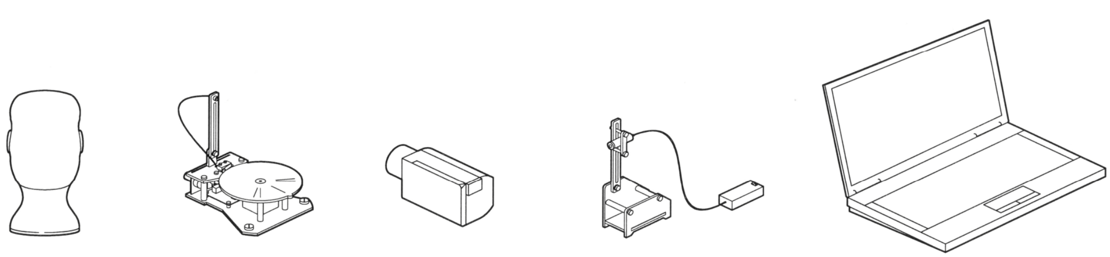
TriAngles
3D SCANNER

3D Circumference Scanner Version 2.0



Disclaimer

This software and publication pertains to the workings, manufacturing, assembly and operation of a machine apparatus and the use of a laser. This can be a dangerous undertaking. The use of this software and any information provided is therefore at the users own risk.

In no event shall the author and owner intricad, suppliers nor any related parties that contributed to the creation, marketing and sale of this publication be liable to any party for any direct, indirect, special, punitive or consequential damages (including but not limited to, damages to property, business, person(s), or other pecuniary or loss or claims suits or causes of action involving alleged infringement of copyrights, patents, trademarks, trade secrets, or unfair competition), arising out of the availability, use, reliance on, or inability to use the information contained in this publication.

In addition this applies to any accompanying or further information provided by any means, or any other damage that may result in any way whatsoever, even if this organization or owner shall have been advised of the possibility of such damages, and regardless of the form of action, whether in contract, tort, or otherwise, or for any claim attributed to errors, omissions, or any other inaccuracies in, or destructive properties of any information and/or software/hardware material. The author and owner of this software is under no obligation to provide support, service, corrections, or upgrades to the software programs. This software is supplied “as is” and no warranty of any kind is attributed to it.

It is the responsibility of the reader of this publication and/or user of the included software to determine the integrity and required safety precautions regarding the fabrication techniques, electrical circuits, mechanical construction and software which are described, explained and provided in this Publication and/or software. This project is only for adults with basic understanding of electronics and home machining skills. It is certainly not for children and should be kept out of their reach. If the reader lacks the required skill and/or knowledge to produce and/or operate the apparatus described then he/she should not proceed with this project or should seek professional engineering assistance.

The information and software supplied is for educational purposes and not intended for commercial use. Extensive effort has been undertaken to insure that the information contained in this manual and the supplied software does not breach any currently protected art nor intellectual property. To the best of our knowledge it does not as it is based on technology/art that is now become public domain. However given current practices in industry this cannot be fully ascertained. Use of this software for commercial purposes is at the users own risk.

By proceeding to read or use the information contained in this publication and/or software the user agrees to the above stated.

TriAngles 3D Circumference Scanner, Version 2 intricad
TriAngles; 3D Scanner and 3D Builder intricad

DO NOT LOOK INTO LASER BEAM

3 Worlds

now exist; the real world as we know it, the world of our imagination and the world that we have created within our computers.

While each world offers almost endless possibilities their limitation resides in the ability to efficiently and effectively

***interact**.*

Introduction

Drawing a 3D cube in your favorite graphics program is an easy task by today's standard. But try drawing something more intrinsic like a face or a car or some other complicated shape. Chances are that this will be a difficult task to complete. Fortunately there are other ways to accomplish this. Probably one of the most impressive solutions is to use a 3D scanner.

3D scanning offers the means to take a tangible object and convert it into a 3D computer model through some or other technique. The basic idea would be to have an apparatus detect enough points of an object in 3 dimensions and convert this into information that would allow a computer to display the object as a 3D model. Once it's in the computer you can modify it in almost anyway.

However, unlike 2D scanning, entering the third dimension is somewhat of an art. 3D scanning is not a trivial task to perform as many factors contribute to the integrity of the scanning process. It is important to clearly understand how these factors can influence the scan process and how they should be adjusted accordingly in order to permit the best scanning conditions possible. This product provides the platform to get started. Naturally, your most important tools will be your attention and patience.

3D scanners are a special collection of range mapping technologies that typically rely on an optical process in order to capture the geometry of an object. The technology developed here includes a non-contact, circumference type 3D scanner. Non-contact meaning that the object is not touched during scanning as the scan technique is based on a visual acquisition process. Circumference means that it scans around an object. Apart from the supplied hardware, the basic setup requires things that must of us already have, such as a video camera, tripod and a computer.

The chosen design concept is based on various criteria. One of which is to bypass the economical constraints and electrical/mechanical complexities usually coupled with an apparatus of this type while providing high quality scanning capability. An added feature is that this scanner not only scans objects but also an object's surface color. The result is a 3D-scanner package that can approach the accuracy of high-end range scanners as well as permit scans to be made with texture in less than 2 minutes! Better yet, it does not cost thousands of Dollars. In fact this is probably one of the best cost to performance scanners on the market today.

intricad Amsterdam 2008

Scan Build Export

Table of Contents

Getting started

Maximizing the Scan Process

Getting started

This section provides a quick overview of the basic set up and conditions required to making your first 3D scan. The next section titled “Maximizing the Scan Process” provides a more detailed overview of the process and technology.

3D scanning can be complex as many, seemingly trivial, factors can negatively influence the quality of a scan. While this section provides a quick way to get started it is important to read through the entire manual to get a complete overview. This will save time and lead to better scanning results.

1 Product Overview

The full TriAngles 3D Scanner package includes some sophisticated software programs and hardware.

1.1 The Software

- **3D Circumference Scanner**. Video interface and processing functions to acquire the object and texture scan
- **3D Builder**. Processes raw scan data from the scanner to create the 3D model and allows for export to popular 3D file formats like STL, VRML and OBJ and COLLADA

1.2 The Hardware

- **Turn Table**. Precision rotating platform onto which object is positioned on for scanning a full 360 degrees. Includes micro step driver and motor and USB interface for PC control
- **Laser Support Stand**. Supports the positioning of the adjustable focus laser module which projects a scan line over the object to scanned

1.3 What you Need to supply *

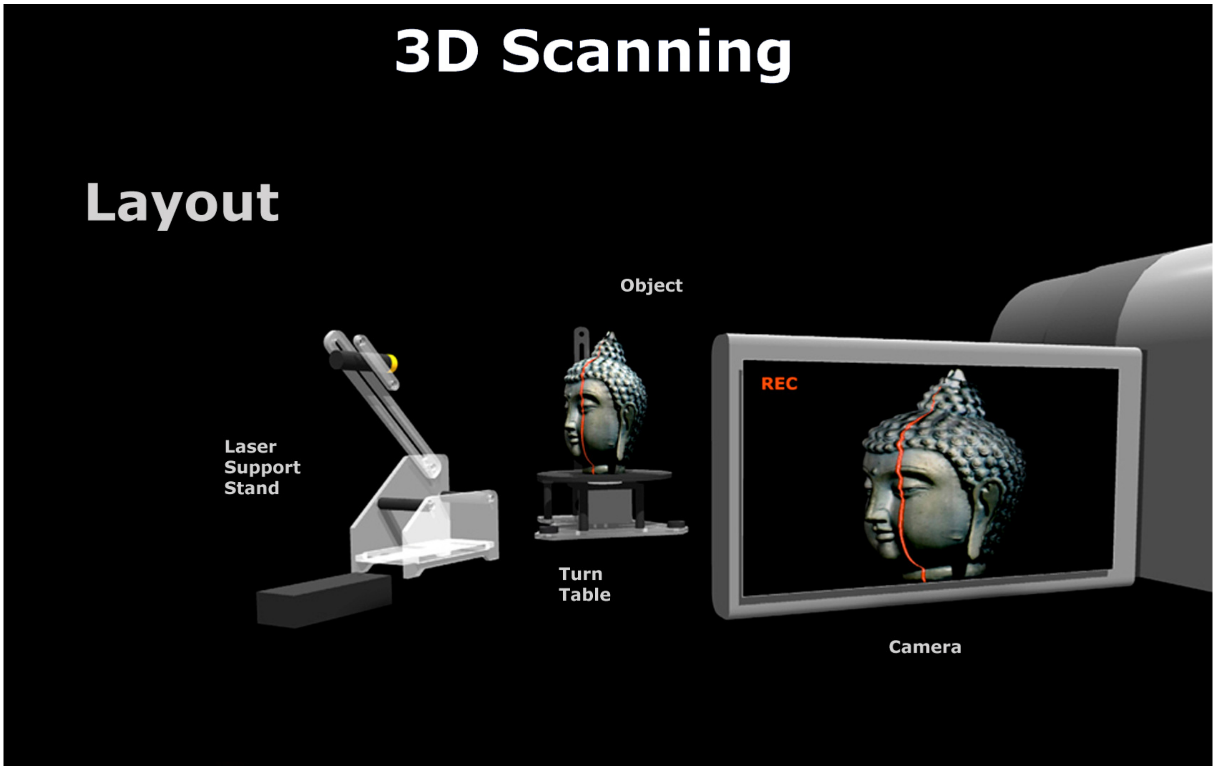
- **Camcorder**. Preferably DV type with FireWire connection, remote and picture stabilization Requires manual iris control and manual focus
- **Tripod**. To support the Camcorder *
- **PC**. High end system with OpenGL supported graphics card and FireWire connection *
- **Halogen Lamp(s)**. For texture scan of object.

*** Please Consult “Absolute Base Requirements” section at the end of this manual for full details**

2. Process Overview

The TriAngles 3D scanner permits several ways to process a scan. For instance, you can choose to make a scan without having to use a PC by recording it to your video camera and then compiling it later on a PC. You can also choose to control the turn table via a USB connection to your PC for complete control of the scanning process. Each method has its own merit and limitations. The reasoning behind including these options is to allow TriAngles to work on a wide range of machines and conditions.

Explanations in these initial sections of the manual will focus on the basic method to capture a scan. Basically, we are going to record the scan on a camcorder and then process this video to eventually reveal the 3D model of the scanned object. This is the easiest way to make a scan. In later sections of this manual we will look into more sophisticated approaches that involve the folding of video, PC control and dual camera scanning.

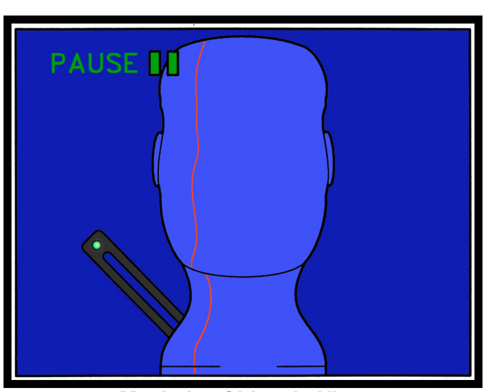


The above illustrates displays the basic layout of the components. One of the main requirements to make a scan of an object is that it is carried out under very low lighting conditions. Room lighting is switched off or set to very low as ambient light will otherwise influence the scanning process. The object to be scanned is positioned onto the Turn Table and a vertical laser line is projected onto the object. The laser line remains stationary while the object turns. The object turns a full 360 on the Turn Table and the camcorder is used to capture this. In case the texture of the object is to be included then a second pass is made but then with lighting and no laser. The captured video is then processed by the 3D Scanner software which produces a raw scan file. This file is then further processed by TriAngles 3D Builder to produce the 3D model ready for export.

2.1 Layout

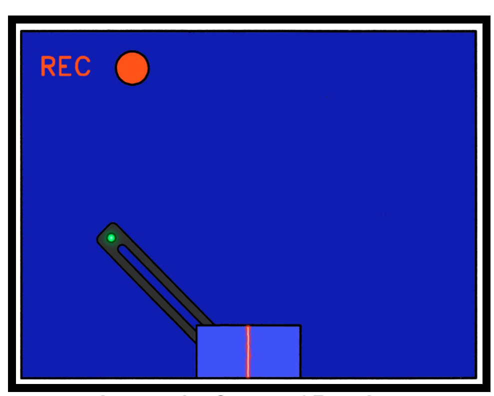
1. The Laser is setup and aligned with the Turn Table. The camcorder is setup at and angle to the laser. An object to be scanned is positioned onto the Turn Table and is centered in the camera's field of view.
2. The object is then carefully removed and a calibration surface (O1) is placed onto the Turn Table. This is done to view the exact center of rotation of the Turn Table. The software will need to know this in order to build the 3D model. This is briefly recorded by the camcorder (10 seconds).

1



Maximize Object in View

2

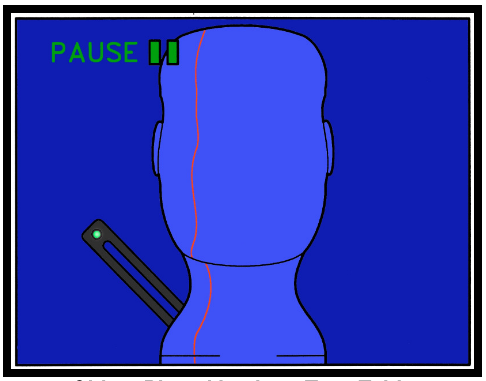


Locate the Center of Rotation

2.2 Object Scan

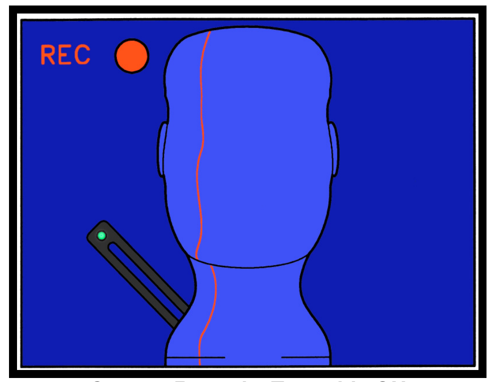
1. The calibrator is then carefully replaced again by the object. The camcorder is set to record.
2. The Turn Table is switched ON to rotate the object
3. During turning, the indicator LED on the Turn Table will automatically switch OFF. This indicates the scan start position. The object continues to rotate.
4. The indicator LED will light up again after the object has made a complete 360 degree turn. This indicates the end of the object scan. Unless a subsequent texture scan is to be made the recording may be stopped.

1



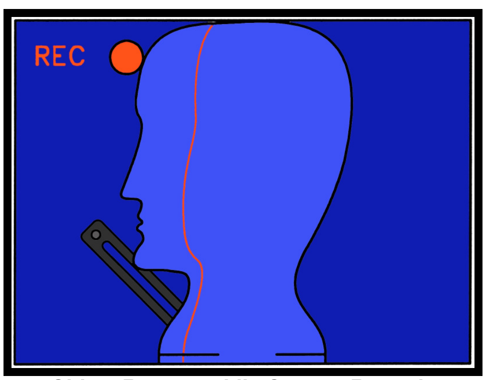
Object Placed back on Turn Table

2



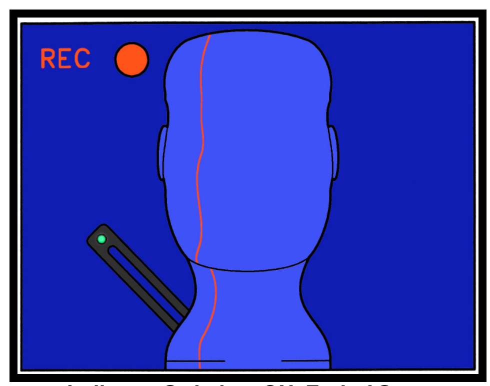
Camera Records, Turntable ON

3



Object Rotates while Camera Records

4

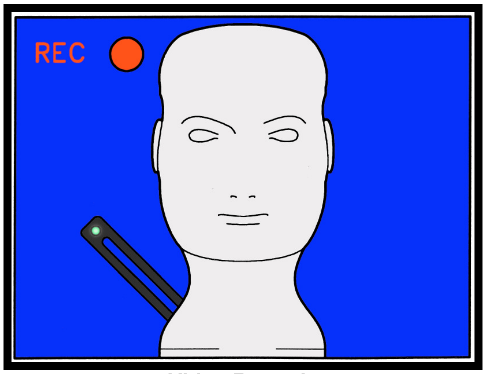


Indicator Switches ON. End of Scan

2.3 Texture Scan

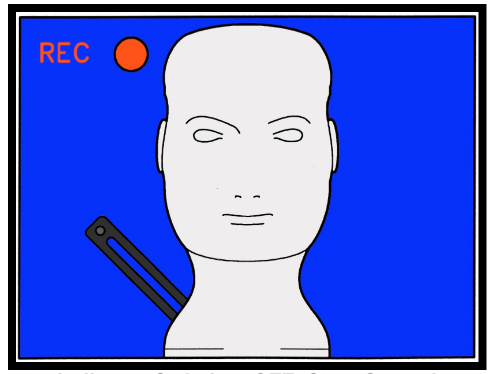
1. The ambient lighting is switched ON for texture scanning of the object. Usually room lighting and a halogen light is used for this. The laser is switched OFF and the video is set to record.
2. The turn table is switched ON. The indicator LED switches OFF after a few moments which marks the start of the texture scan.
3. The object continues to rotate while being recorded.
4. After a 360 degree turn, the LED indicator goes ON indicating that the full turn has been made. Recording can now stop. The captured video can now be processed.

1



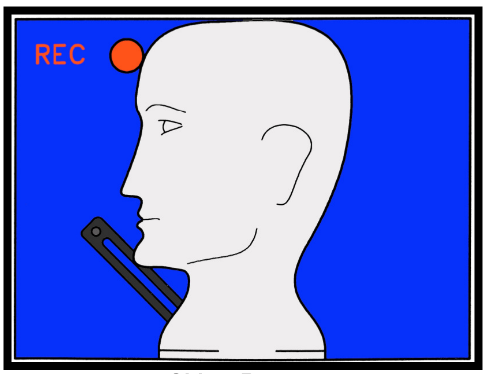
Video Records

2



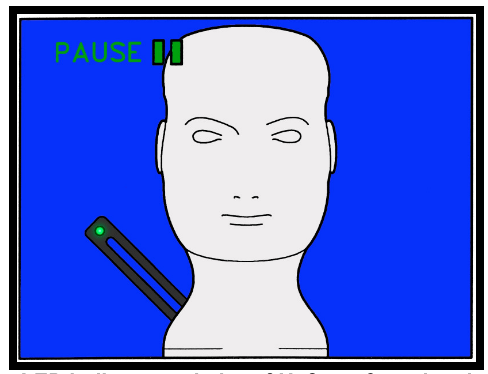
Indicator Switches OFF. Scan Started

3



Object Rotates

4



LED indicator switches ON. Scan Completed

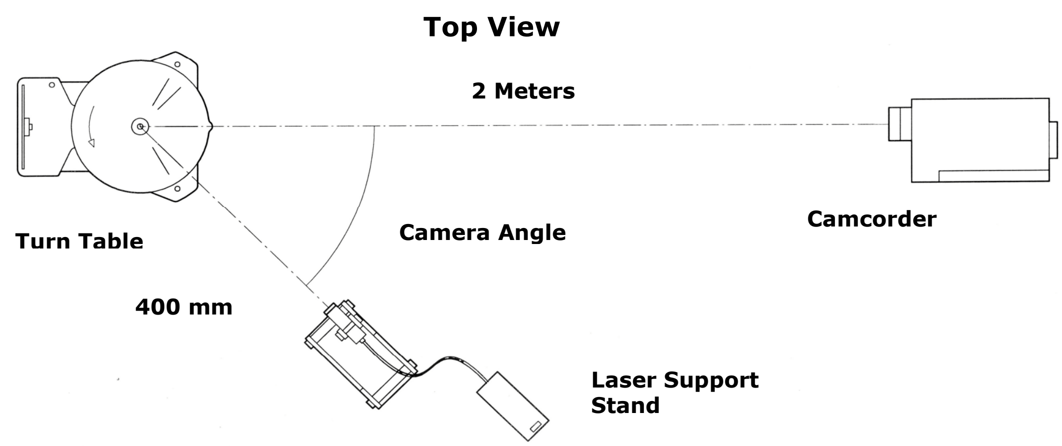
3. Scan Session Setup

The preceding section gave an illustration of the process and what's involved. In the subsequent sections we will actually make a scan.

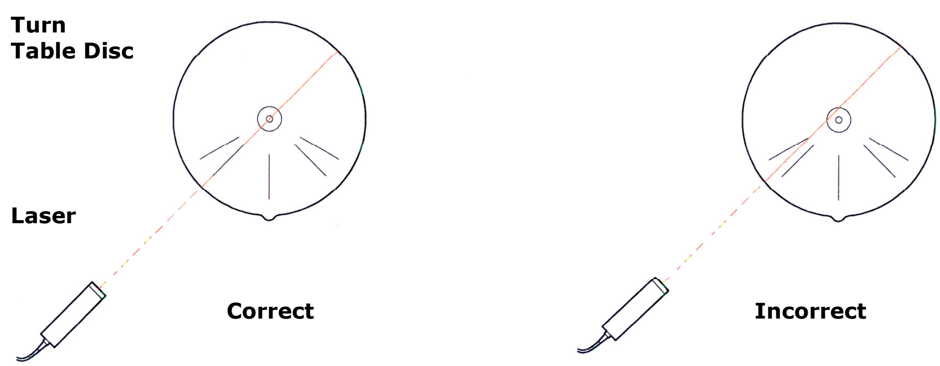
The following explanations presume that the Turn Table and Laser Support Stand have been assembled and tested. Low lighting conditions are required as ambient light affects the scan process. Choose a dark room to perform the scan. The setup should not be disturbed once positioning and settings of instruments and camera have been made. Unpredictable scans will result otherwise.

3.1 Positioning the Turn Table and Laser Support Stand

Place the Turn Table and Laser Support Stand on a flat leveled table. Position as depicted in the drawing below. Hook up the Turn Table to the power supply. The speed setting should be about 45 seconds for a full turn. Pay attention to the Turn Table disc turning direction. The direction of rotation should be counter clock wise when looked down at the table. Turn the Turn Table's disc with its engraved lines to orientate as depicted in drawing.



The angle between the camcorder and Laser Support Stand is 45 degrees when the laser line lines up with the first set of engraved lines on the disc. Place the Camera on a tripod at about the distance indicated in the drawing.

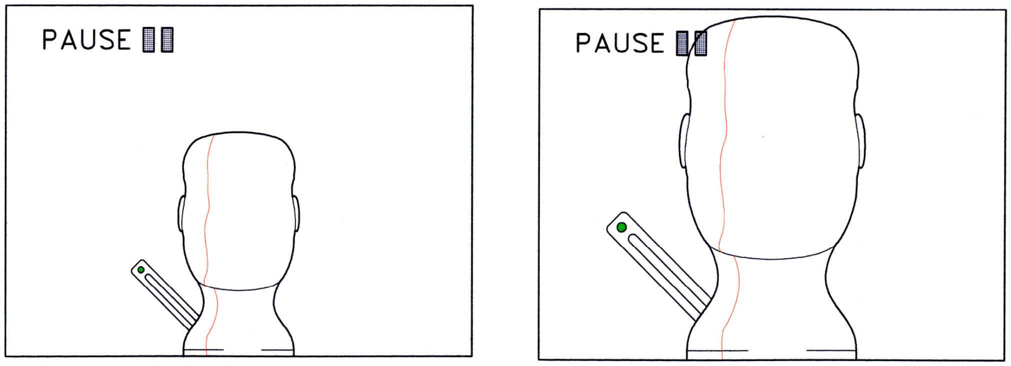


Make sure that the laser line plane is absolutely vertical and it shines exactly over the engraved line of the Turn Table disc as depicted in the above drawing.

3.2 Choosing the Object

As a circumference scanner, objects which are more or less circular in shape tend to make better scan models. The object to be scanned may not be transparent; it should have a mat or flat surface (not glossy) and, preferably, have light colors. Hold it in front of the laser to make sure the laser line projects a distinctive line over the objects surface. The line should not show up as a fuzzy or as a highly blurred line. The software will have trouble identifying it otherwise. Later on in the next main section of this manual you will learn more about how to get the most out of the objects that you want to scan with this type of 3D scanner.

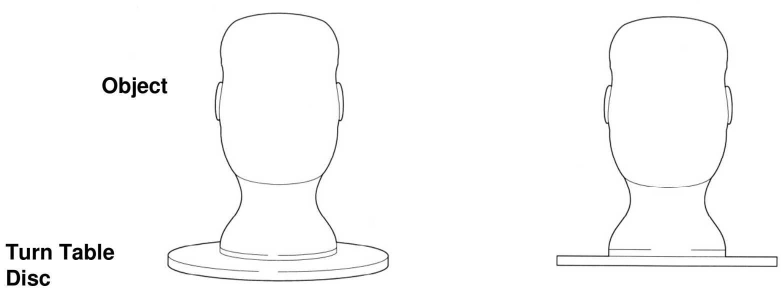
3.3 Setting Up the Camera



Incorrect **Correct**

As depicted in the previous drawing, the distance between the Turn Table and camcorder is about 2 meters (2 yards). Typically, this will require some degree of zooming. Zoom is important since the farther the camera is from the object the more zoom will be required the more **flat** the image will be. The flatter the image the better the shape accuracy of the resulting 3D model will be. At the same time the depth of focus range (DOF) will increase resulting in a better focused image of the object (do not use digital zoom this will only degrade the resolution of the resulting scan).

To take full advantage of the camcorders resolution, maximize the image of the object in the camcorders field of view. The above drawing displays this.



Incorrect **Correct**

The height of the camera must be set to permit the frontal image of the object to be viewed. This is depicted in the illustration above. The illustration on the left shows the image of the object too low in the cameras field of view. The right illustration shows the image that would be seen if the cameras lens center is at the same level as the objects center.

As mentioned in previous sections the camcorder must have a manual focus and iris or at least have the option to fix set these. Scans will fail in case the camcorder starts to auto focus or change its iris settings during scanning.

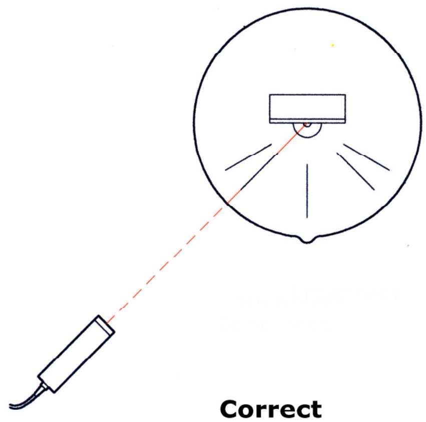
The camcorder should also, preferably, have a remote. Upsetting the cameras set position during or in-between scanning can lead to shifts in the resulting object scan and/or texture scan. By using a remote the layout will not have any chance of being disturbed.

3.4 Setting the Texture Lighting

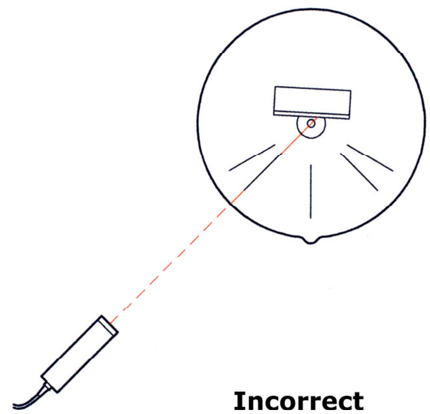
While the object scan is made in dark conditions, with only the laser lighting the object, the texture scan will require lights. Position a halogen lamp in front of the object without obstructing the view of the camera. Highlights and shadows on the object should be made minimal. Search for the best position to minimize this. Multiple lights may be required. Make sure that the camcorders iris is not set too much open (over-lighting).

4. Video Capturing a Scan

With the hardware set up its time to make a scan of an object. Turning the Turn Table disc is now permitted since the camera and other instruments have been set. However the Turn Table, Laser stand and Camera position should not be moved at all. Carefully remove the object off of the Turn Table and position the calibrator onto the Turn Table. The drawing below illustrates the correct positioning.

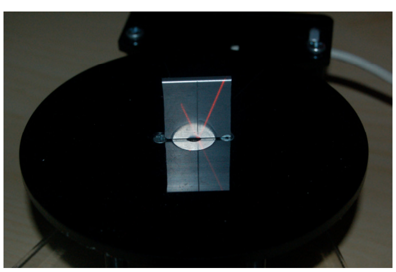


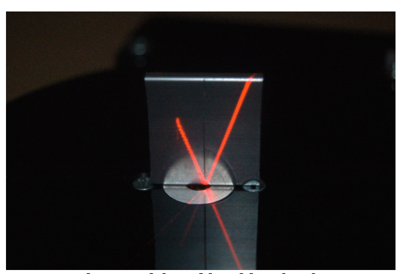
Correct



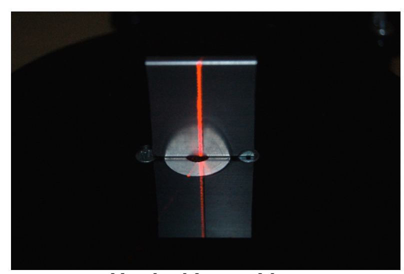
Incorrect

Make sure that the laser line is absolutely vertical on the calibrator. An easy way to determine this is to look for a second reflection of the laser from the laser on the calibrator. This secondary reflection is from the surface of the table disc. The secondary reflection can be lined up with the primary reflection by turning the laser. The laser line is vertical once this is achieved.





Laser Line Not Vertical



Vertical Laser Line

Video record for about 10 seconds the calibrator on the turn table. The laser line on the calibrator must be clearly visible for the video camera (dim lights for better results). Replace the calibrator with the object. Make sure that the setup does not move. While you may rotate the Turn Table disc, the position of the Turn Table must remain fixed.

Turn down/OFF the room lighting. Set the camcorder to record and switch ON the Turn Table. At one point the LED indicator will switch OFF. This is the start of the scan.

After the Turn Table disc has made its full turn (LED indicator lights up again), switch ON the halogen light, switch OFF the laser and Switch ON the Turn Table for a second session to begin the texture scan. The process is same as with the object scan. Stop the recording once the LED indicator has switched ON again after a full turn.

5. Processing the Captured Scan

The following explanations will require that a Camcorder-PC connection (FireWire IEEE 1394) is established and that an AVI file is made of the captured scan using TriAngles. After adjusting certain settings the AVI file containing the captured scan will be processed and compiled to create an RSD file. This is the Raw Scan Data which will be used to build the 3D model of the scanned object in TriAngles 3D Builder.

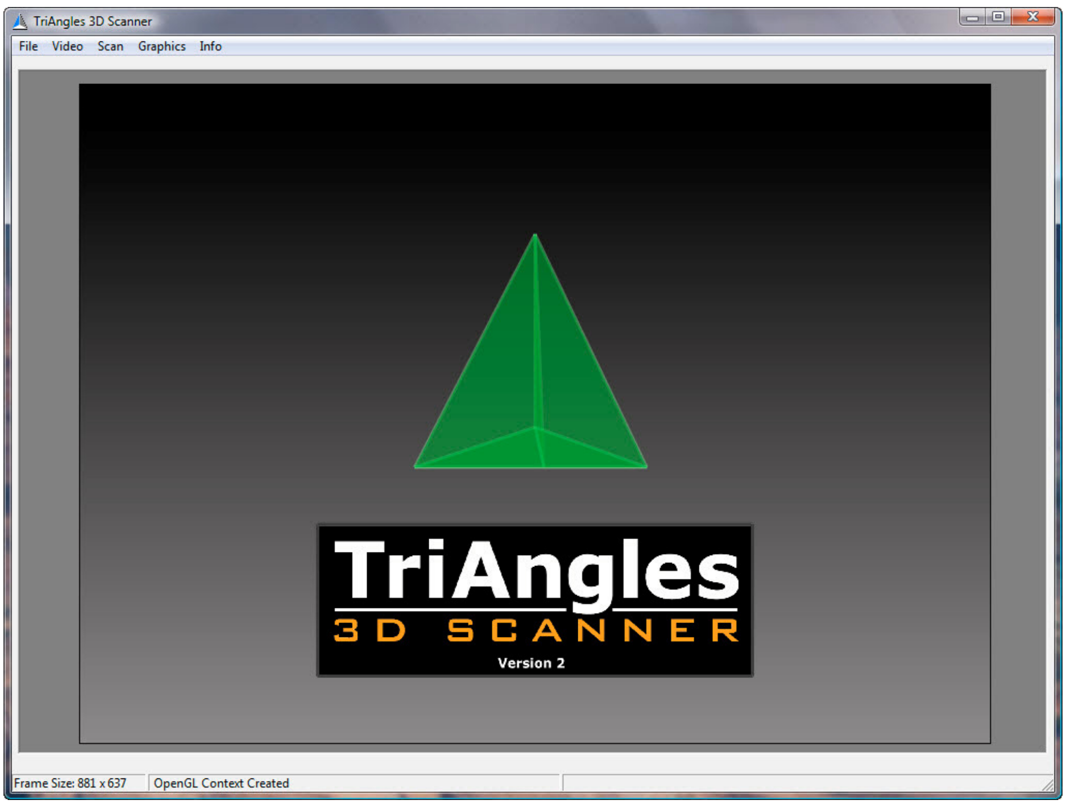
5. 1 Connecting the Capture Device to the PC

TriAngles offers several ways to interface with your camcorder (Video In, USB, etc). However the type that will be used here is a FireWire interface. FireWire offers the highest level of integrity and functionality available. In case you chose for another type of connection or not, you must install the cameras supplied drivers and test your camera workings with its supplied applications before proceeding. After testing always close any application that uses the camera. Cameras usually can not be shared by 2 programs at the same time. TriAngles will piggy back on the driver used for your camera and provide its functionality within the application.

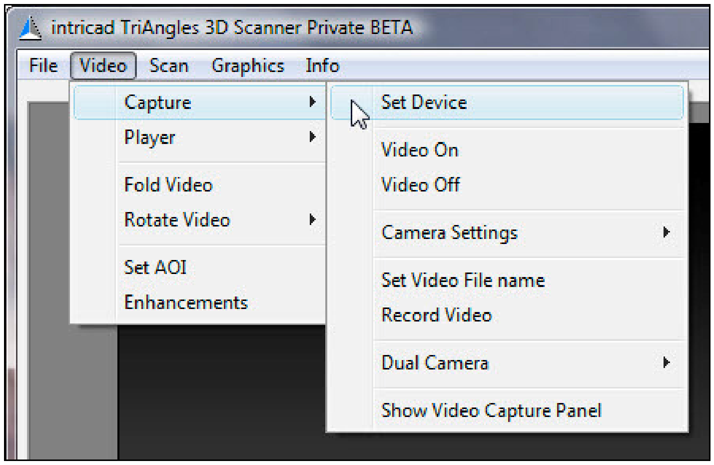
Turn the camcorder OFF. Establish a FireWire connection between camcorder and the PC. Switch ON the camcorder and set it to its playback position.

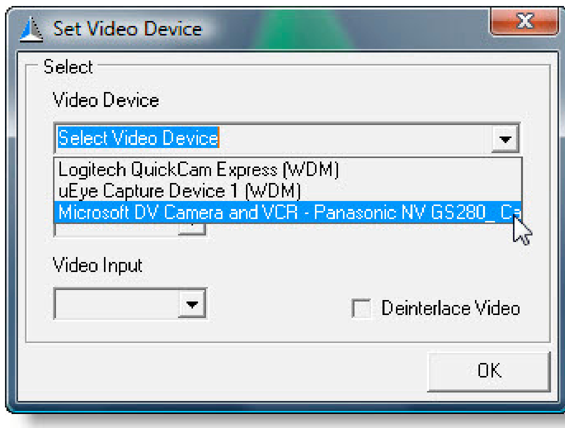
5.2 Creating an AVI file of the Captured Scan

Run TriAngles 3D Circumference Scanner. At start up TriAngles shows a rotating logo banner in its main window. This is a real time rendering that serves to benchmark the computer. In case the logo rotates in an erratic or jittered fashion or exceptionally slow then this may be an indication that your PC does not posses the required performance to process the scan efficiently. This is important as the processing of the scan is time dependant. The following explanations presume that the PC used to process the scan meets specified requirements.



Click Video, then Capture in the applications main menu and select Set Device. This will bring up the Set Device dialog.

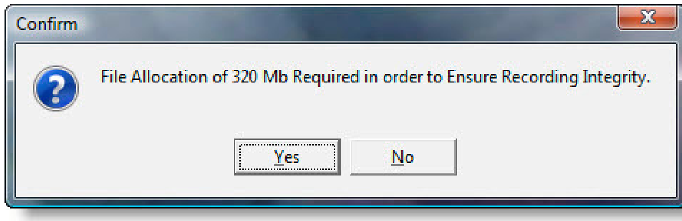




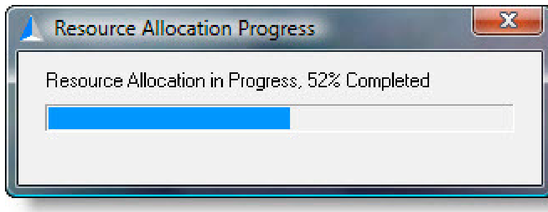
It is not uncommon to have more than one camera hooked up to your system. Here you will be able to select which camera you want to use by selecting it in the Video Device drop down box. You can then set the resolution of the device. It is best to set the resolution to maximum or at least 640x 480. For DV type cameras using a firewire connection this may be labeled as Full. Setting to Full will set the camcorders video to its highest resolution.

After setting the device click on Video then Capture again and choose Video On. The video from the camera should now start to preview on screen.

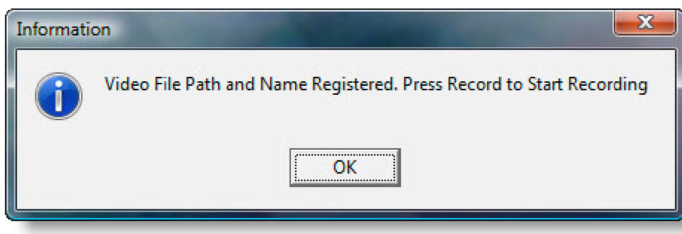
The Video Capture Panel should automatically appear after the video has started. On the panel press the Set File Name button. If this is the first time that video is going to be recorded then a dialog will appear requesting to create an Allocation file.



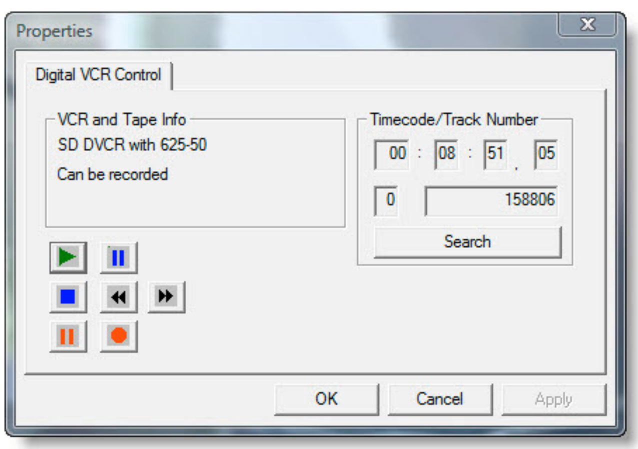
Press Yes and allow the process to complete. This should only take a few moments. The Allocation file reserves space on your hard disc to record video on. This improves the recording integrity and it is advised to use it.



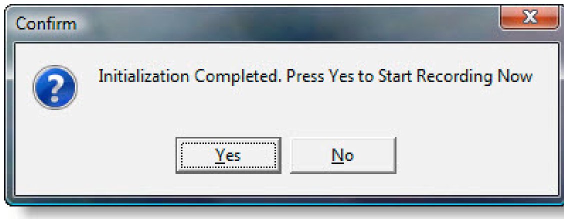
You will then be able to set the name of the AVI file and path of the video that will be recorded from your camera playback of the scan that was made earlier. The following dialog will appear indicating that the file name was registered and that recording is ready to start.



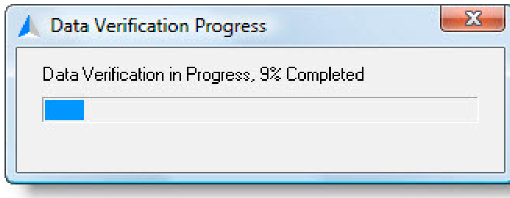
With firewire type connections it may be possible for certain cameras to controlled directly from TriAngles. Press the Std. Controls button on the Video Capture Panel. This will bring up a native dialog that will allow you to control the camera.



In the menu rewind the recorded scan to the beginning of the recorded video of the scan. Press the Play symbol in dialog. Close the dialog, press the Record button on the Video Capture Panel. A message will appear shortly after to start recording.



Press Yes. Record the entire scan, including the recording of the calibrator scene. To stop recording, Press the Stop button on the Video capture Panel.

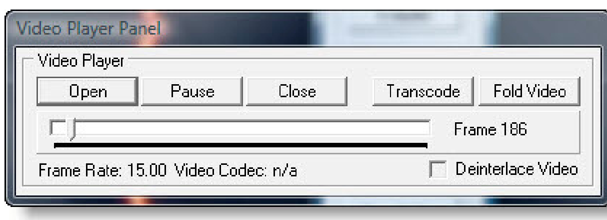


After making your recording a dialog will appear showing the progress being made for the Data Verification. Allow this to complete.

5.3 Allocating Memory for Processing of the Captured Scan

Now that an AVI of the captured scan is available click Video, Player and select Open Video File. This will bring up the Open Video dialog. Open the captured scan AVI file that you recorded. The AVI will now be played back in TriAngles main window.

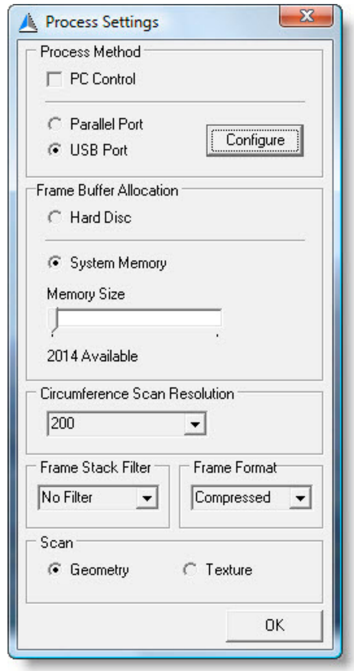
The video is looped to play over and over again to prevent having to re-run the video each time it ends. Press the Close button on the Video Player Panel.



The AVI will play in the applications main window. Click Scan in the main menu of TriAngles and select Show Scan Session Panel. This will bring up the Scan Session Panel. This panel includes the main functions for processing a scan.

The actual processing of the video will involve setting the Frame Buffer Allocation. In order to process the AVI of the captured scan, separate frames will need to be grabbed of the scan. Each frame will be needed.

Press the Process button on the Scan Session Panel. This will bring up the Process Settings dialog.



When processing a scan the frames of the video will need to be temporarily stored somewhere before the scan is compiled. There are several ways to do this which can be selected in the Frame Buffer Allocation group box of the Process Settings dialog. The choice essentially depends on your system resources. There are basically 2 options:

1. **Hard Disc.** This option uses the least amount of system resources and is most typically used. A high speed hard disc is required. It offers good overall performance.
2. **System Memory.** This option offers the highest degree of integrity and processing speed. But it requires a substantial amount of system memory.

For now select to use Hard Disc in the Frame Buffer Allocation group box. The other group boxes pertain to functions that will be explained in more detail later in this manual. As a brief overview; The Process Method group box in the Process Settings dialog is used for PC control scanning in which the Turn Table is controlled from the PC. Uncheck the PC Control check box for now. Also, make sure that Geometry is selected in the Scan group box, Circumference Scan Resolution is set to 200, Frame Stack Filter is set to No Frame and Frame Format is set to Compressed.

Storing grabbed frames on the hard drive includes a read/write penalty which can, in some cases, affect the quality of the resulting scan. This option should only be employed for high-end drives that run at speeds of 7200 and higher. The benefit of using the hard drive is that the system memory size does not have to be that large. Initialization is also almost immediate. TriAngles version 2 includes some important improvements regarding the use of this option. The result is that performance now very strongly compares to using the System Memory option.

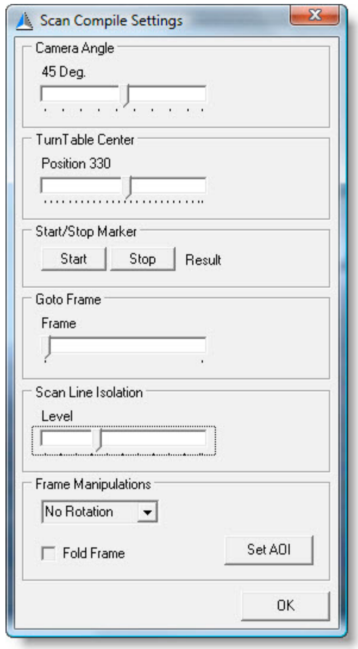
However the recommended choice for best performance is still to use system memory which permits much faster reads/writes than a hard drive and leads to higher frame grabbing rates. The result is a scan that has a higher degree of quality. The big penalty is the required memory size. A Typical scan will yield at least about 400-600 frames using a PAL type video camera. That's about 750 MB of data that needs to be uploaded to memory at real time rates to support all the frames. You will need to have at least 1.5 GB of system memory available to do this.

To determine the max amount of memory you will be able to use when selecting the System Memory option, use the slider in the Frame Buffer Allocation group box. At one point the label listing of memory will turn red indicating that you are reaching the limit of system memory. The amount of memory at your disposal should be at least 1 GB when using this option for basic scans. If it is not, close any other applications running and check again. However, as explained, we will be using the Hard Disc option and not System Memory for processing the video of the recorded scan for now.

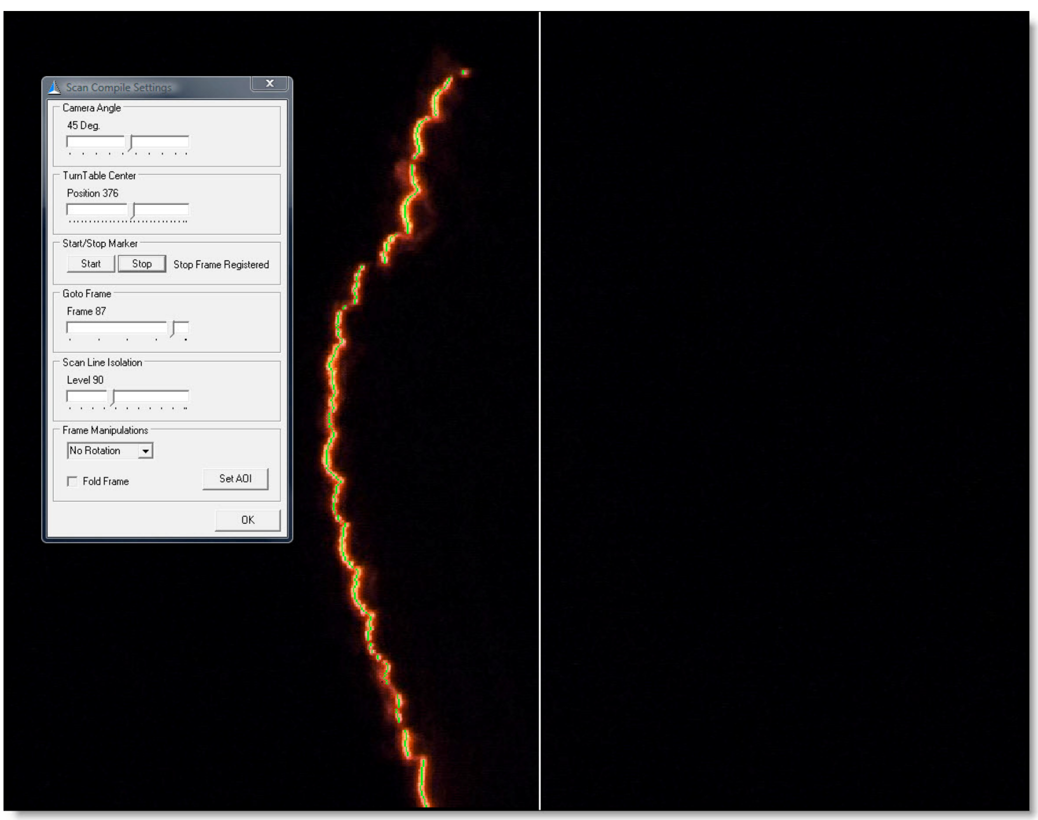
Close the Process Settings dialog by pressing the OK button.

5.4 Setting the Center Mark

Go to Video, Player and select Open Video File. This will bring up the Open Video dialog. Open the captured scan AVI file that you recorded. Use the slider on the Video Player Panel to find the scene that was recorded of the Turn Table's center. On the Scan Session Panel press the Compiler button (not the Compile button). The Scan Compile Settings form will display.

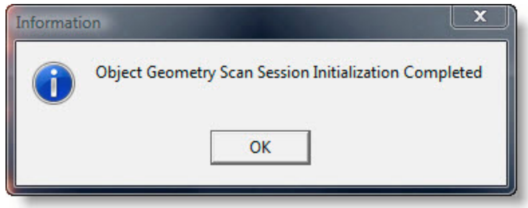


If you move the slider in the Turn Table Center you will notice that a white vertical line will appear in the viewer area of TriAngles. Set this line to line up exactly with the laser line on the calibrator of the recorded video. With this completed TriAngles now knows where the Turn Table's center of rotation is. Press the OK button to close the dialog.



5.5 Processing the Captured Object Scan

With the Frame Buffer Allocation set to Hard Disc press the Initialize button in the Scan Session Panel. The system resources will now be allocated to TriAngles. This will take a moment to complete. Once completed, the following message will appear.



Make sure it reads **Object Geometry Scan**. On the Video Player Panel, slide the player slider to before the actual scan starting point. This is the point that is about 5-10 seconds before the LED indicator switches OFF for the first time. Press the Play button. Immediately after that press the Start button in the Scan Session Panel. TriAngles will now start grabbing frames. The amount of frames grabbed can be read on the status bar located at the bottom portion of the application. At one point the LED indicator will switch ON again indicating the object has made a full turn. When this happens press the Stop button on the Scan Session Panel. The Compiler Settings dialog will appear a few moments afterwards.

The Compiler Settings dialog will require you to adjust several items before the scan can be compiled. Already set the Camera Angle slider to the angle that you used for the scanning of the object.

Slide the Goto Frame slider to exactly one frame **after** the LED indicator switches OFF. Press the Start button in the Start/Stop Marker group box. This tells TriAngles to mark this position as the rotation start position of the scan. Go to the end of the scan by sliding the Goto Frame slider to the right. You will notice that you are scrolling through the frames. Position the slider to exactly one frame **before** the LED indicator switches ON and Press the Stop Frame button in the Set Start/Stop Marker group box. This set the end of rotation position of the scan.

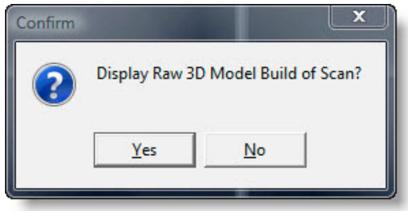
The Scan Compile Settings dialog also contains the Scan Line Isolation slider. Slide this to left and then slowly to the right. Notice that groups of green pixels start to align with the scan line as you move the slider to the right. Adjust to a position that:

1. Best aligns the green pixels with the laser scan line on the object.
2. Best fills the laser line area with green pixels.

The setting should reside somewhere between 60 and 120. This setting adjusts the level of sensitivity that TriAngles will use to identify the laser line.

The remaining items found in the Frame Manipulations group box pertain to PC control mode which will be discussed later. For now make sure that the drop down box is set to No Rotation and the Fold Frame check box is unchecked . Close the Scan Compile Settings dialog.

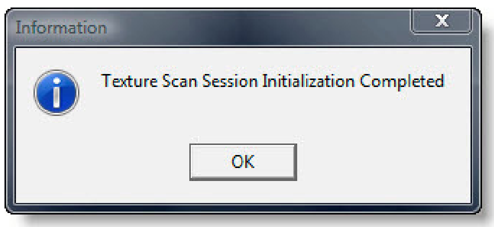
On the Scan Session Panel press the Compile button. The grabbed frames will now be processed one by one. The progress can be read on the status bar located at the bottom of the application. Allow the process to complete. Once the process completes you will get a message to preview the scan. Press Yes. After previewing you can either export the model as an .obj file or save it as an .rsd file for subsequent processing in TriAngles 3D Builder.



5.6 Processing the Captured Texture Scan

The processing of the Texture scan is the same procedure as that of the object scan. But instead of an rsd file the texture scan will produce a bitmap of the objects texture. Open the Process Settings dialog by pressing the Process button on the Scan Session Panel. After the dialog opens select the Texture option in the Scan group box.

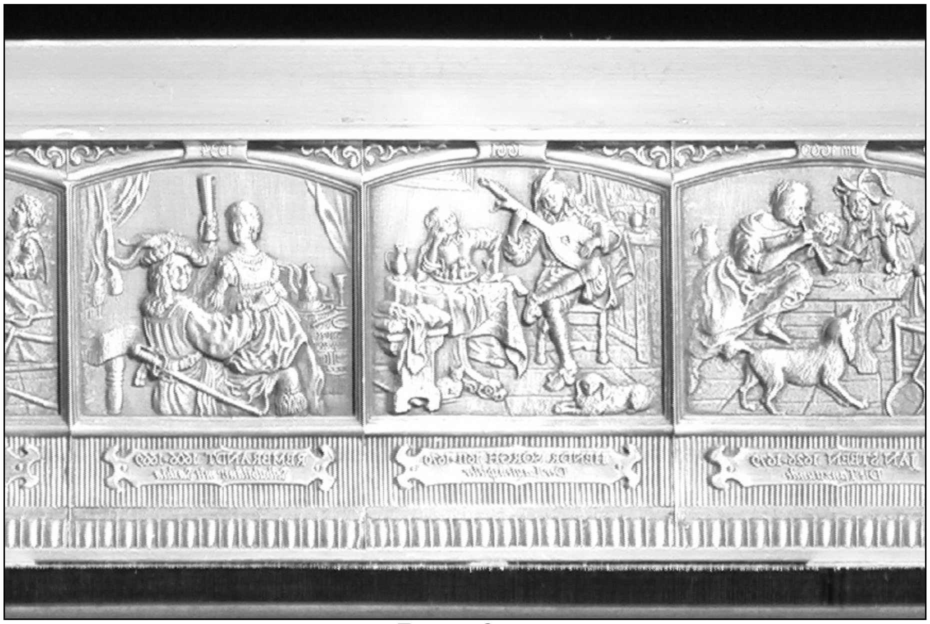
Press the Initialize button on the Scan Session Panel. Wait for the process to allocate the memory and press OK at the Initialization Completed message.



Slide the AVI Player slider to the start of the actual texture scan starting point. This is the point where the LED indicator is about 5-10 seconds before it switches Off for the first time. Press the Play button and then immediately press the Start button. TriAngles will now start grabbing frames. The amount of frames grabbed can be read on the status bar located at the bottom of the application. At one point the LED indicator will switch ON again. When this happens press the Stop button.

The Scan Compiler Settings dialog will appear once the Stop button is pressed. Slide the Goto Frame slider to exactly one frame after the LED indicator switches OFF. Press the Start Frame button in the Set Start/Stop Marker group box. Go to the end of the scan by sliding the Goto Frame slider to the right. Position one frame before the LED indicator switches ON and Press the Stop Frame button in the Set Start/Stop Marker group box. Press OK on the Scan Compiler Settings dialog. Do not change the position of the Turn Table Center slider.

Press the Compile button on the Scan Session Panel. The grabbed frames will now be processed one by one. The progress can be read on the status bar located at the bottom of the application. Once the process completes you will be able to view the scanned texture map. You can save this by going to File and selecting Save Texture. The texture can later be uploaded and positioned over the scanned object model in 3D Builder.



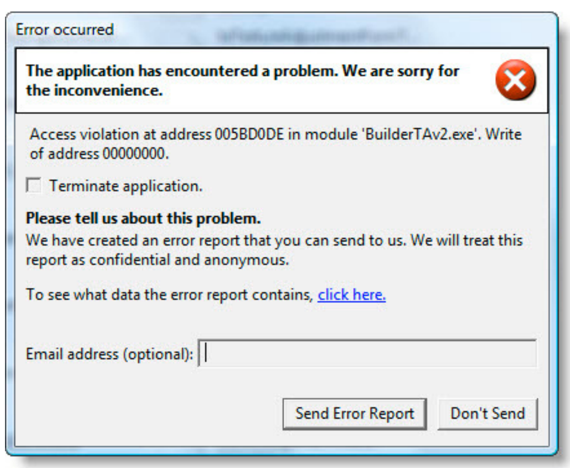
Texture Scan

5.7 Creating the 3D Model

The object (rsd file) and texture (bmp file) scans processing is now completed. The basic process should now be clear. The next step is having the data built into a 3D model. This is done in TriAngles 3D builder (how to do this is included in the TriAngles 3D Builder manual).

There is a good chance that the scan was a success. Still, there is a lot more to making good scans. The following section will take a closer look into what's involved.

6. Catching Errors



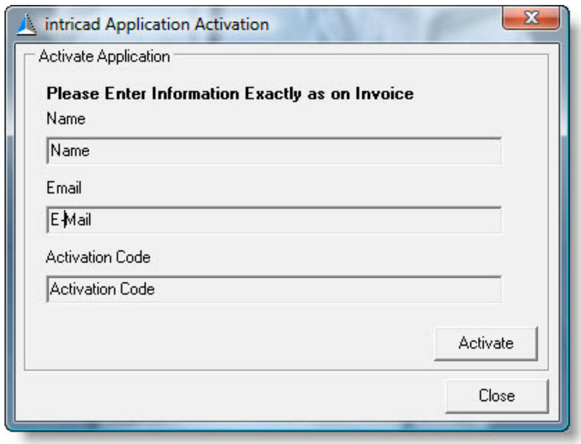
Displaying a screen shot of an error or exception dialog in your product manual usually does not make the best impression. Actually, even the best software runs into a problem or two once in a while. And, we have made every attempt to make the best software we can. Most of the time its those little things in the far reaches of its use that can lead to being confronted with an error. In that case we want to know about it. More specifically we want to understand it in order to find solution as soon as possible.

TriAngles includes a special error catching utility that works in the background. Should you be confronted with an error, the dialog will allow you to send us a report about it. In some cases the error may be repetitive. If you have already sent the report or not you can check the Terminate Application checkbox in the dialog in order to attempt to directly close TriAngles.

7. Product Activation

TriAngles 3D Scanner is supplied in a demo state when downloaded. You will still be able to make scans and build them. In fact you can even save them in the TriAngles native .txs format or directly export your scan from TriAngles 3D Scanner to the .obj file format. The only limitations are that you can not use the 3D scanner's PC control functions, this includes the USB interface, to allow for high resolution scanning and video processing methods. In addition 3D Builder will not allow you to export your finalized scans.

If you have purchased a license then you can activate your copy for full control by including your license information. To do this go to info in either 3D Scanner or Builder's main menu and select Activate Product. This will bring up the Activation dialog. Include your information exactly as listed in your license.



Maximizing the Scan Process

TriAngles Version 2 is a complete rebuild with much extended functionality over version 1. It includes new video noise and occlusion reduction techniques as well as greater ability to make more effective use of your cameras resolution.

If you succeeded in making the basic scans, following the explanations in the previous sections, you will now have the basis to move on to more complex scanning. The subsequent sections will provide an insight on this.

3D scan technology has been around for many years. At least the core technologies have been. Despite this, the technology has not been accessible for most of us. The 3 main reasons for this have to do with the level of complexity involved, the available computing power to process and display the data and, more over, the very high costs of the required instruments and product development.

Like many technologies, 3D scanning can offer some impressive solutions if used correctly. It's important to keep in mind not only what 3D scan technology can do but what it can't do as well. Facilitating a better understanding of the technology will in turn allow you to better determine what can be expected from a scan or, more importantly, how to maximize the scan process to get the best possible results.

3D scanning can be complex as many factors contribute to the quality of a scan. In fact the technology can be considered somewhat of an art since there are so many different ways to scan an object. Also, most all 3D scanners rarely yield the finished product and more often than not require some degree or more of post processing.

The following chapters provide a more in depth overview of the technology. The incentive is to provide you with the basis to make better scans as well as make modifications to the hardware that may better suit your scanning needs.

8. What is a 3D Scanner?

A practical definition of 3D scanning technology is that it entails the process of converting the 3D geometric shape of a tangible object/scene/surface into a 3D-computer model representation. Actually there is a long line of different technologies that have been devised to accomplish this task. This is not that surprising when considering the fact that no single 3D scanning technology can scan the entire range of different objects around us. That being the case there are many different types of 3D scanners. Certain 3D scan technologies can scan large areas of land while others can scan something as small as large molecules. The idea is to choose the right scanner for the right application.

8.1 Contact 3D Scanners

3D scanners are part of a larger group of range mapping technologies. While there are many ways to categorize the different 3D scanning technologies the most popular division is based on Contact and Non-Contact type scanners.

Contact type scanners are very straightforward, purely mechanical registration scanners. All have some or other mechanical probe that touches the object in order to understand its geometric shape/surface. The probe is attached to some type of XYZ axis coordinate measurement system (automatic) or be user assisted (manual). Following a sequence, the probe moves over the object. Once a point on the object has been touched the 3D position is stored in computer memory. The more points registered the greater the resulting scan detail will be.

Contact scanners are known for their paramount accuracy and registration sensitivity, which can go all the way down to the sub micron or nanometer level for certain types. Contact scanners are also not easily fooled and thereby rarely suffer from artifacts (spikes, stray points) normally found in non-contact scans.

Yet, usually, contact scanners entail a bulky apparatus, especially for scanning objects that are shoebox size and up. More importantly they are typically very slow scanners, unless the object being scanned is very very small. Scan times can sometimes be as long as hours and even days in some cases. They can also be very expensive due to the instruments required.

8.2 Non-Contact 3D Scanners

Non-contact scanners include a much wider range of types yet have, traditionally, yielded much lower accuracy than their contact counterparts. They also usually require more involvement from the user to set up correctly. But they have much higher scan rates (faster scanning). They are more easily modified to scan different sized objects. And, as the name implies they do not touch the object during scanning. These properties make them very popular. In addition, some of these scanners can actually scan within certain objects as well. For instance, the Magneto Resonance Imager (MRI) scanner can scan within a living organism.

Two of the most popular types of Non-Contact scanners are, Structured Light (Scan Line Deformation) and Time of Flight. SLD, Non-Contact type scanners find wide spread use and employ triangulation to determine the 3D points of an object. Typically some type of line scanning instrument is used that projects a straight line over the object to be scanned. The deformation of the line, when looked at an angle, as it follows the curvature of the object's surface functions as a cue that represents the surface's depth for a specific section of the scanned object.

The laser scanner is probably the most impressive and well known type known within this category. However there are other techniques that can sometimes offer more versatility than a laser scanner. Instead of a laser, a projection system can be used to project a structured image onto the object.

Both of these approaches can be used for this product. Each has some important benefits that will be explained in detail in subsequent sections of this manual.

Time of Flight type scanners work much like sonar or radar technology. A pulse of acoustic or electro magnetic energy (this can include light) is transmitted to the object that is being scanned. The energy is reflected back. The time it takes for the energy to reflect back is a cue for the distance (depth) between the object and the transmitted energy source. A 3D model can be built by repeating this process for many different points on an object.

9. The TriAngles 3D Circumference Scanner

The TriAngles 3D Scanner a 3D non-contact, circumference scanner. As mentioned before, non-contact meaning that the object is not touched during scanning as the scan technique relies on a visual based process. Circumference meaning; that the scanner scans around an object.

The technique employed to acquire 3D information about an object's surface involves projecting a distinctive, thin line over the object called a scan line. A camera (sensor) views the scan line that is projected over the object at an angle. From the projector's or laser's point of view the projected image is a straight vertical line that is displayed onto the object. Yet viewing the object at an angle will reveal a deformed line as it follows the curvature of the object's surface. Using the known camera angle (angle between camera and scan line), the relative 3D position of each point of the line can be calculated through triangulation. The object is then rotated one increment and the procedure is repeated. Repeating the process over the entire object's surface creates a full 3D-model data set (range map) of the object. This data set contains points, each representing the 3D positions of the scanned object. The object is built by connecting these points to form a circumference, or surfaced, 3D-computer model representation.

9.1 Scan Line Mechanics

It should be evident that scan line quality represents the foundation of this type of 3D scanner. Hence, the line quality, its position and how well the capture device is able to see it will have direct effect on scan accuracy and quality. Incorrect positioning of the scan line, for instance, will affect the size and shape of the resulting scanned object. Visual aspects, on the other hand, affect the integrity of the scanned data as well as the amount of authentic data acquired during scanning. Parameters that determine visual line quality include:

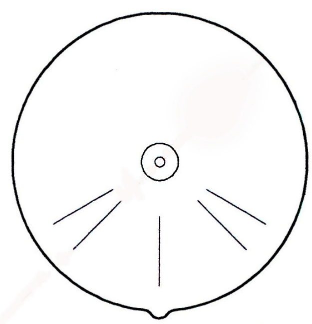
- **Object Reflection** (should be: medium)
- **Line thickness** (should be: thin, accurate, consistent)
- **Line Intensity** (should be: high, consistent)
- **Line/object contrast** (should be: high)

Approaching these values will allow the camera to view the scan line more clearly. Still, the camera itself has a very limited efficiency when it comes to the picture quality it produces. While most all of today's camcorders are digital this only pertains to the method of data storage. The imaging element (CCD) is still an analogue (non-digital) device which has a signal to noise ratio. Basically the image produced by the camera always contains some degree of noise. Noise (also sometimes refereed to as static) shows up as the pixels of the imaging element randomly changing in intensity. Noise can obstruct the process of detecting the actual scan line and it needs to be filtered out. Along side noise, glow and reflection that surround the scan line, which are generally attributed to the quality of a camera's lens system, make it difficult to detect the actual scan line. These attributes can leads to unnecessary loss of detail and even artifacts such as spiking, which is frequently found on many scanners.

TriAngles includes a sophisticated algorithm to limit these affects while achieving sub pixel accuracy. It also allows the user to choose the best level of scan line detection sensitivity. The Scan Compile Settings dialog includes the Scan Line Isolation slider. Basically, the lower the setting the higher detection sensitivity will be but with less noise compensation.

9.2 Occlusion and Shape Accuracy

The Turn Table disc includes 5 engraved lines. The middle line should be in alignment with the camcorders center line of sight. Of the 4 remaining lines the 2 that are nearest to the middle line are each exactly 45 degrees from it. The remaining 2 lines are 60 degrees from the middle line. These angles represent the camera angle or, more specifically, the angle between the camera and the scan line.



The choice of camera angle has a direct influence on the quality of a scan. More specifically, the shape accuracy and occlusion probability of the resulting scanned object. It can mean the difference between smooth or bumpy scan lines or open areas or not.

Larger camera angles yield better shape accuracy since the camera is able to view a more pronounced curvature of the scan line. The curvature is more spread out over the camera pixels and more effective use is made of the camera's resolution.

On the other hand the greater the camera angle the greater the chance is that certain parts of the object will not be seen by the camera. The scan line is obscured from camera view at larger angles, which leads to holes in the 3D data. To get a better idea on how this works, imagine scanning a head. While the head object tends to be circular in shape the nose on the face sticks out. As the object rotates on the Turn Table the scan line is clearly seen by the camera traveling over the nose. However at one point the scan line will reside behind the nose as the object continues to rotate but this area of the object is not yet visible to the camera. The camera can not see this yet because one side of the nose is obscuring that view. The scan line will reside on other parts of the object by the time this area is visible for the camera.

The basic rule is to always strive for the largest camera angle but choose smaller camera angles when scanning objects that have over extending shapes or protrusions.

Most objects will always have some degree of occluded areas. Fortunately TriAngles 3D Builder includes a patching function to fill this up. Also, the use of texture mapping can offer some solution to this problem (this will be described later).

A more common yet rigorous solution is to make 2 scans at different angles and then merge these in a 3D application.

9.3 Scan Resolution and Accuracy

Probably one of the most frequently asked questions is “what is the resolution or accuracy of the scanner?”. The resolution is actually determined by the capture device. While HD type cameras are entering the market most all camcorders have a fixed resolution. For PAL this is 720H x 576V and for NTSC this is 720H x 480V. It should be evident that PAL type cameras are the better choice.

However, when it comes to the accuracy of the scanner it is a bit of a different story. For one thing since the resolution of the camera is fixed the size of an object will relate to its detail. It should be obvious that scanning a face will unlikely reveal the hairs of an eyelash while scanning just an eye probably will.

Fortunately, it is possible to say something about the expected accuracy of a scan. The answer is divided between the vertical and horizontal accuracy.

With a PAL type camcorder the amount of vertical pixels is 576. If an object’s height is 250mm and it uses all of the vertical pixels (the objects height is exactly set and maximized in the cameras view) then you could say that the vertical accuracy is 250mm/576p=0.43mm. Hence details smaller than 0.4 mm can not be seen by the scanner. This is of course under ideal conditions, which is only very rarely achieved. Scan line quality, the camera lens system and other aspects all contribute to determining the accuracy of the scan. In practice the resolution will reside more between 1-2 mm than 0.4 mm.

Practice reveals that the accuracy of the scanner using a PAL type camera is about 100-200 times less than the cameras viewable height of an object.

The horizontal accuracy on the other hand is related to the vertical accuracy, the diameter of the object and the amount of scan lines acquired. Smaller diameter sections of a scanned object will contain more detail than larger diameter sections. The scan lines acquired are more densely packed in these smaller diameter sections. Hence the more scan lines acquired the greater the detail the greater the accuracy. A typical object should yield about 450 scan lines but as many as a 1000 lines or more is not uncommon. However even with this many scan lines the horizontal resolution will only approach but usually not be greater than the vertical accuracy. Typically, the amount of scan lines would have to be substantially greater than the above mentioned to rise above the vertical accuracy level.

To achieve higher scanning resolution TriAngles allows you to set the video frame to portrait mode. The idea is to turn the camra 90 degrees on its side. The result is that for the same camera resolution you will be using more pixels and hence greater resolution. This can be as much a 30% more resolution for PAL type cameras.

9.4 Scan-able Objects

Probably the most important part of the 3D Scanner set up is actually the object that is to be scanned. All objects have certain visual properties which may make some better suited than others. Some of these properties include:

- Opaqueness
- Size
- Dimensional Proportion
- Shape
- Color
- Texture
- Detail

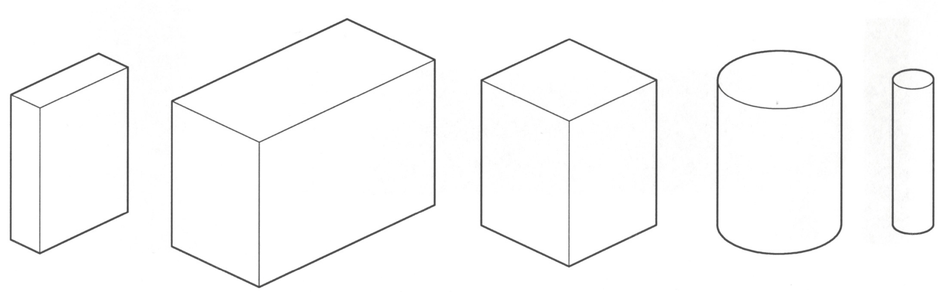
The properties of an object can have a direct effect how well it can be scanned or not. For instance, since the scanner relies on visual information it is obviously not possible to scan an object, which is transparent such as glass. It is however possible to powder/paint such an object in order to permit it to be scanned. A smooth mat white surface offers the ideal visual conditions for an object to be scanned.

Theoretically this type of scanner technology could scan something as large as the earth or as small as an ants head. This is obviously not very realistic, but what it implies is that what ever object your camera can view, can rotate on a turn table and can project a laser line onto can usually be scanned.

As a Circumference scanner the types of objects best suited for scanning tend to be circular in shape and dimensional proportion. A bottle, for instance is an ideal shape to scan using this technology. Rectangular objects, such as a shoe, are usually suited but flat/thin objects such as a mobile phone are more difficult. Simply stated; objects with significant difference in dimensional proportion are difficult to scan. This is due to the fact that the chances of an entire scan line being occluded from camera view increases. In addition the sudden change in object diameter leads to loss of detail as the scan line more rapidly moves across the objects surface yielding less data.

The basic rule is that objects tend to result in better circumference scans when length is no more than 3 times width and height or more than 5 times width or diameter.

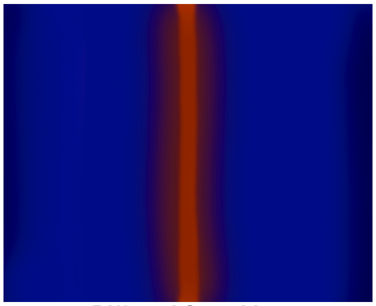
Different Dimensionally Proportioned Objects

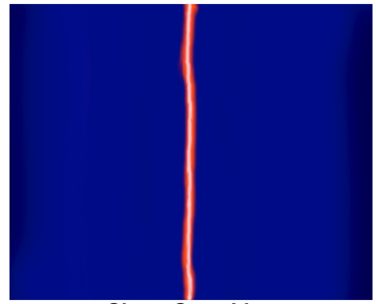


Very Difficult **Difficult** **Acceptable** **Ideal** **Good**

Fortunately TriAngles version 2 includes new occlusion reduction techniques such as “Video Folding” (Paten Pending) and “Dual Camera Scanning”. These techniques can significantly reduce occlusion. Their workings will be addressed later in this manual.

Object color and texture have bearing on the expected quality as well. Dark glossy surfaces or materials that diffuse the intensity of the scan line or have a fuzzy texture will have significant effect on the quality of the scan.


Diffused Scan Line


Sharp Scan Line

The diffused scan line lacks intensity and discreetness and will be difficult for the camera to see in relation to the sharp line. Materials such as marble and furry textures tend to result in diffused scan beam and are difficult for any non-contact type 3D scanner to capture correctly.

10. Alternative Scan Line Projection Methods

Up until now the type of scan line projection method employed was to use a laser. However there is another way to produce a scan line which offers certain benefits. Instead of a laser the scan line can also be projected onto an object using a slide projector.

10.1 Laser Properties

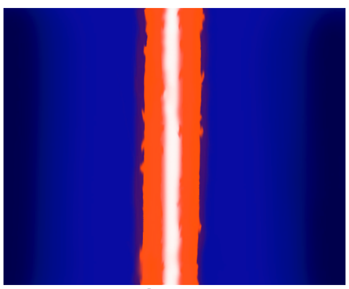
When it comes to surface color and range the laser can scan a much wider variety of objects than the slide projected scan line and do this under various lighting conditions. Lasers throw an intense coherent light which provides a distinctive scan line on an object at many different ranges and under many different surface color conditions. By this same token the laser can also cause severe reflections on certain material surfaces as well as cause certain surfaces profiles to light up. The intensity of the line can vary significantly as well and as show up as beading (high intensity areas). These attributes can all contribute to confusing the line detection function of TriAngles and thereby impair its ability to identify the true scan line over the object. It also makes it more difficult to choose and appropriate Scan Line Isolation level.

10.2 Slide Projector Properties

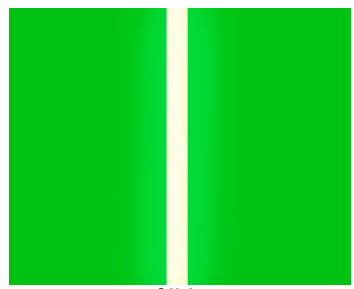
The slide projected scan line projects a more distributed and balanced intensity and suffers much less from the problems found when using a laser. It may not have as wide a range as the laser but it offers better peak performance under certain conditions. The projected line is much smoother and sharper than the laser. These contribute to more accurate and cleaner looking scans which include more detail and require somewhat less post processing.

However the slide projected method may require that the object be prepped since the intensity of the projected slide may not be sufficient otherwise. Prepping includes spray applying a washable layer of mat white paint to the object’s surface. This will result in a more visible scan line.

Another aspect is the Depth Of Focus of the slide projected scan line. The DOF is the range that the object remains in focus if moved closer to or farther from its set focus point in front of the projector. To increase the depth of focus the projector will have to be moved farther away from the object. This, unfortunately, reduces the light intensity or contrast as well as makes the scan line wider.



Laser



Slide

11. Capture Processing Options

TriAngles includes 3 ways to acquire a scan from the capture device:

1. Directly from the live video feed of the camera (on the fly) in either stand alone or PC control mode
2. Playback a recorded scan made with the camera to the computer
3. Playback a recorded scan made with the camera or live video feed and record this on the computer's hard disc

Each method offers certain specific benefit. The easiest and fastest way is to process the video stream directly from the camera during the scanning of the object. However it is also possible to have the camera record the scan and then play it back to the computer after the object has been scanned. This method offers more freedom to make more accurate adjustments so that a better scan can be produced. If you make wrong adjustments simply rewind and try again. It also has the benefit that a computer connection is not required during the object scanning. Hence, scanning can take place at a remote location without having to be directly dependent on a PC connection. The last method involves recording the playback or live video feed from the camera to your hard disk as an AVI file. This method offers the highest degree of post scan adjustments to be made.

The final method, which is related to the first method, is create a PC connection to the Turn Table to control it. This offers the absolute highest degree of control and performance.

11.1 Portrait or Landscape

TriAngles version 2 allows you to set the view to portrait or landscape by rotating the view. This option can be found by going to Video and selecting Rotate Video. In many cases the object that you are scanning does not use the full area of your cameras viewing field width, even when it is maximized within view. By setting the camera 90 degrees on it side you may be able to use the viewing area of your camera more effectively. The result can, in some cases, mean that you have effectively increased the resolution of your scan by as much as 25-30% while using the same camera.

11.2 What type of Camera?

While it is certainly possible to use a webcam as the capture device it is not recommended. Sure, you'll get a scan made and it may even turn out the way you want. But if you are serious about getting the best results try using a camcorder or anything better. Most webcams have CMOS type image arrays. Although this type of imager has come a long way, in terms of its technology and performance, the image it provides is only good under ideal conditions.

CCD type sensors have a much better signal to noise ratio and provide a much better picture, even in less than ideal conditions. Still webcam's, CCD or not, do not have very good optics, their maximum resolution is usually no more than 640 x 480 and they frequently include functions which can disrupt the scanning process.

Digital video camera's with picture stabilization and manual iris control or iris lock work best. These types of cameras typically have higher resolutions and have much better optics. 1080P camcorders are also now available. TriAngles allows their use as long as the required video codecs are installed on your machine.

TriAngles version 2 now also allows you to use mega pixel type video cameras found in industrial applications. Combined with the PC control feature you will now be able to make very high density scans. Just make sure your PC is up to the task!

11.3 Tricks with Textures

2D Texturing mapping is simply the mapping of a photo onto the surface of a 3D model. Yet once a texture is wrapped around a 3D model it can add an almost magical realism. It can also offer important solutions with regard to shape accuracy, elevated detail and 3D model file size.

Texture maps affect the appearance of a 3D model and not the mesh data. Basically this means that you can display a model in two different ways; the model surface or the model with the texture.

Tri Angles creates 2D circumferential texture maps which can be used to enhance the level of detail of a 3D scanned model. More precisely, this gives the appearance of a much higher level of detail.

Circumferential Texture Map

As mentioned earlier it is sometimes necessary to choose a small camera angle for certain objects. The consequence is that the shape accuracy will suffer unless occlusion reduction techniques are applied. Applying the scanned texture map of the same object can do a lot to compensate for this.

After you have made and saved a couple of scans it will be evident that the scanned models usually have very large file sizes. Typical file sizes can be as much as 70-180MB. This is huge in comparison to your regular 2D photo. Opening and closing files this large also involves a lot of processing time. Texture maps offer a trick to reduce file sizes without losing the detailed appearance of the scanned model. By setting the Circumference Scan Resolution, found in the Process Settings dialog, to a low value, during PC controlled scanning, the amount of scan lines acquired will be less. The resulting file size will also be much less. While this at the cost of scan detail applying a high resolution texture map of the object onto the low resolution scan will still yield a high level of detail.

Colored Surface

Surface with Blended Texture and Shine

Surface with Blended Texture

12 Occlusion Reduction Techniques

Up until now the scanning setup has included the use of a single camera and a laser to make a scan. While this permitted the scanning of basic shapes more complex shapes will suffer from occlusion or undercut. TriAngles includes Video Folding and Dual Camera Scanning that can effective reduce and even eliminate this. PC Control will be described before going into detail regarding these approaches.

12.1 PC Control

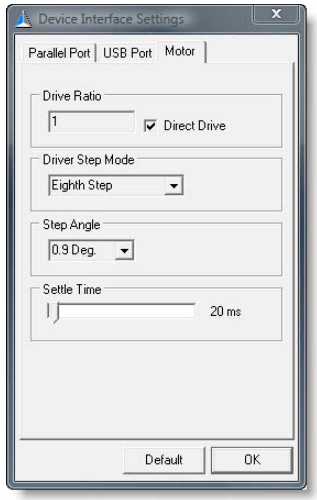
With the introduction of PC Control in TriAngles V2 the scanning process is now almost completely automated. PC Control allows new important features to be included as well as offsets the resource load allowing less powerful machines to be used for scanning. While not absolutely needed for Video Folding, PC Control is mandatory for Dual Camera Scanning.

The basic idea behind PC control is to control the Turn Table to make a certain amount of steps then stop to capture a frame and repeat this until a full 360 turn is achieved.

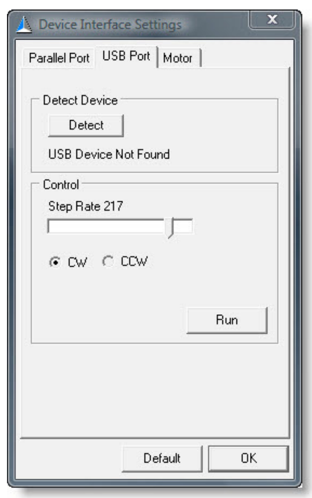
PC Control allows complete scanning control of the Turn Table through a USB or parallel port. Some of the features of PC Control include:

- **Setting Circumference Scan Resolution** You can now set how many scan lines you want. This allow you to better **match** the vertical resolution of your camera with the circumference resolution.
- **Image Frame Stacking** Noise from the imaging array (CCD or CMOS) is random. That being the case the noise in each frame of a static scene is different. By stacking frames of the same capture shot together you can cancel out much of the noise. This in return allows you to set a to a lower scan line isolation level and thereby more accurately capture detail with even less chances of spikes.
- **Mega Pixel Camera** Mega-pixel cameras equal out to greater resolution and hence higher accuracy. Apart from super dense geometry you can now make mega pixel texture maps that approach 2K (2048*2048) sizes. Make sure that you PC can handle the denser models.

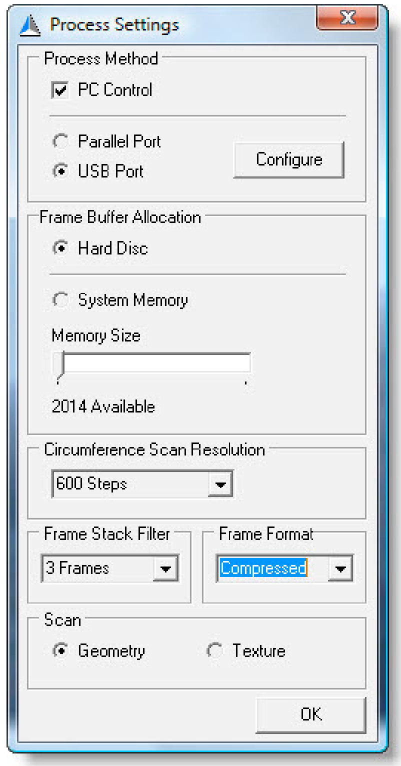
To use PC control simply set up the scanning layout. Connect your camera to provide live capture in TriAngles, power the turn table and then connect the USB to your PC. When first connected you will notice that the USB is being detected as a Human Interface Device (HID). The drivers are part of the operating system and are automatically loaded.



Once detected go to Scan > Device Interface Settings in TriAngles. This will bring up the Device Settings Dialog. Select the Motor tab. Set the various settings. Typically this would be to select the Direct Drive option in the Drive Ratio groupbox, Set the driver step mode to Eighth Step, Step Angle to 0.9 (400 step) and the Settle Time to about 20 ms. The Settle Time is a feature which sets a delay time between scan steps. Although not always directly noticeable the object may very slightly shake back and forth between steps. By introducing a settle time delay you prevent capturing these shaky frames. This is of particular importance when making texture scans which would otherwise making them slightly blurry.



Select USB from the tabs in the Device Settings dialog and then press the Detect button. TriAngles will now attempt to detect the Turn Table. When detected Set the Step Rate to about 250. The turning direction will depend on how the motor is wired up. The direction selected should turn the table counter clockwise when the table is view from above. Press the Run button. The Turn Table should now start making steps. Use the Step Rate slider to set the rotation speed. During scanning if the speed is to high you will be able to set this here.



We can now start to make a scan with the above achieved. Go to Scan > Process Settings. In the Process Settings dialog select the PC Control checkbox and the USB radiobutton in the Process Method groupbox. In the Frame Buffer Allocation groupbox select the Hard Disc radiobutton. Set the Circumference Scan resolution to a very 600 steps. Select Geometry in the Scan groupbox.

The two remaining groupboxes are Frame Stack Filter and Frame Format. Frame Stack Filter should be set to 3 Frames. In subsequent scans you can set to this to other image stack frames settings and thereby reduce noise. Using this option will however increase scan time. The Frame Format can be set to Uncompressed, Compressed or Clipped. Uncompressed uses the raw bitmap as a frame which captures the exact detail but results in relatively very large frame sizes and slow processing. The Clipped option will also take more processing time but results in very small frame size. In practice the Compressed frame setting offers the best of both and is most typically used.

Close the Process Settings dialog and go to Scan > Compiler. Determine the Center Mark or otherwise the center of the Turntable and set this. Set the Frame Manipulations to No Rotation, uncheck Fold Frame if Checked. Close the dialog.

Go to Scan > Initialize and then press Start. The process will now automatically process frames and then stop once it has made a full turn. Process the scan normally. One annoying aspect of the process are consumer type video cameras which include a standby function. In most cases this standby function cannot be disabled and will set the camera in standby mode after a minute or two which means that the video feed closes. In such cases the only way to circumvent this is to record while scanning. The recording is not used but it prevents the camera from going into standby mode.

12.2 Dual Camera Scanning

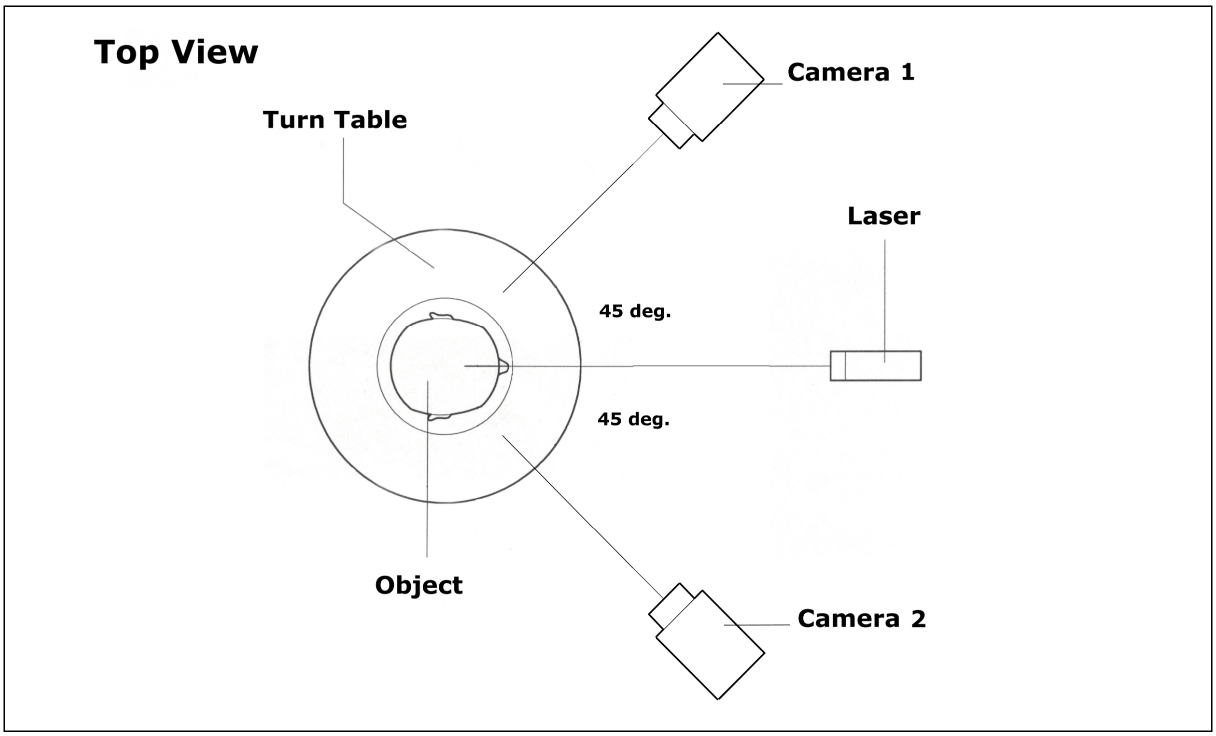
Dual Camera Scanning should be evident in terms of workings. Hence, instead of a single camera, which is prone to occlusion, use 2 cameras and set them at opposite angles facing the object that is to be scanned. The video feed of both cameras is combined. If one camera can’t see a particular area during scanning then there is still a good chance that the other camera can see it. Occlusion is thereby brought down to a minimum and in some cases even eliminated. Dual camera scanning requires two identical cameras. It sets a heavy load on your PC and requires a lot of adjustment to set up correctly. It is however perfect for applications in which many similar type objects need to be quickly and accurately scanned in a fixed layout with certainty of result.

The Dual Camera layout only works in PC Control mode since it requires a substantial amount of resources.

IMPORTANT NOTE

One very important aspect regarding the use of the Dual Camera mode is the interface. Most camera drivers should allow multiple cameras to be used but in practice this is not always the case. The result is that while two identical cameras will both be separately detected when plugged in, the unplugging leads to a confusion for the OS. The typical result is a system crash (blue screen). The only way to avoid this is to only unplug one of the cameras and unplug the other only after switching off the PC.

In order to use the Dual Camera function plug in two identical cameras. Make sure that the sum of their connection load is not hogging the bandwidth of a single interface. For instance, when using a hub to connect two USB cameras the second may result in too much bandwidth being required. In this case use another root USB connection. With both cameras connected run TriAngles and then go to Video > Dual Camera > Set Devices. This will bring up the Set Devices dialog. Select your 1st camera from the drop down list and set its resolution. In the second Device list select the 2nd camera. Set the resolution to the same value as the first camera. In case cameras differ in internal settings then this may lead to polarization effects in the video. If so then go Video > Show Video Panel. In the Video Panel press the Dual Camera Button. You will notice that you can select to open Std. Controls for each camera. Do this and check that settings are identical. With bth cameras ready you will notice that the video displayed is a combination of both video camera feeds. This can become confusing at times when aligning the camera. In the Video Capture Panel you can select to hide one of the cameras.



Aligning the cameras to produce a combined view is no trivial task. It is important to first make sure that camera resolution and other settings are same. Next the picture size or zoom as well as iris setting must also be identical.

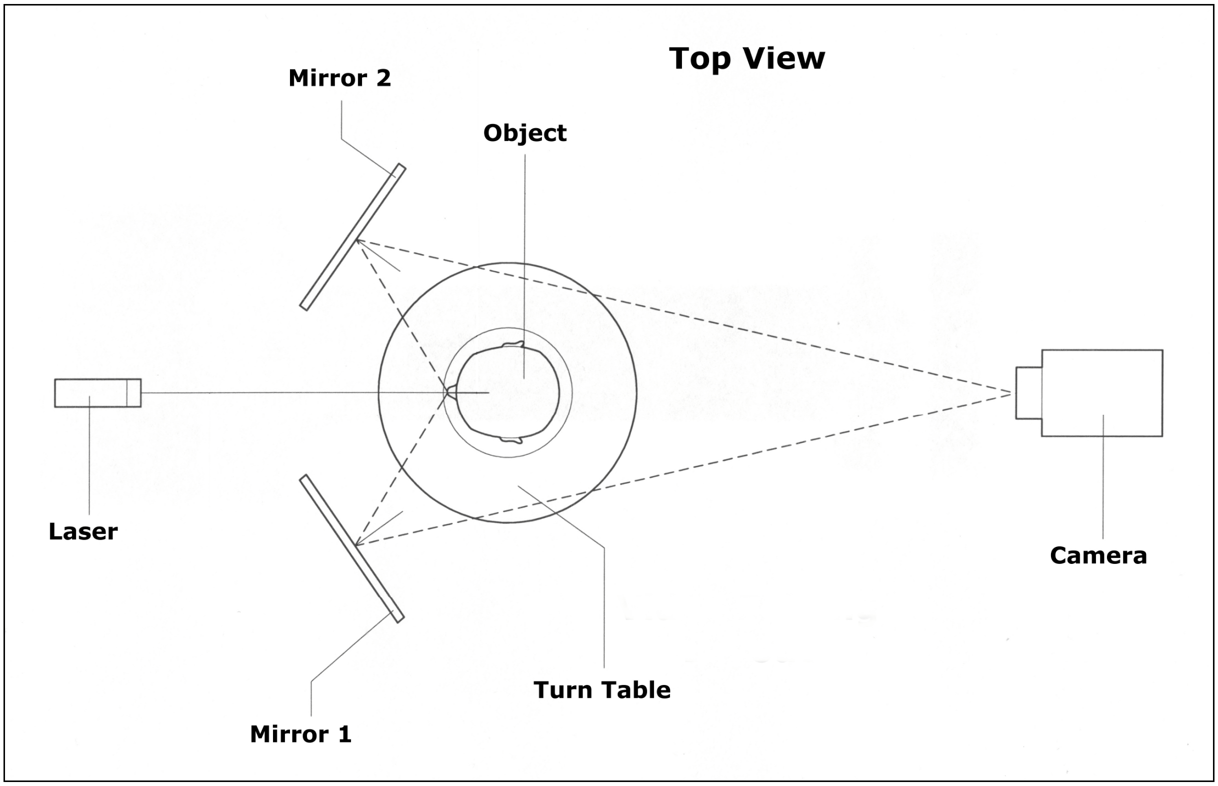
The laser is set to project a line on the object. The laser must be absolutely vertical. At both sides of the laser station each camera about 45 degrees from the laser. Later, when setting the Camera Angle in the Compiler Settings dialog set it for 45 degrees.

The fine tuning now begins. In a docile manner adjust one of the cameras to line up the laser line on the object with the other laser line. This may take some time as you will need to get a feeling as to how the positioning of the camera effects the alignment.

Once alignment has been achieved then the hard part is over. Its now simply a matter of making a scan using PC control as described in the previous section.

12.3 Video Folding

Another approach to occlusion reduction is Video Folding (Patent Pending). In this case a single camera is used along with two mirrors. The idea is to set the mirrors at opposite angles. Both mirrors view the object but at opposite sides. The camera is placed opposite to view the mirrors. One half of the video frame that is viewing one of the mirrors is folded over as it were over the other half of the video. The two views are combined to form a single view. Much like the Dual Scan setup, the Video Folding setup allows you to view two views from opposite sides. Hence if one view has occlusions the other may not thereby eliminating the occlusion. Video Folding is less difficult to setup than the Dual Camera approach but object size is restrict by the size of the mirrors.



To setup the layout for Video Folding place the mirrors behind the Turn Table with a 45 degree spread. The mirrors should be about 120 apart. Between the mirrors place the laser support stand and project the laser onto the object that is to be scanned. Just as with the Dual Camera, the laser must be absolutely vertical in order to facilitate correct alignment. Opposite to the laser place the camera. The camera view must be set to allowing viewing of both of the mirrors. In case the laser is directly seen by the camera then adjust its height so that it is hidden behind the object. In TriAngles capture the camera feed and then select Video > Fold Video. Adjust the mirrors to allow alignment of the left and right side views of the laser line to line up. Once achieved turn the object by hand on the turn table around and view the video. Make sure that the laser lines stay in alignment. If not then adjust the mirrors. It should be obvious that the layout must be on a flat even surface or alignment will be very difficult to achieve. Once the alignment is certain then make scan. During scanning the Video will unfold to reduce the CPU load. You can select the Fold Video checkbox in the Compiler Settings dialog before compiling the scan.

13. Photo Orbit Scan…Not 3D

Apart from 3D geometry and texture scanning TriAngles also includes a Photo Orbit Scan feature. This is a small stand alone application that allows you to scroll through and zoom scan frames. The idea is to make a scan under well lighted conditions. After scanning you can go to File > Save Scan Frames. All of the captured frames will be placed into a folder that you specify along with the Photo Orbit Scan application. By running the application you can load and view the object by using your mouse to drag through frames.

In some cases you may not require the dynamically viewable 3D geometry. You may simply want the ability to easily look around an object. Photo Orbiting allows this. While Photo Orbit viewing is certainly Not 3D it gives a very realistic 3D impression.

By placing your camera onto the turn table and recording while it makes a turn you can also create a Photo Orbit scan of a scene.

14. Absolute Base Requirements

As mentioned throughout the manual, 3D scanning, as well as the post processing of the acquired data, sets a heavy load on a computers CPU, GPU and memory. Certain processes are also time dependant and will fail unless the employed PC offers the required performance. The following chart includes the absolute base requirements needed to run and use Tri Angles.

PC

Unit	Absolute Minimum	Advised
CPU	1 GHz	3 GHz
System Memory	1024 MB	4 GB
Hard Drive	35 GB (high speed)	160 GB (7200 RPM), SATA 2
Free Drive Space	3 GB	25 GB
Graphics Adapter	64 MB (not Shared), OpenGL Compliant	256 MB (not Shared), OpenGL Compliant
Operating System	Windows 2000, XP (Vista not Tested)	Same
Video Interface	USB, FireWire, Composite In	Same
Pointing Device	3-button, scroll-wheel mouse	Same
Other	DirectX 8 and Above	Same

Camcorder

Unit	Absolute Minimum	Advised
Focus	Auto/Manual	Auto/Manual
Iris	Auto	Auto/Manual
Picture Stabilization	-	Yes
Digital	Analog/Digital	Digital
Tape/HDD/DVD	Tape/Hard drive	Tape
Remote	-	Yes
FireWire	USB, FireWire, Composite Out	FireWire

Note: HD 1080i type camcorder resolutions have not been tested. However provided that the required codec's are available on the PC that is processing the video then this should permit the use of Tri Angles. High end PC will be required as the processing load will be 4 times greater than using standard video.

15. Tri Angles 3D Scanner Specifications

Scan Type	3D Non-Contact Circumference Scanner
Scan Technique	Point Triangulation
Scan Method	Deformation of projected pattern (stripe) over the 3D object/scene (laser, projection) to indicate depth points
Scan Sensor	CCD type visual array, video camera (recommended)
Scan Range	Depends on scan set up and optics
Scanning Speed	Typically less than 60 seconds at full video resolution per rotation pass
Scanner Accuracy	Factor 100-200 times less than height of object
Scanable Materials	Most opaque surfaces. (Mat white surfaces are best)
Texture Scanning	Yes
Hardware Footprint	Desk top
PC-less scanning	Yes
Hardware control	Manual (Motorized turn table)
Software Features	Auto interface to CCD video (Composite, USB, FireWire), AVI recorder, Pre scan filters and process control, device interface control, post process transformations (patching, smoothing etc.), hardware rendered graphics, export to popular formats: STL,DXF,RAW,PNT,VRML,OBJ and a compressed native format TXS