GRID Structure Based Processing of Geographical and Environment Data

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- MedioGRID project
- GRID based processing
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- Vegetation indices based classification
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- GIS and LBS Kernel
Research objectives

- Computer Graphics and Interactive Systems Laboratory
  Computer Science Department, Technical University of Cluj-Napoca

- GRID computing
  Graphical processing of geographical and environment data
  MedioGRID Software Platform

- Satellite image processing
  GRID based processing
  Huge data management
  Data processing and visualization

- Active Object Model based modeling and simulation
  Virtual geographical space
  Distributed data
  Distributed processing
  Flexible structure and behavior
  User interaction

- GIS and LBS platform and application development

- Graphics modeling and interaction
  3D surface modeling and simulation – particle based
  2D and 3D space user interaction
MedioGRID

Parallel and distributed graphical processing on GRID structure of geographical and environment data, 19CEEX-I03 (2005-2008)

The MEDIOGRID project aims to accomplish a pilot program to process the images acquired in real time from meteorological and resource satellites, in order to extract the meteorological and environment parameters that characterize the atmospheric and terrestrial state.

Web site: http://mediogrid.utcluj.ro
MedioGRID Project

The project schedule:

- 1st year achieves and experiments the grid infrastructure, and analyzes the raw data and the processing techniques.

- 2nd year develops the Software Platform Kernel consisting of fundamental algorithms and components for image segmentation, and parallel and distributed data processing. It follows the kernel system experimentation over the grid by test and real input data.

- 3rd year develops and tests a pilot application specific for the analysis of social and ecological systems.

Project consortium:

1. Computer Science Department, Technical University of Cluj-Napoca, coordinator
2. Faculty of Geography, Babes Bolyai University, Cluj-Napoca
3. iQuest Company, Cluj-Napoca
4. National Administration of Meteorology, Bucharest
5. Computer Science Department, Politehnica University of Bucharest
6. Informatics Department, West University of Timisoara
7. Computer Science Department, Politehnica University of Timisoara
MedioGRID Project

- **Main objectives**
  - Develop GRID structure to support the parallel and distributed processing of huge data (geographical and environment)
  - Develop algorithms for GRID based processing of satellite images
  - Develop and experiment environment supervising applications with data extracted from satellite images
  - Model and visualize the virtual geographical space

- **Outcomes (2005-2006):**
  - Functional MEDIOGRID network (experimental GRID of 6 servers - Cluj, Timisoara, Bucharest and more than 50 workstations)
  - Software applications: Image processing MODIS (NASA), Cloud detection, Vegetation classification, MedioGRID Software Platform Kernel v1
  - Modeling and visualization of the virtual geographical space, GIS and LBS Kernel (Location Based Services)
  - GRID and Web services based architecture
VPN based MedioGRID architecture
Functional MedioGRID layers

Applications – Pilot Application
MEDIOGRID - Application Framework
MEDIOGRID - Software Platform Kernel
Middleware: Globus
Basic Grid Infrastructure

GIS data  Application Data  Image data
MedioGRID Software Platform

- QuickBird, Ikonos, Modis, Aster, Landsat
- Processing parameters: time window, spatial area, features, …
- Detection and supervision: vegetation, flood, wood fire, …
- Spectral signature
Data Management System

- **Data Mirroring and Indexing Component**
  
  Creates a local cache for the MODIS data granules corresponding to a specified area of interest (Romania and Cluj-Napoca surroundings).
  - Split each data granule into the 36 composing spectral bands.
  - Index the associated XML metadata.
  - Generate a full color representation for the MODIS data granules.

- **Metadata Catalog Service**
  
  Describe MODIS data granule characteristics such as: image type (spatial resolution, size), location (spatial extent), timeframe, satellite characteristics.

- **Data Access Component**
  
  Provides access to MODIS data granules which are used as input for the GRID processing nodes.
GRID processing application
Vegetation indices computation

- **PIMS Project** – Multispectral Image Processing Tool for Semantic Information Detection Based on Vegetation Indices

- **Subject:**
  
  uses the medium and high spatial resolution satellite images to study the extent and structure of the vegetation cover for a certain geographic area

- **Approach:**
  
  - Computes vegetation indices by processing multispectral satellite images
  
  - Classifies vegetation based on vegetation indices
    
    - DVI - difference vegetation index
    
    - RVI - ratio vegetation index
    
    - NDVI - normalized difference vegetation index
    
    - SNDVI - scaled vegetation index
    
    - TVI - transformed vegetation index
    
    - IPVI - infrared percentage vegetation index
    
    - OSAVI - optimized soil adjusted vegetation index
    
    - GEMI - global environmental monitoring index

  - Statistical analysis
  
  - Updates geodatabase
Vegetation indices – Experiments

- Band extraction: From the multispectral data set, the necessary bands are selected.
- Elementary processing: Optional – image transformations and improvements can be achieved.
- Segmentation: Image recodification and color – class correspondence settings.
- Classification: Classification algorithm execution in order to establish the vegetation classes.
- Interpretation: Carrying out a comparative study on the tested vegetation indices.
- Visualization: Result image and statistical data display.

Vegetation indices oriented processing.
Vegetation indices – Experimental results

“False color” image (bands 1,2,3)
Vegetation indices – Experimental results

DVI (difference vegetation index) based classification algorithm
Vegetation indices – Experimental results

TVI (transformed vegetation index) based classification algorithm
Vegetation indices – Experimental results

RVI (ratio vegetation index) based classification algorithm
Vegetation indices – Experimental results

NDVI (normalized difference vegetation index) based classification algorithm
Vegetation indices – Experimental results

SNDVI (scaled vegetation index) based classification algorithm
Vegetation indices – Experimental results

GEMI (global environmental monitoring index) based classification algorithm
Vegetation indices – Experimental results

IPVI based classification algorithm
Vegetation indices – Experimental results

OSAPI based classification algorithm
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Active Objects Based Apps over Grid Environment

- Theoretical model intended for the simulation and presentation of real world systems

- Active Objects Model
  - Accurate representation of real objects with structure and behavior
  - Flexible structure and behavior
  - Message based communication
  - Visual programming based development techniques
  - Dynamic and graphical presentation
  - High computing requirements
  - Implementation on grid network
3D visualization of the model’s presentation
AOM - Framework architecture

Client
- ModelServerProcessor
- ServerProcessor
- BehaviorProcessor

Web-service
- ResourceHome

Observer module
- Presentation Processor
- 3D Scene

- Bound-to message: Value changed
- Notification: update
Web Service Architecture

- **Factory Service**
  - EndpointReference createResource()

- **Client**
  - Requests resource creation

- **Instance Service**
  - void sendMessage(String msg)
  - void setHostName(String msg)

- **Resource Home**
  - Uses the resource home to create resources
  - Uses the resource home to find resources

- **Resource**
  - String message
  - String hostName

- **Requests resource creation**
- **Requests that an operation be performed on a specific resource**
- **sendMessage()** operates on the resource properties contained in the resource
3D visualization of the model’s presentation
Location Based Services (LBS)

Objectives:
- Develop spatial database
- LBS Software Platform
- Desktop and wireless applications
- Development tools
- Web services

MedioGRID extension
- Develop distributed topological database
- Support parallel and distributed grid computing
- Improve the spatial data from various data sources
  - e.g. satellite images, data providers, etc.
- Support LBS oriented processing
  - e.g. routing, geocoding, mapping, etc.
- Develop distributed LBS applications
- Provide geographical and environment information
  - Web services
  - Wireless handheld devices
LBS Platform

Application Level
- Mobile Routing Application
- TUGIS mobile Client

TUGIS mobile Server
- User Management
- POI Management
- Event Management
- Geocoding
- Routing
- Data Editing
- Data Formatting
- Mapping
- Data Access
- Data Visualization
- Data Acquisition and Processing

Legend:
- Yellow: contribution on the server side
- Orange: contribution on the client side
LBS Architecture
Extension of the TUGIS platform by a software package based on SVG and JavaScript to support the development of the interactive web applications.
Dissemination

- ISPDC Conference, 6-7 July 2006, Timisoara
- MEDIOGRID Workshop, 8-9 Dec. 2005, Cluj-Napoca
Dissemination

Publications: MEDIOGGRID vol1&2, more than 30 papers


- Muresan, O., Pop, Fl., Gorgan, D., Cristea, V. : Satellite Image Processing Applications in MedioGRID. ISPDC 6-7 July, 2006, Timisoara


Thanks

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