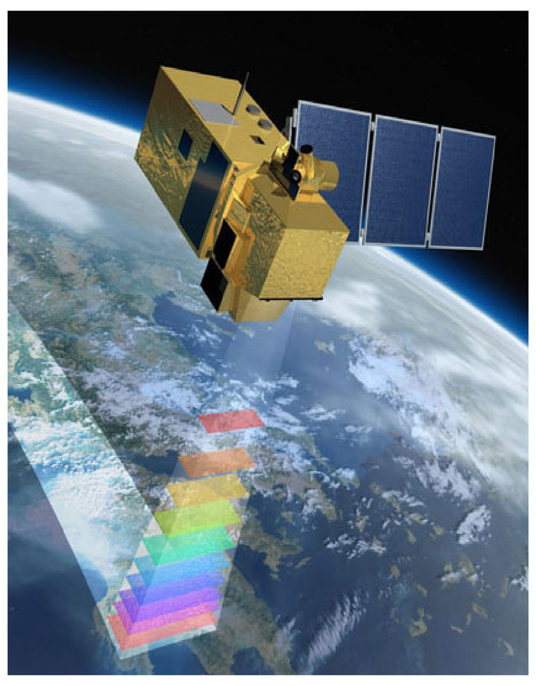
Enriching low-density terrain maps from satellite with autonomous robots data

Edmundo Guerra[a], Antoni Grau[a],Yolanda Bolea[a], Rodrigo Munguia[b]
[a]Department of Automatic Control, ESAII, Technical University of Catalonia, Spain
[b]Department of Computer Science, CUCEI, University of Guadalajara, Mexico

Introduction

• Satellite imagery and remote sensing is a core technology in precision agriculture, used to create soil features maps (humidity, vegetation index, thermal maps…). Multichannel information can provide plenty of information with a drawback: the low resolution of the data correlates each datum a large surface, hindering fine characterization of the target areas.



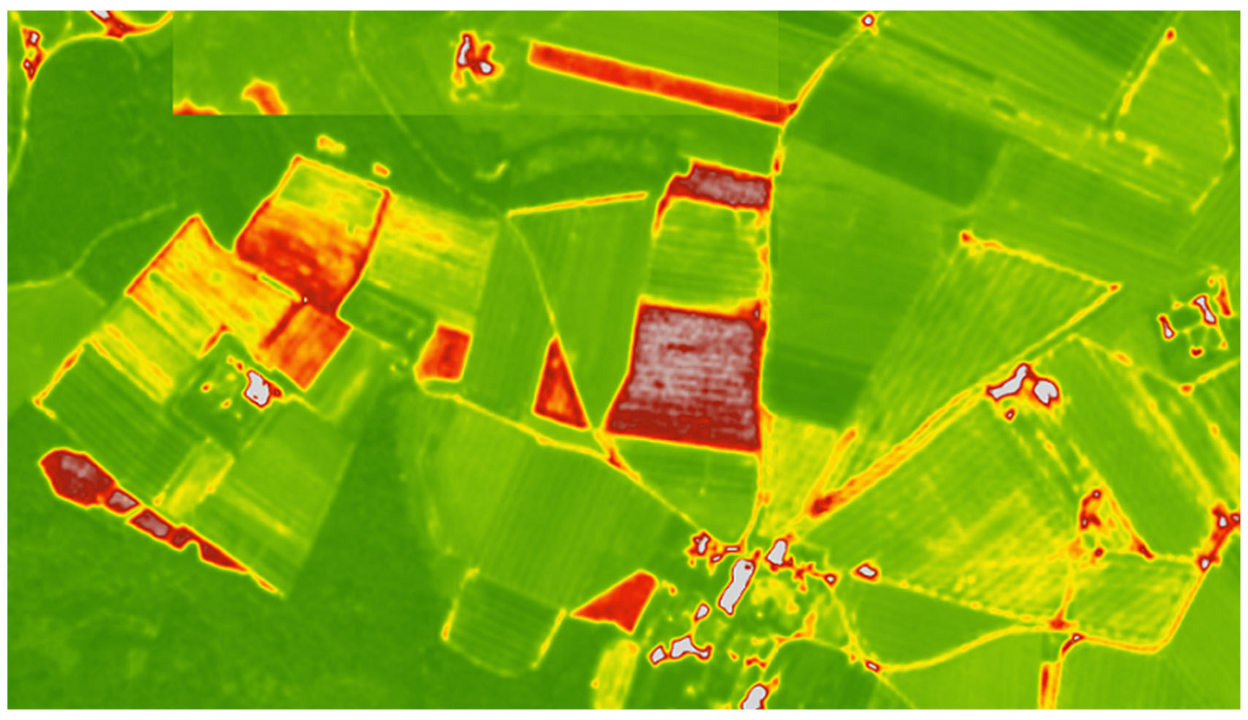
Sentinel 2 satellite, from Copernicus program.

• A method to enrich satellite data is proposed, using of autonomous robots to explore and sense the same targeted area of the satellite but yielding a finer detail of terrain, UAV platforms will produce higher resolution multispectral/LiDAR data, while other robots/stationary equipment provides meteorological and physical measurements. All the data will be stored under a RDF paradigm to simplify further study and dissemination. Through state of the art Deep Learning image enhancing techniques, the satellite images resolution will be enhanced.

Data adquisition for precision agriculture

• Two of the main problems in agriculture precision are evaluating the state of the crop and deciding on policies which should take place to improve it:

• The generalist approach to determining the state of a crop (and so the expected quality/value of the product) is to compute the NDVI (normalized difference vegetation index) through a near-infrared (NIR) source. Both NDVI and other related indexes (moisture (NDMI), moisture stress (MSI), etc…) are usually computed through satellite data, using imagery from Sentinel 2 and Landsat 8 [1].



Sample NDVI estimation from satellite data using Sentinel 2 NIR bands (10-20m spatial resolution) , and RED band (only 20m spatial resolution). NDVI predicts vegetal health.

UAV with multimodal sensor suite for precision agriculture

• The most impact process that can be assessed through data collection is irrigation:

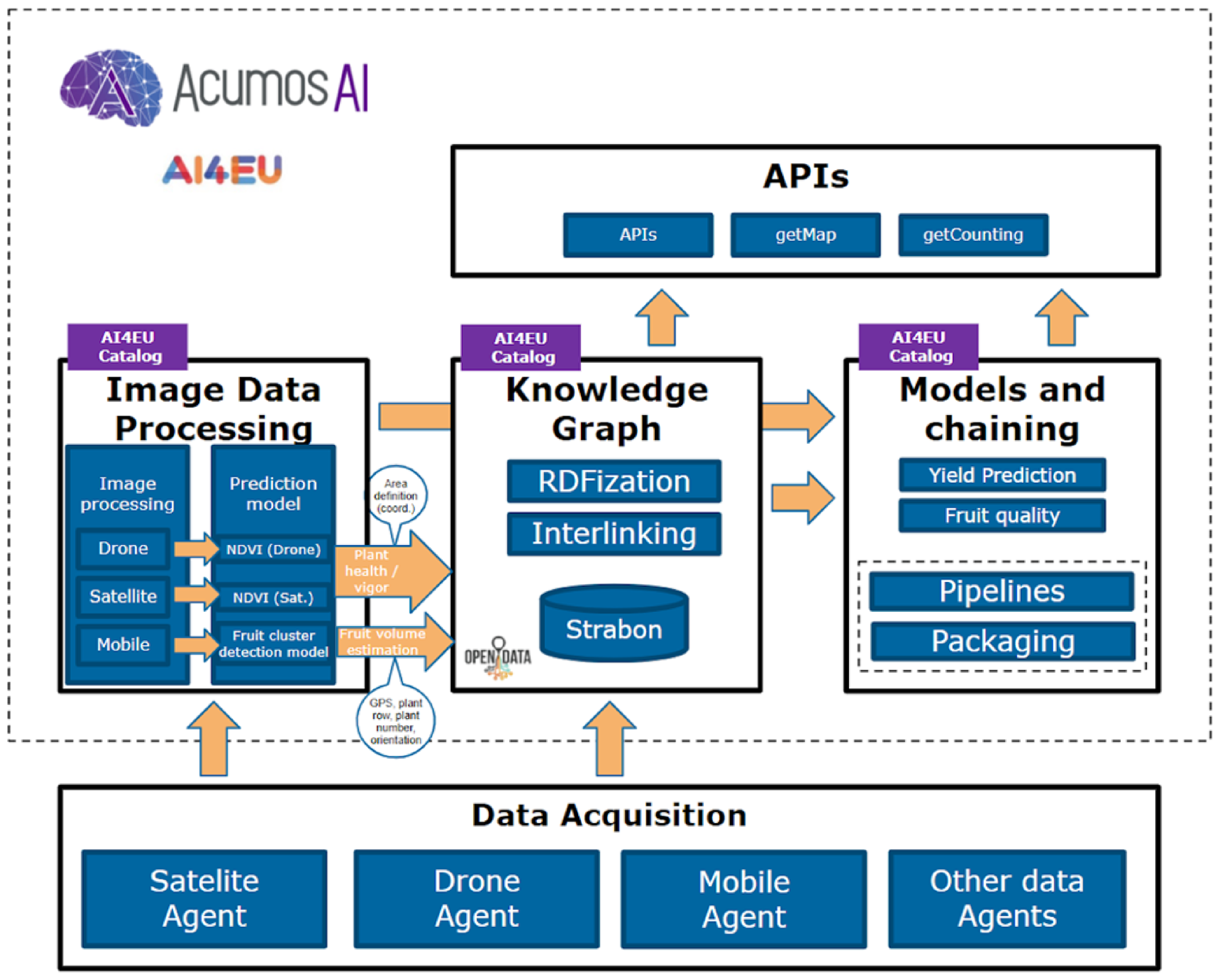
• In-site thermal maps are adquired through thermal imaging (usually in UAV) and additional ground and metheorological data can predict irrigation needs and consumption.

• This process is generally done through in-site imaginery as satellite thermal data does not provide data with enough resolution, though it is common to proxy a guesses estimation of the water potential through NDVI or derived indexes [2].

• Using UAV-based precision agriculture the LAI (Leaf Area Index) is also estimated with LiDAR sensors. This index correlates with NDVI and has been demosntrated to predict crop parametres for grapes.

• All the ground/UAV data is collected under a RDF-base (resource description framework), so it is organized as *linked-data*, making it compatible under a semantic web paradigm.

• The AI4EU project is a flagship project which aims to build the first European Artificial Intelligence On-Demand Platform and Ecosystem. The core element, the ACUMOS platform will allow to share data, models, knowledge and expertise.

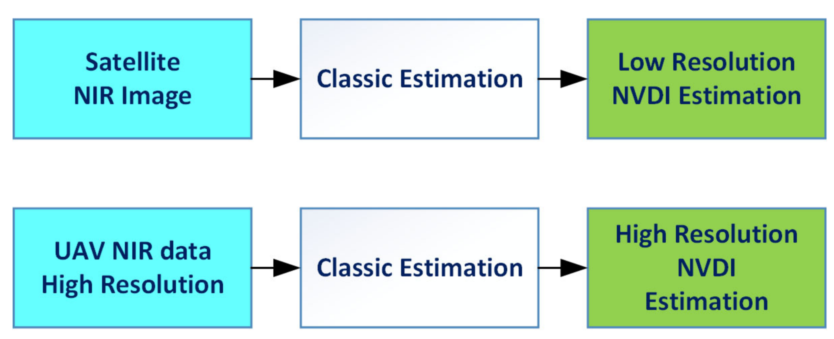


Data adquisition, pre-processing, data fusion in the knowledge graph and model use under the ACUMOS platform.

• In this context, all the data captured in our precision agriculture scenario is modelled into a semantic knowledge graph and stored into a SPARQL database, making data available through semantic and spatially referenced searches. Thus, UAV, satellite, ground and meteorological are linked.

Satellite image enhancement

• Deep Learning (DL) approaches based in convolutional neural network (CNN) have been successfully applied to classical vision problems with great success, with the latest generational adversarial networks (GAN) being used in image correction and generation problems [3].



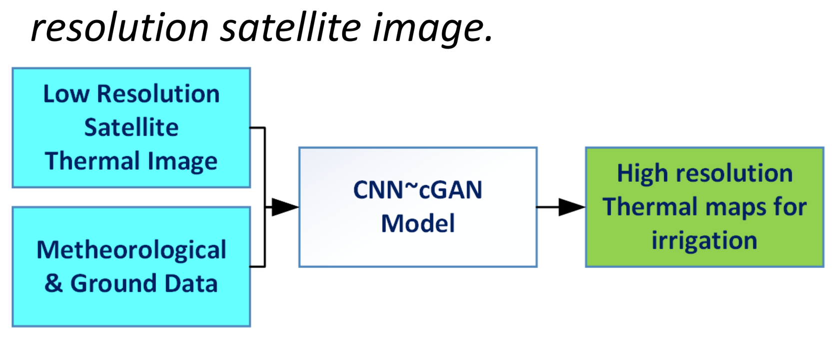
Classic NDVI estimation pipelines, satellite image provides low res estimations.

• To train CNNs **large datasets** are required, containing both the inputs and the desired outputs, or **labels**. The precise agriculture data acquisition scenario and knowledge graph organises the data and helps labelling it.

• The conditional GAN model to train will learn how to infer from satellite data and meteorological and ground data a more precise NDVI estimation, will pixels resolution below 30m (Landsat 8 NIR resoltion, 20 for Sentinel 2).

• In the thermal imaging scenario, current resolutions for Landsat and Sentinel are at 100m and 60m respectively. The proposed model aims for 10m or less.

High resolution NVDI pipeline from low resolution satellite image.



High resolution thermal mapping from satellite for irrigation.

• This will rely heavily on assumptions found on literature about validity of NIR/NDVI data as proxy for thermal/irrigation needs estimation .

Funded by the MINECO national project reference (PID2019-106702RB-C21 / AEI/ 10.13039/501100011033)

[1]Zhang K. et al. "Characterization of Sentinel-2A and Landsat-8 top of atmosphere, surface, and nadir BRDF adjusted reflectance and NDVI differences". Remote Sensing of Environment,Volume 215,2018.
[2] Xingbang H. "Agricultural drought monitoring using European Space Agency Sentinel 3A land surface temperature and normalized difference vegetation index imageries".Agri and Forest Meteo, Volume 279.
[3] Firdaus A. "Satellite image processing for precision agriculture and agroindustry using convolutional neural network and genetic algorithm". IOP Conference Series: Earth and Environmental Science. 54.