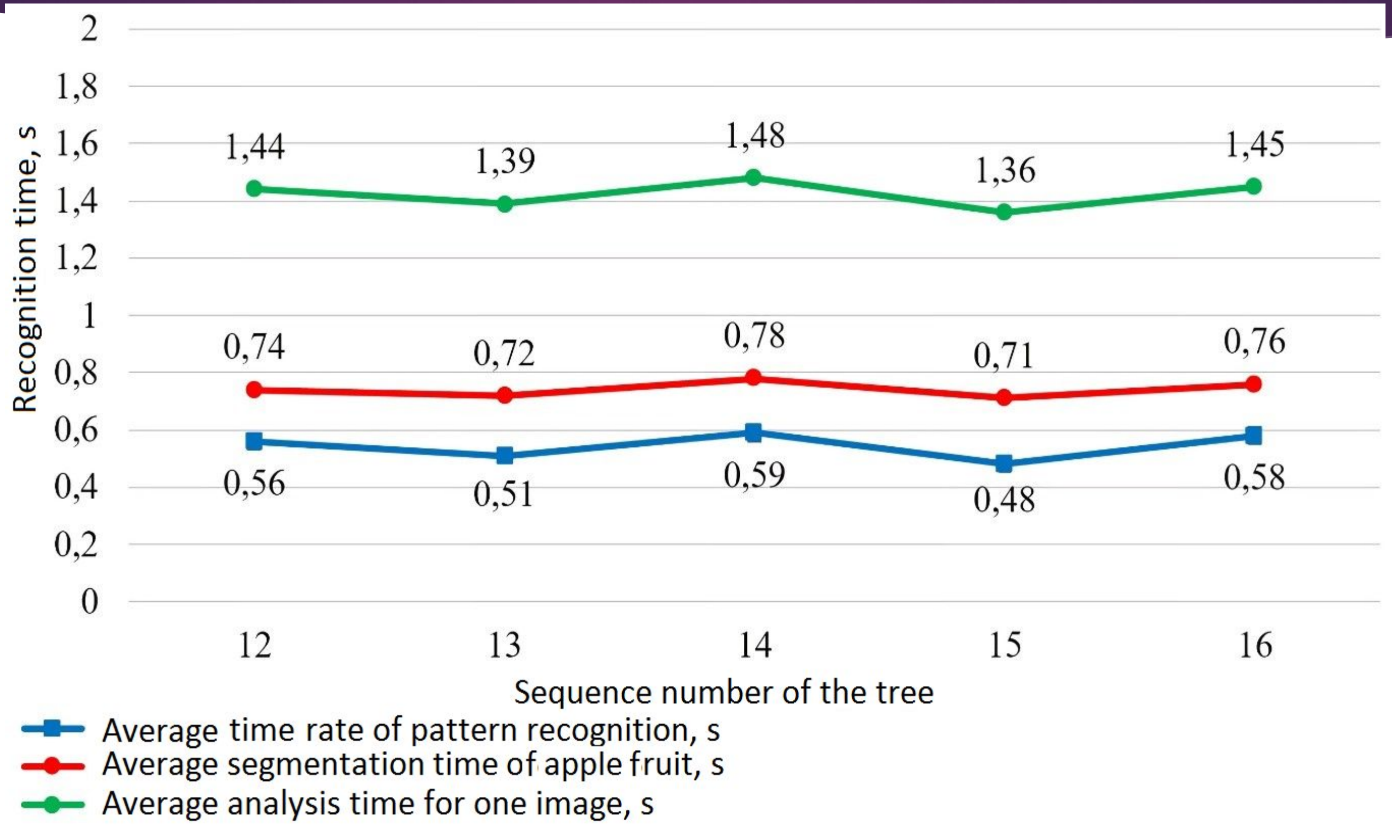
Charts for assessing the accuracy of identifying apple fruits using a monitoring system





Results

Graphs for estimating the identification time of apple fruits using a monitoring system



Discussion

A robot for harvesting apple fruits during testing in the laboratory

Discussion

A robot for harvesting apple fruits during testing in the laboratory

Conclusion

As a result of research, it has been established that for counting the number of apple fruits in industrial garden plantations, a recurrent deep learning network is most suitable, since its use allows one to recognize the outline of the fruits and the foci of diseases on them with high accuracy.

The monitoring system allows you to identify apple fruits on the tree crown, count their number, determine diseases and the rate of ripening of apple tree fruits and the volume of harvest per hectare.

The developed neural network will expand the functionality of the monitoring system for robotic fruit picking by determining the coordinates of each fruit and indicating areas of defects or diseases on the fruit to the controller of the manipulator device

Thank you for the attention!

E-mail
nkiktev@ukr.net *Nikolay Kiktev*
alexeykutyrev@gmail.com *Alexey Kutyrev*
eetc-1402_mazurchuk@ukr.net *Pavel Mazurchuk*