MIDDLE EAST TECHNICAL UNIVERSITY
DEPARTMENT OF COMPUTER ENGINEERING

CENG 491 – REQUIREMENT ANALYSIS REPORT

MİLSOFT - PHOTOGRAMMETRY LAB PROJECT [PHOTOLAB]

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TABLE OF CONTENTS

1. INTRODUCTION

1.1 Project Definition and Scope

Nowadays, in all over the world, new projects have been launched for the Unmanned Air Vehicle (UAV) Systems whose role in defense concepts is becoming more important, and the expenses for UAV systems are increasing above the expectations.

UAVs can do exploration, observation and target detection with the help of a camera that is mounted on them. The images collected by UAVs are just a collection of photos without processing. To make use of these photos, they have to be processed and so become meaningful. This process is called Image Exploitation. Image exploitation, by using some techniques, makes use of image processing algorithms for information extraction.

This project is about Image Exploitation Systems. The data collected from the Unmanned Air Vehicle is not just a collection of 2D pixels, it is a 3D view of the Earth's surface; therefore the image has a depth. In addition, the images may not be taken at the same time or at the same attitude, so there are some difficulties in this project and we need to follow a proper order during this project. The expected four methods and their proper order are as follows:

- **Digital Elevation Model (DEM):** A three-dimensional surface map of an area is usually stored as a grid of elevation points called a Digital Elevation Model (DEM). DEMs are created by collecting elevations and referencing them to corresponding points in the mapped area. The elevations add a Z value to the ground's X and Y horizontal coordinates. So, using a DEM, a user can view an area in three dimensions, giving a clearer understanding of the problem.
- **Orthophoto:** An orthophoto is an aerial photograph that has been geometrically corrected to remove geometric distortion caused by camera tilt and differences in elevation. The digital orthophoto is a photographic image of the terrain - but more importantly, it is true to scale and therefore accurate distances and areas can be measured. These orthophoto images are well suited for detail planning and analysis of what exists on the ground. In order to acquire correct

orthophoto, we need to generate a precise and accurate DEM of the Earth's surface.

- **Mosaic:** Many problems require finding the coordinate transformation between two images of the same scene or object. One of them is Image Mosaicing. It is important to have a precise description of the coordinate transformation between a pair of images. Image mosaics are collection of overlapping images together with coordinate transformations that relate the different image coordinate systems. By applying the appropriate transformations and merging the overlapping regions of warped images, it is possible to construct a single image covering the entire visible area of the scene. This merged single image is the motivation for the term ``mosaic''.
- **Super Resolution:** Super-resolution is a term for a set of methods of increasing image or video resolution. All these methods are based on same idea: using information from a set of low-resolution images to create one or a set of high-resolution images. These methods try to extract details from frames to reconstruct other frames. SR works when several low resolution images contain slightly different views of the same objects. In this case total information about the object is much higher than information in one frame.

1.2 Application Areas

The images collected from UAVs' cameras have wide range usage areas. UAVs are currently used in a number of military roles such as gaining military or medical information and also they are also used in growing number of civil applications. Some of the application areas of photogrammetry and separately the above four methods are listed below:

- Problems in road design and similar civil and military engineering projects.
- Statistical analysis and comparison of different kinds of terrain.
- Realistic display of landforms for such diverse areas as pilot training, weapons guidance, and landscape architecture.
- In observational astronomy, universities and NASA centers that have small telescope operations can use the methods to a wide variety of research areas.

- Photogrammetry is mainly used in archaeological surveys, urban planning and monument restoration.
- Searching and rescuing humans trapped in collapsed buildings or adrift at sea.
- In security issues like scenes of murders, burglars or smugglings, or in damage detection issues.
- In computer applications, such as games, atlases, and encyclopedias.
- In industrial applications such as shipbuilding, traffic engineering, mining engineer, automobile construction, structures and buildings.

2. PROCESS

2.1 Team Structure

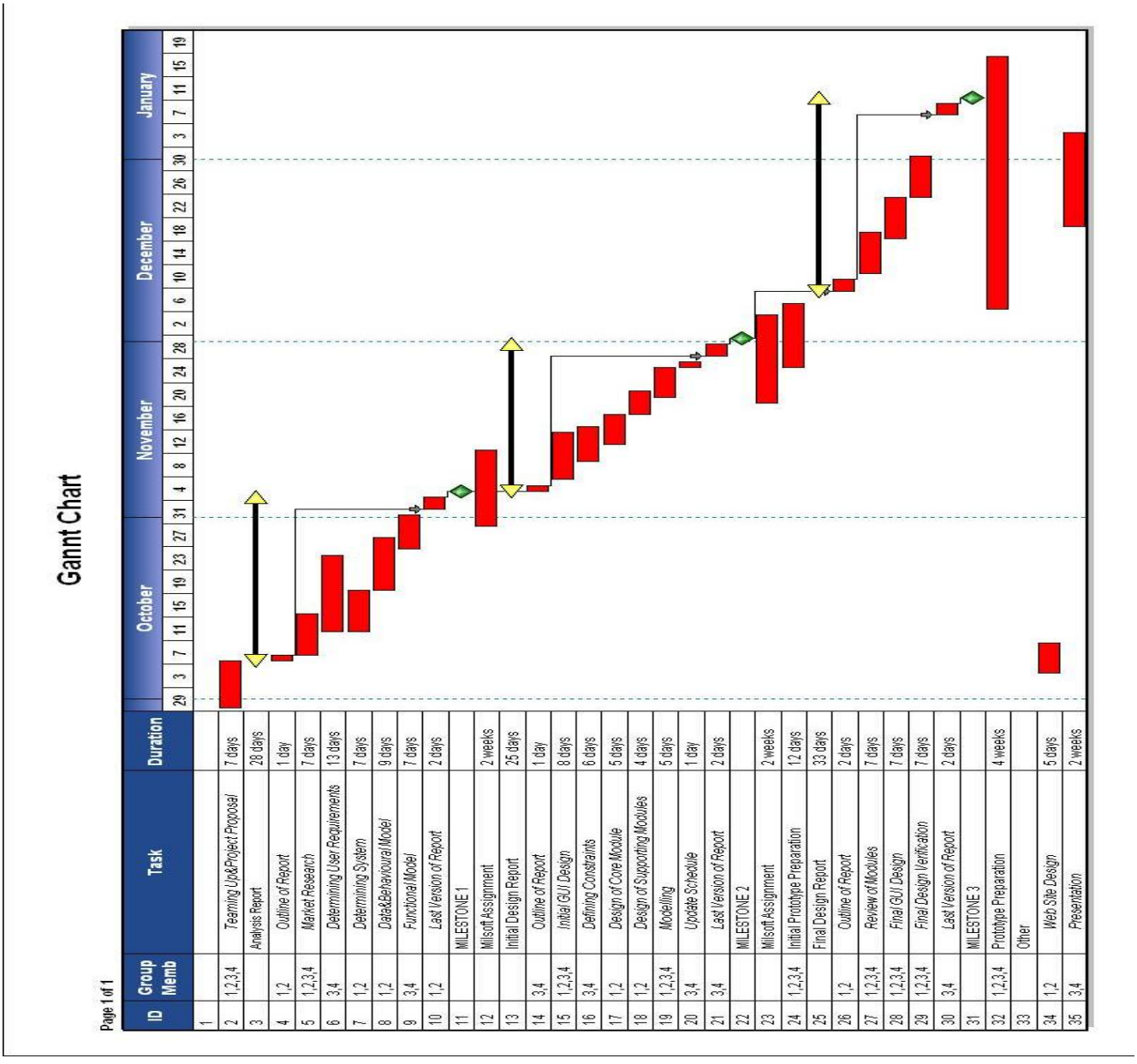
As a group we decided that “Democratic Decentralized (DD)” fits best to our project and project group. Our first priority is cooperation and this model ensures a high rate of cooperation since it forces us to communicate in decision making. We appointed the tasks to the members for short durations at our weekly meetings. Another reason that we have chosen this structure is; we make decisions on problems or weekly tasks by agreement of each member. In case there is a contradiction among the group members, we chose a group leader to say the last word to prevent disagreements.

2.2 Process Model

Our project team will iteratively go through planning, modeling, construction and deployment stages. For this reason, linear (waterfall) model of development best fits to our project. After the requirements analysis, we are going to make our initial design. Actually, Milsoft wanted the process model to be spiral during the design and implementation phases so they wanted more than one prototype. By this way, we will have a chance to go back and correct the faults in the design which we found during implementation.

3. PROJECT SCHEDULE

3.1 Gantt Chart



4. PROJECT REQUIREMENTS

Determining the requirements is a crucial part of the project. For maintenance of the project, it must be guarantied that no unexpected events and requirements should occur during the development. Therefore we must specify the project requirements very carefully. We classified the needs for the project as system and user requirements.

4.1 System Requirements

4.1.1 Hardware Requirements

While determining the hardware requirements, we look after the similar software programs that have been developed till now. The software products that we mentioned at market research part generally had similar hardware requirements. The following requirements for hardware seem to be minimal and enough for our project development:

- P4 or Equivalent Processor
- Minimum 512 MB RAM
- 3D Graphics Card
- Minimum 40 GB HDD

4.1.2 Software Requirements

We will use several tools for different phases during development of the project. The following requirements during documentation and development phases are necessary for project.

Documentation Phase

- Microsoft Office 2007
- Milestone Professional 2008
    - For drawing Gantt Charts for the reports. It is more functional than SmartDraw while drawing Gantt Charts so we preferred Milestone Professional 2008.
- SmartDraw
    - For drawing the diagrams and charts for the reports. SmartDraw is easy to use.
- Adobe Acrobat Reader

- For writing and submitting the reports. We write our reports on Microsoft Office 2007 and submit them after we convert it to pdf format.

Development Phase

- Windows XP and Linux
  - PHOTOLAB must be running operating system independent, so we will work on both Windows and Linux.
- Microsoft Visual Studio .NET 2003
  - From our previous experiences, we are used to work on Visual Studio .NET. Because the language we will implement PHOTOLAB is C++, and .NET provides easy usage, we preferred it.
- wxWidgets GUI Toolkit
  - We will use wxWidgets in GUI design. Software is advised by Milsoft and because it is working with C++, we preferred it.
- Microsoft Visual Assist
  - It is an add-in for Visual Studio .NET and provides generally more accurate and complete code suggestions. It also has the syntax highlighting feature.
- OpenGL Library
  - Since it can be run under both Windows and Linux platforms and it is compatible with C++, we preferred OpenGL libraries for 2D and 3D image visualization.
- OSSIM (Open Source Software Image Map)

- We preferred it since OSSIM is a high performance software system for image processing, geographical information systems and photogrammetry.

4.2 User Requirements

4.2.1 Functional Requirements

Functional requirements are the essentials of the system which form the skeleton of the software. These requirements cover the main parts of a project dependent GUI and main features of photogrammetry, in our project.

4.2.1.1 Create a New Project

Creating a new project is the first expectation from user dependent software. Therefore in our project, creating a new project phase firstly creates a new folder in workspace of the system and expects a project name from the user. If it is not represented by the user, the system gives a default name via a dialog box.

4.2.1.2 Delete/Modify an Existing Project

An unused project can be deleted by the user with all of its folder, included files and its extensions. Deleting prompts user to verify the process since the user can make an unintended deletion. Modifying is different from the deletion since modifying not only means deletion of unnecessary files but also doing some necessary additions to the project.

4.2.1.3 Open/Close an Existing Project

Since development of a project usually requires working several times on it, user needs to open an existing project from workspace or needs to close it for the purpose of opening it in another time. When the user opens a project, it seems with its tree structure in a project explorer window. The tree structure of the project includes the processed images which belong to the project. Another component of the project explorer window is data library which includes the original and unprocessed images. It helps the project in terms of seeing original images when they are needed without an extra opening procedure. Closing the

project comes with two alternatives. One of them is closing the whole system. If the user wants to close the whole system before closing the project systems gives a warning and asks the user whether to save the existing project or not. The second one is to close the current project and to open a new one meaning switching between two projects. In this case, the system again asks whether to save the changes or not.

4.2.1.4 Open/Load/Remove an Image

PHOTOLAB provides the user to work on a single image or multiple images added to a project. In order to process an image the user has to load it to the data library for just working on it or for the further use in a project. All of the projects can access the data library items directly, providing disk space reliability as a result of using only one copy for all of the projects which the image belongs to. If the user wants to work on a single image such as enhancing it or using a DEM on it, the user can open the image independent from a project and can work on it. If the user wants to add an image to the current project and work on it, the user has to load it to the project from the data library. Removing an image from a project or data library is not the same thing. In order to remove an image from a project, the user just needs to remove it from the project tree. In order to remove it completely, the user must delete it from the data library.

4.2.1.5 Open/Load/Remove a Video

PHOTOLAB also works with aerial video input. Aerial videos have same load process with image data in loading data library. However for a created project, the user must specify the data type that will be loaded and opened. After loading a video into a project, all image enhancement and photogrammetry tools can also work for the videos since PHOTOLAB treats videos, like multiple images that are processed sequentially. An aerial video and images can be processed together. For instance, after forming an image of a city from a video, user can mosaic it with the images of adjacent places. Therefore images and videos can be found in the same project.

4.2.1.6 Modes

PHOTOLAB represents the user 2 choices of use which are manual mode and automatic mode. In manual mode, the user can modify the images by giving the necessary parameters manually, and in the automatic mode, PHOTOLAB processes the image(s) by finding the necessary parameters itself.

4.2.1.7 Visual Layout

PHOTOLAB provides the user to view the image(s) in 5 different scenes which are one-two-three-four images on the screen at a time or multiple images cascaded. Another property which PHOTOLAB provides is a toolbar containing some options such as scaling or rotating the image.

4.2.1.8 Enhance an Image

PHOTOLAB gives the user an opportunity to enhance the image(s) by using various enhancement techniques such as setting the brightness values of two images, or filtering an image, or roaming on a path, or making contrast stretching.

4.2.1.9 World File

Geographic information systems use word files to coordinate raster map images. A world file is a plain text computer data file which describes the location, scale and rotation of the map with 6 line. In a world file, parameters describes the pixel size or rotation around an axis or coordinates of the center of the upper left pixel. GIS software can see the images with their original properties by interpreting the information in the image's world file. PHOTOLAB uses the world file format to calculate the original position of the image on earth in order to use it in the main steps of photogrammetry which are DEM, MOSAIC, ORTHOPHOTO, and SUPERRESOLUTION. Worldfile data for every image is shown in the information bar at the bottom of the image window in PHOTOLAB.

4.2.1.10 Process History

The systems that include image processing functions have to provide the user more possibilities to see the whole process step by step. PHOTOLAB has a “History Tool” for this purpose. History feature records last four changes on the project and also the original of the project that the user last saves. Therefore, the user can examine the results of each action on the project easily and learning all the features of PHOTOLAB will be simplified.

4.2.1.11 PHOTOGRAMMETRY

Photogrammetry part of PHOTOLAB is performed by four procedures which will be discussed below.

4.2.1.11.1 DEM

Generating the digital elevation model of the field is the first step of PHOTOLAB since in order to do the correct orthophoto or mosaic, we need to generate an accurate DEM of the Earth's surface. The DEM function of PHOTOLAB will need aerial photographs and the input data (in world file format) which gives the camera calibration parameters etc. By looking only one image and process it with DEM function we may have the DEM image however if we want the exact elevation, we need more than one image. More overlapped points may give more idea about the field. There are many different methods for representing the surface elevation but the basic idea behind them are the same. The main task of the DEM generation is by using the ground information which is kept at the world files, estimating the elevation of some point with the help of collinearity equations and direct linear transformation equations. We can simply store the estimated elevation values representing the height of the earth at the given latitude and longitude and then by joining these points by straight lines, we can have a DEM visualization which seems as a rendering of a surface.

4.2.1.11.2 ORTHOPHOTO

One of the main features of PHOTOLAB is Digital orthophotography. Orthophoto is simply an aerial image that has been purified from its distortions which are originated from lens, attitude of camera and the shape of earth itself. The Orthophoto function of PHOTOLAB will need aerial photographs, ground control information and DEM as input. To look and process

single photo will not create a reliable and detailed Orthophoto, therefore PHOTOLAB will use some information such as camera calibration information for lens related distortions, etc. The ground control information is kept in world files. The system can find the world files of each image from data library. The central task of the Orthophoto generation is rectification and georeferencing the image by using mathematics with world file information. Rectified and georeferenced photo will have geometrically correct position ,specific level and the scaling of the needed output image according to DEM and digital terrain model(DTM). The next task is radiometric correction. Solar illumination, atmospheric variables, topographic variations and sensor failure will be corrected by radiometric correction. And final task is the completion of the black points of the rectified and enhanced output image by using some techniques such as overlapping band, least-squares-approach, etc. The final output is geometrically reliable map equivalent image.

4.2.1.11.3 MOSAIC

Producing the best mosaic is the main goal of PHOTOLAB. However stitching the overlapping images is not an easy procedure since the images do not always belong to the same position, hight or point of view of the camera (i.e camera model). Therefore in order to make an efficient mosaic, PHOTOLAB needs the image data produced by the courtesy of DEM and ORTHOPHOTO. After getting the image data (in world file format) and the images to be mosaiced, PHOTOLAB starts the mosaicing procedure firstly by doing the image registration. Image registration is finding the transform (homography) that best maps an image on the other, considering a pair of images, followed by a local adjustment to avoid the ghosting and blur in the mosaic. Task to be done after the image registration is image blending. The idea behind the blending is to take a pixel from a background image and a pixel from the source image and combine them together with a specified color assigned to the this overlapping pixel. Blending is also important if there are moving objects in the images. After the blending, here comes the exposure compensation task. Since the digital cameras have automatic exposure control, there may be some brightness difference between the overlapping images. In order to get rid of the outcomes of the automatic exposure, PHOTOLAB computes the mean luminance for each images in the overlapping area and derives a relative gain. By applying an optimizing algorithm using the gains to the

overlapping areas, PHOTOLAB adjusts the image brightness which provides the mosaic a more realistic looking. After this last step, a good image mosaic is obtained as an output of the mosaicing.

4.2.1.11.4 SUPERRESOLUTION

The optional feature of PHOTOLAB is Super-Resolution. Super resolution (SR) corresponds to the resolution enhancement process by fusing multiple degraded images. High resolution pixels can be formed by projecting all observations onto a common frame and sampling using reconstruction framework. First step to do is uploading some photos as input and then choosing a target image which is going to be used as a reference frame to warp all images. Target frame is the region of interest where enhancement takes place. There are three main steps after choosing images, first of which is called geometric registration. In this step, matching features are searched, found and extracted from corresponding images especially with corner detection algorithms, and these matched parts are geometrically transformed for warping. The second step in the super resolution algorithm is photometric registration. Since not all images are necesarily taken under the same lighting conditions it may be necesary to adjust for lighting changes.

These lighting changes could be due to automatic camera adjustments or illumination changes. This step is optional and can be processed in case of illumination variation. The last step is reconstruction step. In warping we should use a method of interpolation technique and finish the Super-Resolution process. To sum up, geometric registration, photometric alignment, and reconstruction are the three main steps of Super-Resolution Process.

4.2.1.12 Help Files

PHOTOLAB provides user help files in order to make easier the usage. These help files includes the necessary information about the usage of the software in terms of functionalities. These help files are divided into sections to make an easy access to the needed information. Help files also include a search and index box for faster search.

4.2.1.13 PHOTOLAB File Format Packages (Optional)

According to Bad Sector Team's market research, it is understood that PHOTOLAB will have to deal with various image file formats. The world file formats also may be differentiated such as .jpgw, .tifw. PHOTOLAB will optionally have a Format package feature, to let Bad Sector add new file formats to program, even after installation.

4.2.2 Nonfunctional Requirements

4.2.2.1 Usability

The best interaction between the software and the user is achieved by the usability of the software. In PHOTOLAB project, usability is planned by an easy to use program with a lot of capabilities. A simple and clear GUI increases the usability in PHOTOLAB. If a usable program is intended, then it should not have wide range differences from the software developed for the same purpose. It should also follow a step by step behavior without making the user complicated about the functionalities.

4.2.2.2 Reliability

PHOTOLAB is software which is designed for processing the real earth photos. Its output must be error-free since it will be used in serious geographical system analysis. PHOTOLAB's photogrammetry functions will create map equivalent images. Therefore, it has a wide scale use all over the world. The most important reason for the software to be reliable is that the outputs are not controllable with the human eye. As a result, PHOTOLAB must represent the exact outputs without any error or conflicts.

4.2.2.3 Platform compatibility

Platform compability is one of the basic architectural concepts of PHOTOLAB. This simply means PHOTOLAB will be operating system independent software.

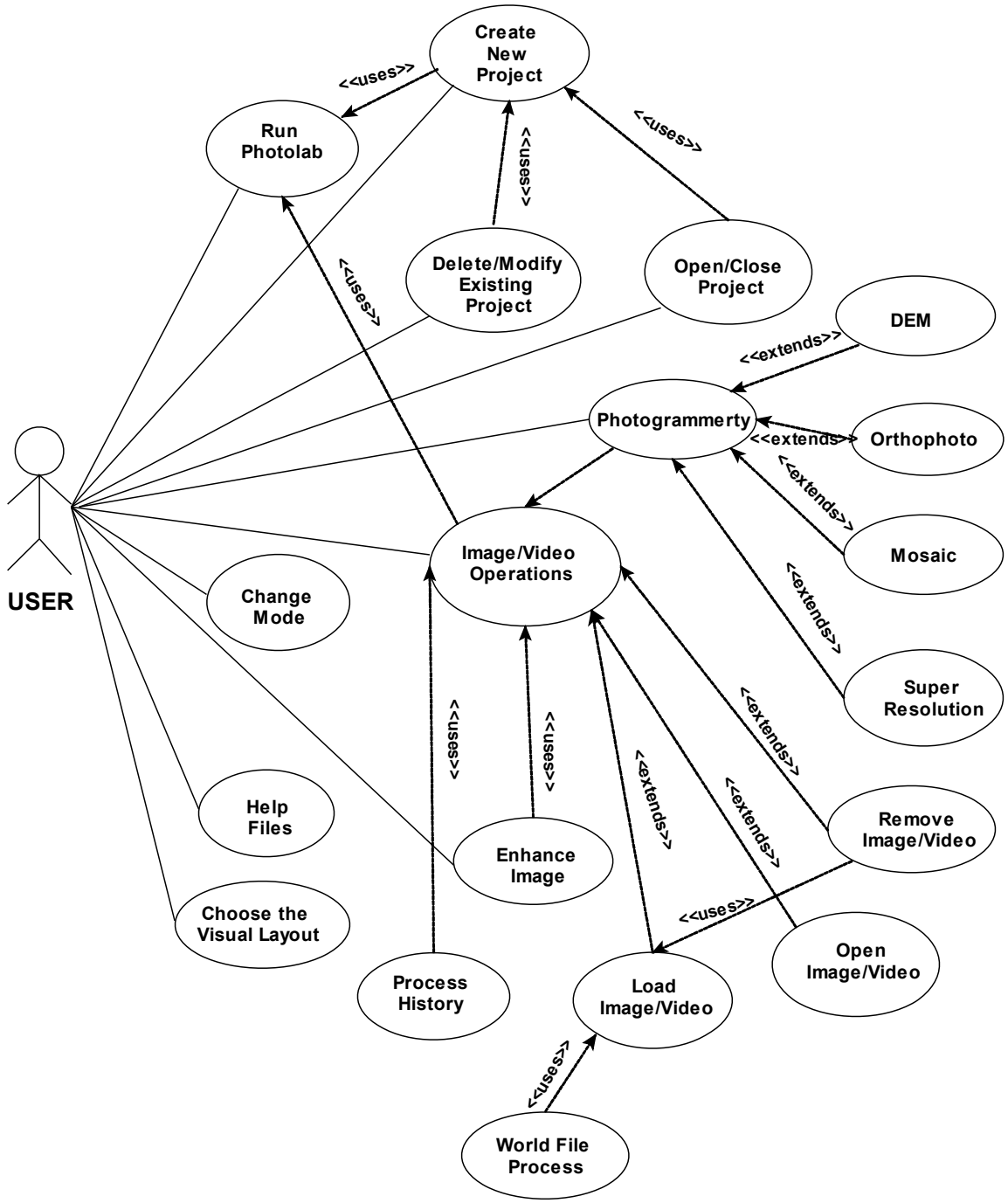
4.2.2.4. Performance / Response time

PHOTOLAB is designed to work on a variety of images at the same time. For instance, a video is a continuous fllow of images, and PHOTOLAB will process the shots in succession. Therefore, all the tasks and subtasks must have a good performance namely a short response time on their own.

4.2.2.5. Extensibility

As Bad Sector team, optionally,we plan to develop PHOTOLAB as package adaptable.(i.e. adding features, and carry-forward of customizations at next major version upgrade, [wikipedia]). Package adaptation will provide PHOTOLAB working on different and new file formats namely image and world file formats.

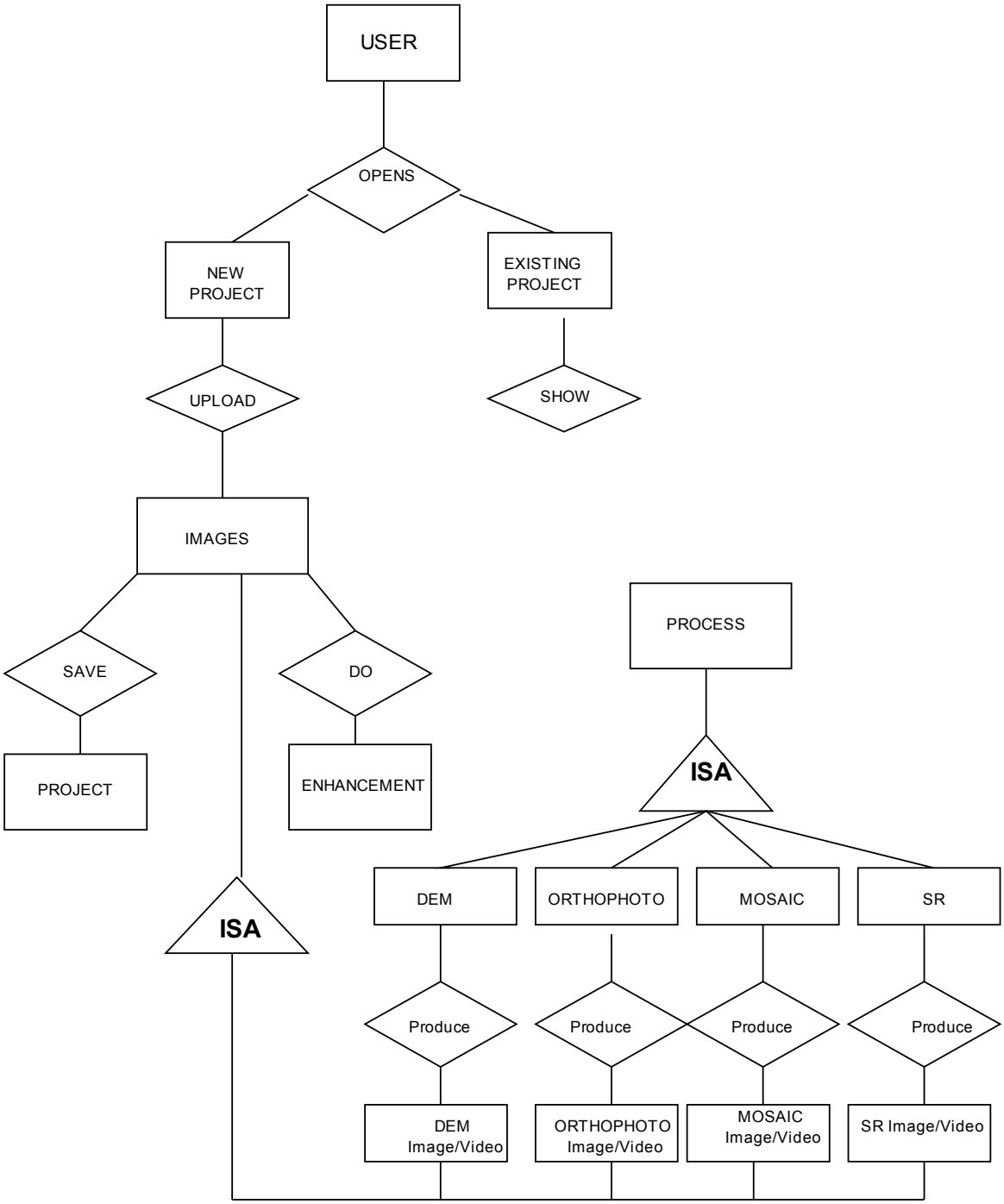
4.2.3 Use Case Diagram



5 MODELING

5.1 DATA MODEL

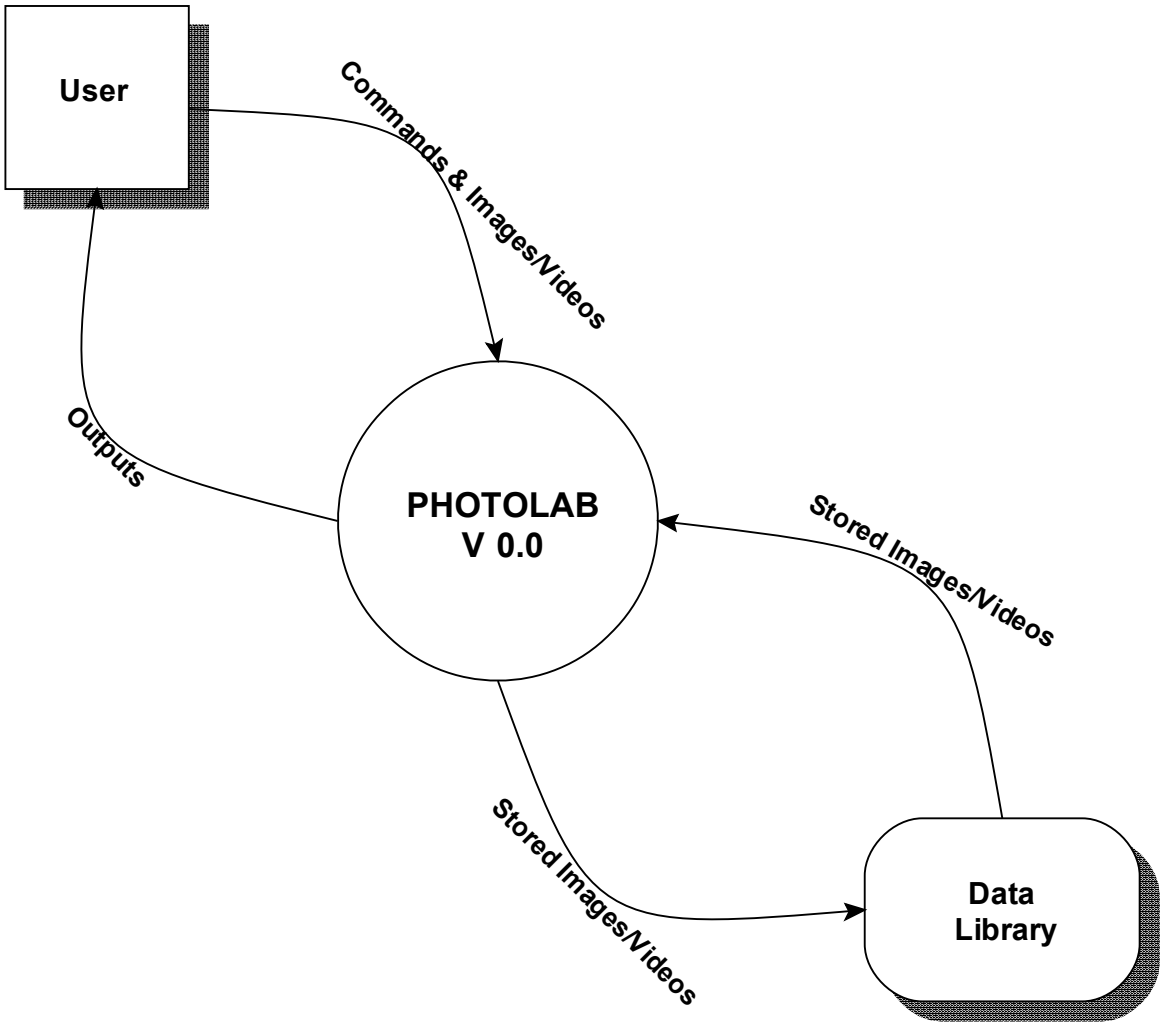
5.1.1 ER Diagram



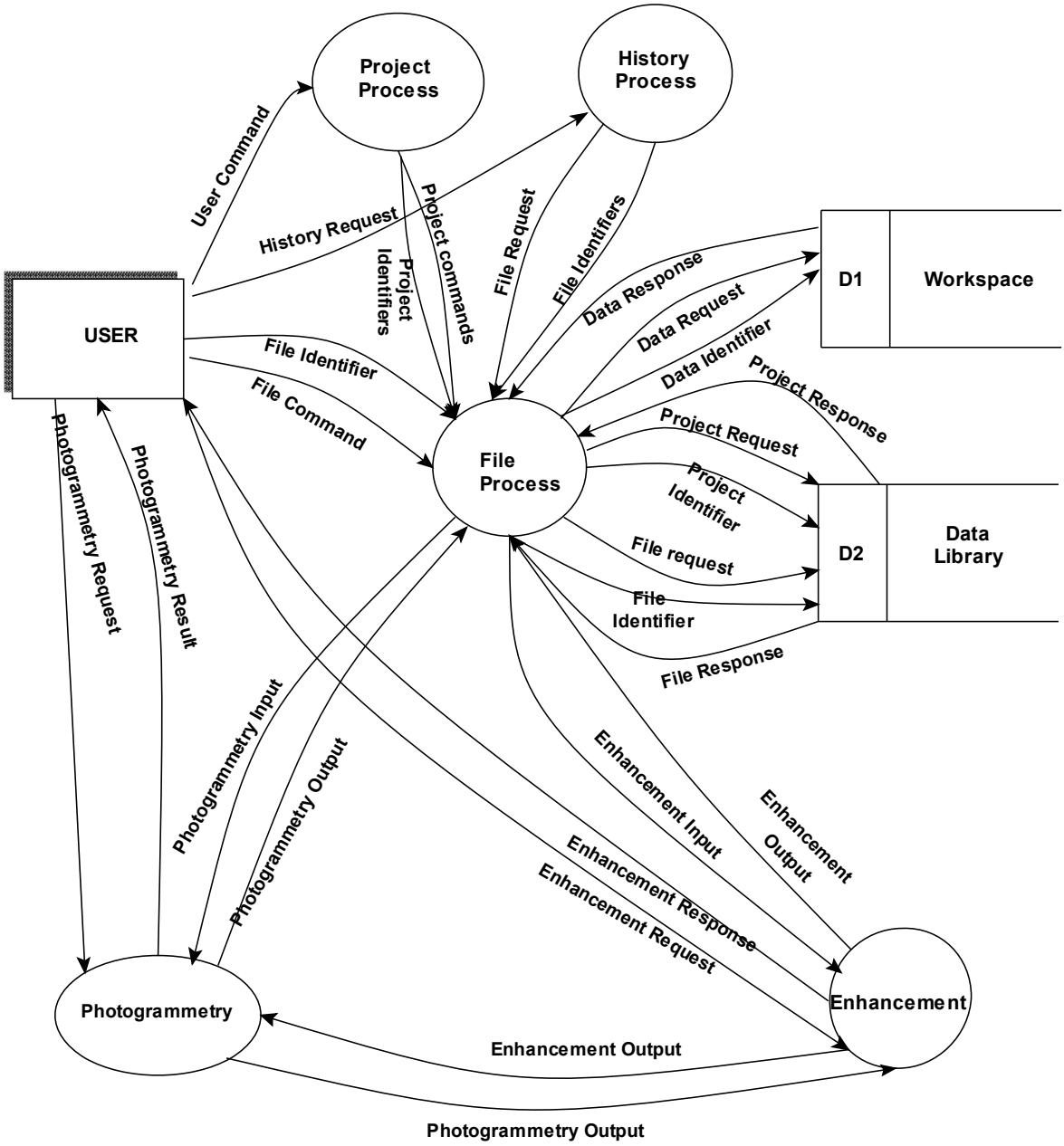
5.2 FUNCTIONAL MODEL

5.2.1 DATA FLOW DIAGRAM

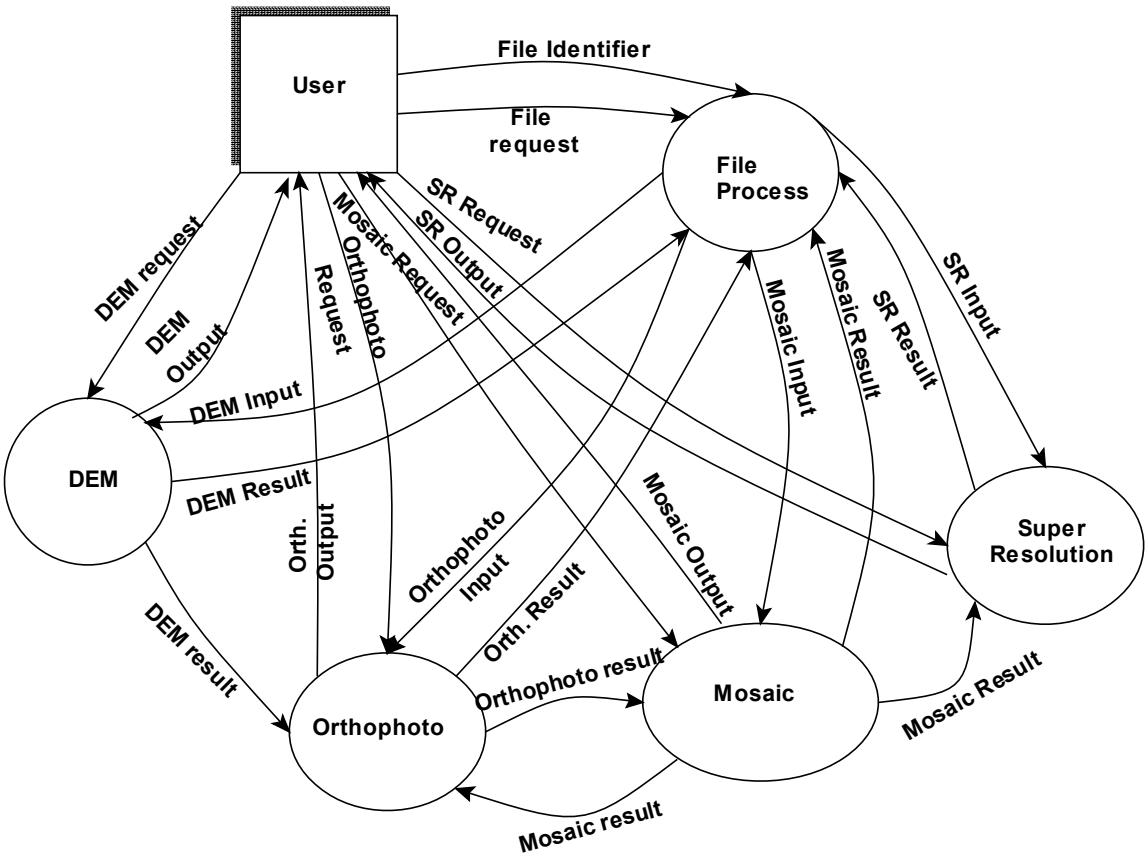
5.2.1.1 DFD LEVEL 0



5.2.1.2 DFD LEVEL 1

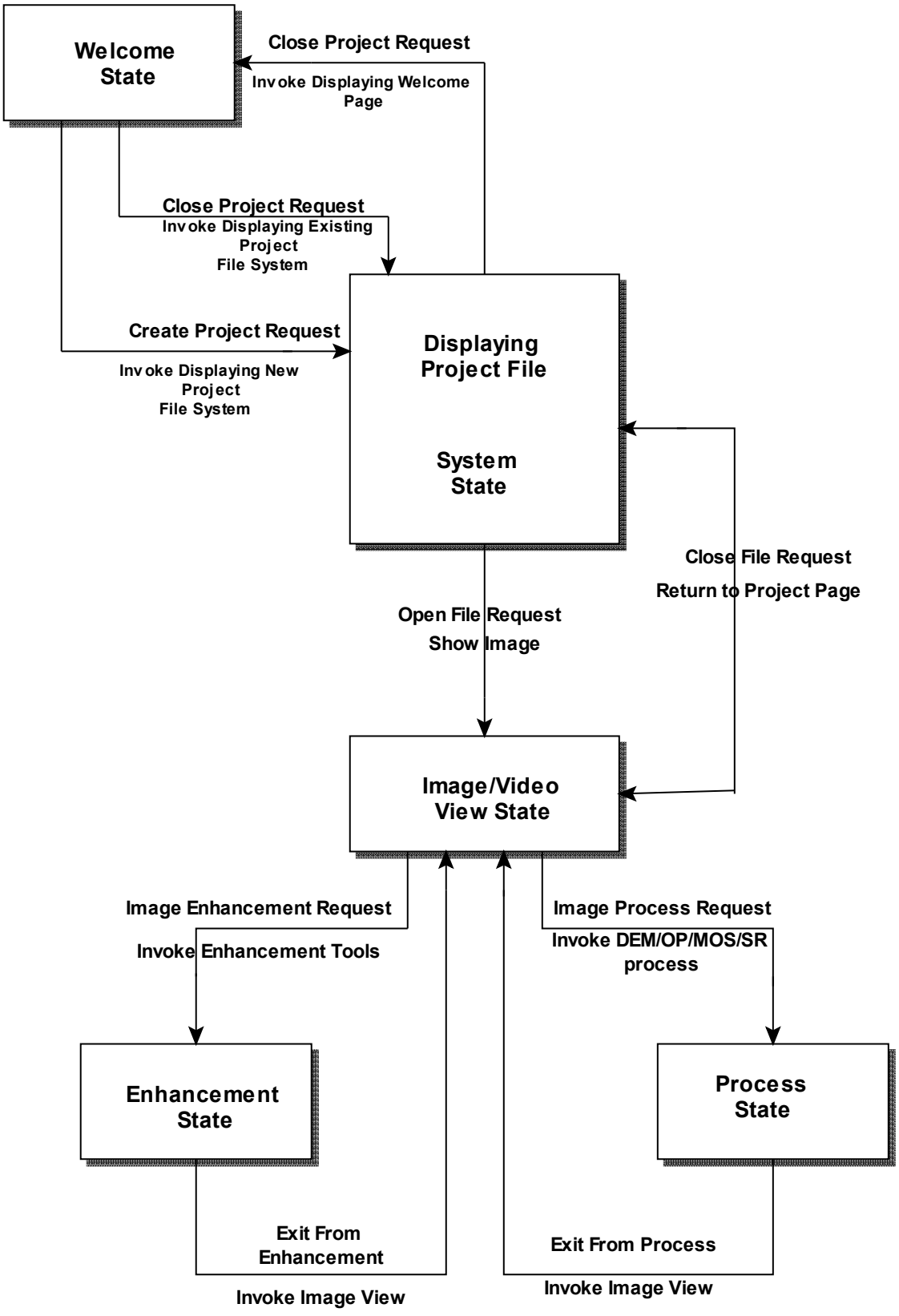


5.2.1.3 DFD LEVEL 2 (Photogrammetry Process)



5.3 BEHAVIORAL MODEL

5.3.1 State Transition Diagram



6 MARKET RESEARCH

6.1 Introduction

Photogrammetry is a vast research area in image processing and a lot of new software products are being developed nowadays. We have made a complete survey on the software products that has been produced till now. Market research had to be done in order to gain background knowledge, to ensure that the project is realizable, to infer useful ideas from both successful and unsuccessful projects and to broaden our imaginations. We mentioned about two photogrammetry software that include DEM, orthophoto and mosaic methods, and then we examined several software about DEM, orthophoto, mosaic and super-resolution in four headings.

6.2 Market Research about Photogrammetry

6.2.1 Leica Photogrammetry Suite

Leica Photogrammetry Suite is a collection of seamlessly integrated software tools providing accurate and production oriented photogrammetric tools for a broad range of geospatial imaging applications. It allows users to work with imagery from a wide variety of sources and formats including black and white, color or multispectral with up to 16 bits per band. Projects can be completed in any of hundreds of coordinate systems and map projections. The Leica Photogrammetry Suite (LPS) is a process- and workflow-driven system, which consists of numerous photogrammetric production tools, including the LPS Project Manager, LPS Automatic Terrain Extraction (ATE), LPS Terrain Editor, Mosaic Tool, and PRO600.

LPS Project Manager

Using the LPS Project Manager, you can:

- collect ground control points (GCPs) in the field or office
- measure GCPs and tie points on multiple images

- perform quality control in order to verify the overall accuracy of the final product
- use photography and satellite imagery from various camera and satellite sensor types including: standard aerial, digital, video, amateur 35 mm cameras (including terrestrial and oblique photography), and SPOT pushbroom sensors
- integrate data from airborne global positioning system (GPS) and other photogrammetric sources
- triangulate multiple images automatically
- orthorectify multiple images

LPS Automatic Terrain Extraction

Using LPS Automatic Terrain Extraction (ATE), you can:

- extract elevation data from an image pair
- output elevation data in the form of ASCII files, TerraModel TINs, DEMs, and 3D shape files
- create a single comprehensive DTM mosaic for the entire block of imagery, or a single image pair
- specify regions for DTM extraction using areas of interest
- define specific strategy parameters for the extraction of elevation data, which account for terrain type
- review detailed reports about the quality, precision, and speed of processing for each generated DTM
- create additional files, such as contour maps and point status images, which help to evaluate accuracy

LPS Terrain Editor

Using LPS Terrain Editor, you can:

- view terrain data in mono or stereo
- edit existing DTMs in format such as digital elevation model (DEM) and triangulated irregular network (TIN)
- use special devices such as the Leica Geosystems TopoMouse to edit data

Mosaic Tool

Using the Mosaic Tool, you can:

- apply Image Dodging and Color Balancing to remove bright patches or shadowy areas
- apply histogram matching to correct atmospheric effects
- exclude areas from the Mosaicing process
- load cutlines from a vector file
- edit cutlines as vectors in a Viewer
- clip, extend, and merge cutlines that cross multiple image intersections
- set overlap functions, including cutlines
- generate cutlines automatically
- use weighted or geometry-based cutlines generation techniques

PRO600

Using PRO600, you can:

- collect features from digital stereo models

6.2.3 ENVI

ENVI has a complete image-processing package that provides user an easy-to-use tool to work on all types of digital imagery. ENVI with GIS tools entagrate image information for the GIS related applications. These processed imageries are used for upgrading GIS databases, and provides images with extracting relevant information and converting to common vector data format. ENVI uses satellite imagery and provide cost-effective, solution for updating GIS databases with accurate layers such as roads, parcels, and natural phenomena including wetlands, land-cover, and invasive species.

Features

- Data Analysing

ENVI provides the user to access the algorithms in order to analyze imagery quickly, easily and accuretly with a variety of data analyis tools. ENVI's data analyzing tools can:

- Create geospatial statistics such as autocorrelation and semi-variance
- Calculate image statistics such as mean, min/max, standard deviation
- Extract linear features
- Synthesize radar imagery
- Calculate principal components
- Detect change
- Measure features
- Model topopgraphic characteristics
- Apply common and user-defined filters
- Perform custom band and spectral math functions

- Spectral Analysis

. ENVI has the most advanced yet easy-to-use spectral analysis tools that provide access to established, scientific mapping methods for imagery analyses. These tools provide classifying imagery , identifying spectral signatures using robust libraries, detecting and identifying targets, identifying features of interest, analyzing & mapping materials of interest, perform whole-pixel and sub-pixel analyses, and using of post classification tools to refine the results.

- Pre-Processing

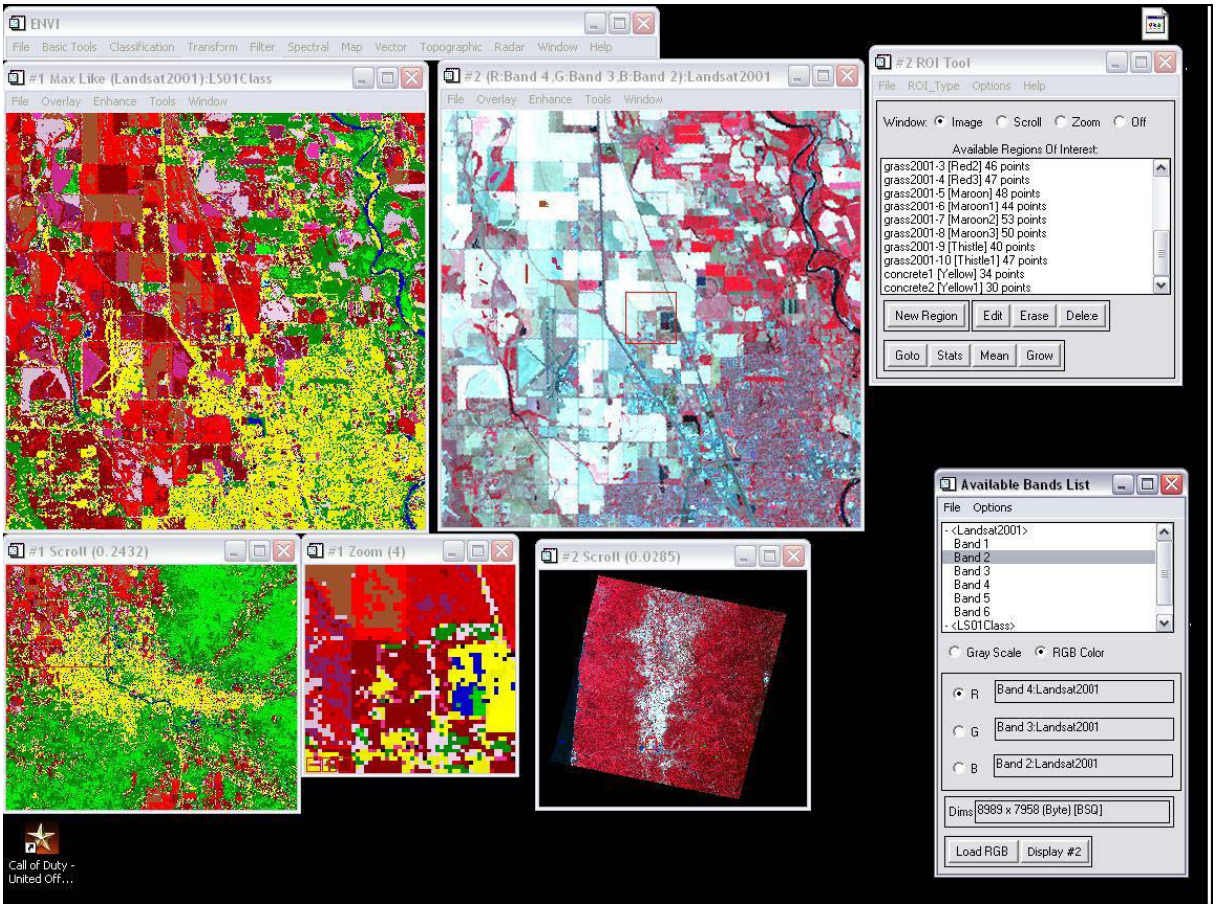
ENVI has a lot of pre-processing options for preparation of the images for viewing or additional analysis. With ENVI one can orthorectify imagery, register two or more images, create vector overlays, resize or convert data type or rotate the images, calibrate imagery, create DEMs, identify regions of interest, correction for distortions, perform filtering and mosaicking.

Advantages

- Easy to use
- A relatively low price
- Advanced functionality
- All in one package
- High performance
- Can be extended with new packages, customized menus and tools by the courtesy of being implemented with IDL.
- Interactive
- Robust
- Can output images to common vector and raster formats for cooperation or presentation
- Read virtually any imagery type and format

Disadvantages

- Requires some experience because of the abundance of evaluation methods
- Do not support the ESRI Geodatabase format
- QuickMap tool needs improvement and enlargement for professional use and more sophisticated standards.



6.2.4 IDRISI ANDES

IDRISI Andes is an integrated GIS and Image Processing software solution providing over 250 modules for the analysis and display of digital spatial information. It offers the most extensive set of GIS and Image Processing tools in the industry in a single, affordable package. With IDRISI ANDES one can explore, predict, and model impacts on land cover change with the innovative Land Change Modeler facility**,** process remotely-sensed imagery with a full suite of image processing techniques including innovative soft classifiers and neural network and decision tree analyses**,** utilize cutting-edge decision support and uncertainty management tools to allocate resources and create suitability map, compare pairs of images or analyze trends and anomalies from long time series imagery and **i**mport/export with a wide variety of data sources, including all major vector and imagery formats.

IDRISI ANDES MODULES:

GIS Analysis :

IDRISI includes a variety of analytical tools for geographic analysis.

- Database Query & Mathematical Operators
- Distance & Context Operators
- Statistics
- Decision Support Tools
- Change & Time Series Analysis
- Surface Analysis
- GIS Modeling

Image Processing:

IDRISI has a lot of image processing tools for the processing of spatial data.

- Image Restoration
- Image Enhancement
- Image Transformation
- Fourier Analysis
- Signature Development
- Hard Classifiers

- Soft Classifiers & Mixture Analysis
- Hyperspectral Image Analysis
- Accuracy Assessment

Utilities:

IDRISI provides a variety of tools to facilitate data entry, import and export data and manipulate existing data. Display and map composition utilities provide tools for visualization and enhancement.

- Display & Map Composition
- Import & Export
- Reformat & Data Entry

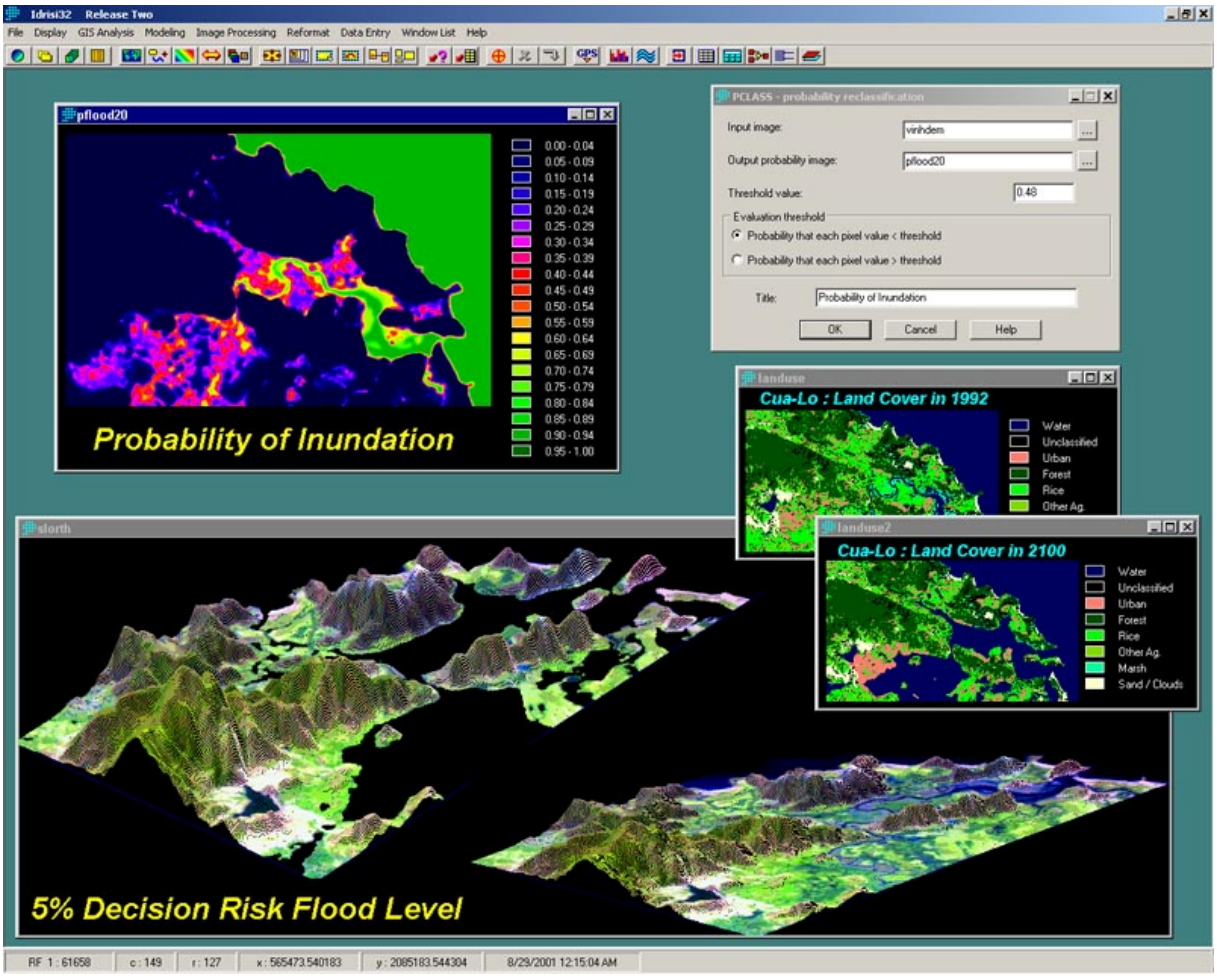
Advantages:

- Easy to use
- Inexpensive - exceptionally wide functionality for such low-cost software.
- Robust
- Good mailing list support
- Good documentation (on line and on paper)
- Good geographical analysis features
- Minimal hard disk requirements
- Hard for students to make errors which are not easily recovered
- Standard Windows menu system means shallow learning curve.
- Actual use is very close to conceptual idea of GIS
- Lots of 3rd party modules.

The Disadvantages:

- It is an operating system dependent software. It supports only WINDOWS NT/2000/XP/VISTA.
- It needs a 512 MB RAM(min), 1 GB free disk space and high resolution
- It lacks VRML file format.

- It lacks some algorithms such as triangulation
- It's orthographic display is not so good.



6.3 Market Research about DEM

6.3.1 3DEM™ Software for Terrain Visualization and Flyby Animation

3DEM produces three dimensional terrain scenes from 2D images and can render MPEG flyby animations. It uses the OpenGL libraries for high-speed three dimensional rendering and it is designed to run under Win95/98//NT/ME/2K/XP or Windows Vista. Some features of the program can be expressed:

- 3DEM is capable of merge several DEMs. If there are two or several DEMs, 3DEM can merge them. Upon loading a DEM or group of merged DEMs, the Overhead View is automatically scaled to fit the entire terrain surface into the available 3DEM window area.

- The Overhead View can be rescaled to a larger or smaller size.
- Users can plot elevation profiles, line-of-sight visibility profiles and create animations that rotate around a fixed point on the terrain.
- Keyboard controls allow users to climb, dive, turn, etc.
- 3DEM will fill the missing elevation points with values derived from the surrounding area by linear interpolation
- 3DEM provides the capability to convert any terrain using Geodetic (latitude-longitude) projection into a Universal Transverse Mercator (UTM) projection.
- The Elevation, translation and rotation of the terrain scene, relative to the observer, is possible.
- A flyby animation is a stored series of 3D scenes (or frames) which are played back rapidly in sequence to produce the appearance of a flyby. 3DEM compresses these frames into either an AVI or MPEG file.
- The software can read GPS waypoints and tracks via a serial interface, and use them for displaying GPS tracks which allows you to view the track of any journey across a high-resolution 3D image of the terrain.

The Disadvantages:

- Program is designed to run under windows applications, it does not support Linux.
- 3DEM can render three dimensional scenes and flyby animations only for a limited data formats. It does not support some of the very popular data formats.
- 3DEM computer program is only for general visualization so it may not give accurate results.

6.3.2 MicroDEM

MicroDEM is a scientific, military, and educational program for MS-Windows that deals with computer mapping, remote sensing, GIS, cartography and DEMs. It is written by Professor Peter Guth of the Oceanography Department, U.S. Naval Academy and it is available free. It is a program for experimenting with and viewing digital elevation models (DEMs).Users can

display and merge elevation models and imagery from sources such as USGS. Some features of MicroDEM:

- MicroDEM can directly read in DEMs in many standard formats, and also includes converters for other formats that it doesn't support natively.
- It can be used to manipulate DEMS to provide colored maps, contour maps, topographic profiles, and oblique and perspective 3-D views of terrain.
- Variable sun angle and altitude, slope calculations (finds slope between two specified points or slope of a particular point), distance (straight-line or stream selection) and area calculations.
- Calculates LOS graph between two user-specified points(plots visible as green, invisible as red)
- Calculates area visible from a specific point on DEM
- Shows what areas are visible as you travel along a route, as a static map and animation or calculates percentage of a target area visible from a specific point
- Creates a fly-through animation that can be saved as a movie. Fly Through follows a pre-determined route, while Live Flying allows you to control the flight with keyboard controls.
- Interfaces with GPS for real-time tracking, waypoint download/upload.

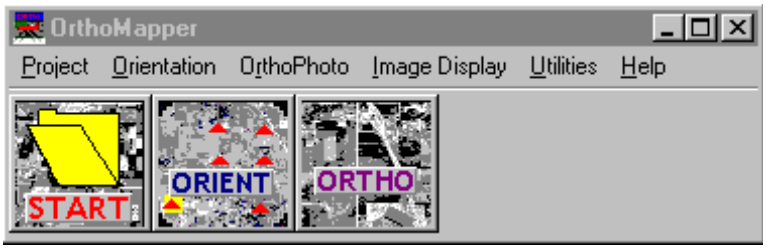
The Disadvantages:

- It has a limited file handling capacity.
- It is only available for Windows 95/98/ME/2000/XP and Windows Vista

6.4 Market Research about Orthophoto

6.4.1 OrthoMapper

Orthomapper creates an orthophoto from a DEM and an unrectified photo. OrthoMapper differentiates other orthophoto programs with the use of Visual Orientation. This feature makes the OrthoMapper nearly the simpliest Orthophoto maker. It is used under Windows XP, Windows 2000, Windows NT 4.0, Windows ME, Windows 98, Windows 95 (OEM Service Release 2). It needs minimum 64 MB of RAM.



figure(Main Menu of OrthoMapper)

Features:

- Visual Orientation:

OrthoMapper [tm] includes the Visual Orientation [tm] method of entering control points. The user identifies the same point on the aerial image and an existing orthophoto. Then OrthoMapper creates the orthophoto by the point and click method of orienting images. Additionaly, the user can chose using traditional ground survey points for control instead of this feature.

- Formats:

Uses .LAN format and two additional ones; taking .tif files as input and givin .img format as output. Compressed jpeg files can be used on OrthoMapper.

- OrthoMapper is actually not only a orthophoto maker. It is an all in one software which makes Mosaic, DEM and Orthophoto.
- Can use desktop scanners or photogrammetric quality scanners as image source. Therefore it can give a easy solution to image source standards.
- Can be used with or without camera calibration data
- Orthophotos can be created from a single aerial image or block of images. OrthoMapper provides orthophotos from DEM and Mosaicked images.
- Color, tones and imagery settings for some differences on composite orthophotos are automatically corrected on OrthoMapper.
- Update existing orthophoto from new imagery
- Display digital images in color or black and white
- Coordinate transformations between projections and datums

- Import DEMs from Text or SDTS format

Disadvantages:

- Orthomapper is operating system-dependent, it does not support Linux.
- It has a limitation on the file and folder names. OrthoMapper can not deal with names that have spaces.

6.5 Market Research about Mosaic

Apart from all-in-one Photogrammetry Tools, there are also mosaic tools which does only mosaicking. Some of these mosaicking tools in the market are explained below:

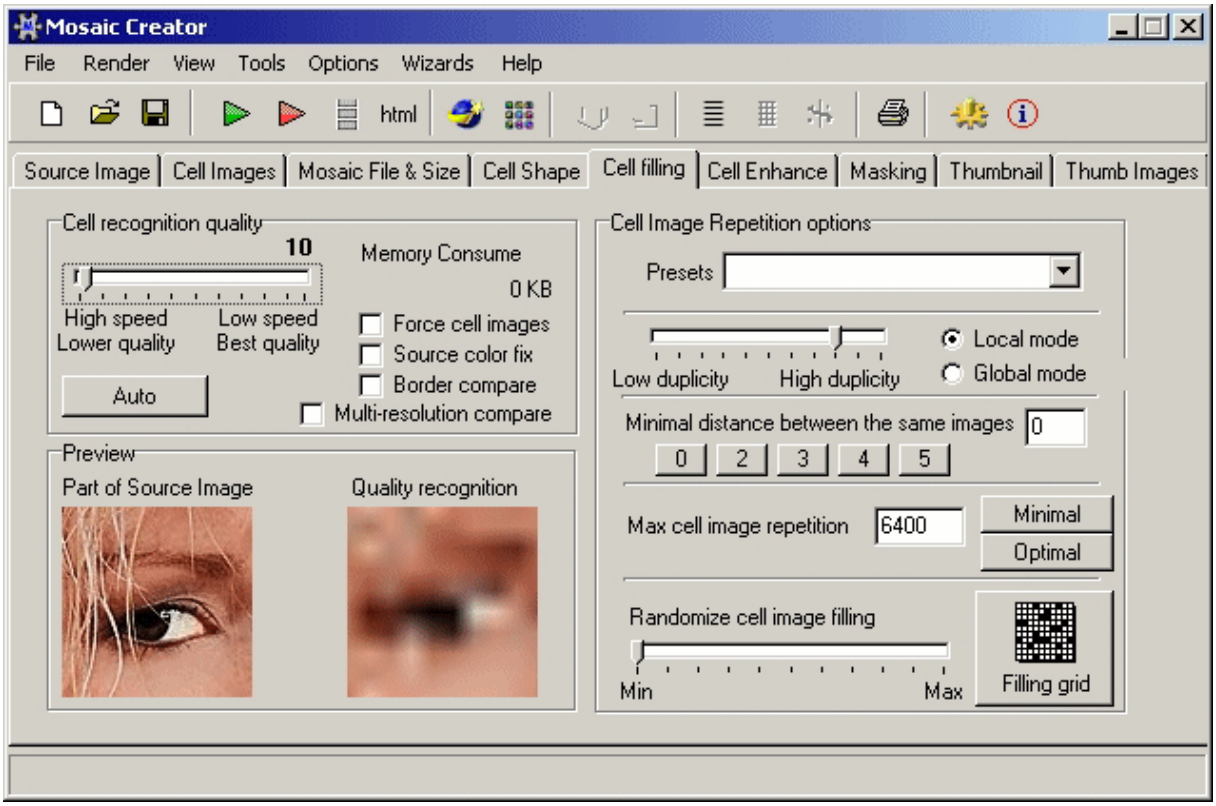
6.5.1 Mosaic Creator

Mosaic Creator provides user to create standard mosaics as the other photo mosaic software in the market. It has also fine enhancement techniques to render good images. The tool also has a pattern shape editor for user defined patterns as well as standard pattern cell shapes. Mosaic Creator even can prepare thumbnails with clickable image map and render video animations. It has also a mosaic wizard simplifying the mosaic process. There are some features of Mosaic Creator which can either be an advantage or disadvantage.

Features:

- Cell image database which is transparent to user
- Unlimited number of images to produce mosaic
- User controllable cell size and cell filling
- Alpha and color masking
- Rendering video mosaics
- Calculation of tile mosaics
- Image watermarking

Mosaic Creator is not only a mosaic software but also a full thumbnailer. It is relatively cheap and easy to use.



6.5.2 EasyMosaic

Easy mosaic is a fast mosaic maker which creates high quality mosaics. It can be used for both personal or commercial mosaicking. It works even with an unlimited number of images to create big mosaic project. EasyMosaic also has a user friendly interface with a variety of user controllable options.

6.5.3 Mazaika

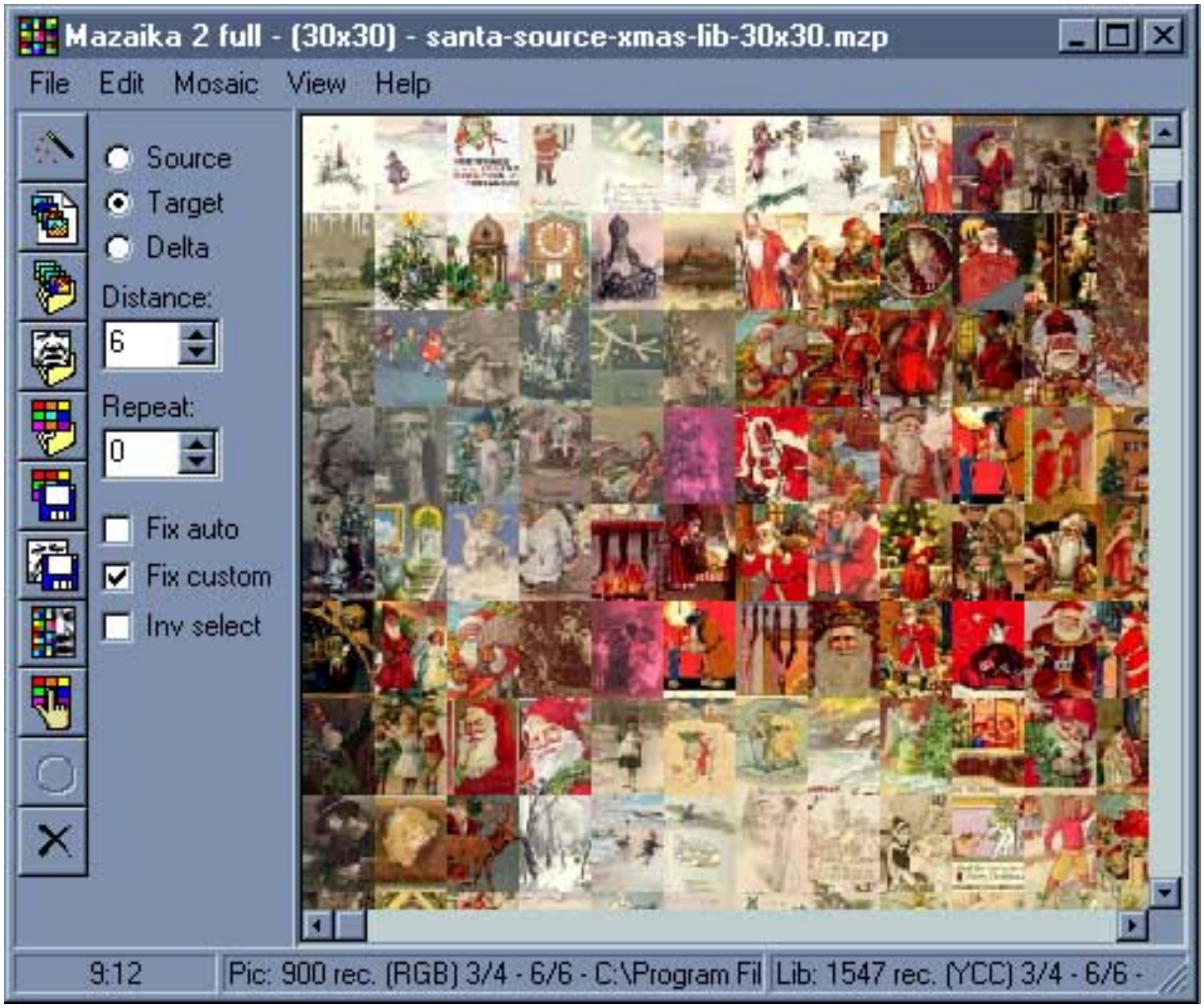
Mazaika is an advance mosaicking tool which can work on almost every type of image formats.

Advantages:

- No limit on the image database size even in trial version
- Only mosaic tool allowing manual changes to every single tile
- Fast
- Qality mosaic output
- Run on all operating systems with addition of related packages
- Single output size up to 3.84 GB

Disadvantages:

- Hard to understand rendering options
- High price compared to other mosaicking(only) software in the market



6.6 Market Research about Super-Resolution

6.6.1 PhotoAcute

To produce high-resolution and low-noise pictures, PhotoAcute Studio processes sets of photographs that are taken in continuous mode. It removes noise without losing image details, increases image resolution, corrects image geometry and chromatic abnormalities and expands the dynamic range. Below are some specific properties of PhotoAcute Studio:

- Image resolution increase beyond camera capabilities:

PhotoAcute Studio produces an image with super resolution from a sequence of continuous photographs, thus acquiring more graphic information than it is available from a single

photograph. It combines individual frames using special algorithms to produce one high-resolution image. Unlike the digital zooming and image sharpening, resultant photographs produced have higher spatial resolution. Small, thin and far away objects, traceries, textures and inscriptions become recognizable.

- Noise reduction without losing image details:

PhotoAcute Studio automatically reduces the noise in the photographs, by combining several photographs. The main problem in the process of the usual noise reduction techniques is that as much as the noise is reduced, the more image details are lost. PhotoAcute Studio provides high noise reduction without losing the image details.

- Image geometry correction:

Camera optics causes some geometric distortion but PhotoAcute Studio corrects these distortions. This gives photographs right perspective and natural look.

- Removing the unneeded moving objects:

Some scenes happen to be constantly overlapped with unwanted moving objects - for example, people walking in front of a sight. With PhotoAcute Studio, you can take photograph of such scene, automatically clearing away the unneeded moving objects.

6.6.2 QE SuperResolution

QE SuperResolution is a tool for enhancing the quality and resolution of images. It is based upon combining image information from several similar images taken from a movie sequence, or consecutive shots from a still camera. The software automatically extracts the information about a particular region of interest from all images, and uses the information to recreate an image with higher resolution and quality, compared to any individual image of the sequence. This software performs only super resolution process and allows different output resolutions (x2, x4).Software is currently optimized for video sequences from DV (digital video) camcorders. Material from other video sources can be used as well; however, the quality of the enhanced image may depend on the quality of the source.

6.7 Conclusion

During the research period of requirement analysis report, we have gained valuable knowledge about Photogrammetry Market. We have seen what kind of seen what kind of applications for generating DEM, ORTHOPHOTO, MOSAIC and SUPERRESOLUTION are present in the market. We have downloaded the ones which are shareware or have trial versions and examined them. We especially concerned with the inputs and outputs of the systems. We have run the products with suitable input, and decided how much satisfactory their output are, like we were ordinary users. At the end a general photogrammetry product characteristic map was formed.

The first advantage of making research about products is to find out the deficiencies of each product. The main shortage in market is that usually most of the products are operating system dependent. In other words, the software is generally run under Windows. Additionally, most products have a limited file handling capacity which forces the users to convert their input data into the programs acceptable data format types. Furthermore since these products are image and video related, for the big input values, system needs a great amount of disk space. Determining these deficiencies may help us to avoid such uncomfortable properties of the previous applications in the market. On the contrary, generally all the software products in the market have good graphical user interface design. They have many features in order to make the programs easy to use. To conclude, market research helps us to bring PHOTOLAB to life conceptually, as a whole and one step front of the systems like it.

6.8 Interview with Other Concerned Students

We made an interview with some students that take courses about image processing or have interest in this area. Below are the questions and the answers from a group of students from Bilkent University.

Q: We are working on some Photogrammetry methods which are mosaicking, orthophoto, Digital Elevation Model and Super-Resolution. How much do you know about each?

A: We are interested in these methods and their applications. We have got some information about some methods from lectures we took and got some information about the others because of our interest.

Q: What can you say about the images to be processed with these methods? What do you know about their properties?

A: Any photo of any place can be an input image for orthophoto, Digital Elevation Model or any other method, but if you think of a more general or more functional problem, Unmanned Air Vehicles make this job nowadays. With UAV's you can take photographs of wide areas practically.

Q: What about the usage areas of these photographs taken by UAV'S?

A: There are so many usage areas and it depends on where you need it. Because the area that can be photographed can be more wide if you take them by UAV's, they are especially used for examining large areas such as a map of a city or river or somewhere wide like that. Beside this, UAV's are especially used for military purposes, to take photos of areas of military importance.

Q: Did you examine any software product about these photogrammetry methods?

A: Yes. There are lots of small software products processing them separately, but in market there are also some software products like Leica which are more functional and used for processing most of the methods.

Q: What is the position of photogrammetry do you think in market nowadays? What about its future?

A: Its usage area is too wide as we mentioned. Its share in market is growing too fast because the study on this area is wide. Maybe it is not used in applications widely nowadays, but according to us, in near future it will be more and more popular.

Q: Our optional method is Super-Resolution. What will you say about it?

A: Super-Resolution is not a developed process as far as we know. There are not much software products for it, but we see it too important especially on security issues. Most security cameras fail in this issue of determining the criminal.

7 PLANNING

7.1 TEST PLANNING

As Bad Sector team we will test our software in order to ensure that all the system and user requirements specified in this document are implemented successfully. Testing will be done several times during the implementation of PHOTOLAB to get feedback on accuricy,cost,time and efficiency. Bad Sector team plan to do the testing according to the below procedure flow:

- Collection of reference material such as Quality Assurance Plan or relevant standards,
- Specification of the strategy used in testing,
- Identification of the test items (Requirement Analysis Report, Software Detailed Design),
- Identification of requirements to be tested,
- Identification of test cases,
- Identification of test methods used in each specific test case,
- İdentification of expected results for each test case,
- Determination of pass/fail criteria,
- Identification of the responsibilities of the group members on testing,
- Determination of the schedule for each test case and for the overall test procedure,
- Performing the test(s),
- Documentation of the successfull and unsuccessfull test results.

7.2 QUALITY PLANNING

As Bad Sector team, we think that PHOTOLAB will be a perfect tool with a good quality planning. Therefore PHOTOLAB will be designed according to below quality criteria specified by Bad Sector team:

- Completion on deadline:

PHOTOLAB is expected to be completed at the end of the 2007-2008 spring semester of METU.

- Functionality:

PHOTOLAB is expected to be functional in terms of suitability, accuracy, and interoperability.

- Reliability:

PHOTOLAB is expected to be mature and error-free when the reliability is in consideration.

- Efficiency:

PHOTOLAB is expected to be efficient on time behavior and resource utilization issues.

- Maintainance:

PHOTOLAB is expected to be analyzable, testable, stable and upgradable when the maintainance is in question.

- Comply with the naming, documentation and user interface standards,
- Portability :

PHOTOLAB is expected to be portable in terms of installability, replaceability, and adaptability.

Bad Sector team believes that during the design and implementation of the project, mistakes will be made. However the main point is to detect these mistakes early and to correct them quickly and easily by focusing on the mistakes as a team since early correction of the mistakes provides the team to finish the project on time.Bad Sector team also belives that the way things are built affects how they can be built better. Therefore, Bad Sector team plan to use a feedback mechanism in order to analyze the most efficient method among the others. Quality Assurance is preventing the faults during the design and implementation of the project. Bad Sector team plans to focus on QA by creating templates, outlines, checklists and guides.

7.3 RISK PLANNING

Bad Sector team has decided to use “Accept Risk” as risk strategy. This means, as a team, we have some preparations for each risk type. As one year continuoing project, PHOTOLAB has some risks arrise from human-source and event-source. At first, human-source risks must be handled. Lack of motivation, lack of knowledges, some psychological problems, incompatibility between team members, personal time management problems and according to this problem missing meetings, or delaying on duties are risks that Bad Sector will have to face during the whole project. The plan to cope with these risks, is simply to solve the personal problems as a team; namely, increasing workloads of each other, listen to each other, help in work schedule, using some pressure by deadlined duties and additional informal meetings. The second risk type is event-source risks. Short-time ilnesses, unexpected work intensity, some hardware and software-related risks are event-source risks and these are harder to solve. The main solution is to share out the missing members duties between other team members. However this may not be enough when high work intensity of all team members at a time. In this situation, team members have to make a new time scheduling. The last risk is to lose some parts of project due to the hardware and software error. The best solution which Bad Sector will use in PHOTOLAB project is to back up whole project frequently and in different machines.

8 CONCLUSION

The requirement analysis report gained its importance by forming concrete system of PHOTOLAB from some abstract information collection. At the beginning, as Bad Sector team members we were not familiar with the Image Processing, Photogrammetry and Geographical Information Systems. During the research on requirement analysis report, we have started to gain experience on these main issues. While market research has familiarized us with GIS and Photogrammetry software market area, Bad Sector team has decided to make some innovations and also specialties from other software in the market. Market research also has given ideas on requirements specification and GUI design. With the drawing diagrams and specification of requirements, the general design of PHOTOLAB has been constituted. Bad Sector team members have had the opportunity to work in a more systematic way on the project with the preparation of project schedule on Gantt chart. To conclude, as Bad Sector team, we believe this requirement analysis report will be a main guide to the way on the initial design of PHOTOLAB.

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