Tender: Purchase of software services for image analysis in phenological research with implementation, licensing, support and maintenance - AI4PHENO

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Problem Definition

Domain of Interest:

- The heart of the problem lies in the domain of *Phenology* - a discipline studying vegetation's temporal changes.
- Targets seasonal events like budding, fruiting, flowering, and ageing.
- Offers insights into the state of our landscape's vegetation cover influenced by environmental factors and human activities.

Relevance in Context of Climate Change:

- Critical in understanding the health and occurrence of plant species.
- Progressive shifts due to climate changes challenge plant life.

Existing Gap and Proposed Solution

The Gap:

- Multiple methods detect phenological stages.
- Absence of open tools for collection and analysis of digital phenological imagery with machine learning (ML).

The Proposed Tool:

- Aims to fill the market void.
- Provides an automated, efficient way to apply ML in time series image analysis of vegetation affected by climate changes.

Objectives

The overarching aim is to co-develop this solution with the EOSC DIH and the Research Community, ensuring its accessibility via the EOSC Marketplace. By procuring these solutions from the private sector, EOSC DIH aims to meet the research community's needs while also enriching the EOSC with novel offerings.

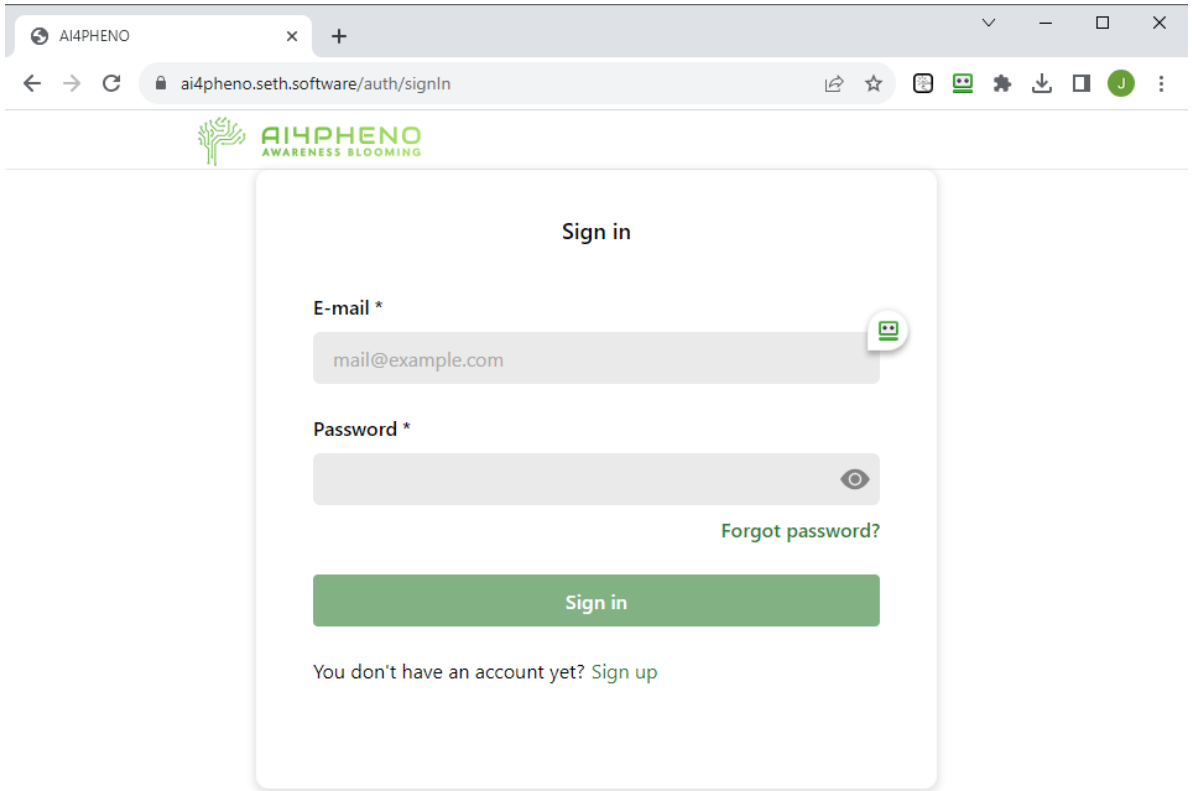
Specific Objectives

1. Acquisition of a digital platform for phenological imagery.
2. Provision of digital tools for manual and automatic image analysis.
3. Introduction of digital tools to utilize hand crafted AI models for phenological imagery analysis.
4. Development of AI models for automatic ROI detection.
5. Facilitation of management tools for the platform concerning data and users.

Web Application Access

The web application is available and can be accessed at the following URL:

`https://ai4pheno.seth.software`



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GFR_1:System

Description:
The whole system (web application) was shared as open source software under the Apache License 2.0. The entire source code could be used, modified, and redistributed. Source code and documentation shared at EOSC-AI4PHENO GitHub repository.

GFR_2:System

Description:
The system was developed in-house and hosted on-premises. Developed in JAVA, deployment was for Ubuntu. AI models in Python using TensorFlow and PyTorch frameworks.

GFR_3:System

Description:
The infrastructure was designed for high availability. Web application on HA services, making it fault-tolerant. Assumptions allowed operation in the Market Place EOSC for at least one year post-delivery.

GFR_4: System

The web application was compatible with most of the then-current version browsers for Windows, Mac, Android, and iOS systems. The application was written in React, communicating through an API backend, which then interfaced with the AI inference server.

GFR_5: Users

In the system, min. 3 roles were developed:

1. Administrators
2. Power users –users of cameras and analysis tools
3. Regular Users - mainly users in read-only mode

Based on the roles created, 3 types of users were introduced. The power user was the most frequently used.

Functional requirements: GFR_6

During the sign-up functionality, each user had created a detailed profile in which she/he had provided at least the following information for statistical purposes:

- Organisation
- Country of organisation
- Position/level of expertise
- Scope of activity
- Purpose of use
- Project/funder

Functional requirements: GFR_7

The standard functionality of accounts and profiles in the system was implemented.

SFR_DAS_1: Camera Data

- Two data sources are used: Dahua 5mpx and Dahua 12mpx.
- Configurable image stream schedules.
- Download images at scheduled times.
- Communication functionality based on administrator role.

SFR_DAS_2: Camera Data

- Additional data sources on premises.
- Verification of services using devices at tenderer premises.

SFR_DAS_3: Camera Data

- Transfer data from SD Card.
- Download images on demand from SD card.

SFR_DAS_4: Input Data

- Appropriate image standard: JPG/JPEG.

SFR_DAS_5: Camera Data

- Scheduled image data downloads.
- Option to download from SD Card during communication issues.

SFR_DAS_6: Camera Data

- Alerts for camera malfunctions.

SFR_DAS_7: Camera Auxiliary Data

- Store additional data apart from image data.

SFR_DAS_8: Camera Auxiliary Data

- Manage, shape, clean, filter data.
- Upload and download data.

SFR_DAS_9: Third-party Data Sources

- Retrieve meteorological data from databases like EDWIN Meteo API.

SFR_DAS_10: Image Data

- Load, zoom, select, and delete ROI.
- Choose region shapes.
- Save data to json.

SFR_DAS_11: Image Data

- Image source search module with criteria.

SFR_DAS_12: Image Data

- Image selection based on brightness.
- Decisions based on sun's position and histogram algorithm.

SFR_DA_1

- The tool for manual ROI (mROI) definition is currently available in the system. This tool allows users to define and modify the vertices of the polygon.

SFR_DA_2

- The tool for manual ROI (Region of Interest) definition currently allows users to create more than one ROI in the reference image, referred to as multi manual ROI (mmROI).

SFR_DA_3

- After loading the raster image, there is a functionality (represented by a dedicated button on the web page) that invokes automatic detection of ROI (aROIs) using the state-of-the-art machine learning algorithm Mask-RCNN for Linden and Apple trees.

SFR_DA_4

- Uploading any pre-trained model (specifically for automatic definition of ROIs) into the system or service must be compatible with the *MaskRCNN* model and requires support from the system administrator.

SFR_DA_5 - ROI data

- For segmented ROIs, functionality of ROI analytics data will be provided: RGB indexes, height, width, area.

SFR_DA_6 - ROI data

- For segmented ROIs, the functionality provides additional analytics data for the ROI (red DN and green DN, red DN and blue DN, green DN and blue DN).

SFR_DA_7 - ROI data averaged

- In the current approach, the computation of red, green, and blue digital numbers (DN) is carried out over the ROI. The DN values for each color component range from 0 to 255.

SFR_DA_8 - ROI data averaged fitting

- In the current setup, we are fitting a vegetation curve to the ROI data.

SFR_DA_9 - Image ROI meta data

- Time and data retrieval from file properties or/and images (via date stamp) or/and filenames is currently possible in the system.

Functional Requirements for SFR_DA_10

- Customised colour indexes (CIs) can be uploaded with administrator support.

SFR_AIM_1

- Based on the training images provided, a ready-to-use AI model for automatic ROIs semantic segmentation of apple fruit is developed and deployed in service.
- The desired quality for the model is given by $mIoU > 0.75$.
- In our approach, we achieve $mIoU = 79.19$.

SFR_AIM_2

- On the basis of the training images provided, a ready-to-use AI model for automatic ROIs semantic segmentation for the flowering stage of the European linden is being developed and deployed.
- The desired quality of the model is specified as: mIoU > 0.70.
- In our approach, we achieve: mIoU $= 85.21$.

Functional Requirement: SFR_DV_1

- **Print ROI on the Selected Image:** The Region of Interest (ROI) is dynamically highlighted on the chosen image, allowing for an immediate visual analysis.
- **Export Results to JSON Format:** After the analysis, users have the option to export their results directly into a JSON format, facilitating easy data sharing and further processing.

Functional Requirement: SFR_DV_2

A screen is prepared that presents the captured images in the form of a list with photo thumbnails. The list can be filtered by camera, species, and date range. Upon selecting an item from the list, a full-size image is displayed with defined ROIs marked on the photo.

Functional Requirement: SFR_DV_3

Currently, we visualize the quantity and characteristics of the identified objects. This encompasses various presentation methods such as graphs and statistical analyses.

Functional Requirement: SFR_DV_4

Currently, we are visualizing the results of the Region of Interest (ROI) analysis over time. One of the primary methods applied for this visualization is the use of graphs. These graphical representations provide an intuitive insight into the temporal progression of the ROI data.

Functional Requirement: SFR_DV_5

In the present context, visualizing vegetation curves becomes pivotal for numerous ecological and environmental studies. By using the *Region of Interest (ROI)-averaged approach*, one can derive significant insights from such visualizations.

Functional Requirements: SFR_DV_6

- Various types of charts are implemented in the system.
- Allows for the overlay of different analyses.

Functional Requirements: SFR_DV_7

Visualization of images, where defined objects (Linden and Apple) are identified by the AI algorithm, is available in the system.

Functional Requirements: SFR_DV_8

Visualization of apples identification results provided by the AI algorithm are available in the system.

Functional Requirements: SFR_DV_9

Visualization of camera data in the form of images is available in the system.

Functional Requirements: SFR_DV_10

- Based on the location data of the camera, a screen is prepared for presenting the location of devices using Google Maps.
- Locations are visible on the screen in the form of "pin" markers.
- Descriptions displayed after hovering over the object.
- Depending on the presentation area, Google Maps displays the location data of devices within the presentation area.

Functional Requirement: SFR_DV_11

- A list of all users/user account data can be displayed in the system.

Functional Requirement: SFR_DV_12

- A list of all additional information for users/user account data can be displayed in the system (for admin account).

Functional Requirement: SFR_DE_1

- The system allows for the export of images to local media.
- Also provides the capability to export to Google Drive.

Functional Requirement: SFR_DE_2

- The system allows for the export of analysis results to local media.

Functional Requirement: SFR_DE_3

- The system currently offers the functionality to export ROI data (polygon coordinates) to a JSON file.

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Performance Requirements

- **Service Level Agreement (SLA)**
  - Current SLA level: 99.50%
  - Allowed downtime:
    - Daily: less than 7m 12s
    - Weekly: less than 50m 24s

Performance Requirements (contd.)

- **Data Durability**
  - Current durability level: 99.97%
  - Protection against bit rot, degradation, data corruption or loss
- **Response Time**
  - Regular webpage: 1000 milliseconds
  - Machine learning functionalities: variable times due to complexity

Performance Requirements (contd.)

- **Batch Processing**
  - Completion time: within 60 minutes
- **System Monitoring**
  - Tool used: phpservermon
  - Logs availability issues to a MySQL database

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Platform and Infrastructure Requirements - Overview

- Infrastructure: On-premises (non-cloud).
- Servers: Dell servers with high availability based on virtualization/containerization.
- Web app and REST API: Exposed by at least 2 nodes with a load balancer.
- ML models: Provided by a Python environment (tensorflow/pytorch).
- Web form application: Developed in Java.
- Source code and documentation: Public access under Apache License 2.0.
- AI server: Uses Rabbitmq for queuing and distributes tasks with Celery.
- Inferences: Executed through Nvidia Triton, results returned to Redis.

Thanks!