Geospatial Scripting

Pipeline Image Processing

A *pipeline* is an efficient, modular software architecture commonly employed for tasks that can be broken down into a series of independent processing steps. MicroImages has integrated a pipeline image-processing architecture into the TNT products and the Geospatial Scripting Language (SML), where it can be used in combination with the wide array of other SML functions and classes.

Pipeline Stages

A pipeline consists of a chain of processing elements arranged so that the output of each element (*stage*) is the input of the next. There are three types of stages (see more complete definitions in the box to the right): *source* (image input), *filter* (processing element), and *target* (image output). Sources and targets can be raster objects in a MicroImages Project File, or files in other formats supported for direct use in the TNT products (see lists of source and target types below). Filters are provided to perform a variety of operations such as resampling, mosaicking, applying spatial filters, cropping, applying a mask, and many others (see list of filters on the reverse).

Pipeline Connections and Operation

Each type of source, filter, and target is a separate SML class with its own predefined properties and methods (class functions). Pipeline connections are forged when a stage class is constructed in a pipeline script by specifying the previous stage that provides its input as part of its definition. A pipeline can have one or several sources, but only one target. Filters can be applied in series to one image or in parallel to multiple source images. Once the pipeline is constructed, a single method is called on the target stage to initiate processing and pull all of the image data through the pipeline. Some examples of simple pipeline designs are diagrammed below.

Pipeline Benefits

Pipeline stages encapsulate their data, data properties, and operations. They also interact with each other in simple, defined ways. This modular design simplifies coding in SML and makes it easy to construct, modify, or extend a processing pipeline in a script. For example, in an SML pipeline georeference information is an inherent property of an image, so it is automatically pulled through the pipeline and assigned to the target. Likewise, pyramid tiers are automatically produced for target rasters in Project Files. Scripts run on single and multi-core computers automatically use any multi-threading incorporated into the stages such as in JPEG2000 compression and decompression operations.

Pipeline Terminology

IMAGE: a raster object, file, or equivalent structure in memory consisting of one component / band, or a set of co-registered components / bands. If there is more than one component, each has the same DIMENSIONS (total number of rows and columns), data type, and georeference. Examples: an elevation raster object in a Project File, an RGB color-composite raster object in a Project File, or a GeoTIFF file containing four bands of an Ikonos or QuickBird satellite scene.

SAMPLE: the numeric value for a particular image row/column position and component. A sample has a Data Type property (e.g. unsigned 8-bit, signed 16-bit, 32-bit floating-point, and so on).

PIXEL: the set of SAMPLES (one sample per component) for a particular image row/column position. A PIXEL has a Pixel Type property that specifies the number and relationship (if any) of its SAMPLES (e.g. grayscale, multiple, RGB, CMYK, and so on).

STAGE: any pipeline element that represents or processes an image.

SOURCE: a pipeline stage that inputs an image. A source stage has no pipeline inputs and one output.

FILTER: a pipeline stage that applies some processing or transformation to the image. A filter stage has one or more inputs and one output.

TARGET: a pipeline stage that represents the final output image. A target has one input and no pipeline output. Its properties are derived from the input stage it is connected to.

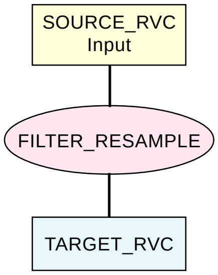
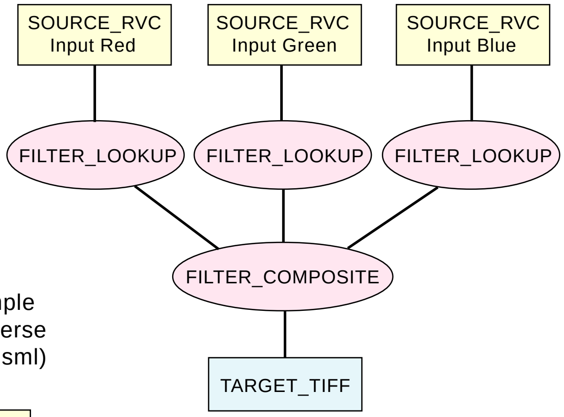
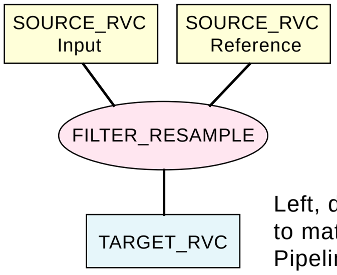


Diagram of pipeline to resample an image in the script on reverse (PipelineResampleToGeoref.sml)



Above, diagram of pipeline to apply contrast to red, green, and blue grayscale images, make a color composite, and output it to a TIFF file (see sample script PipelineContrastCompositeToTiff.sml).



Left, diagram of pipeline to resample an image to match a reference image (see sample script PipelineResampleToMatch.sml).

Pipeline Source Types:

RVC	Raster object in MicroImages Project File
PNG	PNG file
TIFF	TIFF file
JPEG	JPEG file
MRSID	MrSID file
WBMP	Wireless Bitmap (WBMP) file
REGION	Region to use for masking/cropping
CONSTANT	Source with constant value

more sources by request

Pipeline Target Types:

RVC	Raster object in MicroImages Project File
RVC_MULTIFILE	MicroImages tileset
J2K	J2K (JPEG2000) file
TIFF	TIFF file
PNG	PNG file
JPEG	JPEG file

more targets by request

Pipeline Filters in MicroImages Geospatial Scripting Language (SML)

COLORBALANCE color-balance an image
COMPOSITE create composite from multiple sources
CROP crop an image
DATATYPE change sample data type
DEINDEX change indexed-color to separate samples
DIVIDE divide one image by another
EXTEND extend image by adding null pixels around outside
FOCAL_TOPOOGRAPHIC compute topographic properties
FOCAL_AMPM Adaptive Mean P-median spatial filter
FOCAL_CONTRAST Locally-adaptive contrast spatial filter
FOCAL_CS Comparison/selection spatial filter
FOCAL_FROST Frost radar noise reduction spatial filter
FOCAL_GRADIENT gradient edge-detection filter
FOCAL_KUANADAPTIVE Kuan radar noise reduction filter
FOCAL_LEE Lee radar noise reduction filter
FOCAL_LUM lower-upper-middle spatial filter
FOCAL_MLM multilevel median spatial filter
FOCAL_MULTIPLICATIVE weighted averaging filter
FOCAL_OLYMPIC olympic spatial filter
FOCAL_PMEDIAN P-median spatial filter
FOCAL_RANGE range spatial filter
FOCAL_SIGMA sigma radar noise reduction filter
FOCAL_STATISTICS compute focal mean, median, sum, etc.
FOCAL_TEAGER Teager spatial filter
FOCAL_VOLTERRA Volterra-unsharp spatial filter
FOCAL_WMMR weighted-majority/minimum range-median filter
FUSION_BASICHBS multiresolution image fusion via HBS
FUSION_BASICHIS multiresolution image fusion via HIS
FUSION_BROVEY multiresolution image fusion via Brovey method
FUSION_MODHIS multiresolution image fusion via modified HIS
FUSION_TEXTUREPCA multiresolution image fusion via TexturePCA

more filters by request

LINEAR perform linear combination on samples in image
LOOKUP apply look-up tables to samples in image
MASK_SELECT select between images using mask
MASK_VALIDITY apply mask to image
MORPHOLOGY_CLOSING morphological operation “closing”
MORPHOLOGY_DILATION morphological operation “dilation”
MORPHOLOGY_EROSION morphological operation “erosion”
MORPHOLOGY_OPENING morphological operation “opening”
MOSAIC mosaic images
MULTIPLY multiply images
OVERRIDETYPE override pixel type of image
PIXELTABLE apply pixeltable (e.g. color palette) to image
PIXEL_TYPE change pixel type of image
QUANTIZE quantize samples in image
REPLACE_NULL replace null pixels with specified value
RESAMPLE resample/reproject image
SCALEOFFSET apply scale and offset to samples
SELECT select specified component samples from image
STEREO generate stereo image
TESTEQUAL test pixel for equality
TESTRANGE test pixel for containment inside or outside range
VALIDITYNEAR set validity based on nearness to specified value
ZOOM zoom image (change pixel size) up or down by fixed amount

Special Filters that Apply Pixel-by-Pixel Computations using a User-Defined Delgate Function

GENERAL_CHGPROP apply user-defined function to image with change of pixel type
GENERAL_INPLACE apply user-defined function to image
MARGIN automatically buffer margins when iterating with user-defined function

Pipeline Script to Resample/Reproject Image to Specified Cell Size: PipelineResampleToGeoref.sml

error checking procedure

```
proc ReportError(numeric linenum, numeric err) {
    printf("FAILED -line: %d, error: %d\n", linenum, err);
    PopupError(err);
    }
```

CHOOSE INPUT RASTER to be resampled

objItem for input raster

```
class RVC_OBJITEM riObjItem;
DlgGetObject("Select raster to resample:", "Raster", riObjItem, "ExistingOnly");
```

PIPELINE SOURCE: set input raster as source

```
class IMAGE_PIPELINE_SOURCE_RVC source_In( riObjItem );
err = source_In.Initialize();
if (err < 0)
    ReportError(_context.CurrentLineNum, err);
else   print("Pipeline source initialized.");

printf("Source image has %d lines and %d columns.\n", source_In.GetTotalRows(),
         source_In.GetTotalColumns() );
```

check that source has valid coordinate reference system

```
class IMAGE_PIPELINE_GEOREFERENCE sourceGeoref;
sourceGeoref = source_In.GetGeoreference();
```

get coordinate reference system from the source georeference

```
class SR_COORDREFSYS crs;
crs = sourceGeoref.GetCRS();

if (crs.IsDefined() == 0 or crs.IsLocal() ) {
    PopupMessage("Source coordinate reference system is undefined or local;
             exiting script.");
    Exit();
    }
else   printf("Coordinate reference system: %s\n", crs.Name );
```

CHOOSE OUTPUT RASTER

```
class RVC_OBJITEM rastOutObjItem;
DlgGetObject("Choose raster for resampled output", "Raster", rastOutObjItem,
                     "NewOnly");
```

get line and column cell sizes from source's georeference

line and column cell sizes as x and y values of POINT2D; column and line location for which to obtain cell size

```
class POINT2D scaleIn;

class POINT2D locIn;
```

location at center of image

pixel scales in meters

```
locIn.x = source_In.GetTotalColumns() / 2;
locIn.y = source_In.GetTotalRows() / 2;
sourceGeoref.ComputeScale(locIn, scaleIn, 1);
printf("Source image cell sizes: line = %.2f m, col = %.2f m\n", scaleIn.y, scaleIn.x);
```

prompt user to enter desired output line/column cell sizes

cell size to set for the output raster

```
numeric lineCellSize, colCellSize;

string prompt$ = "Enter desired line cell size for output raster:";
lineCellSize = PopupNum(prompt$, scaleIn.y, 0, 1000, 2);
prompt$ = "Enter desired column cell size for output raster:";
colCellSize = PopupNum(prompt$, scaleIn.x, 0, 1000, 2);
```

[code to compute appropriate resampling method omitted]

PIPELINE FILTER to resample source image

```
class IMAGE_PIPELINE_FILTER_RESAMPLE filter_rsmp(source_In, crs,
          lineCellSize, colCellSize, rsmpMethod$);
err = filter_rsmp.Initialize();
if (err < 0)   ReportError(_context.CurrentLineNum, err);
else   print("Resample filter initialized.");
```

PIPELINE TARGET: set up the target for the pipeline

```
class IMAGE_PIPELINE_TARGET_RVC target_rvc(filter_rsmp, rastOutObjItem);
target_rvc.SetCompression("DPCM", 0);
err = target_rvc.Initialize();
if (err < 0)   ReportError(_context.CurrentLineNum, err);
else   print("Pipeline target initialized.");

print("Processing...");
target_rvc.Process();

print("Done.");
```

EXECUTE pipeline process