C-3PO v1.0.2
Installation and User Guide

Revision Date:
17 August 2014

Author:
Devin White, PhD (Devin.White@gmail.com)

Introduction

The Compact Parallelized Photogrammetric Projection Object (C-3PO) is an ENVI plugin that enables fast and rigorous image orthorectification and reprojection on multi-core computers. C-3PO works by launching ENVI in full batch mode on every available hardware thread through the IDL-IDL Bridge, passing each one a small part of the larger task, retrieving the results, and assembling the final product. Because each ENVI process is completely independent, this approach is referred to as *weak parallelization*. The same approach is used on high performance computing clusters, albeit on a much larger scale.

C-3PO does not use any of ENVI's built-in orthorectification or reprojection support. Instead, routines were built from the ground up using proven photogrammetric methods. The results have been validated against output from several vetted geospatial software packages and are consistently more accurate than what ENVI can generate natively.

To process an image in C-3PO, it must either have a valid map projection or functional fit sensor model (RPC or RSM). In the former case, a reprojection will be performed. In the latter case, an orthorectification will be performed. A DEM, registered to Mean Sea Level, can be provided to enable more accurate orthorectification. If a DEM is not provided, C-3PO assumes the earth is flat and its height is the same as the "height offset" parameter in the functional fit model.

C-3PO can be accessed interactively through the ENVI menu system or through an application programming interface (API) that enables batch processing. The API is presented after brief discussions on the system requirements, installation, and use of the plugin.

Minimum System Requirements

C-3PO requires the following in order to run:

- ENVI 4.4 or later. This ensures that IDL-IDL Bridge functionality is available.
- At least four cores. Apart from a more accurate result, systems with only two cores (mostly laptops) will receive little benefit from this plugin.
- At least 10MB of available RAM per core. So, a four-core system should have at least 40MB of RAM available. This is not a hard and fast rule, just a suggestion based on experience.

Installation

To add C-3PO to your ENVI Classic installation, place the C-3PO folder in your save_add directory and then restart ENVI. To launch the interface, go to Map->C-3PO. C-3PO now works in ENVI 5.0+, which requires you to install the C-3PO folder in its extensions directory. After doing so and restarting the application, you should see "c3po" in the list of available extensions.

Using C-3PO

C-3PO is fairly straightforward to use and, by design, its interface looks very similar to ENVI's Generic RPC and RSM Orthorectification tool. The following steps will guide you through the process of using C-3PO:

1. Click on the Select Image button, which launches the standard ENVI file selection dialog. From here, select the image you wish to process and perform any desired spatial or spectral subsetting. While extensive testing has not been performed, C-3PO should be able to handle selecting an image that is stored in a multi-segment file (e.g., NITF and HDF).
2. Click on the Output File button, which launches the standard IDL file selection dialog. From here, specify the name of the file into which C-3PO will write the processed results.
3. Adjust the Output Tile Size as necessary. This is the amount of memory each core is allowed to use while processing the image. A larger value indicates that each core can work on a larger part of the image. However, it is a balancing act. The larger the chunk of data, the longer it takes to move it around, so any gains achieved through parallelization could be lost due to transport time (and you might run out of memory). On the other hand, if the chunk is too small, the overhead time required by parallelization will outweigh any benefits. The default is 10MB and this seems to work well for most systems. You are encouraged to experiment, though, as your system may be able to efficiently handle larger chunks of data.
4. Select a resampling method from the dropdown list. Nearest Neighbor does the best job at preserving the original data, Cubic Convolution produces the nicest-looking results. Bilinear is a compromise between the two and as such is used by default.
5. Input a background value, if desired. This is the value that will be used to fill in the portions of the outputted image that do not contain valid image data. A value of 0 is used by default.
6. If the image you have selected to process has a valid RPC or RSM functional fit model associated with it, C-3PO automatically understands that orthorectification is the best method for generating output and subsequently activates the Elevation Source and Select DEM options in the interface. The Elevation Source toggle enables you to choose between a Flat Earth orthorectification and one that uses a DEM. If DEM is chosen, click on the Select DEM button to launch the standard ENVI file selection dialog and highlight the DEM band you wish to use.
7. The last input step is to select the desired output map projection. Geographic Lat/Lon is chosen by default, but you can either manually change the projection using the provided widget or simply click on the Use Default UTM Projection toggle. In the latter case, an appropriate UTM zone is calculated using the selected image's estimated geographic extents.
8. Click the Process button to start the orthorectification/reprojection process or the Cancel button to exit C-3PO.

Once the Process button has been clicked, you will see two successive progress bars. The first indicates the progress on launching the necessary background ENVI processes. You may see ENVI's interface flash and/or go out of focus during this step. I have no control over that behavior. The second indicates the overall progress of the output process. In general, you will see the bar alternate between pauses and rapid progress. This is normal, as each batch ENVI process will take about the same amount of time to complete its part of the overall task and report back the results. The pauses are when the batch processes are working, the rapid progress is when the results are being written to disk.

NOTE: At present, C-3PO does not allow you to supply a ground control points (GCP) file to improve orthorectification accuracy. It is possible to do this, but I have not had enough time to integrate and test the necessary routines. It is also not currently possible to specify the desired X and Y ground sample distances (pixel sizes) through the interface. This can be done through the API. Both options will be added to a future version of the plugin.

RUN_C3PO

Use this procedure to orthorectify or reproject an image by taking advantage of all available hardware threads on your system.

Syntax

RUN_C3PO, FID, OUT_FILE, [DIMS=array], [POS=array], [DEM_FID=file ID], [DEM_POS=value], [TILE_SIZE=value], [INTERP={0 | 1 | 2}], [PROJ=structure], [PS=array], [/PROGRESS], [R_FID=variable], [ERROR_MSG=variable], [/DEFAULT_UTM], [BACKGROUND=value] [,BRIDGES=*object array*]

Keywords

FID

Use this positional parameter to specify the ENVI file ID (FID) associated with the image to be processed.

OUT_FILE

Use this positional parameter to specify a string with the output filename for the processed image.

DIMS (optional)

Use this keyword to specify a five-element array that defines the spatial region of the image to be processed. Please consult the ENVI Help System for a description on how the array should be populated. If the array is not specified, the image's entire spatial region is used.

POS (optional)

Use this keyword to specify an array of zero-based band positions, indicating the band numbers that should be processed. Please consult the ENVI Help System for a description on how the array should be populated. If the array is not specified, all bands will be used.

DEM_FID (optional)

Use this keyword to specify the ENVI file ID (FID) associated with the DEM that should be used during orthorectification. The DEM band position that contains the relevant elevation data must be specified using the DEM_POS keyword. The DEM_FID keyword is ignored if the image to be processed does not have an RPC or RSM sensor model associated with it. If it does have a valid model and a DEM FID is not specified, a Flat Earth orthorectification will be performed.

DEM_POS (optional)

Use this keyword to specify the zero-based band position that contains the elevation data to be used during orthorectification. This keyword is ignored if the DEM_FID keyword does not contain a valid ENVI file ID (FID) for the DEM to be used. Since most DEMs contain a single band, a value of 0 is the most common one to use for this keyword.

TILE_SIZE (optional)

Use this keyword to supply a value, in MB, that indicates how much memory should be used by each C-3PO background process. The default is the current value for Image Tile Size in the ENVI Preferences. A value of at least 10MB is recommended.

INTERP (optional)

Use this keyword to indicate the type of interpolation that should be used during output.

- 0 — Nearest neighbor

- 1 — Bilinear

- 2 — Cubic convolution

Bilinear is used by default.

PROJ (optional)

Use this keyword to supply an ENVI projection structure that will be associated with the output process. If a structure is not supplied, Geographic Lat/Lon is used by default. If the /DEFAULT_UTM keyword is set, this keyword is ignored.

PS (optional)

Use this keyword to supply a two-element double precision array that contains the desired X and Y ground sample distances (pixel sizes) for the output. The supplied values must be in the units associated with the desired output projection. If values are not supplied, defaults are calculated internally.

PROGRESS (optional)

Setting this keyword instructs C3PO to use ENVI's progress bar feature to communicate processing status. It is recommended to not set this keyword if you are going to operate C-3PO in full batch mode.

R_FID (optional)

Use this keyword to specify the name of a variable that will contain the ENVI file ID (FID) for the processed image. If the process fails, the specified variable will contain a value of -1. The error message associated with this failure is returned via the optional ERROR_MSG keyword.

ERROR_MSG (optional)

Use this keyword to specify the name of a variable that will contain an error message if the process fails. If the process does not fail, the specified variable will contain a null string.

DEFAULT_UTM (optional)

Setting this keyword instructs C3PO to calculate the most appropriate UTM zone for the supplied image, build an ENVI projection structure for it, and use that projection for the output. If this keyword is set, the PROJ keyword is ignored.

BACKGROUND (optional)

Use this keyword to specify the value to use for the portions of the output that do not contain valid image data. The default value is 0.

BRIDGES (optional)

Use this keyword to provide an array of IDL-IDL Bridge objects if you want to create and then reuse the same set of bridges to process multiple files (otherwise C3PO will create and destroy them each time). This can save a lot of time on large jobs. The array can be generated by calling the C3PO_CREATE_BRIDGES function and destroyed by calling the C3PO_DESTROY_BRIDGES procedure. Examples of how to use the routines can be found in the batch example file that comes with this distribution. DO NOT CREATE AND DESTROY BRIDGES WITHIN A LOOP.