Digitizer Plugin for CamBam

[Version 1.1.1]

Purpose:

To provide a simple way of taking a file containing digitized point data obtained from a digitizing process, e.g. from Mach3, or from any other digitizing device, and to create an STL (Stereo Lithography) file, and optionally imported to CamBam to create a surface object for machining. The saved STL file may be used for other purposes.

The digitized model is expected to be only 2.5D, i.e. a relief type shape, not a full 3D shape. The surface triangulation will not work on true 3D models, or cloud models that have coincident points in the X-Y plane.

From version 1.0.5 the digitized data can come from a 6 axis scanner (i.e. the axes X, Y, Z, A, B and C). It is assumed that the surface being digitized is still essentially a 2.5D surface, i.e. the coordinate axes are coming from any, and only, three of the six possible axes. With the appropriate scaling a 3D surface MOP can be created which then in turn can be transformed into a multi-axis G-Code model using the built in post processor. *This feature is experimental only*.

From Version 1.0.10 the point cloud can be cropped to a 3D rectangular prism before processing (see **Post Processor Option**)

From Version 1.1 it is possible to create an STL file from a surface model that has been created from the G-Code MOP -> Surface option in CamBam (see **Pre Processor Option**).

Installation

The DigitizerPlugin.dll file should be placed in the CamBam plugins folder. On restarting CamBam the plugin is then found in the Plugins menu.

Data Requirements

The data must be prepared in a text file, with each line containing the X, Y and Z (and A, B and C if appropriate) coordinates values of a digitized point. Each line must contain at least 3 values, and at most 6 values. Each value can be prefixed by an axes symbol (X, Y, Z, A, B, C – upper or lowercase) to define which axis each item is associated with. If the axes symbols are not included then the order of the data is assumed to be X, Y, Z, A, B then C. There must be no space between the prefix and the number value.

The values must be separated by commas <,>, semicolons <;>, tabs <\t> or spaces <sp>.

- Non-European CSV files expect to have: decimals with a <.>; and <,>, <\t> or <sp> value separators.
- European CSV files expect to have decimals with a <,>; and <;>, <\t> or <sp> value separators.

The following combinations will work:

	Data line contains	Assumed Culture	Valid Number Separator Character	Valid decimal character
If	<.>	“en”	<,><sp><\t>	<.>
Else if	<;>	Not “en”	<;><sp><\t>	<,>

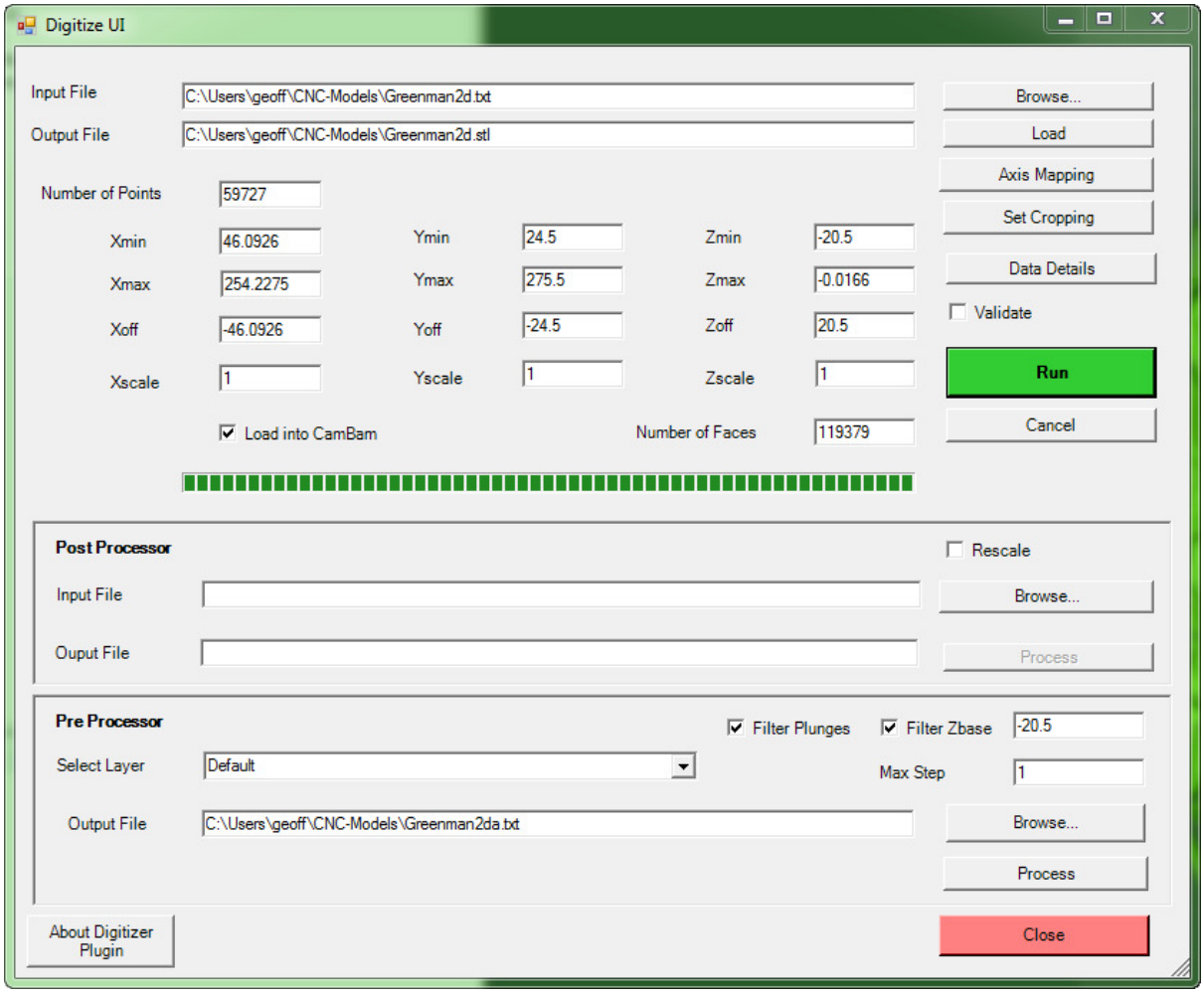
else		Current machine settings are: • "en": • Not "en":	 <,><sp><\t> <;><sp><\t>	 <.> <,>

The data points do not have to be on a regular grid, or be uniformly distributed over the model space. The quality of the resulting surface will, of course, depend in the spacing's of the data points and how well they follow the surface.

The digitized data is defined in measured coordinates, while the STL file is defined in model space coordinates.

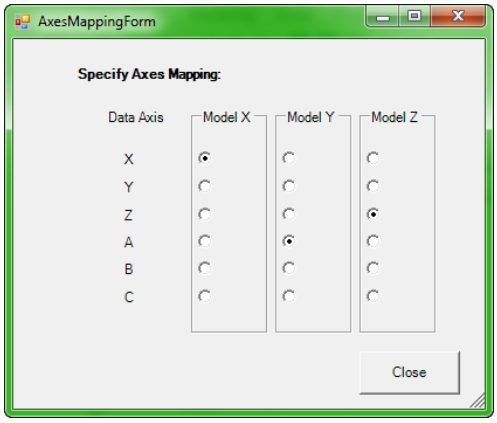
The STL file contains a set of triangular faces to define the model surface. The file name must have a ".txt" or a ".dat" extension. Note that the created STL file will always be in non-European format (i.e. decimal points <.> are used for numbers).

The User Dialog



The fields are:

- **Input File**: the file name containing the digitized data; it must be specified from the <Browse> button.
- **Output File**: the name of the STL file to be created; by default it takes the name of the input file with an ".stl" extension, but can be changed to suit. If the output file already exists a warning is given before overwriting this file.
- **Axis Mapping** button: provide access to the mapping table for mapping the input data (X,Y,Z,A,B,C) coordinates to the model (X,Y,Z) coordinates. When clicked the Axes Mapping dialog is shown:

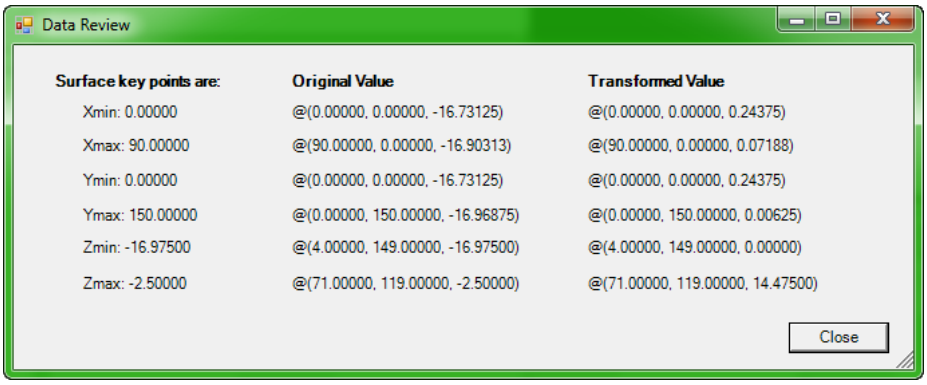


The user is required to select a single option in each column (Model X, Model Y and Model Z) for three of the Data Axes. In the above example, the data X axis maps to the model X axis, the data A axis maps to the model Y axis and the data Z axis maps to the model Z axes. The plugin works in model space, after transforming the digitized data.

This mapping must be configured if more than 3 axes have been digitized in the input file. If only 3 axis (X,Y,Z) are being used, then the default mapping is used.

- **Load** button: loads the input file and displays the properties of the (model) data in the relevent fields (**Xmin, Xmax, Ymin, Ymax, Zmin, Zmax** and the **Number of Points** after mapping as required).
- The input data can be translated and scaled to build the surface model. The offset values (**Xoff, Yoff** and **Zoff**) are first applied, then the coordinate values are scaled by the specified scale values (**Xscale, Yscale** and **Zscale**), i.e. Tx = (x + offset)*scale. By default the offset values are taken to be those sufficient to translate the model to fit into the positive X-Y-Z quadrant. Transforming data from 4 to 6 axis data sets required special care.
- The **Run** button then completes the surface triangulation and saves the STL file in model coordinates. This is performed using a Delaunay Triangulation algorithm applied in the X-Y plane, and with Z being the surface height.. As implemented it is not the most efficient and will probably not perform well for models with more than 100,000 points
- The **Cancel** button will stop the computation if it is going on too long.
- The **Progress Bar** shows the progress of the computation. If the **Validate** checkbox is selected then the progress bar has two phases: firstly the progress of the validation process is shown, then the progress of the triangulation process is shown.
- The number of resulting faces is then displayed in the **Number of Faces** field.
- If the **Load into CamBam** checkbox is checked, the STL file is loaded into CamBam as a Surface object. Note that this will remove any existing model in CamBam.

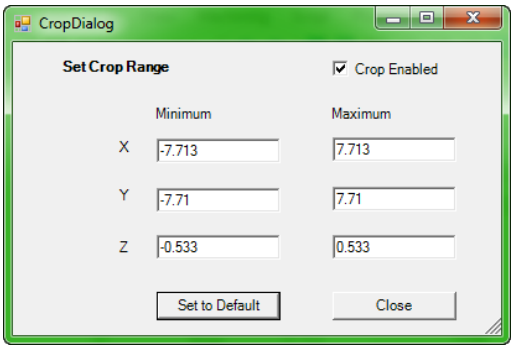
- The **Data Details** button shows a dialog containing the locations where the various minima and maxima coordinates have been found, like this:



  Both the original (as digitized) and transformed (model) values are shown.

  Note that these locations will represent the first one found if several matching points exist in the set of data points.

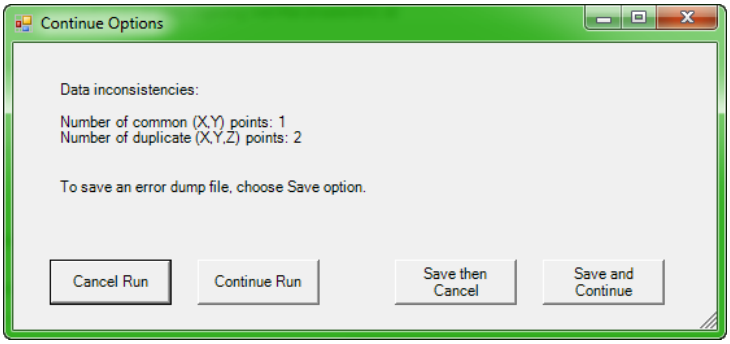
- The **Set Cropping** button enables a simple 3D crop box to be specified and be optionally applied to the source X,Y,Z data. The cropping is applied to the raw data before any transformations are applied but after any axes mappings are applied.



  The **Set to Default** button inserts the crop values to match the data range found in the digitized data just loaded. To change the crop limits enter the required minimum and maximum values for each axis, then **Close**. To enable cropping the **Crop Enabled** checkbox must be checked. When cropping is enabled, any data points found in the input file that are outside this box are simply ignored for the purposed of building the 3D surface.

- The **Validate** checkbox, if checked, will cause some data validation to occur before triangulating the surface when the **Run** button is clicked. It will test for the number of common (X,Y) points, i.e. the number of points that have the same X and X coordinate values, but with a different Z value; and the number of identical (X,Y,Z) points, i.e. the number of points that have identical X, Y and Z values. The triangulation algorithm used may not give correct results if either of these values are non-zero.

  If any “errors” are found then the following dialog is displayed:



If no errors are found this dialog is not displayed and the triangulation is completed.

In this dialog there are four options:

- **Cancel Run** – terminates the current task.
- **Continue Run** – ignore errors and continue with triangulation.
- **Save then Cancel** – saves an error log file, then cancels the task.
- **Save and Continue** – saves an error log file and continues with the triangulation.

The save options will save the full list of bad points, and their model (X,Y,Z) values, to a text file with the same name as the input file with an added ".err" extension. This file is saved in the same folder as the input file. The format of this file is like this:

```
Common (X,Y) points:
0 [4]: 1.000000, 0.000000, -16.743755    [1]: 1.000000, 0.000000, -16.743750

Duplicate (X,Y,Z) points:
0 [3]: 0.000000, 0.000000, -16.731250   [0]: 0.000000, 0.000000, -16.731250
1 [5]: 2.000000, 0.000000, -16.753125   [2]: 2.000000, 0.000000, -16.753125
```

Where the index numbers in [..] are the line numbers (counting from zero) in the input data file of the identified point(s), and the three following numbers are its (X,Y,Z) model coordinate values. Also, some points may appear multiple times. Resolution of these errors requires knowledge of the cloud data model.

- **Close**, closes the dialog.

Post Processor Option

If the model was created from a 4 (to 6) axis scanner/digitizer then the **Post Processor** section can be use to transform a G-Code file in (X,Y,Z) model coordinate axes back to the original (X,Y,Z,A,B,C) data axes. To use the **Post Processor**, select **Digitize Input Processor** again from the main CamBam **Plugins** menu.

The process to create a multi-axis digitized MOP follow these steps:

1. Set the required axes mappings.
2. Import the multi-axis data set, transforming the data to the current axes mapping.
3. Create a surface MOP with CamBam.
4. Generate and save the G-Code file.
5. In the Post Processor section: **Browse** to this file to select the required G-Code input (.nc, or .tap) file. The output file will be named the same with "Transformed" added.
6. If the original digitized data was scaled on import, then it can be re-scaled (reverse transformed) by checking the **Rescale** checkbox. If checked, the reverse transformation is applied to each axis: x = Tx/scale – offset.

7. From the **Process** button, the new transformed G-Code file will be created.

Note that the **Load** button is not enabled until an input file is selected from the **Browse** button, and the **Run** button is not enabled until the data file is loaded from the **Load** button.

Pre-Processor Option

The Pre-Processor option is used to create an XYZ data file (like a digitizer file) from a surface that has been created in CamBam generated from a G-Code file import. This XYZ file can then be treated like any digitizer file to create a 3D surface model using the triangulation process described above.

CamBam can import G-Code files to create a MOP directly. This MOP can then be converted to a geometry object from the context menu of the MOP, after choosing *Toolpaths to Geometry* option. A new geometry object is created composed of a number of Polylines that follow the surface defined by the MOP. This object can then be further manipulated in CamBam.

Providing that the tool size used to create the original G-Code file (in your favourite G-Code generating package) is small (say 0.5mm dia, along with a small stepover) then the generated surface will be quite close to the original surface from which the G-Code was derived from.

In this option:

- The **Selected Layer** combo is use to select the layer containing the required geometry. Only Polylines are currently recognised, and only one layer can be processed at a time.
- The **Output File** will be the name of the XYZ file to save.
- The **Filter Plunges** checkbox (checked by default) will remove any paths in the geometry that might have come from plunge moves in the MOP.
- The **Filter Zbase** checkbox will filter out all parts of polylines that have a Z-coordinate value below this set value.
- The **Max Step** field is used to set the maximum size of the interval of XY points along each Polyline for the creation of XYZ points.
- The **Process** button does the work and saves the resulting XYZ file

This XYZ file can then be imported in the main part of the plugin to create a triangulated surface and then saved as an STL file for further processing or for including into CamBam as a re-engineered surface model.

The suggested workflow is as follows:

1. Create or obtain your source G-Code file, created so that the machine paths are close enough to the actual required finished surface. This file must only include the final finishing cut.
2. Load this file into CamBam, then create a surface geometry from the MOP.
3. Launch the Digitizer plugin and:
    a. Select the required layer that contains the geometry (as Polylines).
    b. Select/enter the required file name for the XYZ data file to be created.
    c. Probably check the **Filter Plunge** checkbox to remove any plunge cuts (up or down) that might be in the G-Code file.

d. If the model contains large flat areas at, or below, a base Z value then it is possible to ignore these for the XYZ file (reduces size of file) by nominating a **Zbase** value and checking the **Zbase** checkbox. Note that while this filter can remove large areas of XYZ data, any STL file created may introduce edge artefacts if the outer edge of the resulting XY region is not wholly convex.

4. Click the **Process** button to create the XYZ file.
5. Select this file as the **Input file** in at the top of the dialog, then the **Load** button. The properties of the XYZ file are then displayed.
6. From the **Run** button, create the STL file. It might be best not to import this model directly into CamBam in case it is too large. The STL file can be huge (several 100,000s of faces).

   Where the resulting STL file is too large to be imported and used into CamBam directly, it is best to simplify it using a mesh editor, like *MeshLab* (*meshlab.sourceforge.net*) which is a free mesh viewer/editor that can be used to view, edit (repair, remove artefacts, etc.) and simplify (decimate) complex meshes.

7. With a manageable mesh, import this into CamBam from where it can be further manipulated (transformed, etc.) to build your model, and then generate a suitable MOP.

Interaction with CamBam

If any unsaved surface model currently exists in CamBam when the plugin is launched, a warning is given to save this before proceeding.

Revision History

Version	**Notes**
1.0.3 and prior	First attempts
1.0.4	1. Fixed problems with decimal formats in STL file 2. Validation check added 3. Label layout corrected
1.0.5	1. Data Review dialog reformatted 2. Bugs on updating changes to transformations fixed. 3. It is now possible to Cancel the validation step. 4. New options provided to continue if a validation step detects data errors. 5. Error dump file now forces “en” culture for decimals. 6. Digitized data files can now contain axis labels (X,Y,Z,A,B,C) to prefix each coordinate value (e.g. “Xnnnn.nn”). 7. The capability to accept data with up to 6 dimensions has been added. Any, but only, three of these dimensions can be chosen for modelling. 8. MOPs create from multi-axis digitized data can be transformed back to multi-axis MOPs ready for cutting.
1.0.6	1. A number of translation errors in the user interface corrected. 2. The post processor can now re-scale the model if required.

1.0.7	1. Fixed a number of non-translatable fields/labels
1.0.8	1. Bug with translatable inside a sub-panel fixed.
1.0.9	1. Update to STL file format after advice from Armando (CamBam Forums)
1.0.10	1. Number of small bugs fixed. 2. Errors found during loading the digitized data file are reported but do not stop the import. Bad lines of data are just ignored. 3. A new facility to crop the raw data to a rectangular box has been added.
1.0.11	1. A number of non-translatable buttons fixed. 2. Error in message fixed so it does not translate multiple times.
1.1.1	1. An option added to convert a surface model created from the MOP -> surface option as a XYZ data file.