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

PhD Thesis

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The author

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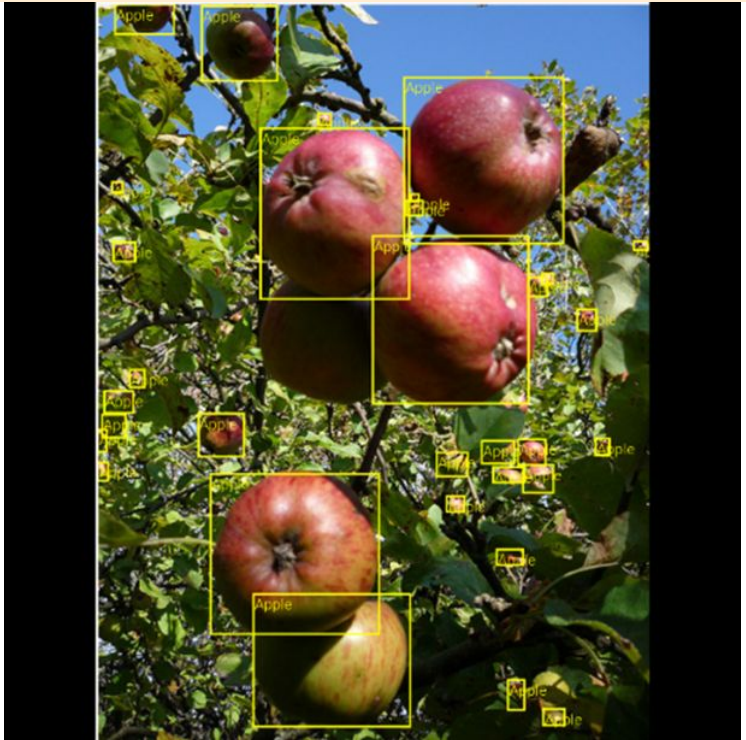
RTA
RĒZEKNES TEHNOLOĢIJU AKADĒMIJA

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 phatogene 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 pesticeds 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

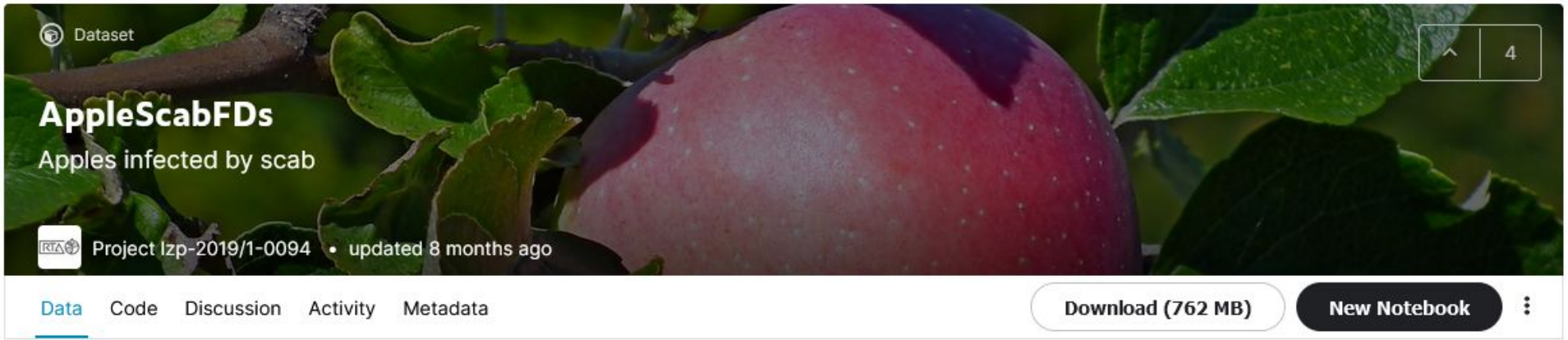
- The subject of the study is the **development** and **evaluation** of deep learning-based image analysis **methods** using different **types** of **image data** for early-stage detection of plant pathogens.

06

Materials and methods

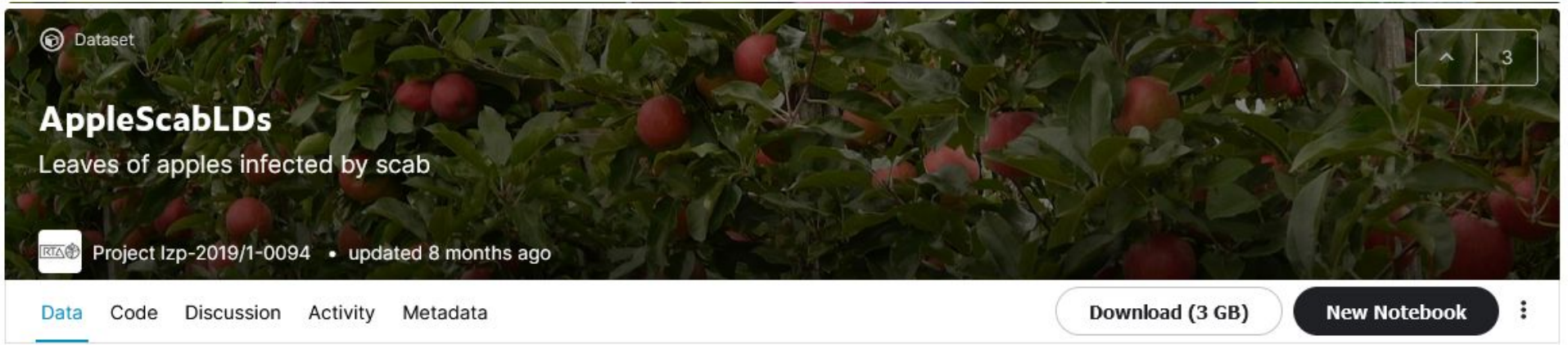
Materials and methods

- **AppleScabFDs** – apple images with scab



Materials and methods

- **AppleScabLDs** – apple images with scab



Materials and methods

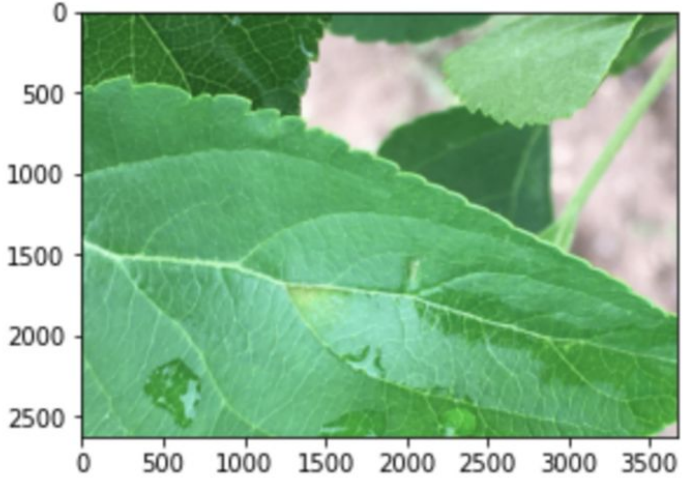
- AppleScabLDs
  - dataset pictures were grouped by apple scab stages;
  - I and II stage of apple scab pictures;

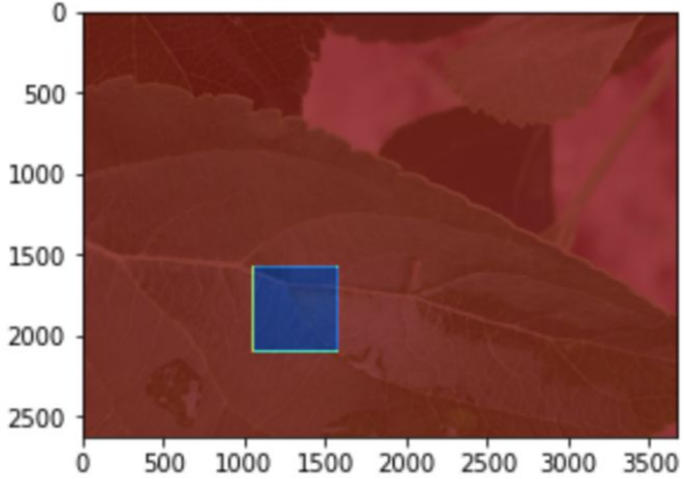
Materials and methods

- **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

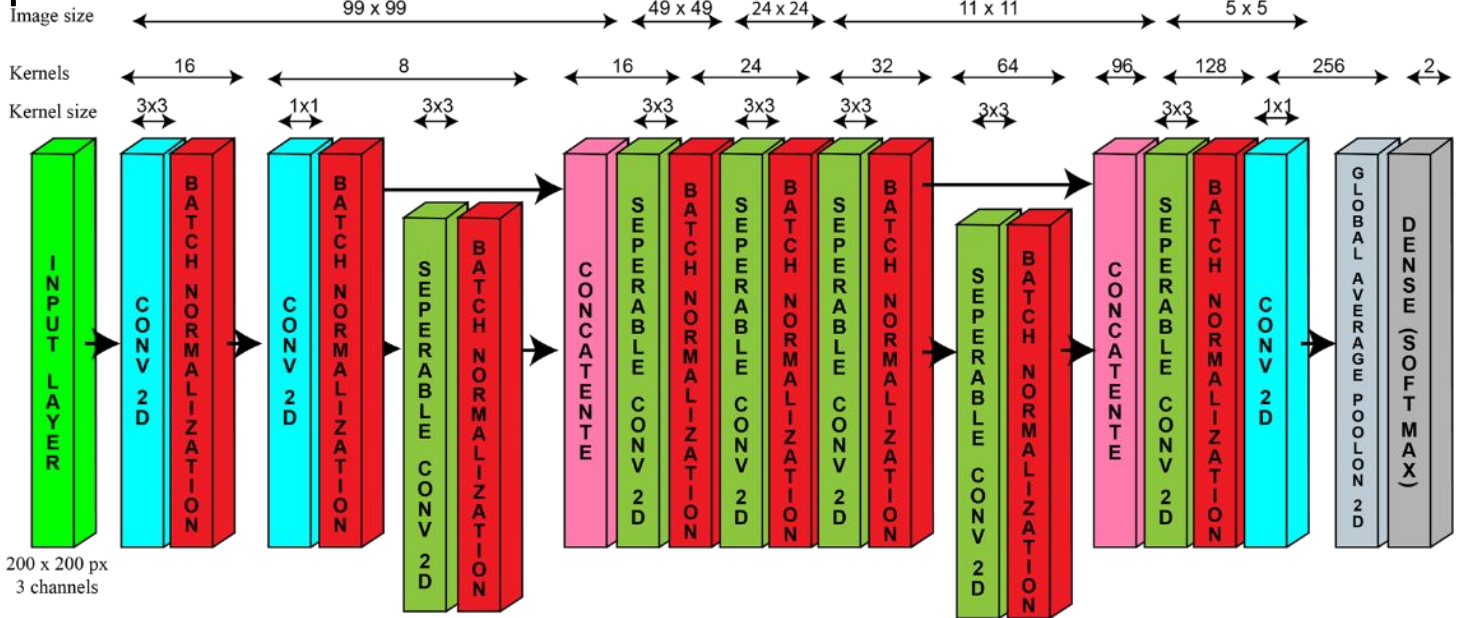
Materials and methods

Materials and methods

Materials and methods

Materials and methods

- Optimized **MobileNetv2** architecture;

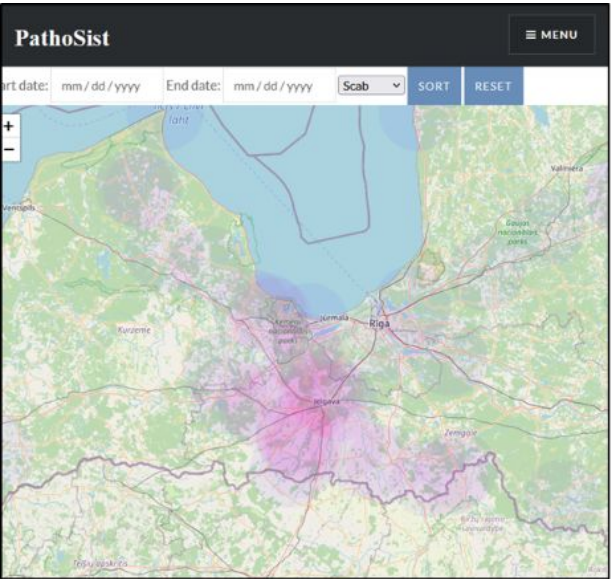


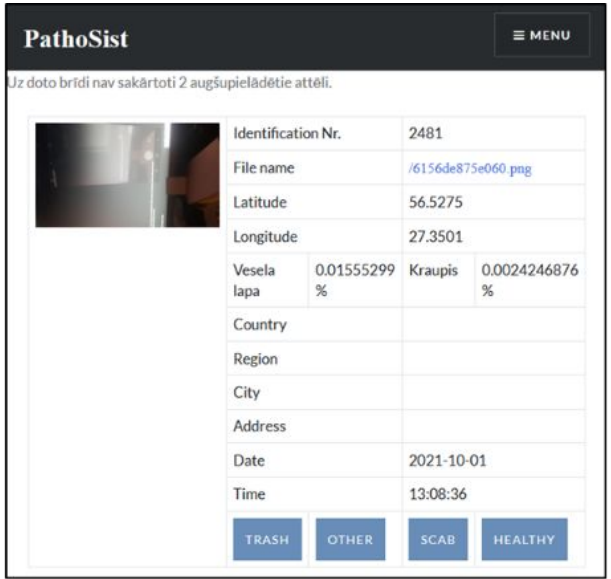
Materials and methods

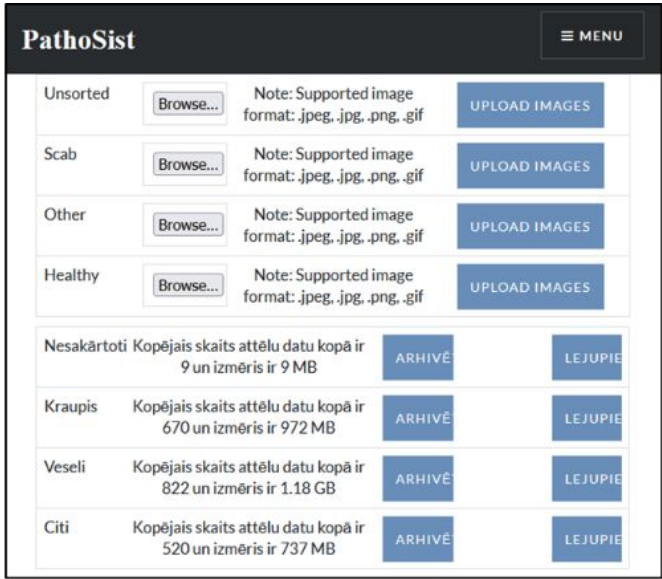
- Convolution Neural Network **prototype**:
  - Suitable data sets:
    - Earth's Mover Distance method;
  - Transfer Learning;
    - iFood251X -> Flowers -> Plant Pathology 2020 -> eScab

Materials and methods

- **Crowdsourcing** system

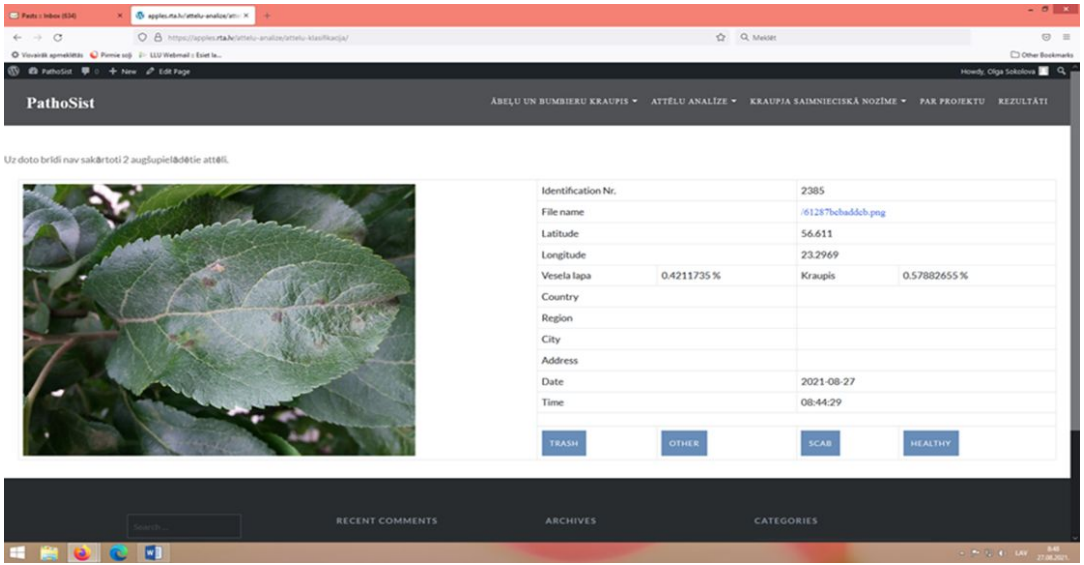






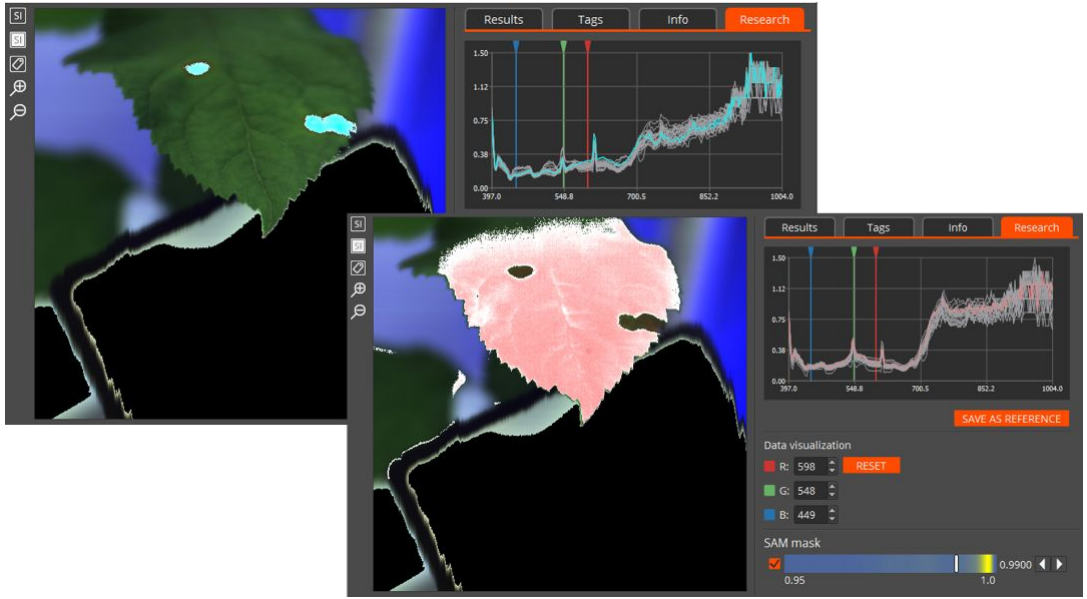
Materials and methods

- **Expert** validation



Materials and methods

- Repeat with **hyperspectral** images



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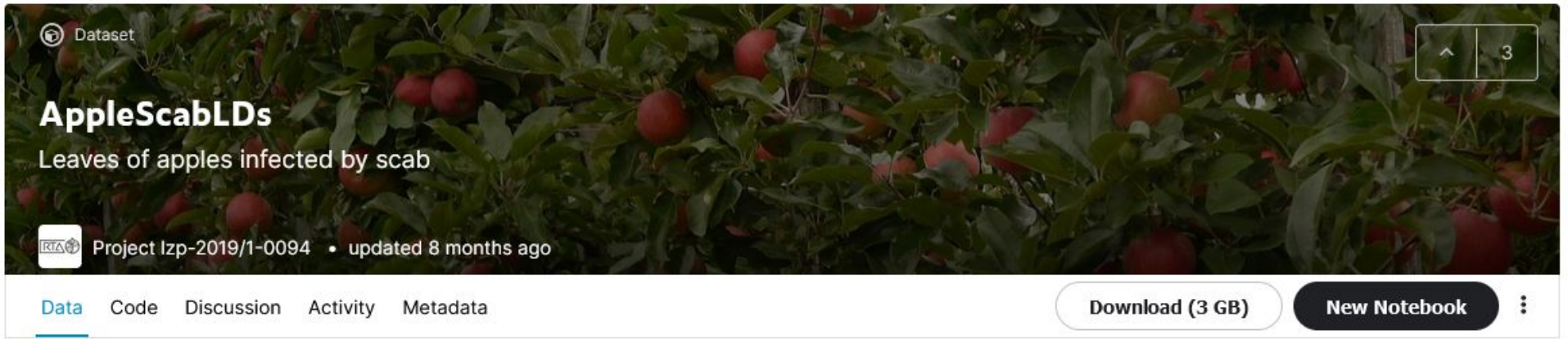
Results

Results

- AppleScabLDs:



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

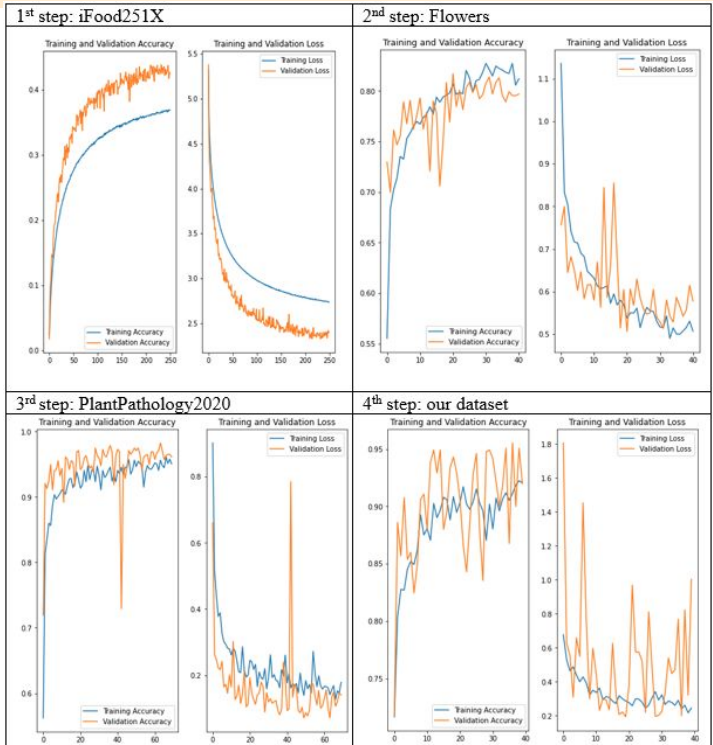
- DatasetScabImages525x525:
  - Classified in **3** classes;
  - Stage **separation**;
  - **Reduced** file size;
  - Reduced background **noise**;
  - **Still** adding images;

Results

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

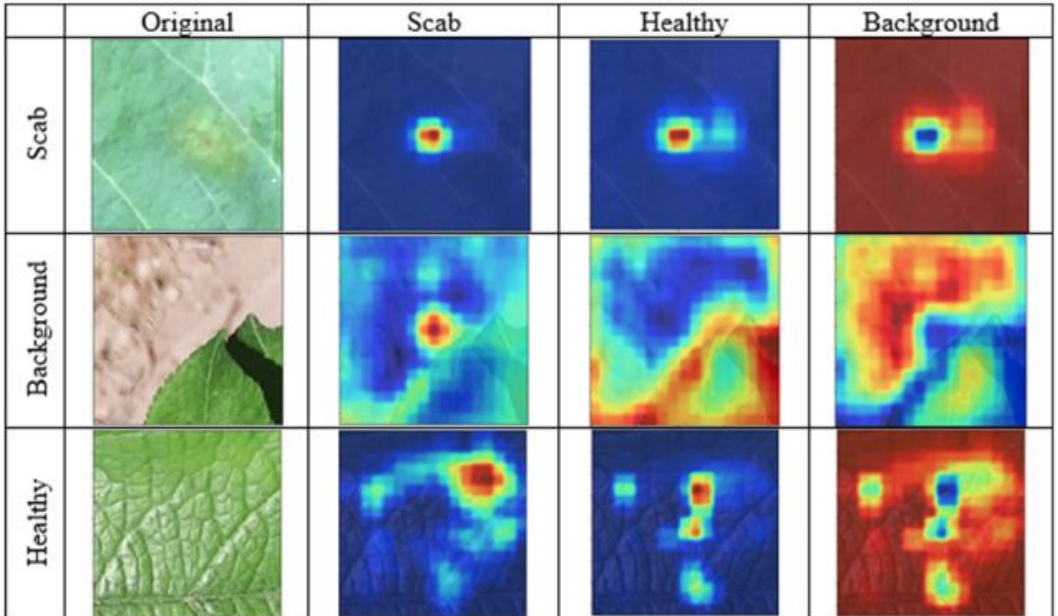
Results

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



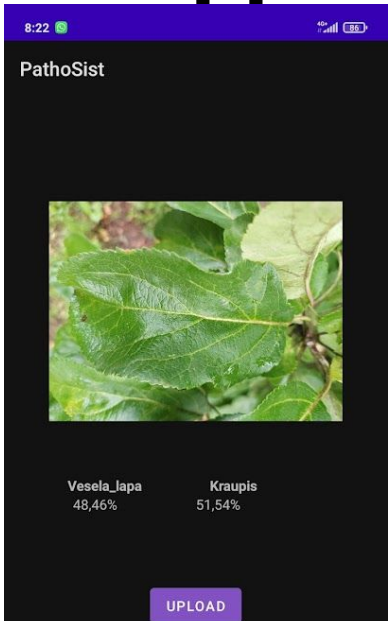
Results

- Convolution Neural Network prototype:



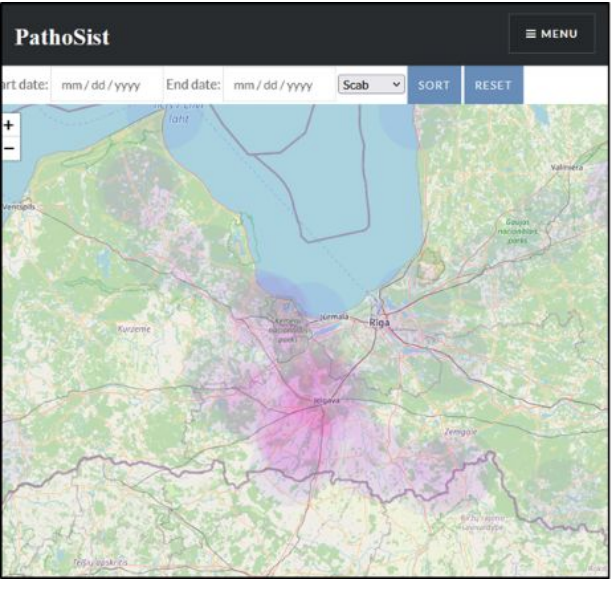
Results

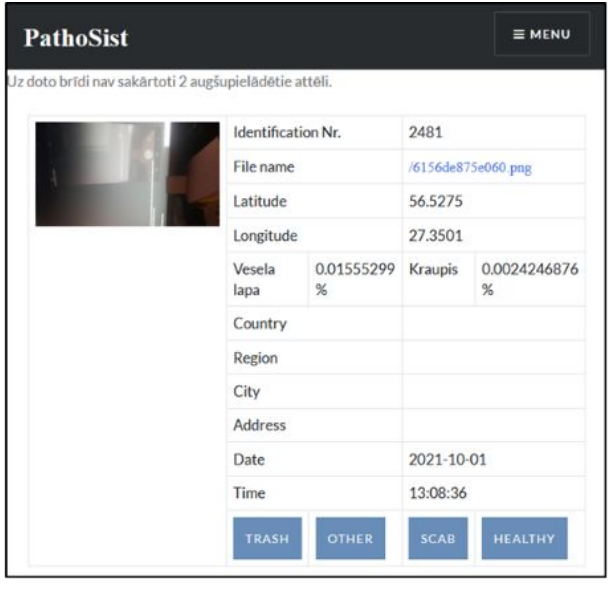
- PathoSist v0.5.0.1 **app**

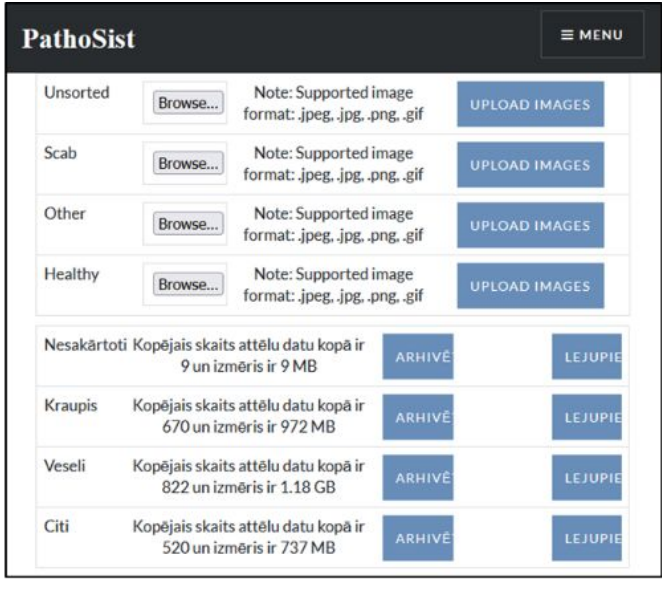


Results

- Crowdsourcing system







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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

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Questions or suggestions?