

# Diagnostic of plant pathogens in the early stage by using deep learning algorithms for different image types

PhD Thesis

TED4LAT Doctoral Summer School  
Vidzeme University of Applied Sciences  
Valmiera  
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The author

# The author

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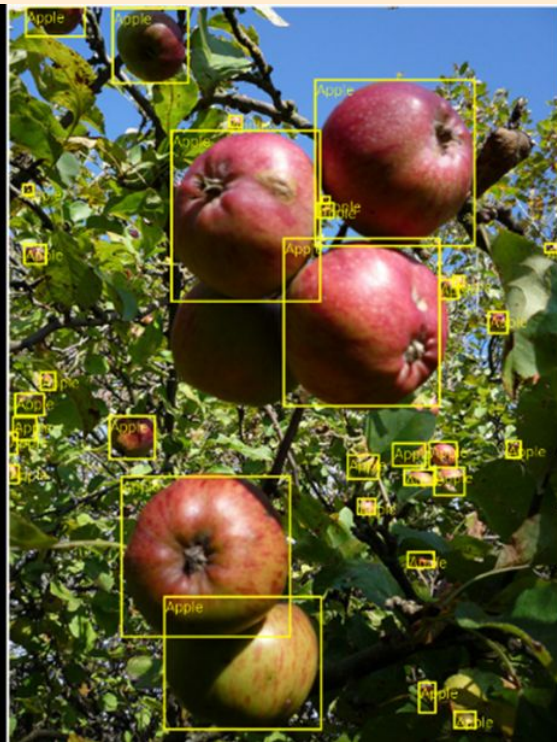


# 01

The problem

# The problem

- For example apples are among the most widely grown and **economically** important fruit species **worldwide** and in Baltics;



# The problem

- Scab disease caused by fungi is **economically** the most **important** disease worldwide for apples;



# The problem

- Due to environmental and food safety concerns, high adaptation ability of pathogens to applied fungicides as well as cost-effectiveness requirements, the need for **changes** in growing **strategies**



# The problem

- It is **important** to detect apple scab in the **early** stage of disease development.



02

Scientific novelty

# Scientific novelty

- The Aim is to **develop** artificial intelligence solutions for different plant pathogen detection in the **early** stage of disease development, which can be applied for precise horticulture to make **preventive** diagnosis of apple trees.

# Scientific novelty

- Objectives:
  - to **collect** and **annotate dataset** with natural images of plant diseases in the early stage of disease development;
  - to **train** artificial intelligence for pathogene early detection.

03

Practical significance

# Practical significance

- The proposed approach **enhances** early stage diagnosis of plant pathogens by using deep learning algorithms across diverse image types.

# Practical significance

- This contributes to **improved precision** in plant disease identification, enabling timely intervention and **reducing** reliance on pesticides treatments.

# Practical significance

- As a result, the method supports **sustainable** agricultural practices and strengthens food **security** through precise horticulture.



04

Object of the study

# Object of the study

- The object of the study is the **application** of **artificial intelligence**—specifically deep learning algorithms—in the field of agricultural **diagnostics**.

05

Subject of the study

# Subject of the study

- The subject of the study is the **development** and **evaluation** of deep learning-based image analysis **methods** using different **types** of **image data** for early-stage detection of plant pathogens.

06

Materials and methods

# Materials and methods

- **AppleScabFDs** – apple images with scab



Dataset

## AppleScabFDs

Apples infected by scab

Project Izp-2019/1-0094 • updated 8 months ago

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# Materials and methods

- **AppleScabLDs** – apple images with scab



Dataset

## AppleScabLDs

Leaves of apples infected by scab

Project lzp-2019/1-0094 • updated 8 months ago

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# Materials and methods

- AppleScabLDs
  - dataset pictures were grouped by apple scab stages;
  - I and II stage of apple scab pictures;

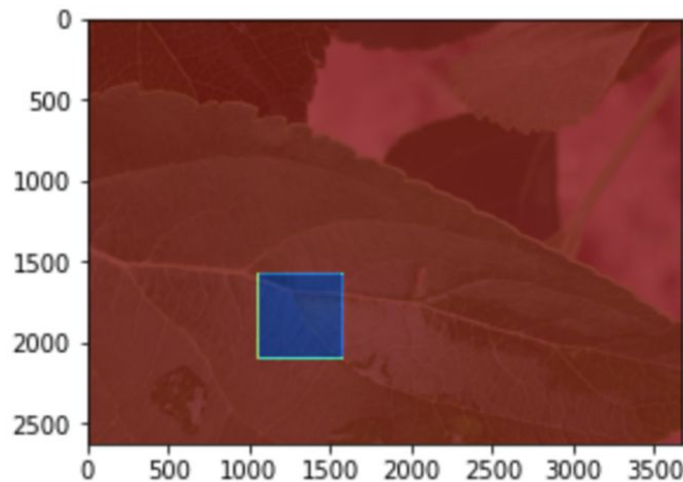
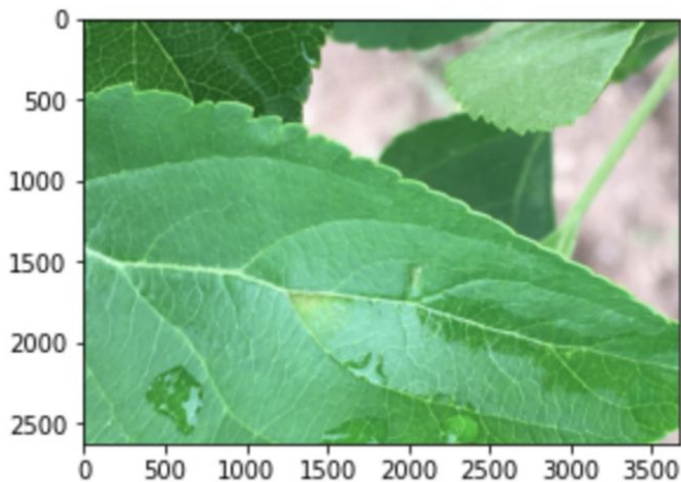


# Materials and methods

- **DatasetScabImages525x525;**
  - Reduced size - from 3024x4032 pixels to 2625x3675 pixels (Divides by 512);
  - Validated by **expert**;
  - Classified in **3** classes: Healthy, Scab, Background

# Materials and methods

- 5x7 grid of pictures (Sliding window), 512 x 512 pixels;



# Materials and methods

Scab



Healthy



Background



# Materials and methods



Scab (729).jpg



Scab (731).jpg



Scab (732).jpg



Scab (733).JPG



Scab (735).JPG



Scab (737).JPG



Scab (738).JPG



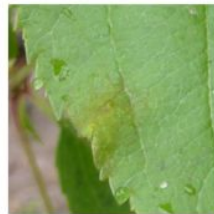
Scab (739).JPG



Scab (740).JPG



Scab (743).JPG



Scab (744).JPG



Scab (745).JPG



Scab (746).JPG



Scab (747).JPG



Scab (748).JPG



Scab (749).JPG



Scab (750).JPG



Scab (751).JPG



# Materials and methods



Healty (207).JPG



Healty (208).JPG



Healty (209).JPG



Healty (213).JPG



Healty (215).JPG



Healty (216).JPG



Healty (218).JPG



Healty (221).JPG



Healty (222).JPG



Healty (238).JPG



Healty (239).JPG



Healty (240).JPG



Healty (241).JPG



Healty (242).JPG



Healty (243).JPG



Healty (244).JPG



Healty (245).JPG

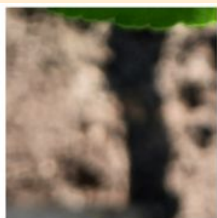


Healty (246).JPG

# Materials and methods



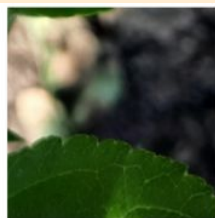
BG (61).jpg



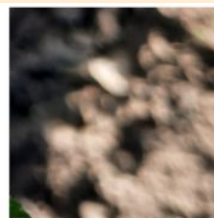
BG (62).jpg



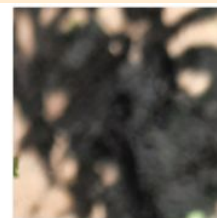
BG (63).jpg



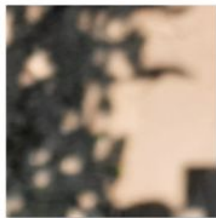
BG (64).jpg



BG (65).jpg



BG (66).jpg



BG (67).jpg



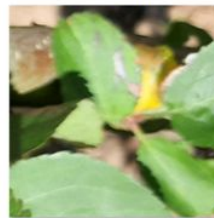
BG (68).jpg



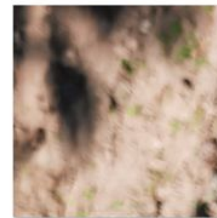
BG (69).jpg



BG (70).jpg



BG (71).jpg



BG (72).jpg



BG (73).jpg



BG (74).jpg



BG (75).jpg



BG (76).jpg



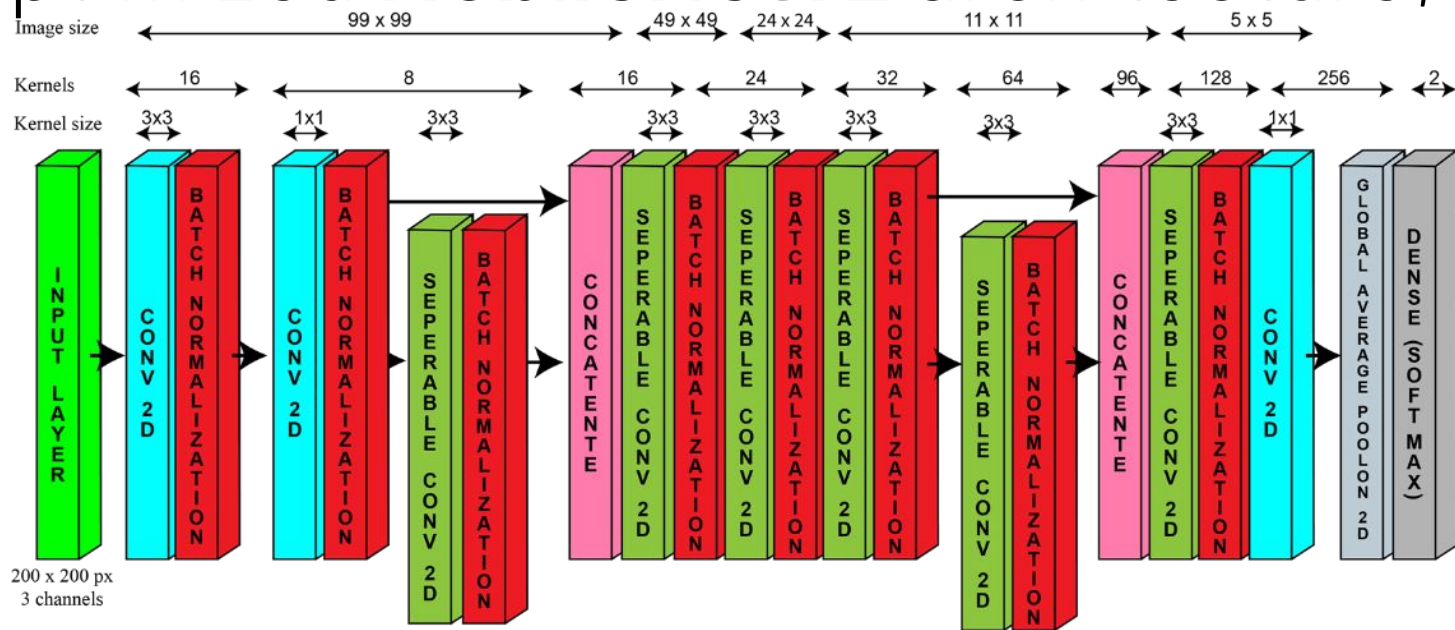
BG (77).jpg



BG (78).jpg

# Materials and methods

- Optimized **MobileNetv2** architecture;



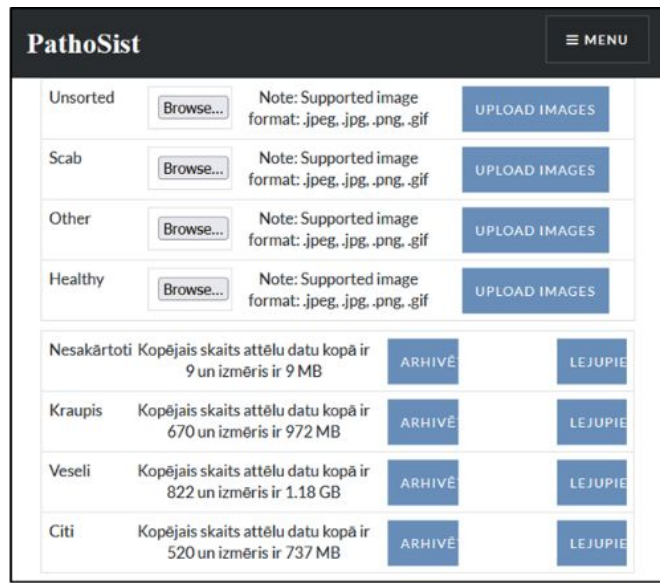
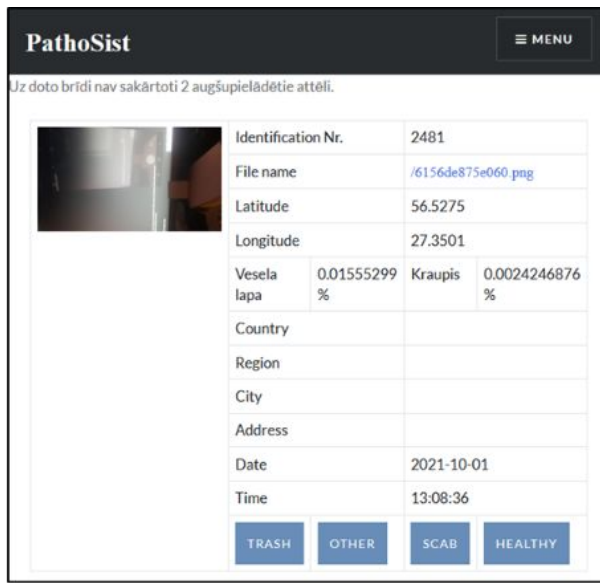
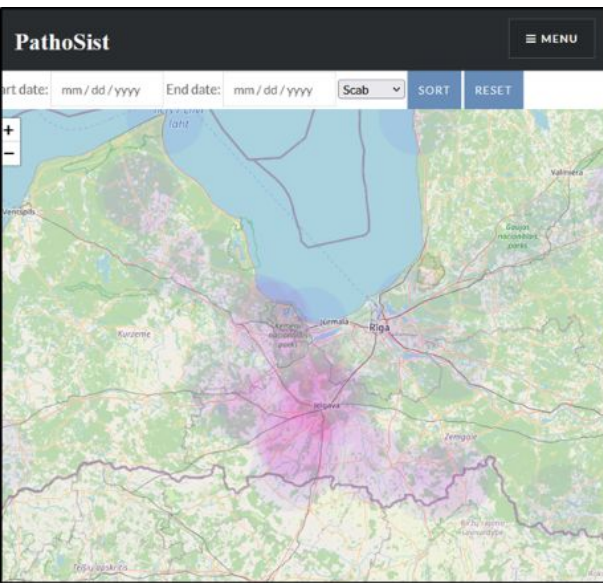
# Materials and methods

- Convolution Neural Network **prototype**:
  - Suitable data sets:
    - Earth's Mover Distance method;
  - Transfer Learning;
    - iFood251X -> Flowers -> Plant Pathology 2020 -> eScab



# Materials and methods

- **Crowdsourcing** system




# Materials and methods

- **Expert** validation

PathoSist

ĀBEĻU UN BUMBIERU KRAUPIS • ATĒĻU ANALĪZE • KRAUPIJA SAIMNIECISKĀ NOZĪME • PAR PROJEKTU • REZULTĀTI

Uz doto brīdi nav sakārtoti 2 augšupielādētie attēli.

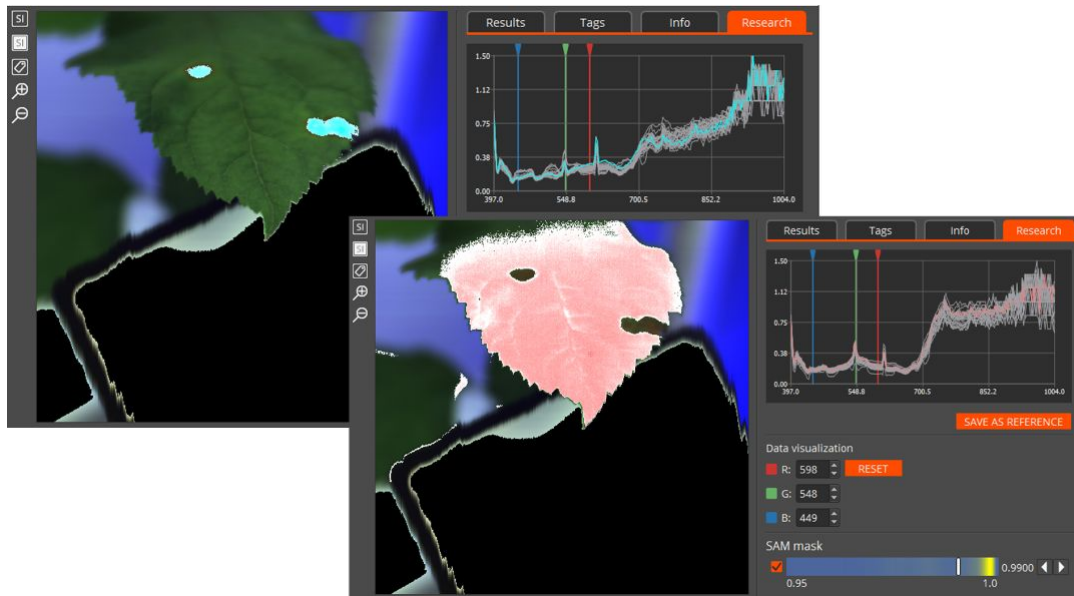


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Latitude	56.611		
Longitude	23.2969		
Vesela lapa	0.4211735 %	Kraupis	0.57882655 %
Country			
Region			
City			
Address			
Date	2021-08-27		
Time	08:44:29		
<div>TRASHOTHERSCABHEALTHY</div>			

RECENT COMMENTS ARCHIVES CATEGORIES

# Materials and methods

- Repeat with **hyperspectral** images



07

Results

# Results

- AppleScabLDs:



Dataset

## AppleScabLDs

Leaves of apples infected by scab

Project Izp-2019/1-0094 • updated 8 months ago

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# Results

- AppleScabLDs:
  - Healthy leaves
    - 207 files
  - Scab infected leaves
    - 983 files

# Results

- AppleScabLDs:
  - +
    - Classified images by **experts**;
    - Different **stages** of apple Scab;
    - Different **conditions**;

# Results

- AppleScabLDs:
  - –
    - **More** files;
    - **No** Even distribution;
    - **No** stage separation



# Results

- DatasetScabImages525x525:

Scab



Healthy



Background



# Results

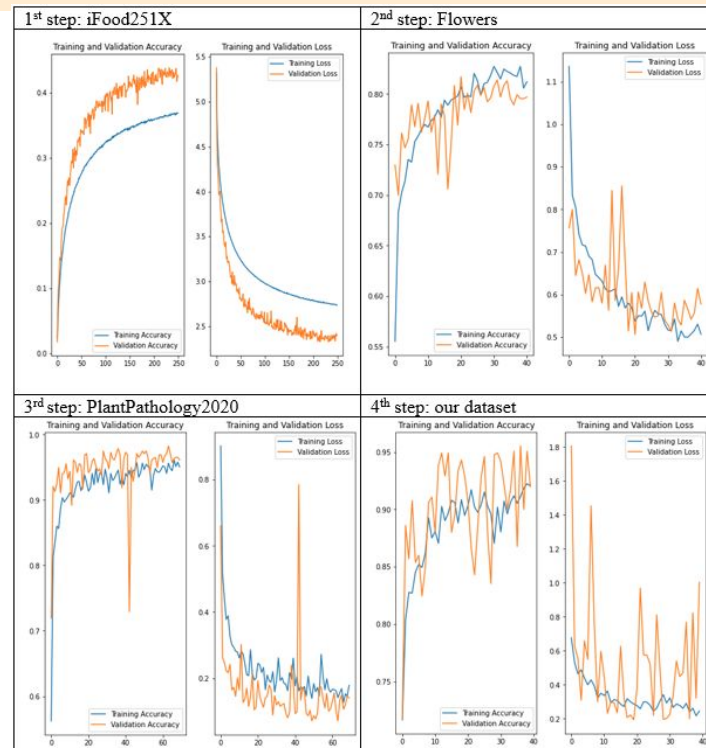
- DatasetScabImages525x525:
  - Classified in **3** classes;
  - Stage **separation**;
  - **Reduced** file size;
  - Reduced background **noise**;
  - **Still** adding images;

# Results

- DatasetScabImages525x525:
  - Large Dataset;
    - Background (1,513 files);
    - Healthy (768 files);
    - Scab (700);
  - Even distribution;

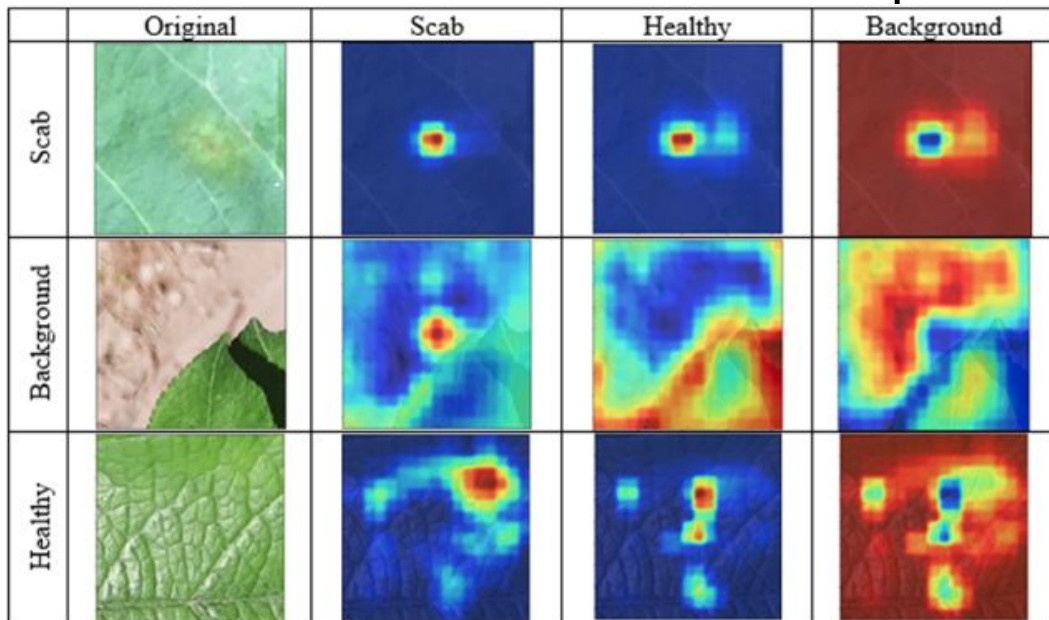
# Results

- Convolution Neural Network prototype:
  - Total accuracy - **96** %
  - Cohen's Kappa - 91 %



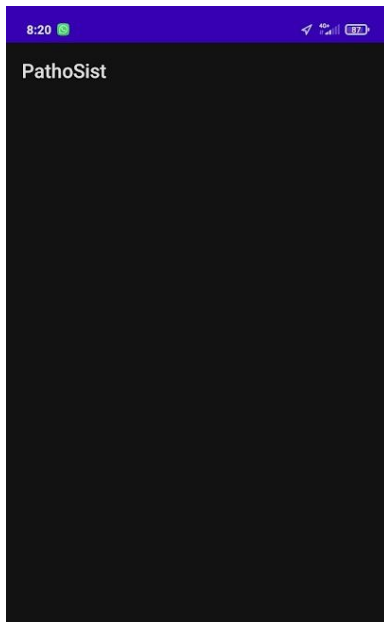
# Results

- Convolution Neural Network prototype:



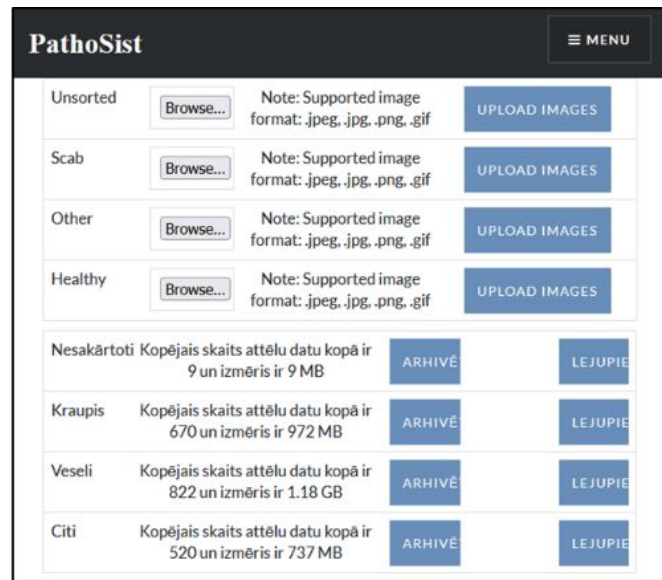
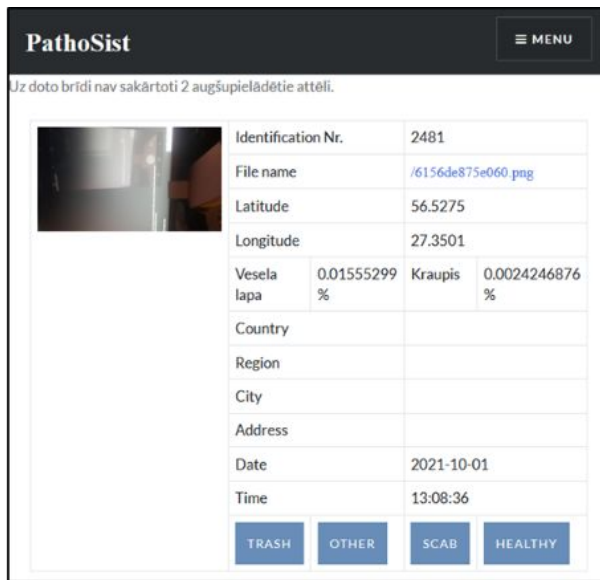
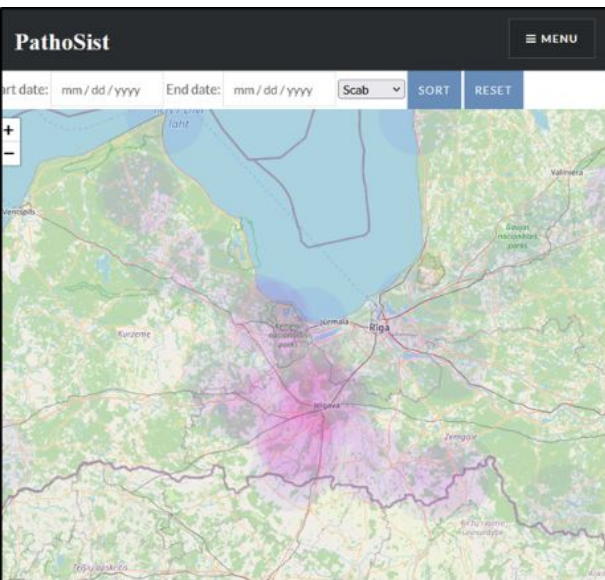
# Results

- PathoSist v0.5.0.1 **app**



# Results

- Crowdsourcing system



08

Still in progress



# Still in progress

- Hyperspectral imaging;
  - Different plant **species**;
  - Different **pathogens**;
  - New data set with **hyperspectral** images;
  - **AI** for hyperspectral images;

# Still in progress

- “New idea born in Paris”



09

THANK YOU

10

Questions or suggestions?