University Applications Using a New Tool to Mosaic and Georeference Imagery: "New Tool = DIME Software"

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ABSTRACT

With the introduction of new imagery from satellites, digital cameras and the increased use of scanned film aerial photography, there is a great need for tools that quickly and cost effectively mosaic and georeference imagery to use in a GIS or Image Processing Systems at universities worldwide. Traditional methods for creating suitable input imagery typically require students to either manage numerous individual image files (which can be cumbersome) or to acquire expensive orthorectification services. However, new technology and production processes, such as those found in DIME Software, have recently been developed to allow users to preprocess their imagery so it can easily become a useful addition to their GIS.

This paper will discuss innovative "image matching" techniques found in the new Georeferencing and Mosaicking Software called DIME and will highlight how DIME can be used in the university environment as an alternative to traditional orthorectification processes. Included will be an examination of how DIME georeferencing and mosaicking is being used in a variety of university research applications to solve specific project problems in both commercial and governmental sectors.

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University Applications Using a New Tool to Mosaic and Georeference Imagery: "New Tool = DIME Software"

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With the introduction of new imagery from satellites, digital cameras and the increased use of scanned film aerial photography, there is a great need for tools that quickly and cost effectively prepare imagery for use in a GIS. Unfortunately, methods for creating suitable input imagery typically require the user to either manage numerous individual image files (which can be cumbersome) or to acquire expensive Orthorectification services. However, new technology and production processes, such as those found in the DIME Software, have recently been developed to allow users to process their imagery more efficiently so that it can easily become a useful addition to their GIS.

This paper will discuss the purpose and applications of using imagery in a GIS, the traditional approaches to preparing imagery for a GIS and the innovative "Image Matching" techniques found in the new georeferencing and mosaicking software called DIME. Included is an examination of how DIME georeferencing and mosaicking is being used in a variety of example applications to solve specific project problems in both commercial and government sectors.

Regardless of whether imagery is black and white, true color or color infrared, imagery has recently become a useful tool in a GIS. Because the human mind thinks in pictures, imagery used as a backdrop in a GIS provides a "real world" view for improved analysis. Imagery is also used to generate, update (with Heads Up Digitizing) and validate data for a GIS. For instance, image classification allows the GIS user to map features, analyze relative depth of features and also proceed with feature identifications.

Currently there are a variety of imagery sources that provide processed (mosaicked, georeferenced, and color balanced) and raw imagery. Both types of imagery may be acquired from organizations such as government agencies, aerial film "stock photography" brokers, and digital and satellite archives. Raw imagery may also be acquired from custom acquisition companies in the same formats (film, digital, satellite) as processed imagery.

Before incorporating imagery into a GIS it is advantageous to mosaic the imagery. Image mosaicking is the process of combining multiple images to form a single image, or image mosaic. The image mosaic process involves geometrically aligning images and then color balancing the mosaic of those images to improve the visual quality of the final image product. The resulting image product can then be easily incorporated into a GIS, Computer Aided Drafting (CAD), remote sensing, or other image processing software to update existing spatial data and to augment spatial analyses requiring the most current data.

There are other distinct advantages to using mosaicked imagery in GIS. First, mosaics allow for improved image file management. As stated, the human mind thinks in pictures and one large picture is significantly easier to process and analyze then several small images. And like the human mind, Personal Computers and their networks also better manage single files. Secondly, mosaics provide the GIS user with an improved tool for analysis and classification. For example, if a project area extends to several images, mosaicked imagery will allow the user to view the complete project at one time.

There are two types of image mosaics, non-georeferenced and georeferenced. The non-georeferenced mosaic is a simple mosaic which combines images by matching the edges of neighboring images to create a single image. In this type of mosaic, there is no georeferencing information; therefore, the resulting image product does not contain any information for transforming the image coordinates to map coordinates. Without map coordinate information, the image cannot be placed at its true earth location for use with mapping software. The non-georeferenced process creates a seamless mosaic which can be used in a limited capacity in a variety of image processing software.

The georeferenced mosaic, in contrast, combines neighboring image frames together in addition to aligning the collection of images to an existing reference image, which contains georeferencing information. This georeferenced mosaic process applies the georeferencing data of the reference image to the final mosaic of neighboring images.

Most often, imagery needs to be mosaicked *and* georeferenced before incorporation into a GIS to allow for better analysis. The traditional approach to mosaicking and georeferencing an image (mosaic or individual) is Orthorectification. In brief, Orthorectification adds georeferencing information to digital imagery by correcting for internal and external effects by utilizing camera calibration information, camera attitude information, 3D ground reference, DEMs and DTMs. Orthorectification can be highly accurate but is also a complex process that can result in a lengthy turnaround time. Also, Orthorectification is typically very costly.

Currently there are two alternatives to the Orthorectification mosaicking and georeferencing process. The user has the option to simply use non-georeferenced imagery in their GIS environment which, depending on application, may be adequate. Or, if their application requires georeferenced imagery, they may choose to use an image product that has had georeferencing information added with the process of image warping.

Image warping is a type of geometric transformation applied to an image that changes the locations of the original pixels. One of the most common applications of this technique, often referred to as rubber-sheeting, is to align the image to a new coordinate system, such as a mapping coordinate system. The process can also be used to correct distortions that are present in the raw imagery, such as straightening roads that appear curved in the image.

The transformation is computed based on a collection of like-features that provide the mapping of the raw image coordinates to another set of coordinates. The calculated result is a series of parameters that determine how the original image is shifted, rotated, scaled, and otherwise transformed into the resulting warped image. In warped images, like-features are used to compute the warp parameters.

Although this technique might seem appropriate only for a georeferenced mosaic, in which one is interested in aligning the project images to a known mapping coordinate system, the same technique can be used to align overlapping neighbor images in a non-georeferenced mosaic project. The process is the same: collect like-features, calculate and then apply the transformation, and then resample the result to produce a non-georeferenced image product. The images are warped to new positions in order to correct for distortions within the images and to improve the alignment between images.

When creating non-georeferenced or georeferenced mosaics using image warping, no camera calibration or exterior orientation information is necessary to complete the process. This is especially useful when processing historical imagery. In addition, the image warping process typically costs considerably less than Orthorectification and takes less time to produce a final product. Even though mosaics created using image warping can be less accurate than mosaics created using Orthorectification, there are a variety of applications where quick, low cost benefits of image warping mosaics apply. These applications are discussed below.

The DIME (Digital Images Made Easy) software is an example of an alternative georeferencing process to Orthorectification. The software uses the automation of a standard Personal Computer to identify like-features or performs "Image Matching" within images to create non-georeferenced and georeferenced mosaics.

At the simplest level, Image Matching is the process of finding the same pattern in two or more images. While there are many applications of this technique, DIME uses automatic Image Matching to find corresponding patterns between overlapping images. Within the overlap area of two or more images, there will be features—road intersections, field boundaries, etc.—which are present in both images and are represented by a pattern of pixels. DIME attempts to identify these shared features based on their pixel patterns.

Image Matching is central to the Automatic Tie Point (ATP) selection process in DIME and is actually what the brain does when one identifies like features between images. One finds a feature in one image and then tries to find the same feature in an overlapping image. Once a relationship has been established, one can connect the two images together by identifying a point on each image at the location that represents the same feature shared between both images. In the DIME software this pair of connecting points is referred to as a Tie Point pair. And because DIME does this image matching automatically, the process is called the ATP process.

The Automatic Tie Point pairs are used to calculate the adjustments necessary for warping the images so that the images align with each other. In a georeferenced mosaic, the collection of tie points are also used to align one or more images to an already georeferenced image that has geospatial coordinate information.

Aside from the ATP process the DIME Software offers another distinct advantage over traditional Orthorectification. DIME offers automated color balancing tools. Color balancing is the process of matching colors between images. In many cases, two images of the same area will exhibit varying degrees of difference in the colors that represent the same feature. For example, a field of grass may appear differently in two overlapping images. In one image the field may be lighter or darker than the other. In addition to the difference in brightness, there may also be differences in contrast, or the range of brightness values. Thus, in one image, there may be a very clear distinction between features while in the other image, the difference may be less clear as the range of values is relatively smaller. Both brightness and contrast will impact the quality of the colors of the output mosaic. DIME provides color balancing tools for adjusting the brightness and contrast values of images to provide a seamless image mosaic resulting in improved visualization and analysis in the GIS environment.

As afore mentioned, there are several applications where the use of non-traditional mosaics apply. Some of these applications include Natural Resource Management, Coastal Mapping, Land Development and Facilities Management. Each of the following applications benefited directly from the automatic Image Matching technology of the DIME software by saving time and money on image preparation for the GIS environment.

The DIME software was recently used to aid in Natural Resource Management in Yellowstone National Park, USA. One hundred sixty-three digital camera images were matched to previously existing black and white United States Geological Survey (USGS) Digital Ortho Quarter Quadrangles (DOQQ) to create a georeferenced image mosaic. The mosaic was used in the GIS environment to assess riparian habitat, evaluate overall management practices within the park and it's watersheds and also used to detect changes between a 1988 dataset and a 1999 dataset.

Coastal Mapping is another application in which the DIME software has been used. Eight 70mm scanned film images were processed in DIME to create a non-georeferenced mosaic of the Gulf Coast, Mississippi, USA. The mosaic was then used in a GIS environment for updating base maps, urban planning, and environmental monitoring.

Land Development and Facilities Management are other examples of applications that have benefited from preparing imagery for the GIS environment with the DIME software. In Whitefish, MT, USA scanned USDA Forest Service NAPP photography was matched to a black and white USGS DOQQ to created a georeferenced mosaic. GIS data was then derived from the mosaic for land use planning. This visual tool was also used in real estate and development programs.

Regarding Facilities Management applications, in 1999 Dr. Jack Stanford of the University of Montana, USA used a georeferenced mosaic of seventy-one digital camera images created by the DIME software for Facilities Management of the Yakima River, Washington, USA. Dr. Stanford used the mosaic to study and analyze salmon habitat and stream flow of the river.

In summary, imagery can be a desirable layer in a GIS. It allows the user to create, validate, obtain and display a variety of information. There are a variety of methods to prepare imagery for a GIS and a variety of applications in which it can be put to use. The DIME software and its automated Image Matching and color balancing features are an example of the alternative technology now available to quickly and cost effectively prepare imagery for a GIS.