# A SOFTWARE FRAMEWORK TO SUPPORT AGRICULTURE ACTIVITIES USING REMOTE SENSING AND HIGH PERFORMANCE COMPUTING

Shamim Akhter and Kento Aida
*National Institute of Informatics (NII) and Tokyo Institute of Technology (TITECH), Tokyo, Japan*

Keywords: Agriculture, Remote Sensing (RS), High Performance Computing (HPC), Web Portal.

Abstract: Agricultural activity monitoring, enclosed quantifying the irrigation scheduling, tracing the soil hydraulic properties, generating the crop calendar etc., is very important for ensuring food security. Farmers want to know these information in a regular basis. Additionally, large scale agricultural activity monitoring requires to congregate information from Remote Sensing (RS) images and that type of processing takes a huge amount of computational time. Thus, optimization on the computational time is a vital requirement. In such cases, High Performance Computing (HPC) can help to reduce the processing time by increasing the computational resources. Moreover, web based technology can contribute an understandable, efficient and effective monitoring system. Still, the merging domain researches on RS image processing, agriculture and HPC are mainly in hypothetical or conjectural theme rather than practical implementation. Thus, this research contributes a new software system to support agriculture activities in real time using both RS and HPC. The main purpose of the system is to serve the valuable crop parameters information to the farmers through a web base system in real time. Additionally, we are going to discuss in details about the implementation issues of the proposed software system.

## 1 INTRODUCTION

Agriculture activity monitoring or prediction on crop parameters such as crop growth in terms of planting date, date of emergence, extents, acreage, planting intensity, water stress, biomass, yield and etc. is important. It can contribute to better policymaking, timely countermeasures, optimization of water resources distributions, damage assessment and finally to supply food security. Particularly, when an on-going experiment covers large area such as a country, satellite imagery plays a vital role by providing useful information. However, some information, or crop parameters, is not visible through satellite images, which reflects a practical problem that we can not generate or observe those parameters from remote places. Indirect method such as inverse modelling technique with crop model can solve the problem. However, processing the inverse modelling with crop model has a problem in practicality, that is, they require a huge amount of processing times. It becomes necessary to introduce methods for using higher processing power such as High Performance Computing (HPC) technologies. Some protocols or tools have been developed concerning the inverse modelling techniques and their HPC implementation models. However, the interoperability protocol between those agriculture applications and existing remote sensing (RS) image processing software is also necessary to improve practicality. Thus, a software framework is required which will make the successful interconnection between the inverse modeling techniques, the RS image processing and the HPC technology. In this study, we are going to propose such web based software framework to support the agriculture activity monitoring system. Additionally, the framework implementation issues or the difficulties for such framework implementation will be discussed in this paper.

Akhter S. and Aida K. (2010).
A SOFTWARE FRAMEWORK TO SUPPORT AGRICULTURE ACTIVITIES USING REMOTE SENSING AND HIGH PERFORMANCE COMPUTING.
In *Proceedings of the 5th International Conference on Software and Data Technologies*, pages 210-213

# 2 BACKGROUND

## 2.1 Inverse Modeling Techniques

Crop models, Soil-Water-Air-Plant (SWAP) (Van Dam et al., 1997) or Decision Support System for Agrotechnology Transfer (DSSAT) (Tsuji et al., 1994), have capacity to simulate soil, water and crop processes and serve as crop productivity monitoring tool. Crop Assimilation Model (CAM) predicts parameters of crop models with satellite images. A new methodology was developed in (Ines, 2004), CAM-GA, to analyze the crop model (SWAP) parameters assimilation with Remote Sensing (RS) data and that parameters assimilation procedure was optimized by an evolutionary searching technique called Genetic Algorithm (GA). CAM with double layers GA, CAM-DLGA, uses directly visible multi-resolution RS images (ASTER Image Webpage, 2009) (MODIS Image Webpage, 2009) and inversely assimilates to SWAP model data for estimating the non-visible model parameters. Other similar functionality models, e.g., CAM-PSO (Kamble and Chemin, 2006) and CAM-PEST (Dorji, 2003), use different evolutionary searching techniques. However, processing the agricultural information with CAM has a problem in practicality, that is, they require a huge amount of processing times. It becomes necessary to introduce methods for using higher processing power such as High Performance Computing (HPC) technologies.

## 2.2 HPC Implementation Issues

Multi computer based distributed systems (Clusters and Grids) have a large processing capacity for a lower cost, naturally, choice turns towards developing HPC applications. However, it is not an easy job to port CAM in HPC environment. The application performance is significantly affected by the data and task distribution methods on the HPC and developers of agriculture or satellite image processing applications need to solve the problem of both data and task distribution, or how to distribute data and tasks among single or multiple clusters environment. The workload in HPC, the bandwidth, the processors speed, parameters of evaluation methods and data size are additional concerning factors. Moreover, interoperability between the agriculture application and existing RS image processing software is also necessary to improve practicality. However, users need to manually extract satellite data from some databases in the existing CAM works. Thus, agricultural researchers require a software or tool for the agricultural activity monitoring so that they do not need to concern about the implementation issues for agricultural models or RS image processing on HPC.

# 3 PROPOSED FRAMEWORK

Figure1 presents the essential components during the building phrase of the proposed system, e.g., combines the agriculture applications with RS image processing tools, models them for HPC and then interacts with web tools. The objective of this research is to develop a complete HPC system or tool for CAM to identify the crop parameters from satellite image. The overall realistic architecture of the proposed tool is presented in Figure2 and the designing steps consists “processing satellite images automatically through HPC”, “CAM HPC implementation with appropriate data and task distribution schemes”. Individually, each step has been discussed and implemented with different data and application domains in (Akhter et al., 2007) and (Akhter et al., 2008). GRASS GIS (GRASS GIS, 2009) tool has been used to process the satellite images automatically. CAM has been implemented as a GRASS module. The interconnectivity between the GRASS on HPC platform has been successfully established and then the GRASS CAM module has been implemented in HPC platform with different data and task distribution methods. However, their combined framework for modeling the overall distributed agriculture monitoring scheme has not yet been established. Web based portal system on HPC for processing RS images protocol need to be established and that will merge those issues together into a unique platform. An excellent, fast and flexible open source mapping web software is UMN/MapServer (GRASSMAP, 2009). WMS (Web Map Service), is on online access to, or integration and exploitation of geospatial information, was successfully implemented in (Ninsawat, 2004) with FOSS (Free Open Source Software) to provide satellite image server. GRASSLink (Huse, 1995), a UNIX shell script based model, is capable to access spatial information from GRASS datasets and displayed necessary parameters in web through web-mapping applications. However, those works provide the mapping concept on static image environment. However, in the proposed framework, the image provider can be from different domains and then automatic data updating process will be a vital requirement. Thus, an interconnection between the domains is required with necessary security infrastructure. Figure 3 presents the web based architecture for the proposed framework. Openlayer (OpenLayer, 2009) or PyWPS (PyWPS, 2009) can be a solution on that circumstance. In our proposed methodology, we are going to select PyWPS, as it is relatively new concept and easy to create connection with GRASS. Additionally, PyWPS supports to create dynamic GRASS location for a given input image during the executable phase, makes the task easier for sharing input images from another repository. Two separate modules for client and server will be provided. In the server module, the CAM modules with GRASS GIS supporting environment and the HPC implementation for data distribution and task distribution schemes will be available. Whereas, in the client module, the user interface will be provided. User can select the specific region from a given image through the interface. XML based parser system will trace the user given queries and submit those queries to the server modules. Server module will execute the GRASS based CAM module with user given queries and generate unknown crop information; those are not directly extractable from RS images.

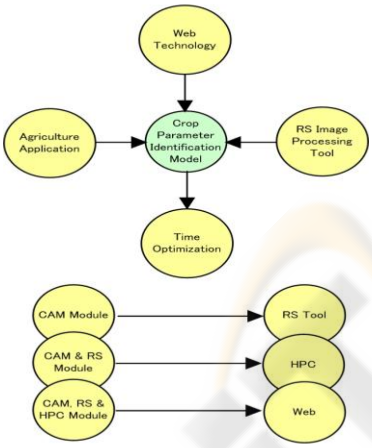


Figure 1: Essential Components to Build the Framework.

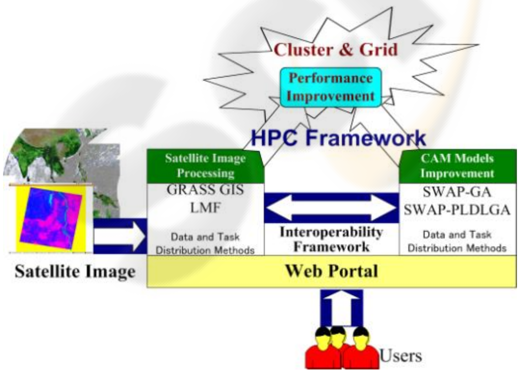


Figure 2: The Overall Realistic Architecture.

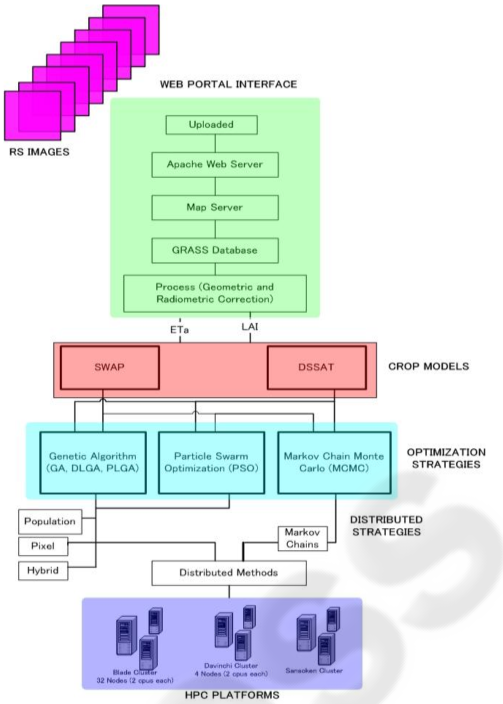


Figure 3: The Web based Architecture Framework.

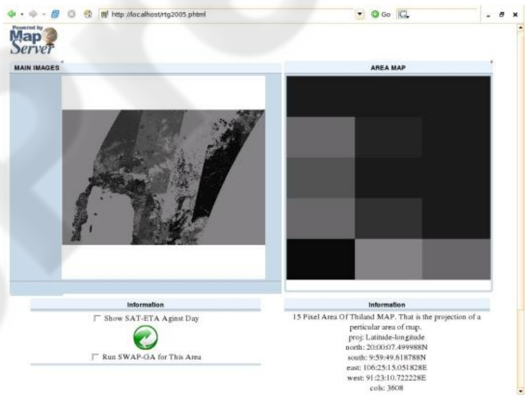


Figure 4: The UMN Mapserver based Static Image Environment.

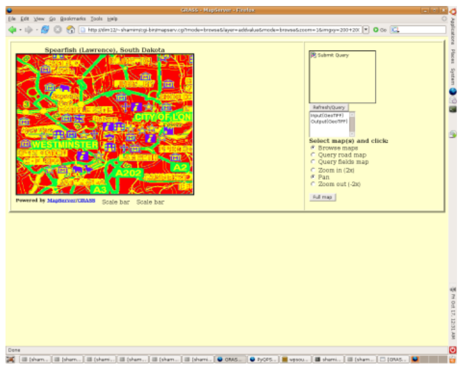

Figure 5: PYWPS based Agriculture System in Web.

# 4 RESULTS

Figure 4 presents the UMN Mapserver based static image environment and here user can watch only the predefined and preprocessed images. The images will not be possible to change without defining the new images inside the map files. Figure 5 presents the expected PyWPS based agriculture system in web. User can select the specific region to execute the agriculture model and then the agriculture model will process the input image and generate the outputs as images in the user interface. This example is a PyWPS demo implementation for CAM models. The entire software framework is in the developing phase. In near future, the fully automated software will be provided as a package or tool with the support of the following implementation issues: a) The RS image and the crop data will be automatically shared from the RS and agriculture data repository, b) users don't need to bother about the backend processes like the crop models or HPC or the distribution mechanisms, c) the expected time for processing image will be within few hours range, and d) multi-users can interact in the system at the same time. So, the portal must be capable to serve multi users processing requests.

# 5 CONCLUSIONS

This type of work will merge the RS based agricultural system with HPC and can be a model application for distributing the RS and agriculture field of study. Specially, this is the first effort to implement CAM-GA, CAM-DLGA, LMF and GRASS on top of HPC to provide the time optimization. The successful implementation of this research can be extended to city or provincial level, helps the policy makers to monitor the on field agriculture behavior and take prompt decision and action regarding any unusual condition. The extended version of the software with necessary crop model input data and RS image can capable to monitor any provincial or country level agricultural activities.

# REFERENCES

Akhter, S., Chemin,Y., Aida, K., 2007, Porting a GRASS raster module to distributed computing: Examples for MPI and Ninf-G, *OSGeo Journal*, Vol2., pp.36-44.

Akhter, S., Osawa, K., Nishimura, M., and Aida,K., 2008, Experimental Study of Distributed SWAP-GA Models on the Grid, *IPSJ Transactions on Advanced Computing Systems*, Vol.1 No.2, pp.193-206.

ASTER Image Webpage, 2009, http://asterweb.jpl.nasa.gov/, Internet.

Dorji, M., 2003, Integration of SWAP Model and SEBAL for Evaluation of on Farm, Irrigation Scheduling with Minimum Field Data, Enschede, ITC, 100 p.

GRASS GIS, 2009, Geographic Resources Analysis Support System, http://grass.itc.it/, Internet.

GRASSMAP, 2009, Simple demonstrational GRASS/UMN/MapServer (Spearfish data), http://grass.itc.it/start.html , Internet.

Huse, S.M., 1995, GRASSLinks: A New Model for Spatial Information Access for Environmental Planning, *PhD Thesis*, University of California, URL: http://www.regis.berkeley.edu/sue/phd/, Internet.

Ines, A.V.M., 2004, Improved Crop Production Integrating GIS and Genetic Algorithms, *PhD Thesis*, Asian Institute of Technology (AIT), Khlong Luang, Bangkok, Thailand, AIT Diss No.WM-02-01.

Kamble, B., Chemin, Y.H., 2006, GIPE in GRASS Raster Add-ons, http://grass.gdf-hannover.de/wiki/, GRASSAddOns, RasterAdd-ons, Internet.

MODIS Image Webpage, 2009, http://modis.gsfc.nasa.gov/, Internet.

Ninsawat, S. and Honda, K., 2004, Development of NOAA and Landsat Image Server using FOSS, *Proceedings of the FOSS/GRASS Users Conference*, Bangkok, Thailand.

OpenLayer, 2009, OpenLayers: Free Maps for the Web, http://openlayers.org/, Internet.

PyWPS, 2009, Python Web Processing Service, http://pywps.wald.intevation.org/, Internet.

Tsuji, G.Y., Uehara, G., and Salas, S., 1994, DSSAT v3.0., Honolulu, Hawaii: University of Hawaii.

Van Dam, J.C., et. al., 1997, SWAP Model, http://www.swap.alterra.nl/, Internet.