Τ1ΕΔΚ-01577

ΑΡΤΕΜΙΣ

"Ανάπτυξη πΡακτικών και δημιουργία Τυποποιημένης υπηρΕσίας παρακολούθησης των οικονοΜΙκών δαΣών"

DEVELOPMENT OF AUTOMATED FLOWS FOR PROCESSING AND ANALYSIS OF REMOTE SENSING AND GIS DATA FOR MONITORING OF NATURAL ECOSYSTEMS

Nikolaos Grammalidis, Thomas Katagis, Papaioannou Periklis, Katerina Fotiou, Yiannis Paraskevopoulos, Christos Kontopoulos, Gitas Z. Ioannis, Charalambopoulou Vasiliki

Goal of the ARTEMIS project

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ΑΡΤΕΜΙΣ

The **main objective** of the Greek research project **ARTEMIS** is the creation of a multiparametric service for processing and dissemination of satellite and other data on an online platform related to the quality, health and sustainable development of economic forests and specifically chestnut forests.

THEMATIC AXIS	**Biodiversity protection in areas of agro-food tourism interest**
PRIORITY	**Development of practices and methods for direct use in agriculture (to produce products) that preserve biodiversity**

Forests and Economy

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ΑΡΤΕΜΙΣ

Forests **provide** :

- A multitude **of products and services**, such as timber, feeding, raw materials, energy resources, biodiversity conservation, etc.,
- a broad set of **environmental, social and cultural benefits** related to climate regulation, human health, recreation, and water supply, among others;
- significant **economic benefits** at the local and national level through industries and investments for the production of forest products.

In Mediterranean areas, some **non-timber forest products** such as cork, mushrooms and pine nuts are more profitable than timber.

A recent revision of the European common policy for the development of the rural sector (regulation EC/1305/2013) encourages the development of such activities, which contribute to the economic strengthening of rural areas .

Forest monitoring with modern technologies

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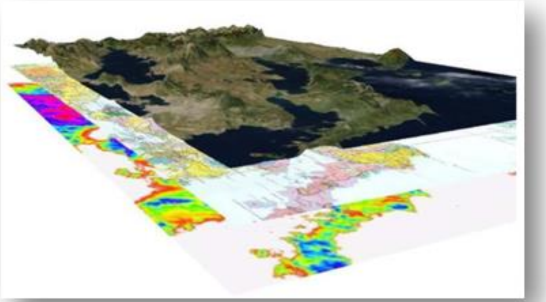
ΑΡΤΕΜΙΣ

- There is a need for continuous monitoring of forest ecosystems in order to increase primary production, quality production and at the same time maintain biodiversity and sustainable management.
- Modern **geospatial technologies**, such as satellite Remote Sensing and GPS, are important tools for the development of reliable, low-cost, monitoring systems.



Components of Geospatial Technology

Methodology of the ARTEMIS project and the work

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ΑΡΤΕΜΙΣ

The implementation of the ARTEMIS system includes four stages:

1. Collection and pre-processing of Satellite Data (e.g. from Sentinel 1 and 2, Pleiades Constellation, etc.)
2. Vegetation segmentation, i.e. automatic identification of the type of vegetation or crop of interest through modern machine learning and artificial intelligence techniques to be trained from specific reference points/areas
3. Analysis of vegetation indices for spatio -temporal monitoring of changes in forest
4. Development of an electronic WebGIS platform for the free dissemination of results and provision of data and services to interested individuals/bodies using OGC/ISO technologies, e.g. WMS, WFS , WCS, WPS services

This work focuses on the second stage (vegetation segmentation)

Proposed Vegetation Segmentation Methodology from Satellite Data

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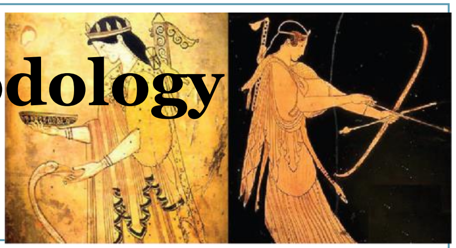

ΑΡΤΕΜΙΣ

1. Define the area of interest (AOI)
2. Collection of available data from Sentinel satellites
3. Identification of cloud masks and valid data
4. Estimation of additional indicators (e.g. NDVI, NDWI, etc.)
5. Conversion of iLots2018 (ground truth) reference data to raster format
6. Temporal re-sampling at constant time intervals using linear interpolation and extrapolation
7. Feature sampling to define training and testing sets
8. Training of machine learning methods (LGBM, CNN, RNN and LSTM)
9. Use the models to estimate vegetation classification for the entire region of interest (AOI) and evaluate the results

- Input: Available Sentinel-2 images (level 1C) at a given time interval
- Data from iLots2018 was used as reference data

Use of eo-learn platform

- The **eo-learn** open software platform facilitates the extraction of useful information from satellite imagery.
- Eo-learn is a collection of open source Python packages developed for easy and direct access and processing of spatiotemporal sequences of satellite images/data.
- It is easy to use, designed in a modular fashion, and encourages the combination and reuse of specific tasks in a typical information mining workflow, such as:
  - Cloud masking (Cloud cover mask estimation)
  - Image co-registration
  - Feature extraction
  - Classification _
  - etc.

Computation of Vegetation Indices

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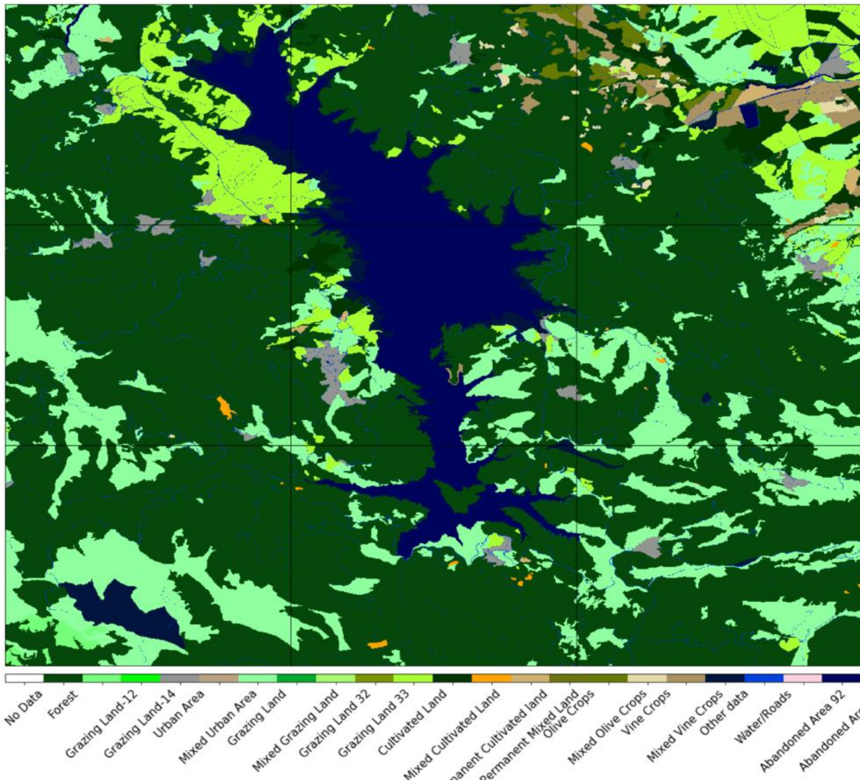
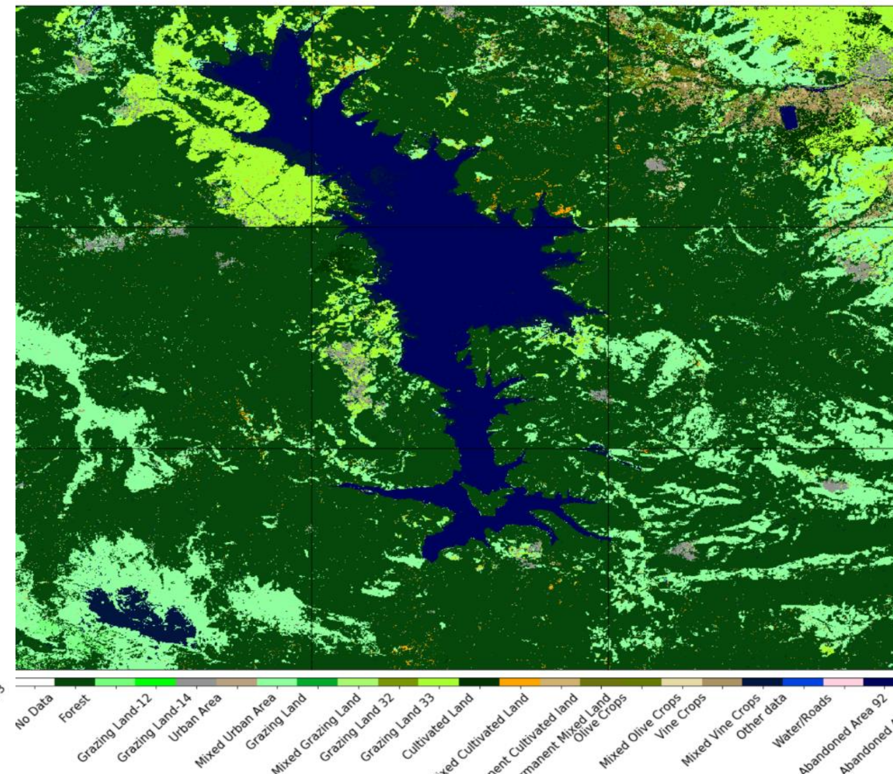
- indices extracted from remote sensing data (Vegetation Indices) are widely used to estimate the state of vegetation.
- Vegetation indices are related to characteristics of plant physiology, such as chlorophyll and carotenoid content .
- In the present work, the segmentation is based on training with data from a) six optical and infrared spectral images: **B, G,R,NIR,SWIR1 and SWIR2** and b) three spectral indices (derived from the previous six): **NDVI (Normalized Difference Vegetation Index), NDWI (Normalized Difference Water Index) and Euclidean norm (measure).**
- Other vegetation indices can be used in the future

Vegetation segmentation Results

Ground truth based on i -Lots 2018



Estimation via LightGBM algorithm



- Strong class imbalance exists (Specific classes are dominant, e.g. forest and lake), so the estimate is worse in areas with few samples (e.g. urban)
- So solve this problem, modified loss functions (e.g. focal loss) can be used.

Variation of segmentation accuracy with respect to the time interval of the images

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Table 1. Variation of segmentation accuracy with respect to the time interval from which the available Sentinel -2 images are selected (full year, first half or first month). The LightGBM machine learning algorithm is used and the results concern the training set

Time interval	Full year (12 months)	6 (six) months (January-June)	One month (January)
Overall accuracy	85.8%	80.9%	66.0%
F1-score	86.1%	82.1%	52.5%

- We notice that using more images (longer time interval) improves the segmentation, since any seasonal changes (e.g. in foliage) are taken into account.

Evaluation of Machine Learning methods

- Different machine learning algorithms, **such** as **LightGBM** , but also deep machine learning algorithms such as a) Convolutional Neural Network - **CNN** , b) Recurrent Neural Network - RNN, and c) Long-Short Time Memory – **LSTM** network
- Indicative results for the test set are presented in the Table below

Method	LightGBM	CNN	LSTM	RNN
Accuracy	77.6%	74.26%	73.28%	72.77%

- We observe that deep machine learning networks do not outperform powerful traditional machine learning algorithms such as LightGBM, possibly because the training dataset used is relatively small (320,000 samples).

Conclusions and Future work

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ΑΡΤΕΜΙΣ

- In this work, a vegetation segmentation methodology was presented using a set of available satellite images within a certain period of time
- The segmentation is based on a) generating workflows, supported by the open source python library eo-learn and b) modern machine learning methods trained on a reference dataset
- iLots 2018 data were used as reference data, but they mainly differentiate crops. Additional site-survey data will be needed for forest tree species segmentation.
- It was observed that the use of multi-spectral and multi-temporal images with appropriate pre-processing can improve segmentation estimation
- The final result of ARTEMIS will be a WebGIS platform that will make the process fully automated, providing new products and services to end users.
- The WebGIS platform will be used as an information center to monitor crop health in the area of interest.

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