GRASS Photo Commands

These commands are internal routines of i.ortho.photo

photo.2image
photo.2target
photo.camera
photo.init
photo.rectify

Other Commands

help home, database, display, drivers, general, grid3d, imagery, import, misc, models, paint, photo, postscript, raster, scripts, sites, vector

---

NAME

i.ortho.photo − An interactive imagery function for the ortho−rectification of imagery group files.
(GRASS Image Processing Program)

SYNOPSIS

i.ortho.photo

DESCRIPTION

i.ortho.photo allows the user to ortho−rectify imagery group files. An imagery group consists of several scanned aerial photographs (raster files) of a common area. Imagery groups can be created or modified using the GRASS Image Processing Program *i.group*, or using the first menu option described below. *i.ortho.photo* guides the user through the steps required to ortho−rectify the raster files in a single imagery group.

The first menu in *i.ortho.photo* provides the user with the following options:

Initialization Options:
1) Select/Modify imagery group
2) Select/Modify imagery group target
3) Select/Modify target elevation model
4) Select/Modify imagery group camera

Transformation Parameter Computation:
5) Compute image−to−photo transformation parameters
6) Initialize exposure station parameters
7) Compute photo−to−target transformation parameters

Ortho−rectification Option:
8) Ortho−rectify imagery group raster files
RETURN to exit
>

To ortho−rectify aerial images the user has to follow the menu options step by step. Generally the user builds a target location containing a projected DEM and a map reference (topo sheet or other map). Another xy−location will contain the aerial photo. The entire rectification process is started within the xy−location. First the target to the projected location has to be set (i.target), then the image references (fiducial points) will be defined. After describing the camera parameters, reference points from aerial image to the topo sheet from the target location will be set. The local elevation will be taken from the target DEM. Finally the aerial image will be rectified.

The options to follow are described as follows:

1. *Select/Modify imagery group*

   The current imagery group is display at the top of the previous menu. You may select another (new or existing) imagery group for the ortho−rectification program using option (1). After choosing option (1) you will be prompted for the name of a new or existing imagery group. Option (1) using the GRASS Image Processing Program *i.group*, for creation or modification of imagery groups. For more information on imagery group creation or modification please the the GRASS manual page for *i.group*.
2. *Select/Modify imagery group target*

   The target location and mapset may be selected or modified using option (2). After choosing option (2) you will be prompted for the names of the target location and mapset, where the ortho−rectified raster files will reside. The target location is also the location from which the elevation model (raster file) will be selected −− see option (3). Option (2) uses the GRASS Image Processing Program *i.target*, for selection or modification of the imagery group target location and mapset. For more information on imagery group selection or modification please the the GRASS manual page for *i.target*.
3. *Select/Modify target elevation model*

   Option (3) allows you to select the raster file from the target location to be used as the elevation model. The elevation model is required for both the computation of photo−to−target parameters (option 6) and for the ortho−rectification of the imagery group files (option 8). The raster file select for the elevation model should cover the entire area of the image group to be ortho−rectified. Currently, the elevation model raster file is expected to be in units of meters. DTED and DEM files are suitable for use as the elevation model in the ortho−rectification program. After selection option (3) you will be prompted for the name of the raster file in the target location that you want to use as the elevation model.
4. *Select/Modify imagery group camera*

   Using option (4) you may select or create an camera reference file that will be used with the current imagery group. A camera reference file contains information on the internal characteristics of the aerial camera, as well as the geometry of the fiducial or reseau marks. The most important characteristic of the camera is its focal length. Fiducial or reseau marks locations are required to compute the scanned image to photo−coordinate transformation parameter (option 5). For a more detailed description of option (4) please see the GRASS manual page for *photo.camera*.
5. *Compute image−to−photo transformation parameters*

   The scanned image to photo−coordinate transformation parameters are computed using option (5). In this interactive option you associate scanned reference points (fiducials, reseau marks, etc.) with their known photo coordinates from the camera reference file. Complete documentation for this option is available under the manual entry *photo.2image*.
6. *Initialize exposure station parameters*

   The use of photo.init (menu 6) is only required when rectifying a tilted or oblique aerial photo. If option (6) is selected, initial camera exposure station parameters and initial variances may be selected or modified. Complete documentation for this option is available under the manual entry *photo.init*.
7. *Compute photo−to−target transformation parameters*

   The photo to target transformation parameters are compute using option(7). Here control points are marked on one or more imagery group files and associated with there known positional and elevation coordinates. Complete documentation for this option is available under the manual entry *photo.2target*.
8. *Ortho−photo imagery group files*

   Option (8) is used to perform the actual image ortho−rectification after all of the transformation parameters have been computed. Ortho−rectified raster files will be created in the target location for each selected imagery group file. You may select either the current window in the target location or the minimal bounding window for the ortho−rectified image. Complete documentation for this option is available under the manual entry *photo.rectify*.

NOTES

i.ortho.photo currently requires the elevation model to be in meters, and the target location to be a metric coordinate system.

SEE ALSO

photo.camera
photo.2image
photo.2target
photo.init
photo.rectify

AUTHOR

Mike Baba, DBA Systems, Inc.

Updated rectification and elevation map to FP 1/2002 Markus Neteler

Last changed: $Date: 2003/09/09 13:10:18 $

This is not a command in itself, but an option of the command i.ortho.photo.

NAME

photo.2image − An imagery function that enables you to mark known reference points (fiducial marks, reseau marks, etc.) on imagery group files, and compute the image−to−photo coordinate transformation parameters. The transformation parameters are required for the GRASS Image Processing Program *i.ortho.photo*.
(GRASS Image Processing Program)

SYNOPSIS

Selected from i.ortho.photo

DESCRIPTION

photo.2image is an imagery function that enables you to mark fiducial or reseau points on an image to be ortho−rectified and then computes the image−to−photo coordinate transformation parameters. The coordinates of the fiducials or reseau marks can be choosen for a camera reference file.

During the process of marking reference points with known photo coordinates, you may compute the RMS (root mean square) error for each reference point entered. *photo.2image* does this by calculating the transformation equation (the same one that is calculated by *i.points*), and then plugging these results into an equation for RMS error.

photo.2image offers a zoom option to locate precisely the fiducial or reseau point to be marked on an image.

To run *photo.2image*, a graphics monitor is required.

The procedure for marking fiducial or reseau points, entering known photo−coordinates, and analyzing the RMS error is described below.

The terminal screen displays this message:

use mouse now...

The graphics monitor displays the following screen:

```
+----------------------------+---------------------------------+
|imagery                     |                                 |
+----------------------------+---------------------------------+
|                            |                                 |
|                            |                                 |
|                            |                                 |
|                            |                                 |
|                            |                                  |
|                            |                                  |
|                            |                                  |
+----------------------------+----------------------------------+
|                            |                                  |
|                            |                                  |
|                            |                                  |
|                            |                                  |
|                            |                                  |
|                            |                                  |
|                            |                                  |
+----------------------------+----------------------------------+
|                            |                                  |
+----------------------------+----------------------------------+
```

A pop−down menu like that shown below will be superimposed on the left half of the screen:

```
+-----------------------------------------+
|Double click on cell file to be plotted |
| Double click here to cancel       |
+-----------------------------------------+
            +-----------------+
            |Mapset imagery  |
            +--------+--------+
            |gs13.1 | gs21.1 |
            +--------+--------+
            |gs14.1 | gs22.2 |
            +--------+--------+
```

Any single file in the imagery group may be used on which to mark points, and you may mark points on more than one file in the imagery group to accumulate the suggested minimum number of 4−8 fiducial or ressue points. The imagery file selected is displayed in the upper left quadrant of the screen.

CAMERA FILE

The camera reference file may be viewed by placing the mouse cross hairs on the words CAMERA. The camera reference file will be displayed in the lower left quadrant of the display:

```
|----------------------------------------------------------------|
|Camera Reference File                                           |
|----------------------------------------------------------------|
|  CAMERA NAME :        camera name                              |
|  CAMERA ID   :        L1234                                    |
|  CAMERA CFL  :        153.021 mm.                              |
|  CAMERA XP   :        0.050 mm.                                |
|  CAMERA XP   :        0.056 mm.                                |
|  number of fid.       4                                        |
|----------------------------------------------------------------|
|                                                                |
|ID        (X PHOTO) mm.                  (Y PHOTO) mm.          |
|________________________________________________________________|
|1         −105.023                         110.123              |
|2          107.987                         109.834              |
|3          110.965                        −104.329              |
|4         −103.932                        −110.352              |
|________________________________________________________________|
```

The following menu is displayed at the bottom of the graphics display:

```
+-----+------+-----------+--------+---------+-------------------+-------------+
|Quit | Zoom | Plot Cell | Camera | Analyze |   Input->KEYBOARD | CAMERA FILE |
+-----+------+-----------+--------+---------+-------------------+-------------+
```

ZOOM

To magnify the displayed file, you must place the mouse cross hairs on the word ZOOM. The following menu will then be displayed at the bottom of the screen:

```
+-------+-----+-------++--------------------+
|Cancel | Box | Point ||Select type of ZOOM |
+-------+-----+-------++--------------------+
```

You have the option of identifying the zoom window either by using the mouse to make a box, or by using the mouse to mark the center of the desired window, and adjusting the magnification factor. The terminal screen will display a mouse button menu to guide you in identifying the window. The section of the image within the zoom window will be displayed in the upper right hand quadrant.

MARKING REFERENCE POINTS

To mark the known reference points (fiducial marks, reseau marks, etc.) on the image, you must place the mouse cross hairs on the corresponding location on the image to be marked and press the left hand button on the mouse. A diamond shaped symbol will be marked on the image.

If you wish to use the camera reference file only as a comparative reference, then the keyboard can be chosen as the means to input photo coordinates corresponding to the marked reference points on the image. This is done by placing the mouse cross hairs on the word KEYBOARD and pressing the left button on the mouse.

The following menu is displayed on the graphics terminal:

```
+------------------------------------+--------------------------+
|Point 1 marked at IMAGE COORDINATES |                          |
|east:  1023.77                      |                          |
|north:  506.56                      |                          |
|                                    |                          |
|                                    |                          |
|                                    |                          |
|                                    |                          |
|                                    |                          |
+------------------------------------+--------------------------+
|Enter PHOTO COORDINATES as x and y:                            |
+---------------------------------------------------------------+
```

You then enter the known (x,y) photo coordinates, relative to the perspective center, for the reference point marked on the image. If you do not wish to enter a coordinate, simply hit RETURN to continue; the marked reference point will disappear.

If you select the CAMERA FILE option, then reference points marked on the image will be associated with selected photo coordinates from the displayed camera reference file. In this option, when you mark a point on the image, the following menu is displayed on the graphics terminal:

```
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−− CANCEL Double click
on the fiducial mark to be referenced
−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−
```

If you would like to select the photo coordinates of a displayed reference mark, this can be accomplished by placing the mouse cross hairs on the reference point to be selected and pressing the left button on the mouse twice. After a reference point is selected from the display, you are prompted with "Look ok? (Y/N)". If you respond with no, the reference point is ignored. If you respond with yes, the following is displayed on the terminal:

```
+−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−+−−−−−−−−−−−−−−−−−−−−−−−−−−+
|Point 1 marked at IMAGE COORDINATES     |                          |
|east: 1023.77                           |                          |
|north: 1065.41                          |                          |
|                                        |                          |
|                                        |                          |
|Point 1 referenced at PHOTO COORDINATES |                          |
|X: −105.023                             |                          |
|Y:  110.122                             |                          |
|                                        |                          |
|                                        |                          |
|                                        |                          |
|                                        |                          |
|                                        |                          |
+−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−+−−−−−−−−−−−−−−−−−−−−−−−−−−+
| use mouse now...                                                  |
+−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−+−−−−−−−−−−−−−−−−−−−−−−−−−−+
```

The photo coordinates and the corresponding image coordinates are automatically saved in the photo_points file associated with the imagery group.

ANALYZE

After a number of points have been marked (4 to 8), you can check the RMS error of the points marked on the image. This is done by placing the mouse cross hairs on the word ANALYZE at the bottom of the monitor. An error report resembling the one shown below is superimposed on the monitor:

```
+−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−+
|       error            image           photo                        |
|                                                                     |
|#     row      col   photo    east    north   x              y      |
|1     0.0     −0.9    1.0     1048.5  −144.8  −105.023    110.122   |
|2     0.4      1.0    1.3     2153.1  −567.2   107.987    109.834   |
|3    −1.2     −0.5    0.6     1452.8  −476.5   110.965   −104.329   |
|4     1.1      0.5    1.3     1034.0  −109.2  −103.932   −110.352   |
|                                                                     |
+−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−+
|    overall   rms    error:   4.46                                   |
+−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−+
```

The following menu then appears at the bottom of the monitor:

```
+−−−−−+−−−−−−−+−−−−−−+−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−+
|DONE | PRINT | FILE | Double click on point to be included/excluded |
+−−−−−+−−−−−−−+−−−−−−+−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−−+
```

The RMS error for the image is given under the column TITLEd "error" and subTITLEd "row" and "col". In the above report, point number 1 is 0.0 rows and −0.9 columns from the predicted location calculated from the transformation equation. The RMS error for the photo coordinates is listed under the heading "photo". This is the RMS error for the x and y coordinates of the photo coordinates but it is presented in the table using one general value. The overall RMS error is displayed at the bottom of the screen in milimeters. Points that create high RMS error are displayed in red on the monitor (represented here in italics).

The location of the point marked on the imagery group file is given under the heading "image" and the subheadings "east" and "north". The location of the point in the photo coordinates is given under the heading "photo" and the subheadings "x" and "y". If you would like to exclude or include a point, this can be accomplished by placing the mouse cross hairs on the point number to be included (if the point is absent) or excluded (if the point is displayed) and pressing the left button on the mouse twice. When a point is excluded, it is not afterwards included in the calculation of the RMS error, or included in the final transformation matrix. However, it can be retrieved within *photo.2image* at any time by double clicking with the mouse as described above.

QUIT

To end the *photo.2image* program place the mouse cross hairs on the word QUIT; the marked reference points (including coordinates) will be saved.

NOTES

A good rule of thumb is to mark at least 4 to 8 points which are evenly distributed over the perimeter of the imagery group file in order to obtain an accurate transformation equation for the rectification process. The RMS error may increase with more points added, but the transformation equation will be more accurate.

An RMS error of less than or equal to approximately one resolution unit (pixel) for the image being rectified is generally considered acceptable.

SEE ALSO

i.ortho.photo
photo.camera
photo.2target
photo.init
photo.rectify

AUTHOR

Mike Baba, DBA Systems, Inc.

Last changed: $Date: 2002/01/25 05:45:34 $

This is not a command in itself, but an option to the command i.ortho.photo .

NAME

photo.2target **−** An imagery function that enables you to mark control points on an image to be ortho−rectified, and then input the ground coordinates of each control point for determination of ortho−rectification parameters. This establishes the absolute orientation between image pixels and ground coordinates. The ortho−rectification parameters are required as input for the GRASS program *photo.rectify* . *(GRASS Imagery Processing Tool)*

SYNOPSIS

Selected from *i.ortho.photo*

DESCRIPTION

photo.2target is an imagery function that enables you to mark control points on an image to be ortho−rectified and then input the coordinates of each point for calculation of rectification parameters. Rectification is the mapping of an image from one coordinate system to another. The geometry of an image extracted into a GRASS LOCATION having an x,y coordinate system is not planimetric. To create a planimetric image, that is, to convert the x,y coordinate system into a standard coordinate system (for example, the UTM coordinate system or the State Plane coordinate system), points from a map having the standard coordinates must be associated with the same points on the image to be rectified. The ortho−rectification parameters are computed in two phases. The first phase computes a transformation matrix between image (row,col) coordinates and photo (x,y) coordinates relative to the perspective center. The transformation matrix is computed explicitly in the option *photo.2image* . The second phase, *photo.2target*, enables you to mark control points on the image and then input the standard coordinates (Easting,Northing, and elevation) to determine the parameters for a three dimensional projective transformation. *photo.init* may be run before running *photo.2target* to modify the initial camera exposure station parameters, and/or modify the standard deviation of these parameters. *photo.init* is not required but generally is helpful.

During the process of marking control points and entering standard coordinates, you may compute the RMS (root mean square) error for each control point entered. photo.2target does this by calculating the transformation equation, and then plugging these results into an equation for RMS error.

photo.2target offers a zoom option to locate precisely the point to be marked on an image. This program also offers you the option of acquiring standard coordinates for a marked point from a map layer in the target database, or from a digitizer.

To run *photo.2target*, a graphics monitor is required.

The procedure for marking points, entering coordinates, and calculating RMS error is described below.

The terminal screen displays the following message:

use mouse now...

The graphics monitor displays the following screen:

```
+-----------------------------+--------------------------------+
|imagery  filename  (mag)     | target  filename  (mag)        |
+-----------------------------+--------------------------------+
|                             |                                |
|                             |                                |
|                             |                                |
|                             |                                |
|                             |                                |
|                             |                                |
|                             |                                |
+-----------------------------+--------------------------------+
|                             |                                |
|                             |                                |
|                             |                                |
|                             |                                |
|                             |                                |
|                             |                                |
+-----------------------------+--------------------------------+
|QUIT ZOOM PLOTCELL ANALYZE   |                                |
+-----------------------------+--------------------------------+
```

A pop−down menu like that shown below will be superimposed on the left half of the screen:

```
           +----------------------------------------+
           |Double click on cell file to be plotted |
           | Double click here to cancel            |
           +----------------------------------------+
                       +--------------------+
                       |  Mapset PERMANENT  |
                       +---------+----------+
                       |gs13.1   | gs14.1   |
                       +---------+----------+
                       |gs21.1   | gs22.2   |
                       +---------+----------+
```

Any single file in the imagery group may be used to mark points, and you can mark points on more than one file in the imagery group to accumulate the 12 points suggested minimum. Any file in the imagery group can be rectified (using *photo.rectify*) based on the rectification parameters computed from these control points.

The imagery file you select is displayed in the upper left quadrant of the screen.

ZOOM

To magnify the displayed file, you must place the mouse cross hairs on the word ZOOM. The following menu will then be displayed at the bottom of the screen:

```
+-------+-----+-------++--------------------+
|Cancel | Box | Point ||Select type of ZOOM |
+-------+-----+-------++--------------------+
```

You may identifying the zoom window either by using the mouse to make a box, or by using the mouse to mark the center of the window and entering a magnification factor. The terminal screen will display a mouse button menu to guide you in identifying the window.

MARKING POINTS

To mark the points on the image that correspond to the points on a standard coordinate system map, you must place the mouse cross hairs on the corresponding location on the image to be marked and press the left hand button on the mouse. A diamond shaped symbol will be marked on the image. The terminal will display the following menu:

```
+------------------------------------+--------------------------+
|Point 1 marked at IMAGE COORDINATES |                          |
|IMAGE X:   1023.77                  |                          |
|IMAGE Y:  −164.41                   |                          |
|                                    |                          |
+------------------------------------+--------------------------+
|Enter CONTROL COORDINATES as east,north,elevation:             |
+---------------------------------------------------------------+
```

You then enter the easting, northing, and elevation for the point marked on the image. If you wish not to enter a coordinate, simply hit RETURN to return control to the mouse; the marked point then disappears.

PLOT CELL

In addition to acquiring control points from a standard map, you have the option of acquiring the points from a cell−map in the target database. The database map is displayed by placing the mouse cross hairs on the words PLOT CELL. The following line is then displayed at the bottom of the monitor:

```
+-------+--------------------------------------+
|Cancel | Indicate which side should be plotted |
+-------+--------------------------------------+
```

Which side of the monitor is to be plotted is indicated by placing the mouse cross hairs on the half of the monitor screen that you would like to use, and pressing the left mouse button. The following pop−down menu will be superimposed on the half of the screen that was chosen:

```
+---------------------------------------+
|Double click on cell file to be plotted |
| Double click here to cancel            |
+---------------------------------------+

+-----------------------------+
|   Mapset user1              |
+--------------+--------------+
|tm.rectified  |              |
+--------------+--------------+
|tm.classified |              |
+--------------+--------------+
|   Mapset PERMANENT          |
+--------------+--------------+
|elevation     | geology      |
+--------------+--------------+
|slope         | soils        |
+--------------+--------------+
|aspect        |              |
+--------------+--------------+
|roads         |              |
+--------------+--------------+
|streams       |              |
+--------------+--------------+
|airfields     |              |
+--------------+--------------+
```

After the map is displayed the following message appears at the bottom of the monitor:

```
+-----------------+----------+--------+
|input method −>  | keyboard | screen |
+-----------------+----------+--------+
```

If you wish to use the plotted map only as a comparative reference, the keyboard can be chosen as the means to input coordinates corresponding to the marked control points. This is done by placing the mouse cross hairs on the word KEYBOARD and pressing the left button on the mouse.

If you select the SCREEN option, points marked on the image will automatically be associated with the coordinates from the corresponding points on the target database map, and a corresponding elevation from the cell−file selected for elevation data. In this option, when you mark a point on the image, the following menu is displayed on the terminal:

```
+------------------------------------+--------------------------+
|Point 5 marked at IMAGE COORDINATES |                          |
|IMAGE X: 1023.77                    |                          |
|IMAGE Y: −164.41                    |                          |
|                                    |                          |
|                                    |                          |
|Control Point location              |                          |
|East:      679132.57                |                          |
|North:    4351080.67                |                          |
|Elevation:  1010.00                 |                          |
|                                    |                          |
|                                    |                          |
|                                    |                          |
+------------------------------------+--------------------------+
|use mouse now...                                               |
+---------------------------------------------------------------+
```

The coordinates for the target database map are automatically saved as the coordinates corresponding to the marked control point on the image.

ANALYZE

After a number of points have been marked (4 to 7), you can check the RMS error of the points marked on the image. This is done by placing the mouse cross hairs on the word ANALYZE at the bottom of the monitor. An error report resembling that shown below is superimposed on the monitor:

```
+--------------------------------------------------------------------------+
|                                 error                                    |
|#  east    north    target    east    north    east    north     elev.    |
+--------------------------------------------------------------------------+
|1  0.0     −0.9       1.0     48.5     4.8   79132.5 351080.6    10.0     |
|2  0.4      1.0       1.3     53.1     7.2   84314.7 399001.4   239.3     |
|3 −1.2     −0.5       0.6     52.8     6.5   67841.4 457682.8   209.5      |
|4  1.1      0.5       1.3     34.0     9.2   77573.8 352626.4   432.5      |
|5 −2.7     14.0      14.2     48.6  −144.9   79132.6 351080.7   985.0      |
|                                                                           |
+---------------------------------------------------------------------------+
|         overall   rms      error:   4.46                                  |
+---------------------------------------------------------------------------+
```

The following menu then appears at the bottom of the monitor:

```
 +-----+------------+-----------------------------------------------+
 |DONE | PRINT FILE |  Double click on point to be included/excluded |
 +-----+------------+-----------------------------------------------+
```

The RMS error for the image is given under the column TITLEd "error" and subTITLEd "east" and "north". In the above report, point number 1 is 0.0 and −0.9 meters (east and north) from the predicted location calculated from the transformation equation. The RMS error for the target map is listed under the heading "target". This is the RMS error for the east and north coordinates of the target map but it is presented in the table using one general value. The overall RMS error is displayed at the bottom of the screen in meters. Points that create high RMS error are displayed in red on the monitor (represented here in italics).

The image coordinates of the point marked on the imagery group file is given under the heading "image" and the subheadings "east" and "north". The location of the control point in the target database is given under the heading "control" and the subheadings "east","north", and "elev". If you would like to exclude or include a control point, this can be accomplished by placing the mouse cross hairs on the control point number to be included (if the point is absent) or excluded (if the point is displayed) and pressing the left button on the mouse twice. When a point is excluded, it is not afterwards included in the calculation of the RMS error, or included in the final rectification parameters. However, it can be retrieved within *photo.2target* at any time by double clicking with the mouse as described above.

QUIT

To end the *photo.2target* program place the mouse cross hairs on the word QUIT; the marked control points (including coordinates) will be saved.

NOTES

During the course of marking control points and computing the ortho−rectification parameters, a matrix inversion error may occur. This is caused by trying to invert a non−singular normal equation matrix. When this situation arises, the status of all previously selected control points are modified, the control points are excluded. Running *photo.init* for the selected imagery group with accurate camera exposure station parameters should remedy the situation. The excluded control points may again be included as described in the section ANALYZE.

A good rule of thumb is to mark at least 12 to 15 points which are evenly distributed over the entire imagery group file in order to obtain an accurate transformation parameters for the rectification process. The RMS error may increase with more points added, but the transformation parameters will be more accurate over the entire image.

An RMS error of less than or equal to approximately one resolution unit (pixel) for the image being rectified is generally considered acceptable.

SEE ALSO

i.ortho.photo
photo.camera
photo.2image
photo.init
photo.rectify

AUTHOR

Mike Baba, DBA Systems, Inc.

Last changed: $Date: 2002/11/27 09:14:11 $

This is not a command in itself, but an option to the command [i.ortho.photo]

NAME

photo.camera **−** An imagery function that creates or modifies entries in a camera reference file.
(GRASS Image Processing Program)

SYNOPSIS

photo.camera option must be selected from the GRASS Image Processing Program *i.ortho.photo* .

DESCRIPTION

photo.camera creates or modifies entries in a camera reference file. For ortho−photo rectification, a camera reference file is required for computation of scanned image to photo−coordinate transformation parameters. There are two coordinate systems: The image coordinate system (in pixels) and the photo coordinate system (in milli−meters). The inner orientation establishes a relation between the pixels and the image coordinates with help of fiducial marks.

The first prompt in the program will ask you for the name of the camera reference file to be created or modified. You may create a new camera reference file by entering a new name, or modify an existing camera reference file by entering the name of an existing camera file.

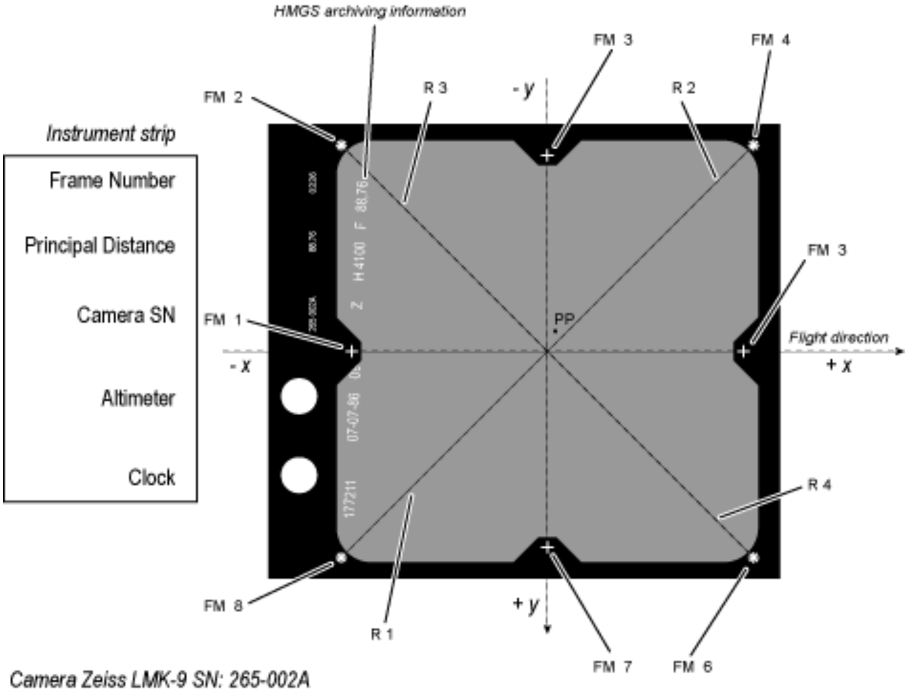
After entering the camera file name, following menu is displayed:

Please provide the following information

```
        CAMERA NAME:       camera name______
        CAMERA IDENTIFICATION:identification___
        CALIBRATED FOCAL LENGTH mm.:_________________
        POINT OF SYMMETRY (X)   mm.:_________________
        POINT OF SYMMETRY (Y)   mm.:_________________
        MAXIMUM NUMBER OF FIDUCIALS:_________________

   AFTER COMPLETING ALL ANSWERS, HIT <ESC> TO CONTINUE
               (OR <Ctrl-C> TO CANCEL)
```

The camera name and identification describe the camera reference file. The calibrated focal length and the point of symmetry are used in computing the photo−to−target transformation parameters. These values should be entered from the camera calibration report (usually available from the photograph supplier).


HMGS archiving information
FM 3
FM 4
FM 2
R 3
- y
R 2
Instrument strip
Frame Number
Principal Distance
Camera SN
Altimeter
Clock
FM 3
FM 1
PP
Flight direction
- x
+ x
Z H4100 F 88.76
07-07-86
177211
R 4
FM 8
R 1
+ y
FM 7
FM 6
Camera Zeiss LMK-9 SN: 265-002A

This example is the camera Zeiss LMK9 265−002A belonging to the Hellenic Military Geographical Survey (HMGS) and calibrated in December 1985

The photo coordinate system origin is the so−called calibrated principal point (PP, Principal Point of Symmetry) which is in the center of the image. The origin of the axes is at the intersection of the radii traced from the fiducial marks. In the ideal case of no deviations in the camera (see camera calibration certificate) the center is the origin and the values are 0 for both X and Y of Point of Symmetry. But usually the principal point does not fall on the intersection of the radii at the center of the picture. This excentricity is usually of the order of a few micrometers.

You are then asked to enter the X and Y photo coordinates of each fiducial as follows. These fiducials (or reseau) marks are index marks imaged on film which serve as reference photo coordinate system. The maximum number of fiducials will determine the number of fiducial or reseau coordinate pairs to be entered below. The origin is the center of the image (or the point of symmetry) and X and Y are left−right and up−down. The order is up to the user, but must be kept consistent throughout the rectification process.

On this screen you should enter the fiducial or reseau photo−coordinates as given in the camera calibration report. The X, and Y coordinates are in milli−meters from the principle point.

Please provide the following information

```
        Fid#    FID ID           X          Y

        1__     _____          0.0___   0.0___
        2__     _____          0.0___   0.0___
        3__     _____          0.0___   0.0___
        4__     _____          0.0___   0.0___
        5__     _____          0.0___   0.0___
        6__     _____          0.0___   0.0___
        7__     _____          0.0___   0.0___
        8__     _____          0.0___   0.0___
        9__     _____          0.0___   0.0___
        10_     _____          0.0___   0.0___
```

```
                     next:  end__

     AFTER COMPLETING ALL ANSWERS, HIT <ESC> TO CONTINUE
                    (OR <Ctrl-C> TO CANCEL)
```

The input display is repeated until the number of MAXIMUM FIDUCIALS is reached.

SEE ALSO

i.ortho.photo
photo.2image
photo.2target
photo.init

AUTHOR

Mike Baba, DBA Systems, Inc.

Last changed: $Date: 2002/11/27 09:14:11 $

This is not a command itself, but an option of the command i.ortho.photo.

NAME

photo.init **−** An imagery function that creates or modifies the optional entries in a camera initial exposure station file for an imagery group.
(GRASS Image Processing Program)

SYNOPSIS

Selected from *i.ortho.photo*

DESCRIPTION

Aerial photographs may be either vertical or oblique. Vertical photographs can be truly vertical (nadir), or slightly tilted (less than 3 degree from the vertical). Usually aerial photos are tilted to some degree. We refer to the term *vertical photograph* up to a tilt of 3 degree.
Oblique aerial photographs are purposely taken with an angle between 3 and 90 degree from the nadir direction.

The use of *photo.init* (menu 6) is only required when rectifying a tilted or oblique aerial photo.

photo.init creates or modifies entries in a camera initial exposure station file for imagery group referenced by a sub−block. These entries include: the (XC,YC,ZC) positional (e.g. UTM) approximate coordinates of the camera exposure station; initial roll, pitch, and yaw angles (in degrees) of the cameras attitude; and the *a priori* standard deviations for these parameters. During the imagery program, photo.rectify, the initial camera exposure station file is used for computation of the ortho−rectification parameters. If no initial camera exposure station file exist, the default values are computed from the control points file created in *photo.2target* .

The following menu is displayed:

```
        Please provide the following information

        INITIAL XC: Meters                ___________
        INITIAL YC: Meters                ___________
        INITIAL ZC: Meters                ___________
        INITIAL omega (roll) degrees:     ___________
        INITIAL phi  (pitch) degrees:     ___________
        INITIAL kappa  (yaw) degrees:     ___________

        Standard Deviation XC: Meters     ___________
        Standard Deviation YC: Meters     ___________
        Standard Deviation ZC: Meters     ___________
        Std. Dev. omega (roll) degrees:   ___________
        Std. Dev. phi  (pitch) degrees:    __________
        Std. Dev. kappa  (yaw) degrees:    __________

     AFTER COMPLETING ALL ANSWERS, HIT <ESC> TO CONTINUE
                  (OR <Ctrl-C> TO CANCEL)
```

The INITIAL values for (XC,YC,ZC) are expressed in standard (e.g. UTM) coordinates, and represent an approximation for the location of the camera at the time of exposure.

- X: East aircraft position;
- Y: North aircraft position;
- Z: Flight altitude above sea level

The INITIAL values for (omega,phi,kappa) are expressed in degrees, and represent an approximation for the cameras attitude at the time of exposure.

- Omega (roll): Raising or lowering of the wings (turning around the aircraft's axis);
- Phi (pitch): Raising or lowering of the aircraft's front (turning around the wings' axis);
- Kappa (yaw): Rotation needed to align the aerial photo to true north: needs to be denoted as +90 degree for clockwise turn and −90 degree for a counterclockwise turn.

The standard deviations for (XC,YC,ZC) are expressed in meters, and are used as *a priori* values for the standard deviations used in computation of the ortho rectification parameters.

The standard deviations for (omega,phi,kappa) are expressed in degrees, and are used as *a priori* values for the standard deviations used in computation of the ortho rectification parameters.

If *Use these values at run time? (1=yes, 0=no)* is set to 0, the values in this menu are not used.

SEE ALSO

i.ortho.photo
photo.camera
photo.2image
photo.2target
photo.rectify

AUTHOR

Mike Baba, DBA Systems, Inc.

Last changed: $Date: 2003/09/09 13:10:18 $

This is not a command in itself, but an option of the command i.ortho.photo .

NAME

photo.rectify **−** An imagery function that rectifies an image by computing a coordinate transformation for each cell in the image using parameters computed by the GRASS programs *photo.2image* and *photo.2target*. *(GRASS Image Processing Program)*

SYNOPSIS

Selected from *i.ortho.photo*

DESCRIPTION

photo.rectify rectifies an image by using the image to photo coordinate transformation matrix created by photo.2image and the rectification parameters created by photo.2target. Rectification is the process by which the geometry of an image is made planimetric. This is accomplished by mapping an image from one coordinate system to another. In photo.rectify the parameters computed by photo.2image and photo.2target are used in equations to convert x,y image coordinates to standard map coordinates for each pixel in the image. The result is an image with a standard map coordinate system, compensated for relief distortions and photographic tilt. Upon completion of the program the rectified image is deposited in a previously targeted GRASS LOCATION.

You are asked to select the file(s) within the imagery group to be rectified:

Please select the file(s) to rectify by naming an output file

```
                    gs13.1 in PERMANENT   gs13.orect...
                    gs14.1 in PERMANENT   .............

     (enter list by any name to get a list of existing cell files)

             AFTER COMPLETING ALL ANSWERS, HIT <ESC> TO CONTINUE
                        (OR <Ctrl-C> TO CANCEL)
```

More than one file may be rectified at a time. Each file should have a unique output file name.

The next prompt asks you to select one of two windows:

```
Please select one of the following options
1.   Use the current window in the target location
2.   Determine the smallest window which covers the image
>
```

photo.rectify will only rectify that portion of the image that occurs within the chosen window. Only that portion will be relocated in the target database. It is therefore important to check the current window in the target LOCATION if choice number one is selected.

photo.rectify will run in the background and notify you by mail when it is finished. The process may take an hour or more depending on the size of the image, the number files, and the size and resolution of the selected window.

The rectified image will be located in the target LOCATION when the program is completed. The original unrectified files are not modified or removed.

SEE ALSO

i.ortho.photo
photo.camera
photo.2image
photo.2target
photo.init

AUTHOR

Mike Baba, DBA Systems, Inc.
Updated rectification and elevation map to FP 1/2002 Markus Neteler

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