



Fallstudie terrestrisches Laser-Scanning

Land- und Gebäude-Vermessung
mit einem Riegl Laser-Radar-Scanner
und Datenaufbereitung mittels
PolyWorks[®]-Software

Duwe-3d AG

Kompetenz in optischer Digitalisierung und 3d-Messtechnik
Exklusiv-Vertriebspartner von InnovMetric für PolyWorks[®]

Hundweilerstraße 15

D - 88131 Lindau (B)

☎ 08382-275 90-0

✉ info@duwe-3d.de

📄 08382-275 90-29

🌐 www.duwe-3d.de

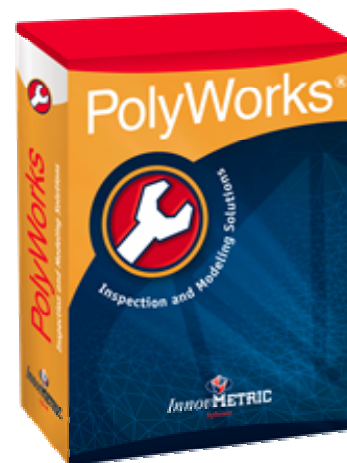
Fallstudie terrestrisches Laser-Scanning:

Am Beispiel eines Laser-Radar-Scanners der Firma Riegl werden die wichtigsten Schritte zur Verarbeitung von Scan-Daten in PolyWorks erläutert.

In der Version 8.0 von PolyWorks sind viele neue Funktionen zur Landvermessung und Gebäudevermessung hinzugekommen.

Scan-Daten lassen sich mit dem Best-Fit-Verfahren aufeinander ausrichten und als ein Gesamtdatensatz bearbeiten.

Nahezu alle optischen Scanner werden von PolyWorks direkt unterstützt.



InnovMetric at a glance

Founded in 1994, InnovMetric pioneered the market for point cloud inspection and polygonal manufacturing software solutions. InnovMetric is a privately-owned company which has sustained an 86% average yearly growth. InnovMetric's culture is focused on its users constant feedback and on the ability of InnovMetric's team to transform such feedback into groundbreaking innovations for increased user productivity. Today, PolyWorks licenses are at work daily in more than 30 countries, benefiting users with the most complete, accurate, and robust 3D point cloud processing software solution on the market.



© 2003 InnovMetric Software Inc. All rights reserved. PolyWorks® is a registered trademark of InnovMetric Inc. InnovMetric, PolyWorks®/Modeler, PolyWorks®/Inspector, IMAlign, IMMerge, IMEdit, IMCompress, IMInspect, IMTexture and IMView are trademarks of InnovMetric Software Inc. All other trademarks are property of their respective owners.

Long Range Data Processing Overview

Data Acquisition



As explained in the previous sections, use a digitizer to acquire data point clouds from the field and then export them into a PolyWorks-supported file format.

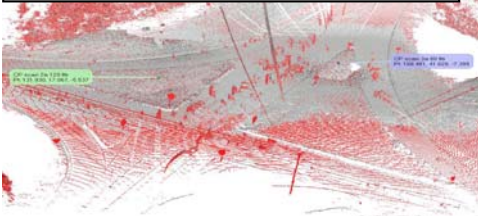
To speed up the next alignment step, get the relative position X, Y, Z of the scanner in a global or local coordinate system.

Alignment of multiple scans



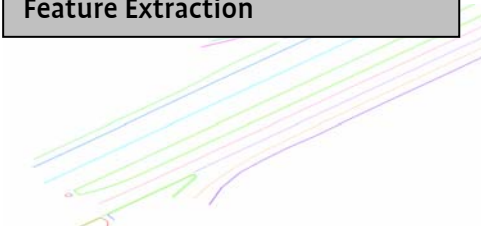
Use **IMAlign** to bring the scans into one coordinate system. No targets are required either – IMAlign's technology uses the object's shapes in the scene to accurately and precisely align the scans. If the scanner position is known, use it as a fixed rotation centers.

Geo-referencing



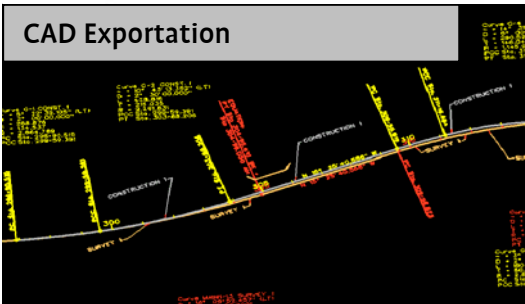
Use **IMInspect** to geo-reference the aligned scans to a large-number coordinate system, such as the ones produced by GPS devices.

Feature Extraction



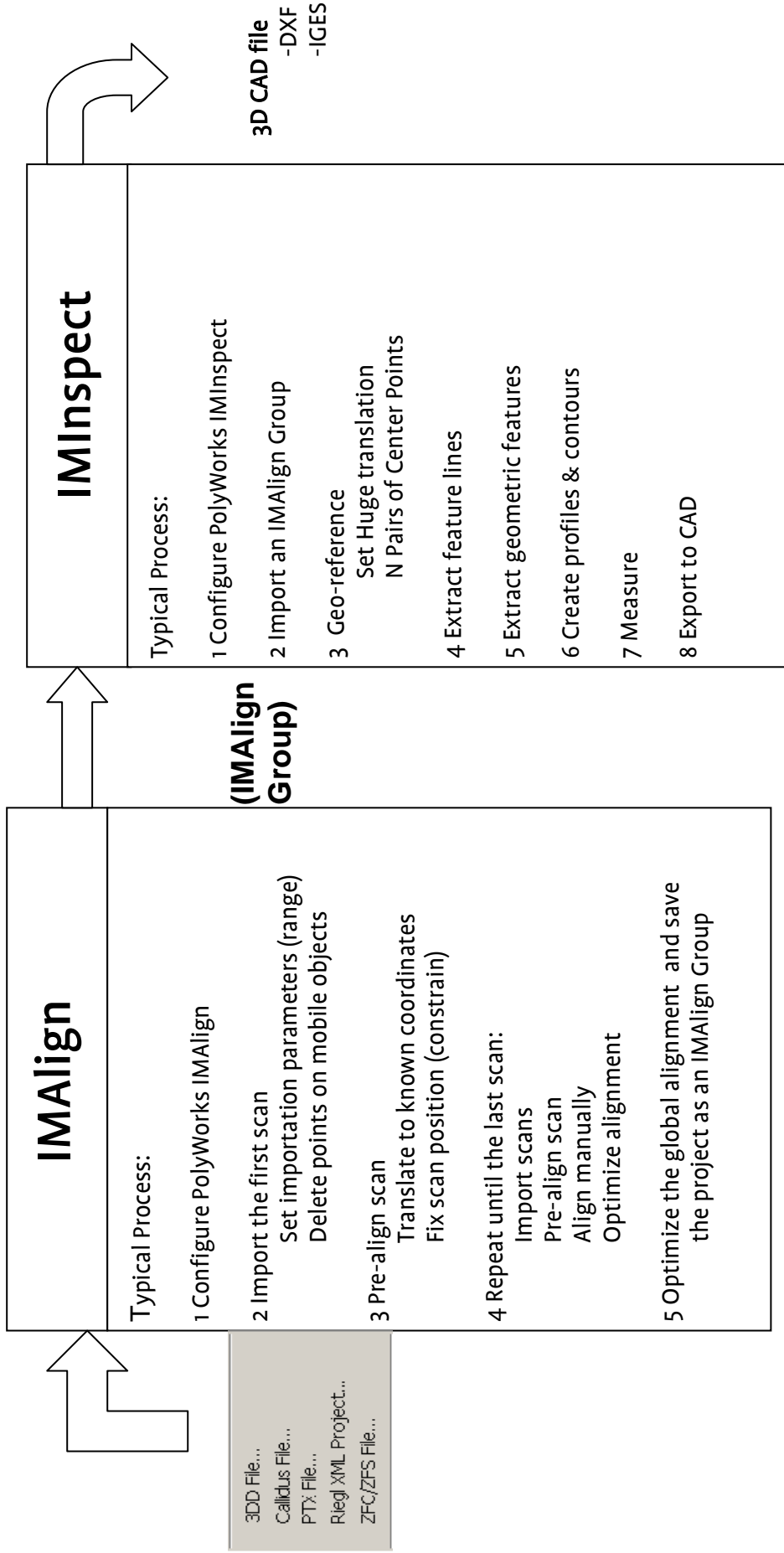
Use IMInspect tools to extract lines and geometric features, create profiles and contours, and take measurements.

CAD Exportation



From IMInspect, export the desired information to the IGES or the DXF file formats. Use the feature code and the DXF layer name.

PolyWorks Long Range Data Processing Overview



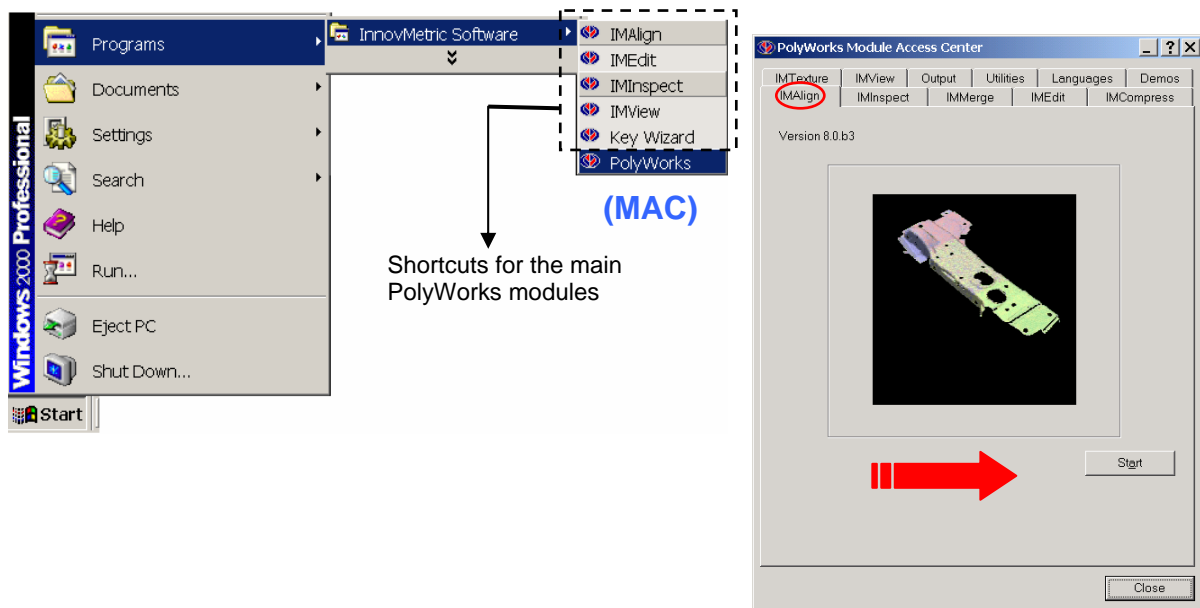
CLIENT APPLICATIONS

- Visualization
- 2D & 3D Drawings
- 2D & 3D Measurements
- Structure Monitoring
- Geo-referencing
- Mining
- Civil Engineering
- Architecture

PolyWorks Basics

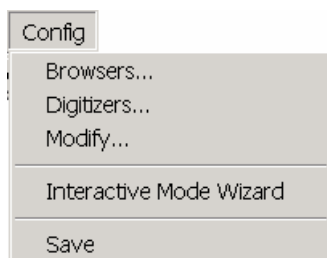
1 – Starting PolyWorks modules

1. Start the PolyWorks **Module Access Center (MAC)**.
2. Start your module by clicking its tab, giving parameters if necessary, and clicking Start.



2 – Interface Basics

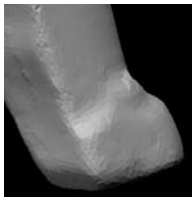
The IMAlign, IEdit, and IMView interfaces work much the same way - saving you time. Here are some common features important for new users. Each interface is detailed in the appropriate learning section.



- 1 Config > Interactive Mode Wizard**
Set the Wizard for a complete description of most operations.
- 2 Undo > Undo (*Description of action*)**
Undo the described action. **ARedo** function is also offered.
- 3 Help > Help Topics**
An informative database.
- 4 Help > Module Reference Guide**
A complete PDF reference guide with dynamic links (Acrobat 3.0 or later).

3 – Visualization in IMAAlign, IMEdit, and IMView

These modules offer various display modes to let you best visualize your objects.



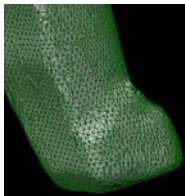
Flat

Displays the 3D surface as a flat-shaded surface made of triangles.



Smooth

Displays the 3D surface as a smooth-shaded surface.



Flat + Wireframe

Displays the 3D surface as a combination of flat shading and wireframe. Offered in IMEdit/IMView.



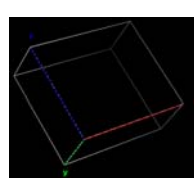
Wireframe

Displays the 3D surface as a mesh-like wireframe display.



Point

Displays the 3D surface as a 3D point cloud.



Bounding Box

Only the bounding box frame of the 3D surface is visible.

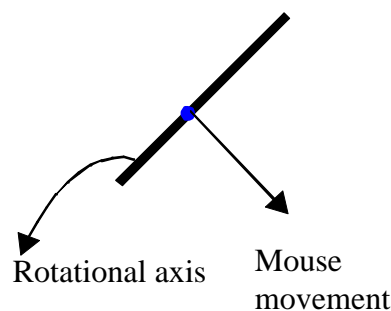
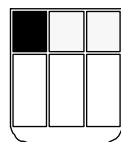
4 – Positioning scans/polygonal models

Use the mouse to position scans in IMAAlign, or polygonal models in IMEdit and IMView, in the 3D scene along the x , y , or z viewing axes. Each of the modes uses its own cursor for user feedback.

ROTATE X&Y

Left-click and drag.

Rotates around the x and y viewing axes.

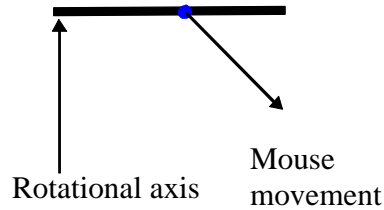
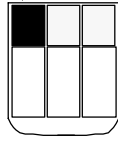


ROTATE X OR Y

Press and hold the SHIFT key, and then left-click and drag.

Rotates around only the horizontal or the vertical viewing axis, depending on the initial 10-pixel direction of the mouse movement.

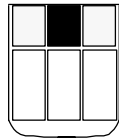
SHIFT +



TRANSLATE

Middle-click and drag.

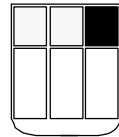
Translates along the x and y axes.



ZOOM

Right-click and drag.

Translates along the z axis. Forward movement increases object size, while backward movement decreases object size.

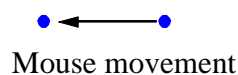
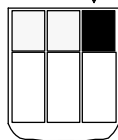


ROTATE Z

Press and hold the SHIFT key, and then right-click and drag.

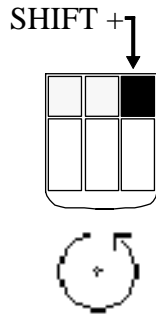
Rotates about the z axis.

SHIFT +



ROTATE Z (90° increments)

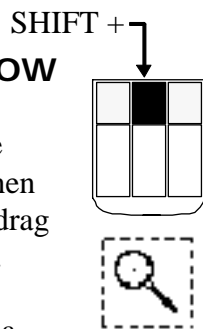
Press and hold the SHIFT key, and then right-click once quickly for a 90° rotation.



Rotates counter clockwise about the z axis by 90°.

ZOOM WINDOW

Press and hold the SHIFT key, and then middle-click and drag to open a window.



Zooms selected features.

MOUSE MAP

For positioning objects in the 3D scene.

Note that if your mouse has a wheel as the middle mouse button, rolling it will perform the zoom function.

	Left	Middle	Right
NONE	<i>Rotation</i>	<i>Translation</i>	<i>Zoom</i>
SHIFT	<i>Horizontal or Vertical Rotation</i>	<i>Zoom Window</i>	<i>Screen Plane Rotation</i>

Hold down the CTRL key during consecutive rotations/ translations to avoid screen redrawing after each action.

Step-by-step

A. Alignment

1. Overview

IMAlign is an invaluable tool for bringing all of your scans in the same coordinate system, based on the object's shapes in the scene.

For IMAlign to work correctly, scans must meet two criteria. First, each scan must share some redundant information with adjacent scans (overlap). And secondly, each scan overlap should contain shape variations in the scene that constrain all of the degrees of freedom, since IMAlign does a shape-based alignment. For example, two scans of a flat surface, even with overlap, may not align properly due to the lack of shape variations.

Depending on the equipment and the information collected in the field, we can align following three typical scenarios:

1ST SCENARIO: Alignment based on the object's shapes in the scene (standard alignment). In this case, we only need sufficient overlap and constraining shape variations in the overlapping regions to align the scans.



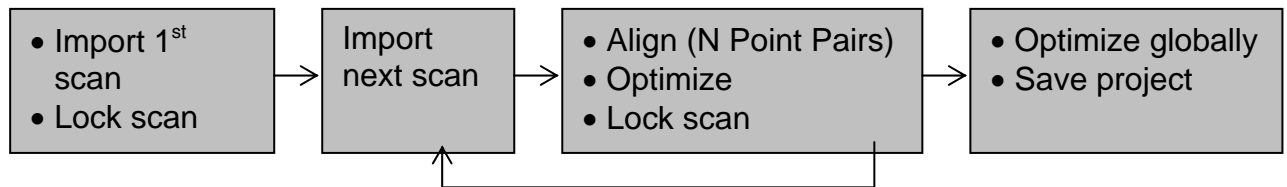
2ND SCENARIO: The relative scanner position coordinates are known (constrained alignment). All but the rotational degrees of freedom are constrained for all the scans. Note that the alignment software doesn't support large numbers, such as those produced by GPS devices.

3RD SCENARIO: The relative scanner position coordinates are known and the orientation of the first scan is known (constrained alignment). This scenario is similar to the second one except that the first scan is exact in position and orientation. The rotational degrees of freedom are free of constraint only for the subsequent scans.

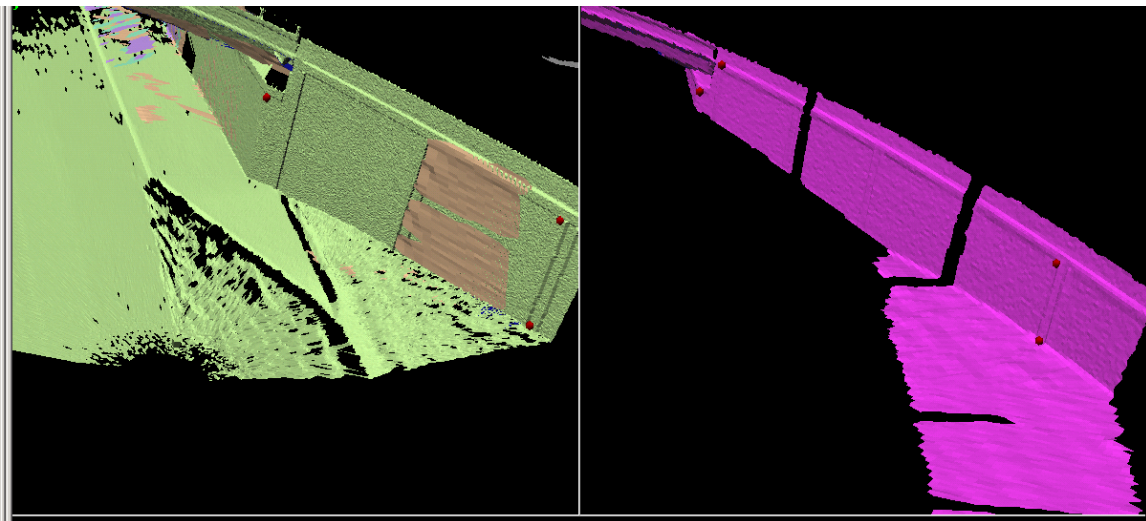
2. Alignment Processes

In the following pages, we present diagrams of the alignment process of the three typical scenarios. You will notice few differences but they are very important for the extraction of all the potential of your data. The output at the end of each scenario process is the same - it's a project file called an IMAAlign group.

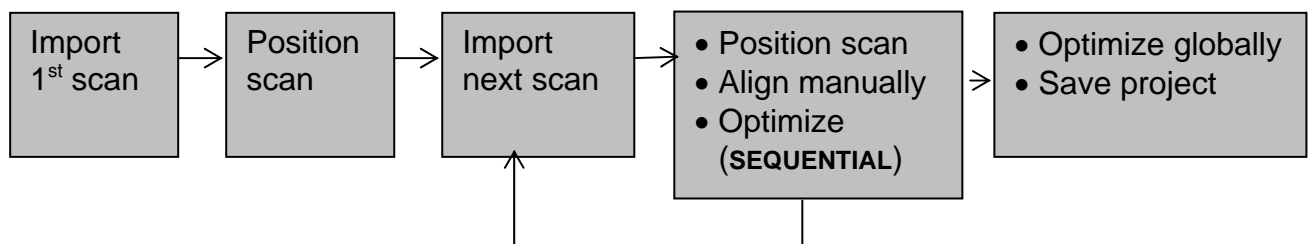
1ST SCENARIO: Alignment based on the object's natural shapes in the scans (standard alignment).



The privileged alignment technique here for the initial alignment is the selection of corresponding pairs of points. PolyWorks IMAAlign has an interface to display side by side the scans to enable an easy picking of corresponding points (G). The initial alignment will then be improved by an iterative best-fit alignment. The best-fit alignment is the step that is labeled Optimize in the diagram.

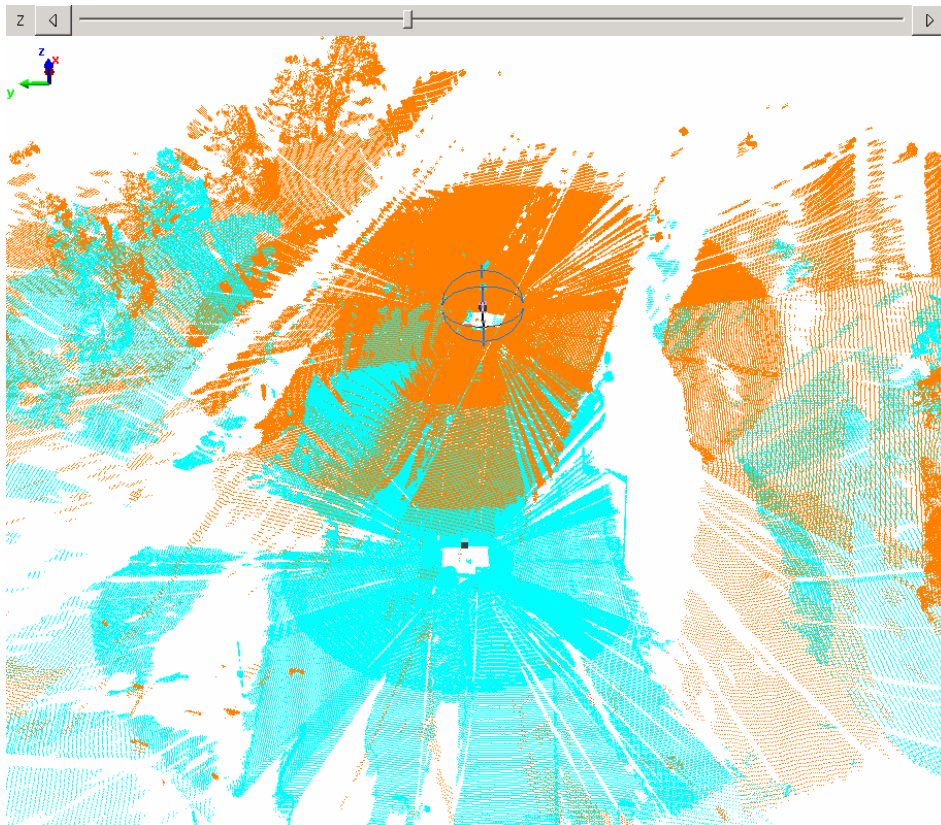


2ND SCENARIO: The relative scanner position coordinates are known (constrained alignment).

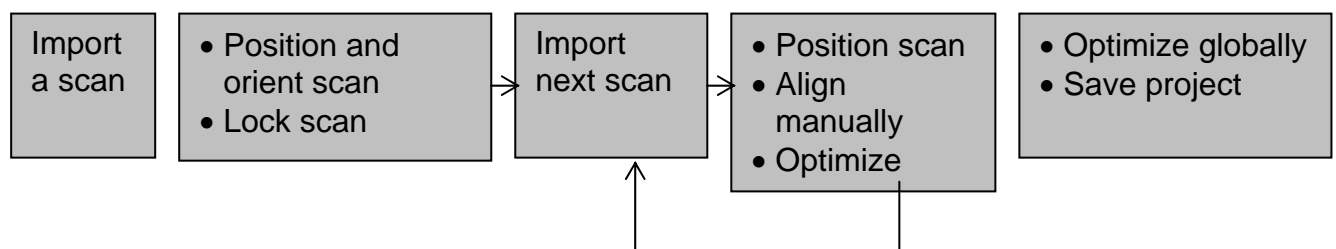


This scenario presents an additional step – positioning the scans using their relative scanner coordinates (also referred to as rotation centers). Then the alignment technique uses fixed rotation centers that only allows you to rotate the scans to provide a rough alignment. The recommended alignment technique is interactive 3D rotation using sliders. This step lets you quickly position the scans one relative to the other.

The use of the best-fit (Optimize) alignment method is also different since none of the scans have an exact orientation. And therefore each scan must be able to rotate to achieve an exact orientation. As a result, no one of them can be permanently locked and have its orientation not change. In this case, we propose a Sequential Subgroup Lock toggle that locks sequentially one scan at a time and runs 1 best-fit iteration at a time.



3RD SCENARIO: The relative scanner position coordinates are known and the orientation of a scan is known (constrained alignment).

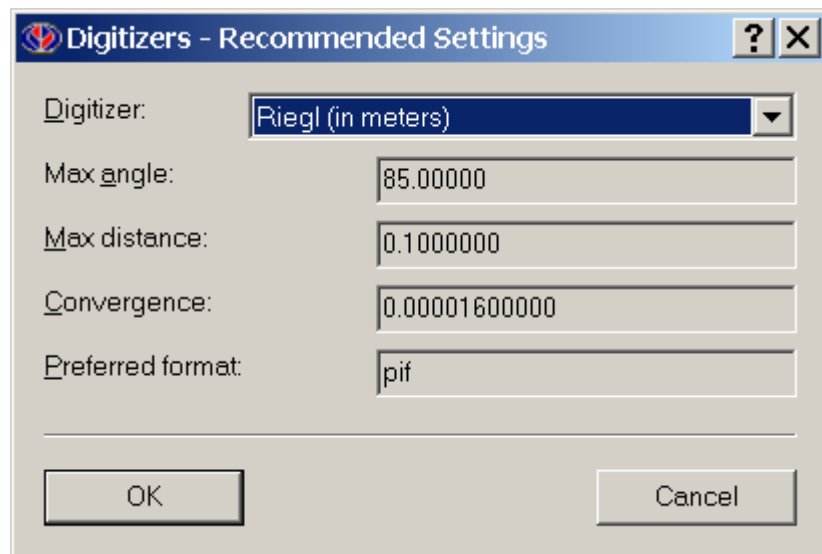


The particularity of this scenario is that a scan must have a correct orientation. The correct orientation is achieved using a minimum of three targets in the scene of the scan, and processing in the 3D RiScan or IMInspect software.

1 Configure PolyWorks IMAAlign

- Open the PolyWorks Module Access Center and start the IMAAlign software
- Choose your digitizer from the proposed list. IMAAlign will automatically assign values to certain parameters.

Config > Digitizer

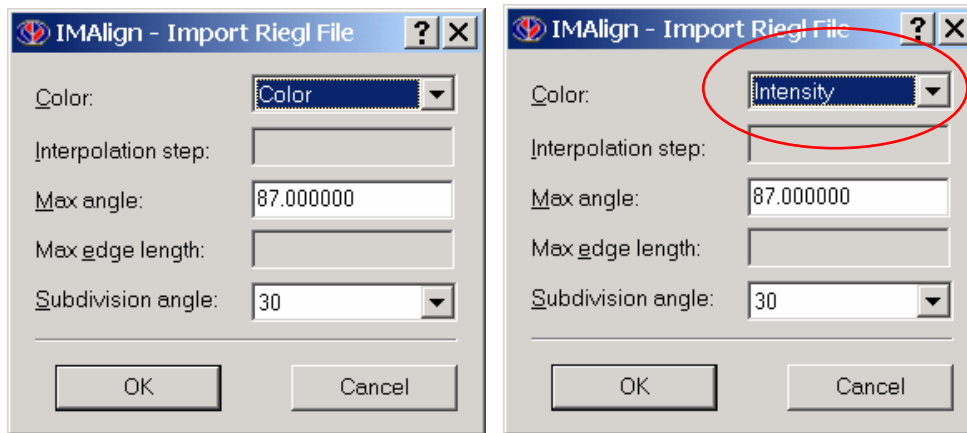


These settings must be adjusted in accordance with the digitizer units

- Save the configuration to set it as the default
Config > Save
- Create a project directory for future imported files
File > Save Group As

2 Import a scan into PolyWorks

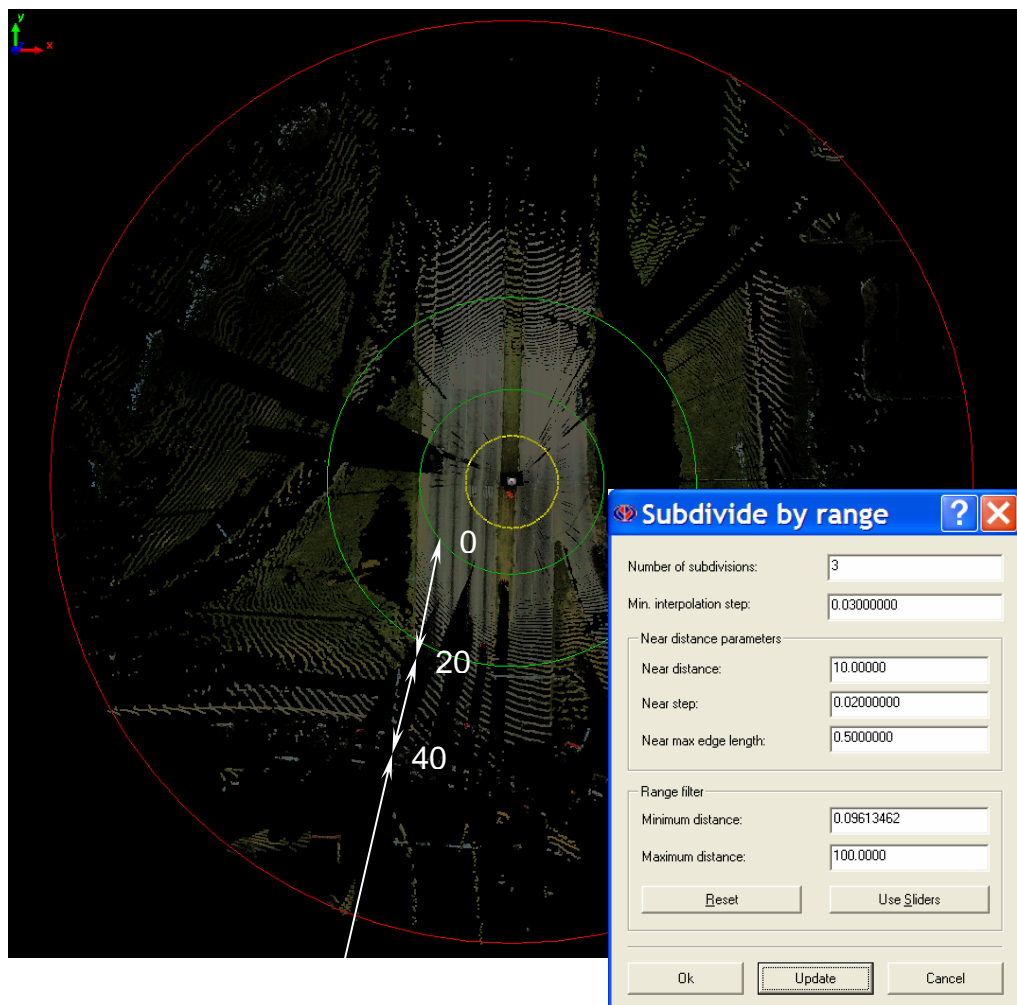
- *File > Import Group > Create Subgroup*
- *File > Import Group > 3DD Files ...*
- Set the importation parameters



Tech Tip

A Maximum angle of 87 degrees is recommended for flat surfaces such as road scans.

- Subdivide by range to assign to each subdivision a progressive step. It's the key to using less RAM and importing many scans.
The recommended near step is approximately $3 \times \text{Standard Deviation (sigma)}$.



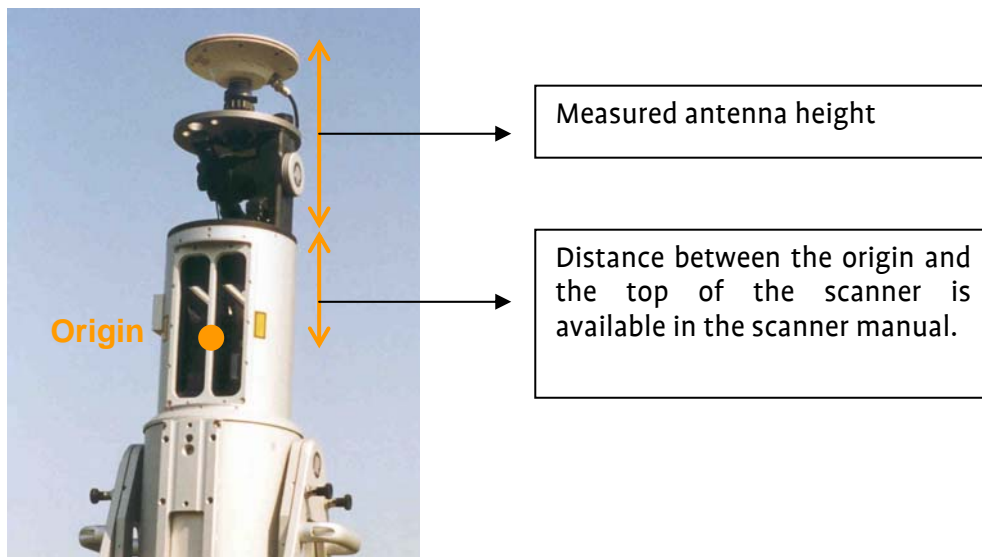
To remove mobile objects like automobiles, we need two scans of the same scene. Why remove the data points captured on mobile objects? Since IMAlign does a shape-based alignment, IMAlign considers those points as objects used to align the scans' position and orientation.

- Delete data points of mobile objects (ex: cars, pedestrians,...) in the scene to improve the quality of the alignment between scans.
In the Tree View, select the first scan to be cleaned, and then Edit > Delete Non-Overlapping Points...
- Delete the second scan that was used for deleting the data points of the mobile objects
In the Tree View, select the second scan, and then Edit > Object Tree > Delete

3 Position the Scan (2nd scenario)

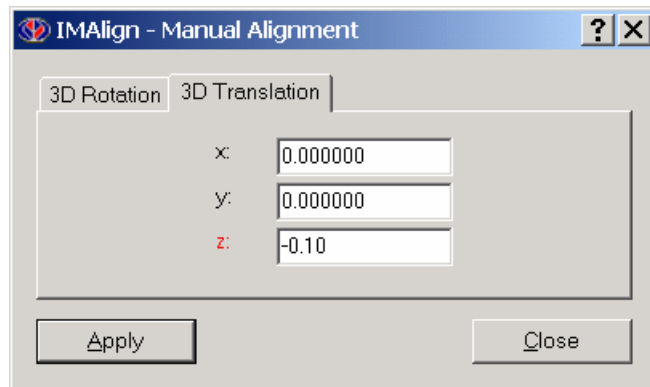
Tech Tip

Position your scan using the relative scanner coordinates. Furthermore, it can also be oriented if, during your scan campaign, you always start your digitizer from the same monument located as far as possible from the scanner and visible from every scanner location. It's as valid as if you start your digitizer using the same direction on a compass (ex: All scans start from the North direction).



- Translate negatively your scan along the **Z axis** by the distance between the origin and the top of the scanner plus the measured antenna height.

In the Tree View, select the images related to the scan, and then
Align > Manual Alignment > 3D Translation

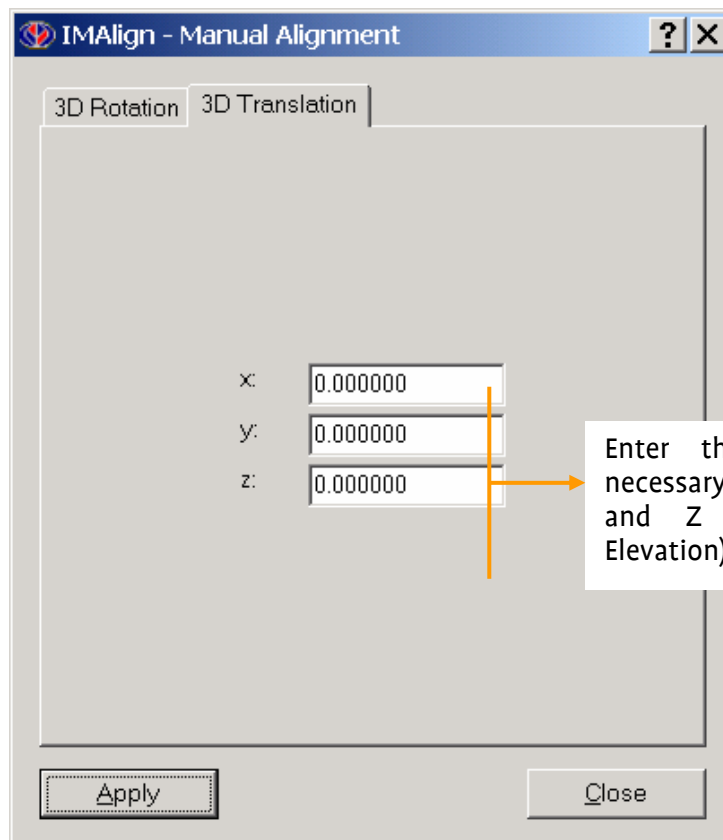


- Translate the scan to its known ground coordinate position. The scanner origin is at 0,0,0 by default. From the field work, the relative scanner position can be obtained from many measurement devices, such as GPS, theodolites, etc. When you translate the scan to the scanner position ground coordinates, you position this scan relative to the others.



IMAlign does not support large numbers. The ground coordinates, such as GPS values, must be truncated. The coordinates must be in the units of the scanner coordinates system.

In the Tree View, select the images related to the scan, and then Align > Manual Alignment > 3D Translation

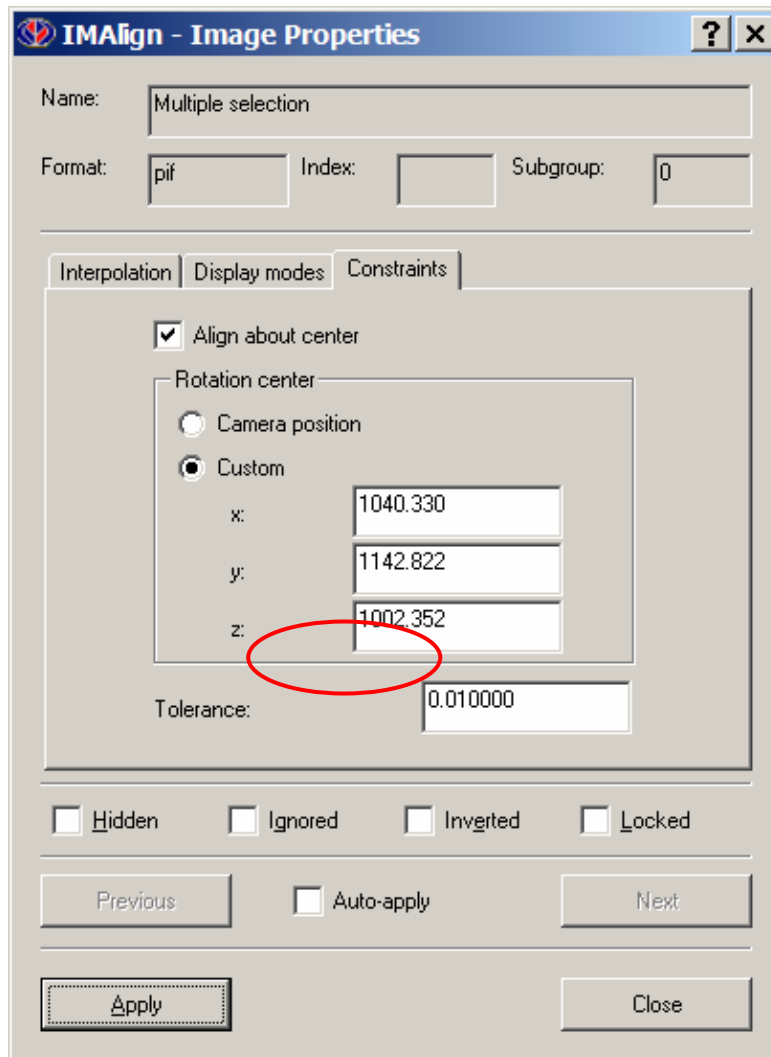


- Constrain the alignment about the customized rotation center within a specified tolerance (potential instrument error) to fix the position of the scanner (now X, Y, and “Z-1st translation” ground coordinates) in the best-fit alignment process.

You must re-enter the Z value in the Custom field without the 1st translation subtraction.

In the Tree View, select the images related to the scan, and then

Right-click and select Properties > Constraints



- Do not lock the imported scan



In the 2nd scenario, you must not lock any scans (or subgroups), the Sequential Subgroup Lock will take care of that operation

4 Position and Orient Scan (3rd scenario)

The alignment of a scan in the 3rd scenario is based on a known scanner orientation. The orientation can be achieved through the application of a transformation matrix, generated by IMInspect. The transformation matrix is the result of using IMInspect's N Pairs of Center Points alignment method, where the center points are provided by a minimum of three targets (or physical details) visible in the scan and their known ground coordinates.

- In IMAlign, position and orient the first scan using the transformation matrix saved in IMInspect.

*In the Tree View, select the images related to the scan, and then
Edit > Image Tree > Apply Matrix*

- Lock the aligned scan

*In the Tree View, select the images related to the scan, and then
Edit > Image Tree > Lock*

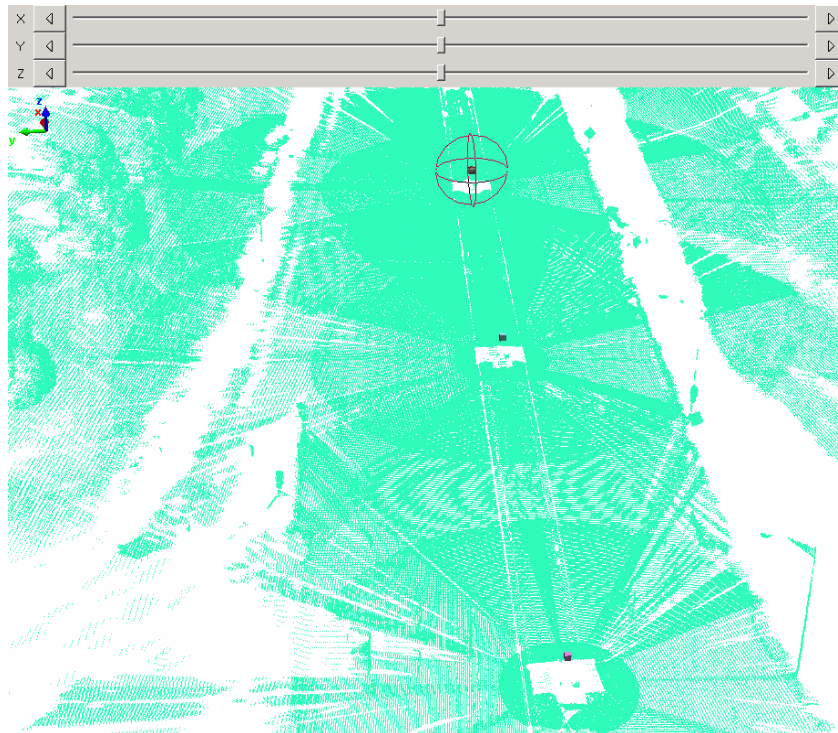
1 Repeat until the last scan

- Import the next scan. Refer to step 2.
- Position the scan. Refer to the previous step 3 (2nd scenario).
- Align graphically the imported scan.

Tech Tip

For a smooth display while you align graphically in the Global mode, set the Static Mode display to Point and 1/64.

*Select in the Tree View the last imported scan, and then
Align > Manual Alignment > 3D Rotation > Use Sliders*



- In the 2nd scenario, optimize the alignment using the Sequential Subgroup lock that lock one scan at a time and run one best-fit alignment iteration.

- In the 3rd scenario, optimize the alignment using the best-fit method. Make sure the Allow constraints is checked

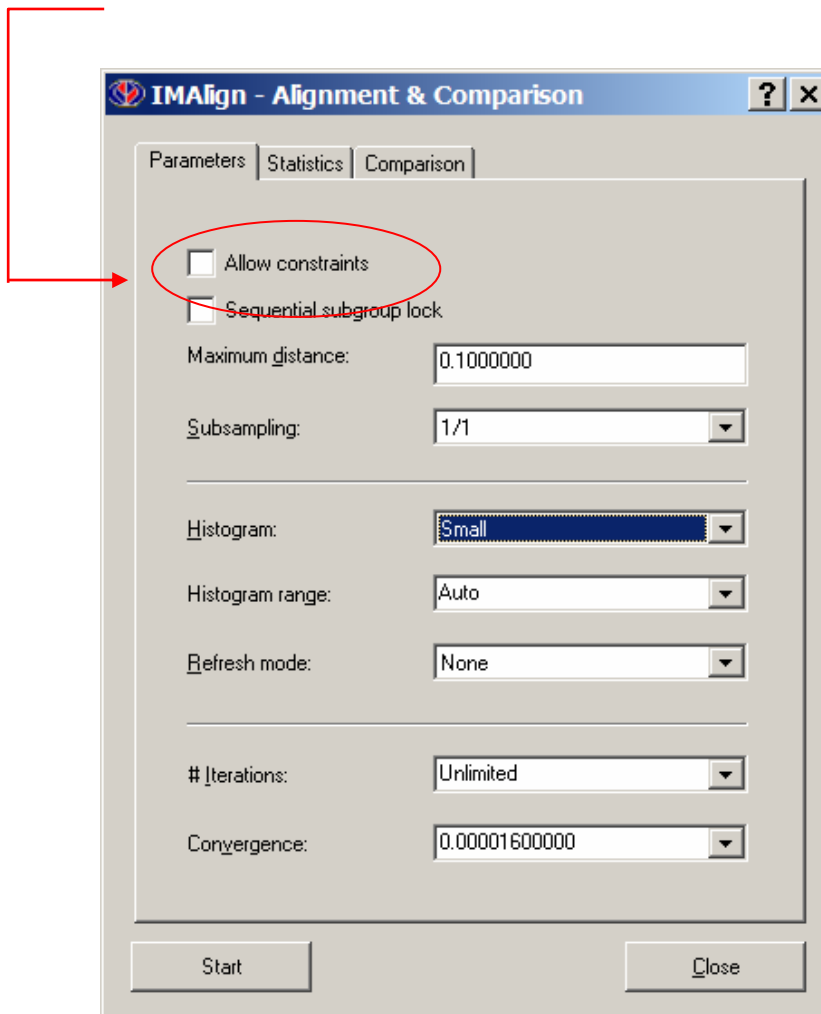
2 Optimize globally the alignment using the best-fit alignment method.



Don't forget to use the Sequential Subgroup lock to do so for the 2nd scenario alignment.

Select in the Tree View all the scans except the first one, and then
Edit > Image Tree > Release
Align > Image Alignment & Comparison

For the 2nd and the 3rd alignment scenarios, Allow constraints must be checked.



- Save the alignment project to an IMAlign Group directory
File > Save Group
- Exit IMAlign

Step-by-step

B. Information extraction

1. Overview of objective and relevant tools

In PolyWorks IMInspect, we have developed unique tools to facilitate the extraction of features directly on the data point cloud, and for exporting these features as CAD drawings.

There are many different tools dedicated to long range applications. Just to give you a sample list:

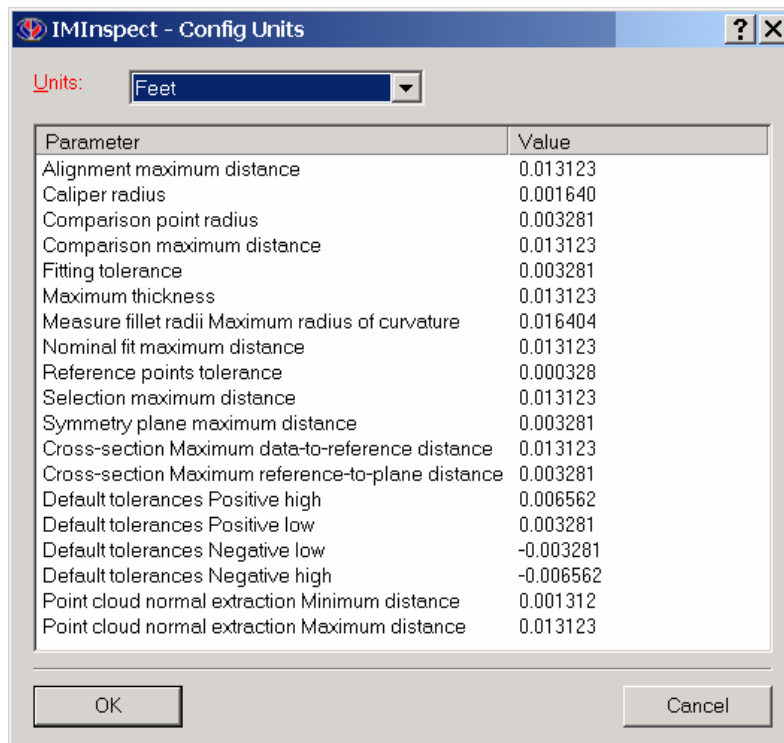
- Unique geo-referencing approach for accurate measurements
- Automatic edge extraction tool
- Extraction of polylines based on color or intensity criteria
- Profile & contour creation from the point cloud
- Polyline feature code and assign a DXF layer name
- Interactive measurements (bearing, azimuth, horizontal distance, ...)

2. Measurement process

1 Configure PolyWorks IMInspect

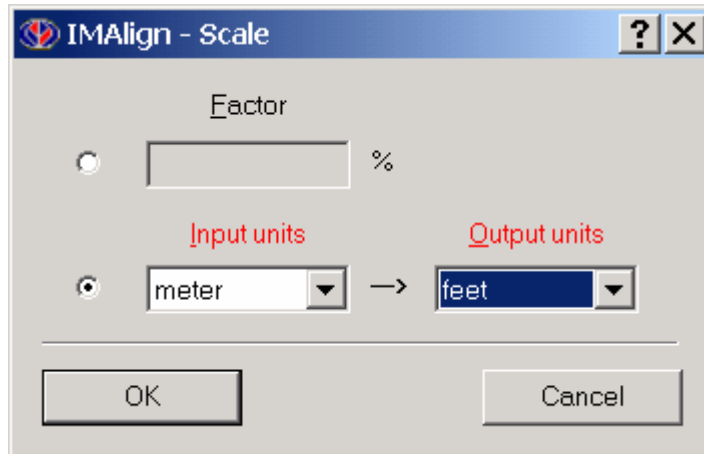
- Open the PolyWorks Module Access Center and start the IMInspect software
- Set the units. In turn, IMInspect will convert a list of default parameters to those units

Config > Units



- Scale your project to establish the correspondence with your ground coordinate system units

Edit > Scale



- Save the configuration to set it as the default

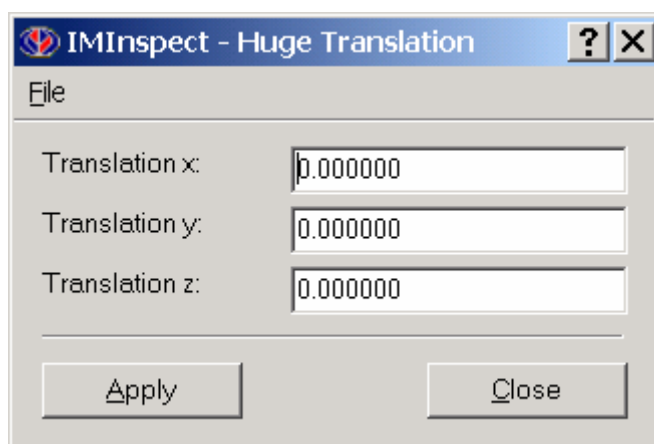
Config>Save

2 Import the IMAlign Group project as Data

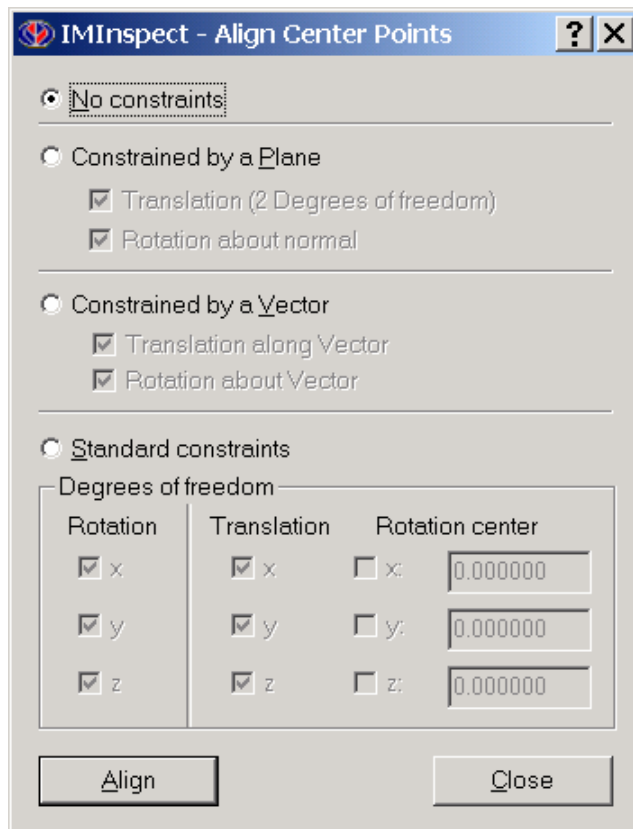
File > Import Data > IMAlign Group

- 3 To prepare the geo-reference, you need to translate your scan to large numbers, such as the coordinate values of a GPS point.

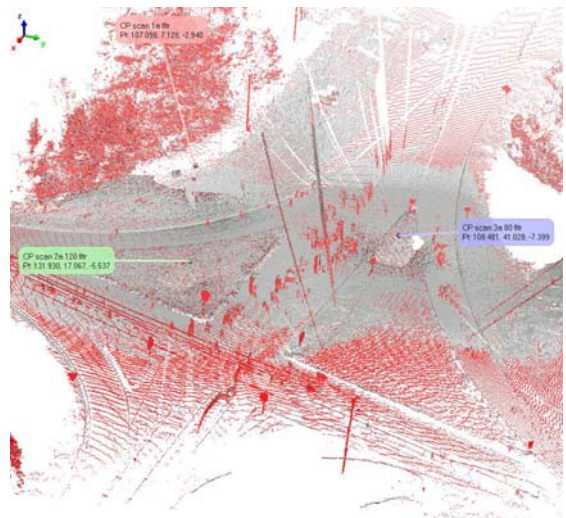
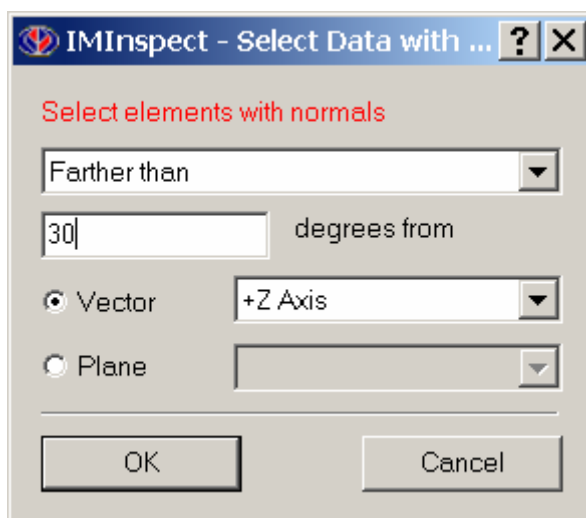
Align > Set huge translation



If you have identifiable targets in your scans, the matching of scene targets with their known ground position is done using:

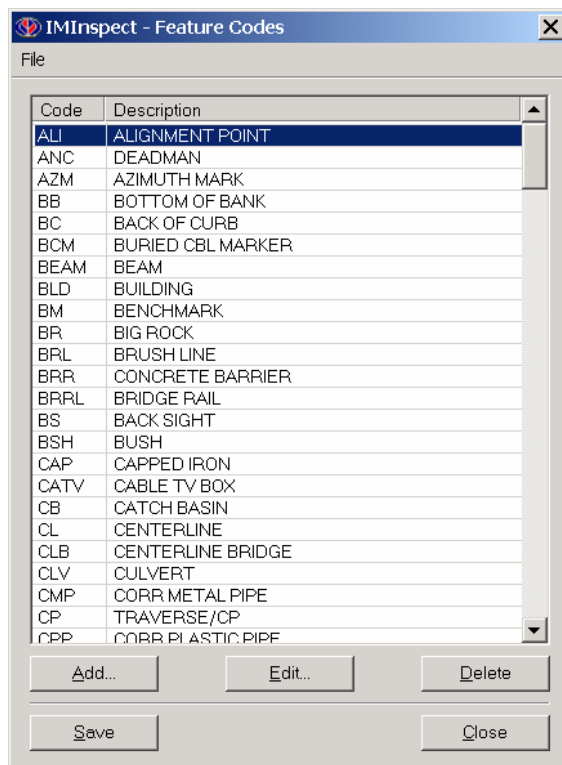
Align > N Pairs of Center Points**4 Extract feature lines**

- To extract clean features lines, some objects may have to be removed from a scene. Here is a quick method for eliminating vertical objects in a scene, such as poles, cars, trees...

*Ignore points without normal**Select > Select data with normal vectors*

- To import a feature code file

Report > Feature Code > Manage List



- Here is a sample list of the available tools that can be used to manually or automatically extract feature lines:
 - Primitive > Polyline > Properties (feature code, DXF layer name)*
 - Primitive > Polyline > Anchor*
 - Primitive > Polyline > Extract Edge*
 - Primitive > Polyline > Extract from Colors*
 - Primitive > Polyline > Extract Step Edge*
 - Primitive > Polyline > Offset*
 - Primitive > Polyline > Magnetize Endpoints*
 - Primitive > Polyline > Project onto Plane*
- Assign a feature code to a selection of primitives
 - Report > Feature Code > Assign Code to Primitives...*

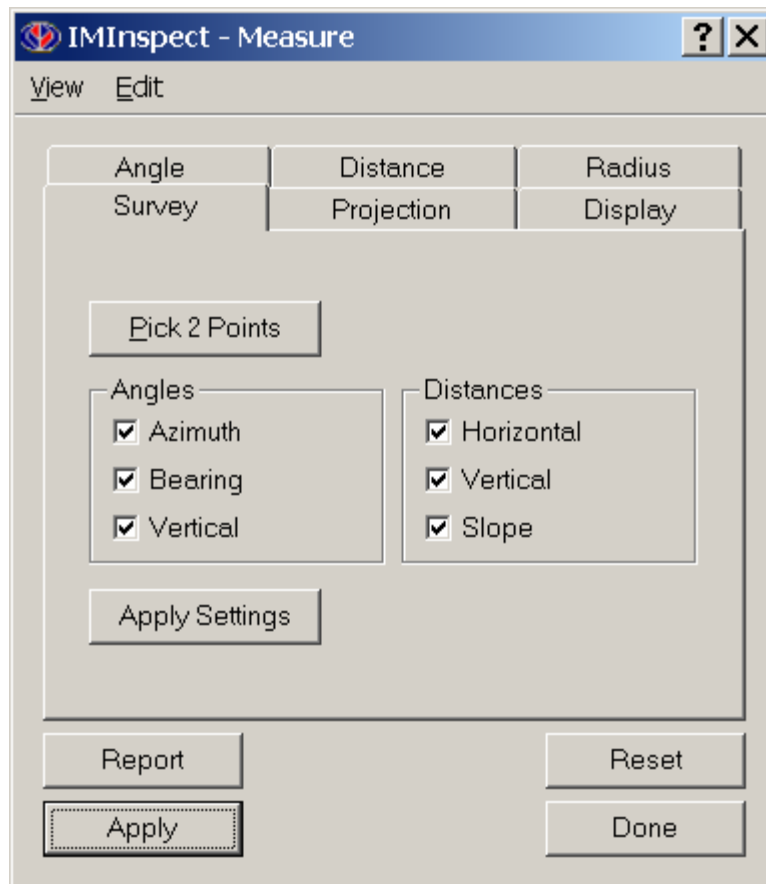
5 Extract geometric features (ex: trees, signs, pole locations...)

6 Extract profiles and contours

- Create profiles along an existing polyline
 - Compare > Cross-Sections > Create along Curve...*
- Generate contours
 - Edit > Triangulate... (breaklines)*
 - Compare > Cross-Sections > Create Parallel...*
- Edit cross-sections
 - Primitive > Polyline > From Cross-Sections*

7 Measure

- *Measure > Angle, Distance, Radius...*



- *Measure > Surface-to-Plane Volume...*

8 Export

- *File > Export Object > Primitives & Cross-Sections to DXF...*
- Save the IMInspect project
File > Save Project As...
- Exit IMInspect
File > Exit