

A Preliminary Analysis of the Application of Panoramic Photography Technology in Architectural Engineering

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Abstract

Panoramic photography is a specialized imaging technology that has gained popularity and been widely adopted in recent years, capable of generating 360° three-dimensional spatial scene imagery. Panoramic cameras such as Ricoh Theta and Xiaomi panoramic cameras feature simple operation and stunning effects, enabling one-click generation of 360° three-dimensional roaming imagery, thus finding extensive application across various scenarios. The introduction of panoramic imaging technology into the construction engineering field facilitates applications such as capturing panoramic samples, creating interactive panoramic tours, and producing full-cycle aerial panoramic records, thereby providing a novel visual experience for site management. Case validations demonstrate that the application of panoramic imaging technology in construction engineering possesses substantial potential for development.

Full Text

A Preliminary Analysis of the Application of Panoramic Photography Technology in Architectural Engineering

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Abstract: Panoramic photography is a special imaging technology that has become popular in recent years and has begun to be widely applied. Using panoramic photography technology, 360° three-dimensional spatial scene images can be generated. Panoramic cameras, such as Velodyne Lidar, Xiaomi panoramic cameras, etc., are simple to operate and apply, produce impressive results, and can generate 360° three-dimensional roaming images with a single shot; their application scenarios are very extensive. Introducing panoramic photography technology into the field of architectural engineering makes it possible to photograph panoramic samples, produce interactive panoramic roaming, and create full-cycle aerial panoramic records, etc., bringing a new visual experience to site management. Case verification shows that panoramic photography technology has considerable room for further application in architectural engineering.

Keywords: panoramic camera; unmanned aerial vehicle; 720 Cloud; VR; PT-Gui; construction management

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1 Introduction

The “panorama” discussed in this paper is not the stitched “panorama” now available on intelligent terminals such as smartphones for fixed-point circular photography. Rather, the panorama discussed here refers to 360° three-dimensional spatial scene images taken by a dedicated panoramic camera, or 360° three-dimensional spatial scene images taken by an ordinary camera and processed with professional software; it is also called VR virtual-reality panoramic photography. The panorama in this paper is a virtual-reality technology based on real scenes: through computer image processing, it realizes 360° restoration of the real scene. On an ordinary webpage or in a professional client, the viewing angle can be controlled with a mouse, and viewing up, down, left, right, near, and far can be controlled, achieving an immersive feeling of being in a three-dimensional virtual space. It can provide elementary experiential material for VR devices. Typical applications include Google Maps Street View, Baidu Maps Street View, and the 720 Cloud panoramic platform.

Panoramic photography technology has the characteristics of realistic and life-like reproduction, smooth playback, low hardware requirements, low secondary-development costs, strong navigation interactivity, and broad application scenarios.

There are many points of application in combining the construction industry with panoramic photography, such as panoramic display of fine-decoration effects. By using a panoramic camera to photograph fine-decoration sample rooms, the results can be publicized on the internet, allowing customers to experience the room effect without leaving home. Panoramic display of physical architectural samples can save the investment required for actual on-site sample production, and can also share sample materials and provide technical handover to workers. Using an unmanned aerial vehicle to shoot images and synthesize them into panoramic images can cover an entire construction project; the project’s image progress and site appearance should be fully covered, making it convenient for managers to supervise project progress and reasonably carry out floor-plan deployment. In addition, recording the entire process is of great significance for the whole project.

2 Application of Panoramic Cameras

2.1 Introduction to panoramic cameras

Most people first come into contact with panoramas through Google Street View or Baidu Street View. Because their novel browsing and experiential modes give people a very striking impression, the cameras used to acquire the images are all professional customized cameras (camera parameters and image-processing technology aside). To achieve the effect seen by users, other high-end hardware support is also needed, such as GPS, gyroscopes, and so on.

The professional-grade panoramic cameras more commonly used in applications

generally consist of four camera lenses, which synchronously expose to shoot 360-degree panoramic images; the panorama is then synthesized through built-in image-stitching technology. At present, foreign brands such as iris360 and GoPro are relatively widely used, but their prices are relatively high and they are generally aimed at enterprise users.

With the popularity of panoramic cameras in recent years, Japan in 2013 first launched an entry-level panoramic camera, Ricoh Theta, based on two 180° fisheye lenses for panoramic stitching. It can shoot and synthesize panoramas quickly with one click, and can also be remotely controlled by a smart terminal for shooting. The imaging basically does not show—

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scratches and stitching traces, and they are not expensive. At present, similar products include Nokia OZO, insta360, Xiaomi Mijia, and others.

Because the core technologies of panoramic cameras involve image acquisition, stitching, processing, and projection, and because the author is not a specialist in this area, only a brief introduction is given here. The panoramic camera used by the author is the non-professional-grade Ricoh Theta; this paper therefore discusses the application of the Ricoh Theta in architectural engineering.

Figure 1 iris360 panoramic camera (image source: Internet)

Figure 2 Ricoh Theta panoramic camera (image source: Internet)

Figure 3 Imaging components (image source: China-Japan Technology Industry Information Network)

Figure 4 Shooting, transmission, and preview on the panoramic-camera APP side

2.2 Use of the Panoramic Camera

The Ricoh panoramic camera is simple to use. After startup, it enters the default shooting program; pressing the camera's physical shutter button completes panoramic shooting. It can also switch between panoramic photography and panoramic video recording. The camera supports wireless connection with smart terminals, but the corresponding control APP for this product must be installed on the smart terminal. Through the APP, remote shooting can be controlled; at the same time, a panoramic preview can be generated on the APP side, so that the panoramic effect can be experienced immediately after shooting. The captured images can be edited in the APP and shared directly to the Internet, but only

Figure 6 panoramic camera PC-end panorama operation preview

Figure 1: Figure 6 panoramic camera PC-end panorama operation preview

Figure 5 Original fisheye preview of panoramic-camera photo on the PC side can upload and share a single image.

The Ricoh panoramic camera can download captured materials to the PC end. The original captured photographs downloaded are JPEG files; when opened with an ordinary JPEG file viewer, what is seen is a horizontal 2:1 distorted image. At this point, the image must be opened with the aid of the Ricoh panoramic camera PC application. The PC application projects the JPEG image onto a spherical surface, and what is seen is a spherical panoramic image.

Figure 6 Panoramic camera photo PC-end panorama operation preview (multiple viewing modes)

2.3 Application of Panoramic Cameras in Architectural Engineering

Like ordinary cameras, panoramic cameras can be used to record project image logs, photograph refined mock-ups, and record the construction process throughout the whole life cycle of a building. The only difference is that the visual experience provided by a panoramic camera is more realistic. With professional programs, multiple panoramic scenes can be integrated and interactive hotspots can be set; it can also be used with VR glasses for virtual scene experience.

(1) Used for photographing full-scale process mock-ups

At many construction sites, full-scale process demonstration mock-ups are made at the beginning of work. This consumes time, labor, and money, and the mock-ups may ultimately be demolished. Now, panoramic cameras can be used to record the entire process demonstration physical mock-up and share it online. At the same time, interactive hotspots for safety and technical briefings can be set within the images, so that the owner, supervision party, construction party, labor subcontractors, and others can all share the resources. Even front-line workers can learn, through a terminal, the mock-up construction process and key points to note in safety and technical briefings, etc.

(2) Used for photographing decoration and fit-out mock-ups

Online house selection and online house viewing are now common marketing methods used by many real-estate developers. By using panoramic cameras to take panoramic photographs of finely decorated model rooms, customers can directly experience the room layout, size, and decoration effect without going to the project site. Some panoramic model rooms use software to virtually synthesize panoramic images; customers can make self-adjustments to the decoration layout and replace materials, thereby creating their own ideal virtual room.

Figure 7 panoramic camera application scenario selection

Figure 2: Figure 7 panoramic camera application scenario selection

(3) Used for photographing panoramic image logs

Image logs are image-record materials that need to be retained during the construction process. The traditional mode at present is camera photography, but the recording angle of a camera is single; sometimes, if there are no surrounding buildings or reference objects, it may be difficult to know the photographed floor and location. With a panoramic camera, the photographed engineering part can be easily identified. This provides good support for recording project progress, controlling the quality and safety of construction work surfaces, site appearance, design-change claims, commercial measurement, and the entry of materials and supplies. It may also become a unified record standard within the industry in the future.

(4) Used for real-scene site navigation

To win social benefits, some engineering projects are often opened to the public to receive visitors. A panoramic camera can record the whole view of a project in advance and produce multi-scene navigation maps, allowing visitors to conduct a full-scene roaming tour of the project on the web in advance. Some advanced, novel, and distinctive engineering projects are highly attractive to people in the industry. Such engineering projects can produce panoramic navigation for publicity and strengthen mutual communication and learning.

(5) Used for integration with BIM technology and VR technology

With the application of BIM technology and VR technology, the author has found that panoramic cameras can be fully integrated with BIM. For example, interactive hotspots can be set in a BIM model to embed the actual panorama of the project site into the BIM model. By comparing the real scene with the model, problems can be discovered. The panoramic camera itself provides image materials for VR devices. By embedding panoramic interactive hotspots in the engineering model, users can enter panoramic hotspots when experiencing the model with VR devices. If historical panoramic records are photographed at the same location, using VR to experience historical scenes will produce an even more novel effect.

Figure 7 Selection of panoramic camera application scenarios

2.4 720 Cloud Platform Creates Multi-Scenario Interactive Panoramic Experiences

With the aid of client software such as 720 Cloud, panoramic materials photographed by panoramic cameras can be integrated, made interactive, embedded, shared, and used for VR experiences. The 720 Cloud client performs cube-

Figure 8 Panoramic camera application scenario selection

Figure 3: Figure 8 Panoramic camera application scenario selection

Figure 9 720 Cloud client-side scene production operation interface

Figure 4: Figure 9 720 Cloud client-side scene production operation interface

map conversion (an image parsing and conversion algorithm) on panoramic JPEG-format images with a 2:1 width-to-height ratio, converting them into VR virtual-reality mode images, and can integrate

multiple images are converted; each image becomes a virtual scene. Images converted by 720 Cloud can have interactive hotspots set within the image. Interactive hotspots include map sand tables, links, text, images, and so on; by using interactive hotspots, multiple scenes can be switched and browsed, producing a navigation effect. The scene results can be published to the cloud with one click, forming resource links that can be opened directly in a browser. Panoramic images generated by 720 Cloud support functions such as Little Planet opening mode, selective activation of the gyroscope on mobile phones, automatic roaming, and VR headset switching.

Figure 8 Panoramic camera application scenario selection

Figure 9 720 Cloud client-side scene production operation interface

Figure 10 Interactive scene switching effect (supervising the progress of a linear infrastructure project of our company)

3 Application of UAV Image Stitching for Panoramas

3.1 Preparatory Work for Applying UAV Image Stitching to Panoramas

UAVs are now being used increasingly widely. The UAVs discussed here are multi-rotor UAVs that carry a camera gimbal and can hover at a fixed point at high altitude, such as the DJI and Xiaomi multi-rotor UAVs currently in use. Taking advantage of the ability of multi-rotor UAVs to hover at a fixed point in the air and shoot from multiple angles, and with the aid of professional stitching software PTGui, images captured by the UAV can be synthesized into a JPEG file with a 2:1 ratio. After this image is then processed through the 720

Figure 10 Interactive scene switching effect (supervising the progress of a linear infrastructure project of our company)

Figure 5: Figure 10 Interactive scene switching effect (supervising the progress of a linear infrastructure project of our company)

Figure 11 UAV fixed-point orbit shooting schematic

Figure 6: Figure 11 UAV fixed-point orbit shooting schematic

Cloud platform, a virtual-reality panoramic effect from an aerial viewpoint can be obtained.

The specific workflow may be summarized as: multi-angle fixed-point UAV shooting of the required scene → PTGui stitching of images (2:1 JPEG file) → Photoshop processing of the image to fill in the sky → synthesis of the panorama and online publishing through the 720 Cloud platform.

3.2 Fixed-Point UAV Orbit Shooting

The UAV flies to a certain height (the height is set according to the desired final panoramic viewing effect), then performs fixed-point orbit shooting for 3 circles, ensuring that there is image overlap between each adjacent shot and between each layer. The overlap should be at least 30% (to reduce stitching deformation). Adjust the angle of the UAV's underslung camera gimbal and the angle relative to the horizontal plane: shoot one circle at the minimum angle (about 8 to 10 images); then shoot 6 to 8 images in the next circle (angle about 30°-45°); then shoot 4 to 6 images in the following circle (angle about 60°-80°). Finally, add one photo directly below (angle 90°). One image is also needed directly above, but the UAV cannot achieve this; other imaging equipment may be used to take a photograph of the sky (as material for later sky filling). The number of images and angles for each circle mentioned here are not fixed requirements; they should be set according to the specific needs, with the final aim of reducing the occurrence of areas not covered during stitching. As shown in Figure 11.

Figure 11 Schematic Diagram of Fixed-Point UAV Orbit Shooting

3.3 PTGui Image Stitching

PTGui is a panorama editor. After importing the images with this software, the lens parameters can be calibrated automatically; the software stitches and blends the images, making it quick and convenient to produce striking panoramic images. Ordinary photographs taken with a camera can also be synthesized into panoramic images, but this requires professional cloud-platform tools and is suitable for ground-level panoramic shooting, so it is not introduced in detail here. Compared with obtaining images using a ground camera, obtaining images with a UAV is faster and easier to operate, and is suitable for panorama production of large scenes. However, when shooting with a UAV, images of the upper part cannot be obtained; other imaging tools must be used to obtain sky-filling material, or image-processing software such as Photoshop must be used to fill in the sky.

PTGui panorama synthesis has three main steps: load images → align images

Figure 12 Panorama editor

Figure 7: Figure 12 Panorama editor

Figure 13

Figure 8: Figure 13

→ create panorama.

Figure 12 shows the alignment operation after PTGui has loaded the images. The intersections of photographs can be edited, images with large distortion can be removed, and the projection mode for the panorama can be selected. It can be seen from the figure that part of the panoramic shooting material is missing; this is because, when the UAV performed orbit shooting, the camera angle and the overlap between images were not strictly controlled. The gray-and-white checkerboard area in the figure is the area that needs sky filling.

It should be noted that all panoramic images discussed in this paper are 2:1 width-to-height algorithmic images. Therefore, when PTGui finally synthesizes the panorama, the equidistant cylindrical projection method should be selected. As shown in Figure 13.

Figure 12 Panorama Editor (a project under construction by our company)

3.4 Uploading UAV Panoramic Images to the 720 Cloud Platform and Application Scenarios in Architectural Engineering

After the images captured by the UAV are synthesized into a panorama by PTGui, they can be used through the 720 Cloud platform to create virtual-reality scene applications. The panorama can be viewed online, and can also be combined with VR and MR glasses for immersive scene experiences.

During building construction, retaining images is highly necessary. Recording in a panoramic manner can break through the experiential effect of the original imaging mode, and can more intuitively and comprehensively reflect the image progress of the entire project, site appearance, safe and civilized construction, and so on. For infrastructure facilities such as railways and highways,

Figure 13 Comparison of panoramic images before and after processing (2:1 aspect ratio, project under construction by our company)

Figure 14 Application in architectural engineering

Figure 14

Figure 9: Figure 14

The project uses a panoramic approach to carry out efficient supervision of progress across the entire line, preliminary site planning, and other work. Through integration with a panoramic camera, virtual floor-plan displays can be produced and interactive experience scenarios can be set up, enabling a roaming-style experience from the exterior of the building to the interior.

4 Application of Panoramic Imaging Technology to Smart Construction Sites

With the rapid development of information technology, the use of panoramic cameras will become increasingly widespread. Our company is also attempting to integrate them with smart construction-site applications. Using the smart construction-site integration platform independently developed by our company, three panoramic material access points have been developed: UAV panoramas, 360-degree roaming, and panoramic views of model areas. This builds an integrated panoramic platform for construction projects and encourages engineering projects to use panoramic cameras and UAV imaging to record every detail of the project. In addition, VR, MR, and other devices are combined to provide virtual-reality experiences for scenarios such as safety technical briefings, as shown in Figures 14–15.

In addition, our company is currently developing the use of panoramic cameras for video monitoring,

Figure 15. Embedded application of panoramic browsing (our company's smart construction-site system)

Replacing existing monitoring methods with panoramic records allows comprehensive, all-time monitoring of engineering projects without blind spots, and better ensures and supervises construction safety on the project site.

5 Conclusion

The emergence of panoramic cameras and the development of panoramic production technology have brought people a new visual experience. With the popularization of basic applications, the reduction of hardware costs, and innovative technological development, the modes of dissemination on terminals are becoming increasingly diverse; their influence will also become broader, and they will penetrate more and more application industries. Panoramic imaging technology still has great room for expansion in its application to architectural engineering. Not only is terminal application a highlight of its use; it may also have an impact on the modification and replacement of traditional hardware.

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Application of Panoramic Photography in Architectural Engineering

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Abstract: Panoramic photography is a special imaging technique that has been popular in recent years and has been widely applied. Panoramic photography can be used to generate 360-degree 3D scene images. Direct generation by panoramic cameras, such as Ricoh or Xiaomi, is simple in operation while producing impressive image effects. With just one shot, 360-degree 3D images can be generated, with extensive applications for scenes. Introducing the panoramic-camera panoramic model, interactive roaming, and periodic aerial panorama records into the field of construction technology will bring a brand-new visual experience to construction-site management. Many engineering examples have shown that there is great scope for the application of panoramic photography technology in construction engineering.

Key Words: Panorama Camera; UAV; 720 Cloud; VR; PTGui; Construction Management

Note: Figure translations are in progress. See original paper for figures.

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