Unleashing the Power of the Panorama - Part II

Part I provided a brief history of panorama paintings and photographs and highlighted the modern trends of using navigable panoramas on the major on-line mapping sites to provide the user with a much more immersive real-world viewing experience than conventional web maps. I am writing Part II to encourage land surveyors to explore using partial and full 360° panoramas for documenting their works as well as actually making quantifiable measurements and mapping visible objects. I will also provide some practical tips on how you can easily obtain birds-eye aerial views and truly unleash the power of the panorama.

Why Panoramas

Panoramas are unique compared to conventional photographs, as they provide a complete 360° horizontal by 180° vertical view of an image space from the point of capture. With the advent of modern digital cameras and automated processing techniques, it is fairly inexpensive, fast and easy for a layperson to capture and create a full 360° panorama.

As land surveyors, you know you cannot map a 360° panorama spherical view onto a plane without distortion. There are many map projections that could be used to map the panorama, however, the most common is cylindrical and equirectangular (Plate Carre) projections. A 360° panorama mapped to an equirectangular projection looks quite normal in the mid-section which is the most commonly viewed portion, however the top and bottom parts become severely distorted. A unique feature of the equirectangular projection is that relative angles (horizontal and vertical) are preserved. This enables the image to essentially function as a direction theodolite. This quality provides the means to be able to measure and map objects from two or more panorama nodes via simple bearing-bearing intersect.

There are many web-based and stand-alone tools available to allow you to immersively view a partial or full 360° panorama. You can zoom in and pan around to see any part of the panorama in a user sizeable window. The software re-maps the panorama image, on-the-fly, to an undistorted rectilinear view (up to about 110°). Panoramas can be immersively viewed on computers, C. E. devices and Smartphones. Simple tools are available to extract rectilinear views centered on any perspective within the panorama. Viewing controls can be added to enable very sophisticated scripted node to node transitions, links to maps, hotspots and many other functions. As you can see, panoramas present a very flexible and robust viewing platform compared to conventional photograph as well as the all-around view potential for measuring and mapping visible objects - a very useful tool for land surveyors.

Another powerful feature for a panorama is to elevate the image capture point a number of metres above the ground. This birds-eye perspective allows you to easily see many more objects in the image scene - you essentially create a theodolite in the sky. These tools enable you to better document projects such as engineering works, construction, facilities, accident scenes, natural boundaries, etc. with the added bonus of being able to latently (in the office) map objects as a quality control check or add a feature where something was missed in the original field pickup.

What Gear Do You Need

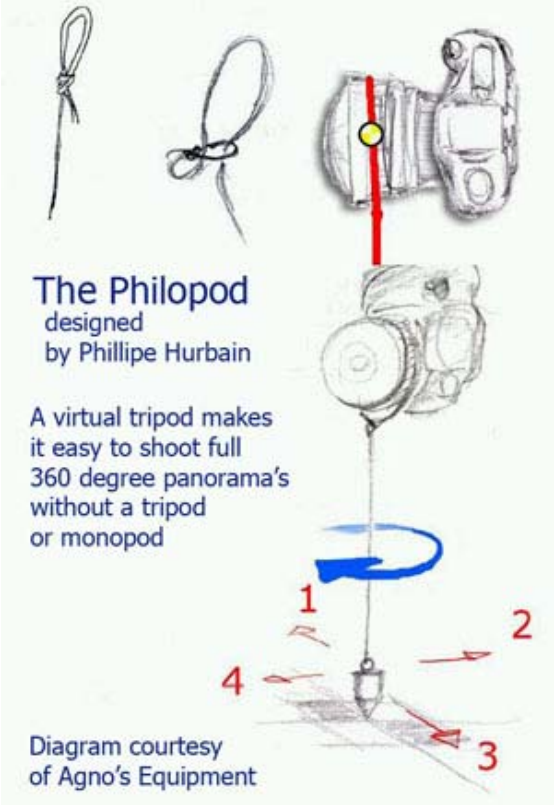
A few years ago, it was most cost-effective to use a Prosumer level digital camera with an add-on full frame or circular fisheye lens to create panoramas. I still use my Nikon 5000 with an FCE8 lens (original cost 4 years ago approx. $1300 (camera) and $360 (lens)). You could probably purchase these on eBay today for about $500. I find that the most critical camera feature is to be able to lock the exposure control. This will ensure that each overlapping image will be at the same exposure setting and will then blend properly. Another critical item is to use a good quality super wide angle lens. This will minimize the number of images and time required to capture the panorama as well as reduce the panorama creation time. The horizontal field of view of the FCE8 circular fisheye lens is about 185°. This will

enable you to capture a full 360° panorama with 3 images, however, I often take 4 images to provide a little more sidelap as it is easy to manually judge taking the images at 90° angles from one another. My Nikon 5000 is a 5 mega pixel camera which provides adequate detail using full circular fisheye images. The standard DSLR camera today provides a 10 mega pixel image

The cost of digital single lens reflex (DSLR) cameras has dropped dramatically over the last few years to a level within the reach of the average consumer (< $1000). These cameras are rich in features and ideal for capturing panoramas. There are a number of excellent fisheye lenses available for DSLR cameras. The most popular are the Sigma 8.5/f3.5 mm ($625), the Peleng 8mm/f3.5 ($380) and the Nikor 10.5mm/f2.8 ($570).

Full 360° panoramas can be taken using a handheld camera by rotating the camera for each shot about the "No Parallax Point" (NPP) of the lens (often referred to as the nodal point). A plumb-bob can be looped over the NPP of the lens to ensure the camera stays centered and at the same height above the point. It is also best to keep the camera as level as practical by using a hot shoe bulls-eye bubble and try to minimize pitch, roll and tilt.

Most often you will want to use a camera monopod or tripod to take panoramas. If you want to take full 360° panoramas you will need to use a panorama camera mount that will allow you to mount the camera so that it will spin about the NPP. This will minimize the effect of parallax which is generally not as critical outdoors where objects are further away, however, you will notice the affects of parallax much more in indoor panoramas.



If you are creating a panorama from multiple sidelapping images, you will need to stitch the images to a seamless single image. Professor Helmut Dersch (Furtwangen University) spawned an international community of panorama enthusiasts by creating a powerful set of open source image processing/stitching tools called PanoTools during the mid 1990's. The original program was command-line based and required significant effort to learn to use it effectively. A number of commercial graphical user interfaces were developed to enable an average user to easily stitch a panorama. These programs have matured greatly and have been enhanced to be very automated so that a layperson can create panoramas effortlessly. The most popular application is PTGUI. It is interesting to note that a SIFT algorithm was developed and patented by scientists at UBC that uses advanced image recognition techniques to automatically stitch a set of overlapping images to a panorama. The user can just point to a folder containing the images and the software will automatically process the image even if they are not in any particular order. A French developer has created a GUI called Auto Pano Pro that uses the SIFT algorithm. There also is a very active open source community that has created a stitching program called HUGIN based on enhancements to Professor Dersch's PanoTools. This is becoming a very powerful package that has features that some commercial packages do not even offer.

One by-product of the image stitching process is the automatic calculation of the field of view and the lens distortion parameters. Once these parameters are known for a camera/lens combination at a certain aperture setting/focus, the user can re-map a fisheye image with a click of a button. The software will also allow you to extract a rectilinear view from any perspective.

The above notes provide a very brief overview of the panorama capture and creation process. I highly recommend that you visit the http://wiki.panotools.org/Main_Page site and wiki (the ultimate guide) to obtain comprehensive information and tutorials on these processes.

Birds-Eye Aerial Panoramas

As land surveyor's work is often outdoors, you may want to explore using birds-eye aerial views to document a scene. It is very easy to do, however, you will need some special equipment. First, you will need a telescoping pole to mount your camera. There are some commercial poles available that will reach up to 25 feet or more above ground level. I use a telescoping fibreglass pole that is used in the hydro-electric industry. These poles are built to withstand an electrical shock from power lines and are dialectic tested to ODHA and ASTM F-711 standards. It is critical to stay clear of power lines when using an elevated pole in urban areas and I highly recommend using a pole designed to the power industry standard. I use the Hasting Industries HMV-40 Tele-pole™. This pole extends up and down quickly and has an easy-to-use push button to lock/unlock the pole sections in place. I have taken panoramas up to 35 feet AGL with the Tele-pole, but that is pushing it - up to 25 feet AGL is practical. The pole can also be inserted into the top centre of a survey tripod for hands-free operation.

If you use a non-commercial pole you will need to fabricate an adaptor for the top of the pole to directly mount your camera or panorama camera mount. This can be easily done using aluminum or plexiglass. It is also very helpful to fabricate a mount for a bulls-eye bubble to keep the pole vertical as well as add a platform for a digital flux compass to set the directions for proper sidelap for the panoramas.

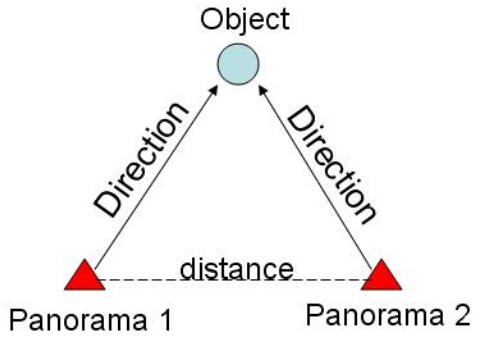
Another good pole option is a standard painting/janitor pole which some will extend up to 18 feet. The mount for these poles is a coarse 5 TPI thread. You will have to be creative to make a camera mount for these poles and you will find some examples on the internet. I find the poles with one foot buttonlock increments are the easiest to use. Some of them will extend up to 12 feet which will still give you a good elevated view. As land surveyors, we have access to prism poles that will extend up to 4.5 metres above ground level. Again, you will have to fabricate an adaptor to mount your camera, however, the pole will have a built in bulls-eye level.

There are a number of ways you can trigger the camera shutter when using a camera mounted on a pole. You could simply use the 10 second camera timer. This is inconvenient if you want to take multiple pictures for a full 360° panorama round. A better choice would be to use a wired remote control which is practical up to about 15 feet AGL. For greater heights, you will need to use a radio remote camera control. There are a number of inexpensive third party suppliers.

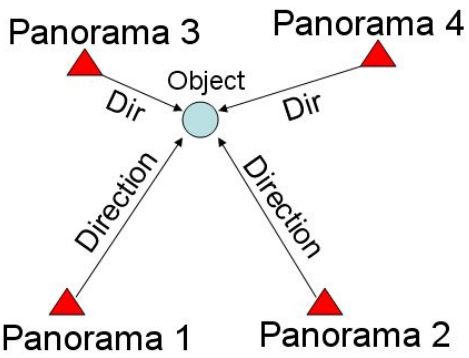
How to Measure or Map Visible Objects

As a minimum, you will need to take panorama images at two intervisible locations in order to measure or map (determine coordinates) of a visible object within the panorama's. The panorama points should be located so that any objects that will need to be mapped are visible from both locations. You can improve the accuracy of the positioning solution by using three or more panorama nodes as shown in the network diagram.

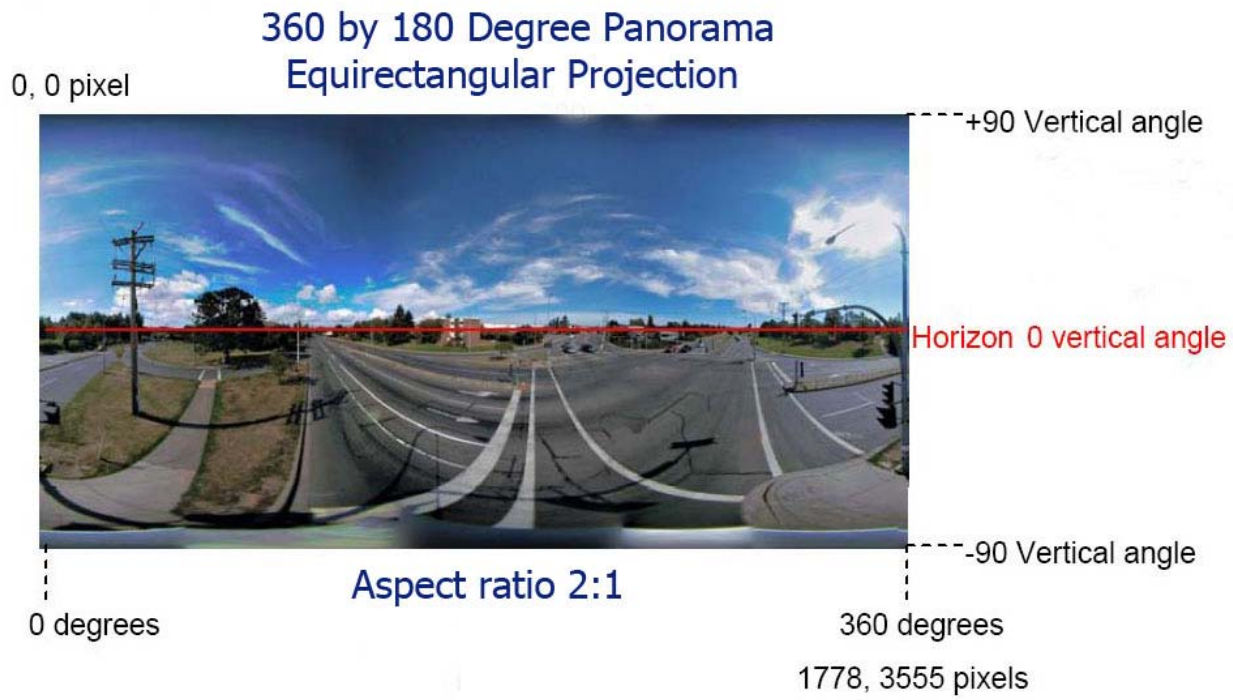
Simple bearing bearing intersect to object point



Four point panorama photo survey network

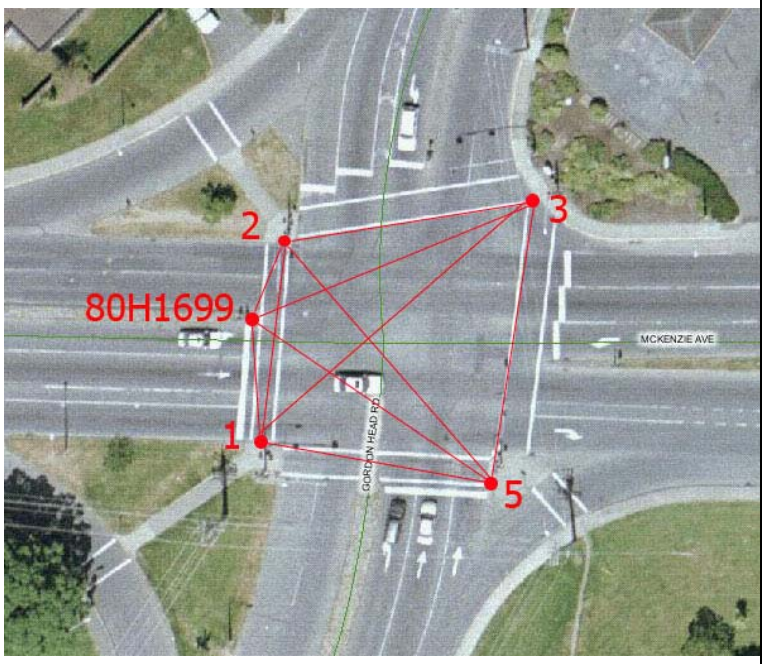


You will see from the diagram that if you know the distance between the two panoramas and you derive relative directions to a visible object from each panorama node you can simply calculate the object coordinate using a bearing-bearing intersect solution. The relative directions to the objects can be derived from the panorama image. If you map the panorama to an equirectangular projection (standard output for stitching software), you can then open up the image in an image processor (Photoshop Elements or equivalent) derive the directions by simple ratios (see diagram). You can derive horizontal directions or vertical angles, although, I have found that it is much more difficult to correctly model absolute vertical angles.



As land surveyors, we know that there is no redundancy in a two point intersection. In order to improve the positioning solution, we could include additional panorama nodes at selected points to form a photo survey network using the same control network principles we would use for legal or site surveys.

This aerial image shows a five point panorama photo network. The directions are derived from the panoramas and scale was derived using a handheld laser ranger. Approximate coordinates were derived from autonomous GPS observations with one minute of averaging position values.

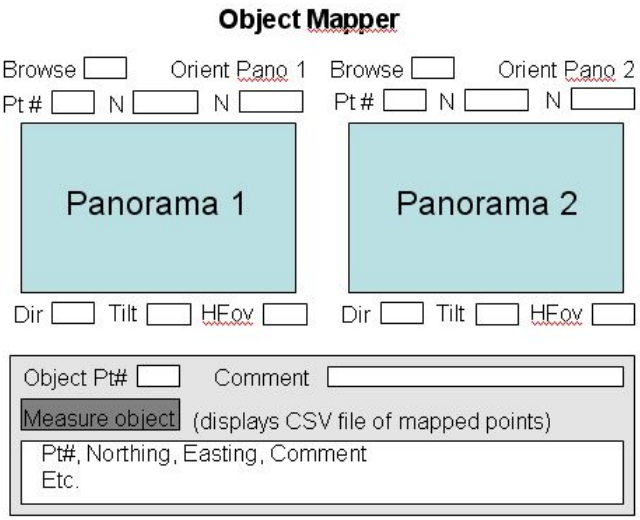


The observations can be easily adjusted using Gama Least square adjustment (open source software) to derive coordinates for each panorama node. Gama can then be used to calculate the coordinates of visible objects by inputting relative directions from multiple panorama nodes. I have found the results can generally be sub-decimetre accuracy.

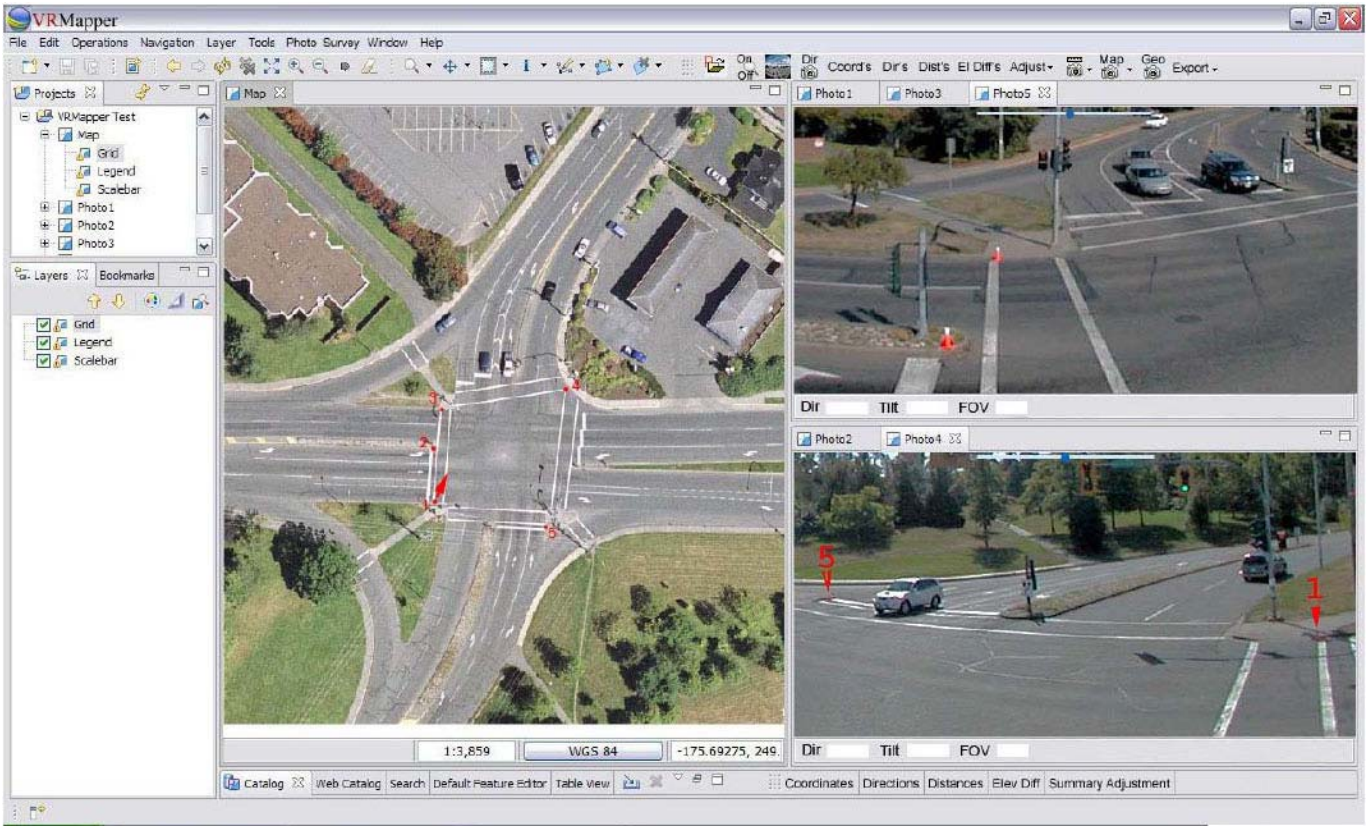
Deriving directions using an image processing program, manually coding the input file and adjusting the observations and calculating object positions is fairly tedious work. It would be relatively easy to create a free user web interface to embed two instances of PTViewer (open source panorama viewer by professor Dersch) to immersively display panoramas to quickly derive direction observations, add input forms to input distances, coordinate observations and run the Gama photo network adjustment and object coordinate calculations. Diagram - shows mock-up interface that would make the whole process simple and fast for any user. If anyone would like to collaborate on this project, please contact me at jim@vrmapper.com.

Basic Workflow:

1) Knowing distance between intervisible panorama 1 and 2, determine coordinates of each and input values to form (could have form tool to calculate this)
2) Browse to open the two panorama's
3) Click *"orient 1"* then mouse click on the location of panorama 2 within panorama 1
4) Click *"orient 2"* then mouse click on the location of panorama 1 within panorama 2
5) If desired, fill in object Pt# & comment and then click *"Measure Object" and* navigate and click on the object within each panorama. Object coordinates are displayed in CSV format in results window



The ultimate solution to me would be to use an open source geographic information system framework like user friendly Desktop Internet GIS (uDig) to create a plug-in that integrates panorama viewing, the Gama adjustment and object calculation functions. Diagram - provides a glimpse of a possible uDig interface containing these functions. This would be an excellent project for a group of graduate students to undertake.



Conclusion

As camera technology and associated panorama processing programs have greatly matured over the last decade, it has become easy and inexpensive for land surveyors to integrate this technology in their business workflow for many projects. Whether it is to simply document works, immersively analyse or showcase a project site or latently measure or map critical objects the opportunity is open for members to truly unleash the power of the panorama.

Footnote – Laser Ranging Platform for Resource Specialists

Land surveyors have access to total stations that provide an easy means to measure distances and coordinate points, whereas, the average person or resource specialist must use a tape measure (not practical in urban corridors) or other economical means to obtain scale. With the maturing market in laser ranging technology, the average person can afford a hand held laser ranging device which has dramatically reduced in price over the last couple of years. Leica GeoSystems and Stanley Tools collaborated to create the FATMAX TLM-100 ($100) laser ranger that will measure up to 30 metres to millimetres accuracy. Bausch recently created the DLR165K laser ranger kit ($150) that has many features and a range of 50 metres which is ideal for adding accurate scale to panorama photo survey networks.

Recent availability and affordability of miniature digital inclinometers (accurate to 0.1 degrees) provides an easy means for deriving accurate slope angles. This provides an opportunity for the average resource specialist to become creative by fabricating a laser ranging platform. One problem with the handheld laser ranger is that it is not visible in bright daylight. Therefore, the biggest challenge is to integrate an effective sighting device that can be calibrated to be in-line with the laser ranger. An easy and practical solution would be to use a red dot sight commonly used for rifles. I am in the process of fabricating and testing a home made laser ranging platform. I will post my test results on my website www.vrmapper.com along with other helpful notes about panorama photo survey networks. Please feel free to contact me with any questions you have and I encourage you to experiment with creating your own tools for capturing panoramas and elevated birds-eye views – please share your experiences.

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