Satellite image processing based on GreenLand application

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Presentation topics

- ICT topics:
  - Satellite image processing overview
  - Satellite image processing applications
  - GreenLand general description
  - System related architecture
  - Vegetation indexes
  - GreenLand GUI description
  - GreenLand user scenario
  - Conclusions
Satellite image processing overview

- Satellite image processing
  - Definition: act of examining images for the purpose of identifying objects and giving them a significance
  - Applicability: used in different Earth Science domains
    - Land cover
    - Air pollution
    - Hydrology
    - Ecology
    - etc
  - Analysis: detecting, identifying, classifying, measuring and evaluating the significance of physical and cultural objects, their patterns and spatial relationship
Satellite image processing overview

- Satellite image processing
  - Types: many types of satellite images used for different purposes
    - Landsat
    - MODIS
    - Aster
    - Quickbird, etc
  - Access: there are several places from where to view and download these satellite images.
  - Size: depending on the geographical region size and on the containing information, satellite images could reach a couple of Gb in size.
Satellite image processing applications

- **GreenLand application**
  - Vegetation index based classification (NDVI, EVI, IPVI, SAVI, GEMI)
  - Works with pre processed Landsat satellite images
  - Runs on GRID infrastructure
    - Jobs are fast executed due to high computation and storage capabilities offered by the Grid infrastructure
  - Based on ESIP (Environment Oriented Satellite Image Processing Platform)
  - Quick and easy access
    - [http://cgis.utcluj.ro:4331/GreenLand1.3/](http://cgis.utcluj.ro:4331/GreenLand1.3/)
GreenLand vegetation indices

- The GreenLand classification process is performed based on vegetation indexes
  - NDVI (Normalized Vegetation Index)
  - EVI (Enhanced Vegetation Index)
  - IPVI (Infrared Percentage Vegetation Index)
  - GEMI (Global Environment Monitoring Index)
  - SAVI (Soil-Adjusted Vegetation Index)

- The classification process combines different bands in the Landsat satellite images in order to correctly make the classification
GreenLand general description

- Classification output (right image) based on input satellite image (left image)
GreenLand related architecture

OpenWater symposium and workshops, UNESCO-IHE, Delft, The Netherlands, 18-19 April, 2011
GreenLand related architecture

- Based on client-server architecture
- Relies on ESIP and gProcess platform

Client side
- GUI modules of the application
- Modules are built using the Adobe Flex technology
- GreenLand built in as a web application

Server side contains
- Java web services and methods that links the GreenLand application and the Grid infrastructure
- Java web services and methods that process the user requests and send it a proper response
GreenLand experiments outputs

![Graphs showing execution time vs. number of images for SAVI, NDVI, EVI, and IPVI metrics.](image)
GreenLand vegetation indices

- **NDVI**
  - The formula used in the NDVI classification process is the following:
    \[
    \text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}
    \]
  - NIR and Red represent two of the bandwidths of the Landsat satellite image.
  - This vegetation index is useful in classify the land cover.
  - Possible values for the NDVI are in \([-1, 1]\).
  - NDVI -> 0 for soil surfaces.
  - NDVI is in \((0, 1)\) for vegetation area.
  - Uncertainty in case of water detection.
GreenLand vegetation indices

- **EVI**
  - Closely related with the NDVI
  - Corrects some distortions in the reflected light caused by the particles in the air or in the ground cover below the vegetation
GreenLand vegetation indices

- SAVI
  - One of the best classifiers
  - Accurate differentiation from vegetation and non-vegetation areas
  - Based on the following formula

\[
SAVI = \frac{NIR - Red}{NIR + Red + 0.16}
\]
GreenLand vegetation indices

- **GEMI**
  - Minimize the atmospheric influence in the classification process
  - Sensitive to the soil noise
  - Uses the following formula

\[
GEMI = \eta \times (1 - 0.25 \times \eta) - \frac{Red - 0.125}{1 - Red}
\]

where,

\[
\eta = \frac{2 \times (NIR - Red) + 1.5 \times NIR + 0.5 \times Red}{NIR + Red + 0.5}
\]
GreenLand vegetation indices

- GEMI
  described as PDG

\[
\text{SG} \cdot (-0.25) + 1 \cdot \text{SG} \cdot \text{Red} - 0.12 \cdot \text{Red} \times (-1) + 1 \rightarrow \text{GEMI}
\]
GreenLand GUI description

1. Input and output dataset

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<th>IPVI</th>
<th>SAVI</th>
<th>GEMI</th>
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</table>
GreenLand GUI description

1. Input and output dataset

- This example uses three input Landsat satellite images (romania1, romania3, romania5)

- For the first image NDVI, EVI, IPVI and GEMI vegetation indexes are used in the classification process
GreenLand GUI description

2. Naming the process

- Before launching the process to execution over the Grid infrastructure the user should name it.

- The **Start processing** button is enabled only if the Process name and the Process description fields are filled in correctly by the user.
GreenLand GUI description

3. Monitor the execution

- Uses the GreenLand monitoring module
- The process execution status is visible for the user in the GreenLand GUI
- Performs periodically updates at GUI level
- Information are displayed using the EditorWS and the ViewerIC modules of the gProcess platform
GreenLand GUI description

3. Monitor the execution

- This module contains a process search and a filter mechanism
- Different search criteria: name, description, status or date
- Different filters: display all the active, completed or cancelled processes
GreenLand GUI description

- Processes are displayed to the user in the **Process status information** table.
- Each table input has a specific color, depending on the process execution status.

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<th>Node name</th>
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<th>End server time</th>
<th>Status</th>
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</table>
Conclusions

- This presentation highlights the main features of the GreenLand application and the land cover classification mechanisms.

- For now the GreenLand application works only with Landsat satellite images, but we intend to improve its functionality by adding the MODIS, Meris, ASTER or other satellite images type.

- The new human computer interactions are also the main features in extending the GreenLand application:
  - Overlay the output results on an interactive map
  - Simulate the evolution of natural phenomena
  - Allow the user to specify its own color legend that will be used to generate the output result

- Include and gridify the GRASS software package by ESIP to extend the standard interoperability.
GreenLand sample

- SAVI described as PDG

\[
SAVI = \frac{NIR - Red}{NIR + Red + 0.16}
\]
Thanks, Questions

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