TITLE OF RESEARCH WORK: A Signal Algebra Operator Approach to the Analysis and Design of Image Processing Algorithms for Java-based Web-enabled Applications

Research Description:

This work deals with the implementation of a Java-based environment (called J-CID) which provides a set of operators for Image Processing according to the constraints imposed by the Signal Algebra of complex-valued images. Implemented operators includes Point operators (Absolute value, Clamp, and Color Convert), Arithmetic operators (Addition, Subtraction, Multiplication and Division between images and by constants; also includes Exponential and Log operations), Spatial operators (Invert color, Crop, Resizing, Rotation, and Flipping), Morphological operators (Dilation and Erosion), Convolution operators (Sharpening, Blurring, Embossing, Edge Detection which includes Sobel, Prewitt, Freichen and Roberts; Filtering which includes Low Pass, High Pass, Laplacian and Gaussian; and 2D Fast Fourier Transform), Cyclic operators (Cyclic Convolution and Cyclic Correlation) and Complex operators (Conjugate, Phase, Hadamard Product and Shifting).

This environment has the option of allowing end-users to add their own customized algorithms as encapsulated operators. Other features of the environment are the remote connection via Java FTP in order to get image files from remote machines, and the connection to a central database that contains raw data acquired by some sensors configured for the research.

WALSAIP GROUP ASSOCIATION: Automated Information Processing Group	
THESIS TITLE: Web-based Data Processing for Hydro-ecological Applications	
THESIS ADVISOR: Prof. Domingo Rodriguez	
INSTITUTION: Electrical and Computer Engineering Dept. University of Puerto Rico at Mayaguez	
PERSONAL WEBSITE: http://www.ece.uprm.edu/~s040639/	**NAME OF RESEACH ASSISTANT:** Lola Xiomara Bautista Rozo

RESEARCH PROJECT OUTCOMES:

Publications:

J. Villamizar, L. Bautista, D. Rodríguez. *A computational signal processing system for correlated digital Interferometry*, Proceedings of the 25th Midwest Symposium on Circuits and Systems. August 2005.
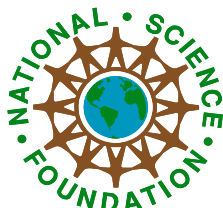
Tools and Applications:

The core of the application has been implemented using Java 2 Platform, Standard Edition, v 1.4.2. Some of the operators invoke methods from the Java Advanced Imaging (JAI) API which supports a simple programming model to manipulate images. Also it is used the Java Image I/O API which provides "a pluggable architecture for working with images stored in files and accessed across the network". As development environment it is being used Eclipse 3.2, because its attributes of being open source and multiplatform.

In order to take advantage of some of the main functionalities of the Image Processing Toolbox of MATLAB, it is being used an interface between Java and MATLAB 7.0. This interface is a JAR (Java ARchives) file which establishes the communication between de Java Virtual Machine (JVM) of Java and the JVM of MATLAB.

Java FTP software from jMethods is used to establish the remote connection to different machines. This software is open source and allow us the availability of integrate it to the main file application of JCID.
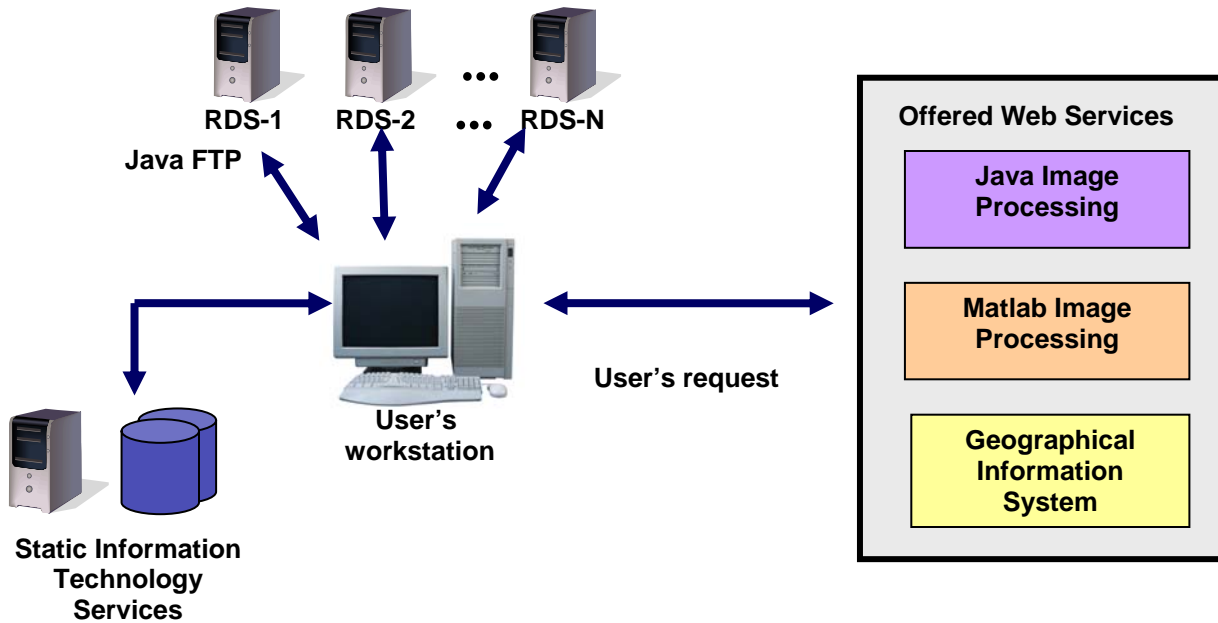
As database manager it is being used PostgreSQL 8.0 because it can connect directly to the own database that belongs to the software manager of the data acquisition from the sensors (MoteView).
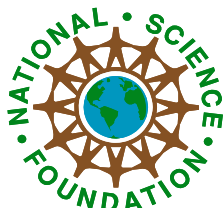
RELATION OF RESEARCH WORK TO WALSAIP PROJECT:

Related to WALSAIP project, this work contributes to provide a software tool for image analysis which could facilitate the work of scientists of related areas to environmental sciences, in this moment in a local manner, and soon in a distributed manner.

IMAGE REPRESENTATIVE OF RESEARCH WORK:

RDS-1   RDS-2   •••   RDS-N

Java FTP

Offered Web Services

Java Image Processing

Matlab Image Processing

User's request

User's workstation

Geographical Information System

Static Information Technology Services

This scheme shows a local user configuration. This considers that user can operate over the information he/she has in its own system, and from remote machines using Java FTP as channel of communication. User can make use of utilities from J-CID (the Java environment), MATLAB and the GIS he / she has installed.
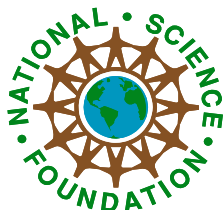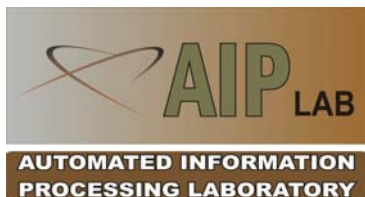
RESEARCH DEMONSTRATION:

Prototype of J-CID is intended to have the following features:

✓ <u>File management:</u> this comprises functions as Opening and Saving of different type of image formats and also text files.
✓ <u>Remote connection:</u> it refers to the availability to establish connection with remote machines, in order to get image files that could be processed in a local setting.
✓ <u>Connection to database of raw data:</u> J-CID will have the option to get data from the database that is collecting data from the sensors used for the research project. At this moment it is being used a database implemented in PostgreSQL 8.0.
✓ <u>Loading and visualization of different kind of image formats:</u> when user requires opening an image file, J-CID will load the image content as a matrix of complex data, this means that is being considered that each pixel of the image is a complex number, with real and imaginary components. This matrix will be the basic structure to perform all kind of image processing operations. In the same way, obtained results from the operations will have the same matrix structure. This representation will be used to visualize the images graphically by means of the Graphic class of Java. When each image is visualized, will appear a tab with the basic features of the image, features such as Width, Height, File name and the histogram that represents the distribution of the grayscale.
✓ <u>Creation of text files for raw data:</u> it is being considered that the results from the queries to the database will be stored in text files in the local system of the user. When these files are open, the data will be represented graphically as Time Series, since the nature of the data.
✓ <u>Implementation of unary complex operators:</u> this refers to the implementation of operators that affects only one image at each time. Examples of this kind of operators are: point operations, morphological operations, and filtering operations.
✓ <u>Implementation of binary complex operators:</u> it refers to the operators that use two images as input to produce a new image. Examples of these operators are mathematical operations, logic operations, cyclic convolution and cyclic correlation.
✓ <u>Encapsulation of operators:</u> this feature refers to the availability to make composition of a sequence of operations performed over an image. In this way a new operator can be created in order to minimize the number of repeated operations over new images. It is intended that the sequence of operations can be visualized in a tab in the form of flow diagram. The set o new operators created by the user will be added in a different tab to be viewed as a repository for new users.
✓ <u>Usability:</u> one of the goals is to provide a useful graphical user interface, in which users can interact with operators in an easy way.
✓ <u>Help and User's Guide:</u> this modules will be available to users in order to guide them through the main functionalities of J-CID and to learn how to use it. Help will be integrated into the system, and the User's Guide will be available in another format, with a good interactivity as be possible.