Using Point Cloud to Inspect the Construction Quality of Wall Finish

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This research used a 3D scanner to scan mortar finish of a wall during building construction, via recorded 3D point cloud information to inspect the wall's smoothness. The scanner was considered as an objective science instrument to inspect the quality of the finish job in order to assure better construction quality.

Keywords: *3D scanner, point cloud, wall finish.*

Introduction

In the building construction process, using plastic-like material to finish a wall is very common, like plaster or masonry. The major reason is that these materials are not limited by construction material size and finish area. They are easy to smooth into the wall. Due to their characteristics of plasticity and coherence, they can hide the wall's seams. Therefore, brick, concrete or other partition wall are usually use plastic like material (Lion 1980).

In general, mortar finish is frequently applied to brick walls, dry wall, or other for smoothing. Wall finish workers use control lines and control points to regulate smoothness, and hope that they can finish the process in accordance with control point locations during the plaster operation. This provides good quality from a control point of view. Quality means adherence to standards established by the owner, designer, and user (Bannister 1991). But, how can one inspect this correctly?

We have had many cases in which the smooth walls were not really smooth upon closer examination, the wall would look smooth to the human eye. But, in follow-up decoration construction, the workers found problems immediately. This is not serious if the goal was only be pleasing to the eye, but it is serious if it negatively influences interior decoration construction, since the problems increase work time and costs. So one must attach importance to this problem, which has usually been ignored in the past.

The 3D scanner can record three-dimensional information from the wall and use point cloud to display the wall three-dimensionally to judge the actual smoothness of the wall. This can be a requirement for concrete conveying methods to constructor to ensure construction quality. In the past, there were few methods to measure the smoothness of walls; the 3D scanner can record the three-dimensional information of a scanned body, so it can use this method to record wall surface finish quality and

inspect wall smoothness by point cloud. It can present a more objective result of the inaccuracy value.
This research tries to use this method to develop a standard for wall finish quality control in a construction site. In the past, the construction company usually ignored wall finish since there were no standards or method to verify smoothness; therefore, the purpose of this research is to create objective measurement standards for wall inspections. By only using vision to inspect a wall, one cannot obtain satisfactory measurement data, and therefore cannot require the construction contractor to improve concrete requirements to improve construction quality. So we use a 3D scanner to record finished walls, its result will certainly be impartial and objective during analysis owing to the record result representing the real status in the construction site. This will have a positive meaning for quality control and requirement.

Building construction applications for a 3D scanner

Since the 3D scanner can scan body shaped with laser light, in the construction process, it can effectively record construction operation, quality, quantity, and other data information. Moreover, the 3D scanner can record and measure wherever measurements are needed and it difficult to inspect (Shih 2003). It will directly help the construction manager with construction quality control issues. This 3D scanner can make scans at long-range and its point cloud information can record whole spatial components located with three-dimensional coordinates. It is not like traditional measurement mode that must use equipment to measure and record at different points in the construction area. It just only scans the construction components on site, and then uses software to analyze the point cloud for relation operation.
This research used a 3D scanner (Cyrax 2500) for the long-range scan operation. The Cyrax 2500 can create a matrix of point cloud up to 999*999 dots in width and height. Each scan may bear a tolerance of 2mm in a range of 50 meter. The density of dots can regulated for scan detail as needed. In addition, it can use Cyclone to register targets to combine multi-scans. In the theory, it is not limited to scanning for shaped volume and range (Shih 2002).
Since the 3D scanner can make long-range records, it can be used to make many record operations of historical buildings other culture legacies. For example, it can create a 3D model of large history sculpture (Rocchini et al. 2001), urban environment (Zhao and Shibsaki 2001), or be used to analyze construction component problems with a RP machine (Shih and Wang 2002), as well as compare inaccuracies between point cloud and building construction models (Shih and Wang 2004).
This research uses the 3D scanner to record walls that were finished in a construction site. It analyzed the wall smoothness from recorded point cloud information. Since the wall information is translated into hundred thousands dots in the three-dimensional spatial it can use Cyclone software to analyze the wall's finished smoothness via slices in order to be an important reference for construction review and follow-up decoration construction, as well as to judge wall construction quality.

The influence of construction quality of a finished wall

In a building space, walls are separated using places to set up an architecture component. It could be an exterior wall, interior wall, or wall of between living units. Different requirements need different designs. So, any material can be used on a wall, like glass, cupboard, or another real wall (like concrete, brick, prefabricated wall partition, and lath with board.). This research used a real wall to determine the final requirement of wall quality.
The wall used in this research is defined as being completely built of limited material and cannot provide a smooth surface to use when it is not finish. Therefore, it must use finishing procedures for wall

decorations and follow-up decoration that is more visually appealing. Plastering has many methods. In general, it is separated into wet and dry. Dry construction usually uses boards that are smooth, and its finish parts are only at the board seam. With this type of construction, the walls will not have problems with smoothness. However, in wet construction, the mortar thickness is not fixed, so to be smooth the worker must smooth it out by hand finishing (Kurobe et al. 2002). This research uses a wet finish for analysis.

In general, the smoothness of a wall relies on the worker's skill. Its result and quality is difference. So to require greater wall surface quality, the worker must use a control line or laser pointing/leveling device to provide a reference for interior renovation (Figure 1.). The original purpose was to use control points to confirm that the final depth and smoothness were within the tolerance of precise range. However, the wall finish job, which still relies on workers to operate the measuring tools, usually ends up with different quality due to the lack of objective standards. The conflict not only leads to inaccurate judgment that is made only by visual inspection, but also causes design variations that cannot be accepted by the client or user.

Wall finish, which heavily relies on the worker's past experience, does not raise the construction quality for a builder who cannot provide data associated with the surface of walls. When the finish comes across protruding columns, it is even harder to align it among walls separated bays. The control of alignment is then referred to the structures or earlier dimension settings that may be covered by other partitions or no longer exist. The loss of the original reference has significant influences on construction quality and design confirmation.

After a wall is finished, beside used painting or wallpaper to decorate, many decoration construction companies are influenced by wall smoothness dimension. For example, with ceiling construction, if wall is not smooth, it will produce chinks between the ceiling and wall connection location (Figure 2.). Moreover, it will influence the visual and construction quality. If the decoration company needs to use board or other decoration material to work on the wall after it is finished, the wall finish quality will influence the decoration operation since the decoration board must match the wall surface and seriously influence decoration efficiency and quality.

Since the wall finish and decoration workers are different, if wall finish is suitably inspected, the wall finish worker cannot provide good quality work and it will disregard the problems because the decoration worker will earn more pay because the wall was not smooth. So if it has an objective wall smoothness inspection method, it will require wall finish worker to provide effective, quality work and to conform the

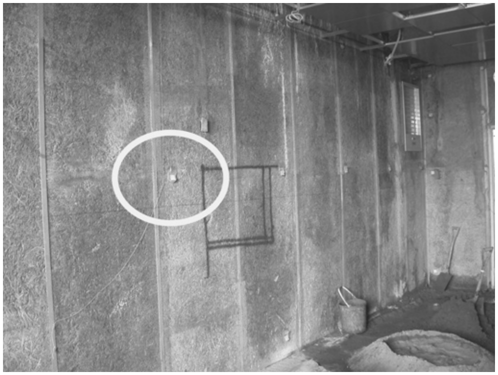

Figure 1
Used control line to provide a reference for interior renovation.

visual and construction requirements.

This research major is creating a wall smooth dimension inspection method. This inspection method can understand smooth dimension and wall differences to determine a basis for acceptance. So if we have this objective analysis tool, it can display immediate finished quality to the wall finish worker and manager.

Use 3D scanner to inspect wall smoothness dimension

This research scanned a building under construction by 3D scanner to record point cloud information of a wall when it was finished. These point clouds can represent the real three-dimensional spatial locations of the wall by using Cyclone to analyze and inspect for wall smoothness dimension.

First, define the wall plane as a reference plane that was calculated from giving inaccurate ranges. This reference plane should be a whole visual image. This should be used as a reference plane to set the cutplane, and move every one cm. It can analyze wall finish inaccuracies by every layer. This allows it to display clearly the wall smoothness dimension by the slice.

This research try used two methods of analyzing the wall smoothness dimension. Since the reference plane slices point cloud location per centimeter we try used different colors to define different layered point clouds to produce the wall smoothness dimension (Figure 3.). Another method to connect every slice point cloud into sloping fields contours for display (Figure 4.), but the wall inaccuracy was not different with sloping fields. Its inaccuracy was small and was easy to watch which area had finish inaccuracies, but it was difficult to inspect the value of the inaccuracies.

From the above-mentioned situation, it is clear that the point cloud analysis can understand clearly the finish quality of a wall. It will help a construction manager to understand and control construction quality and how it will influence follow-up decoration operations. Moreover, it can let the finish worker understand their construction quality and help them determine if their inaccuracy values conform to the original requirements by this objective analysis tool.

The construction quality influence of wall smoothness dimension inspection

In the past, since there were no wall inspection methods almost wall finish quality requirements were not high. Today, we used a 3D scanner to record the wall's real spatial location, which can quickly and accurately control and understand wall construction quality because of the wall smoothness dimension analysis.

From the 3D scanning process, we can obtain three-dimensional information of wall so that it will display the wall smoothness dimension when the point clouds are recorded completely. With this inspection method, wall smoothness will improve in the future. This will not only improve the construction quality of building walls, but also help with follow-up decoration operations. Since wall quality is increased and recondition operation decrease due to the improved condition of the with wall, this will improve construc-

Figure 2
The wall looks like smooth, but watch closely, one can find some chinks between ceiling and wall.

tion efficiency and quality.

Conclusion

Wall finish operation's quantity and cost is not higher in building construction. In the past, if one only does not a great mistake, it cannot confer or inspect construction inaccuracies since the wall smoothness value inaccuracy will influence follow-up decoration operations and aesthetics of the building. This research used a 3D scanner to record wall finish construction results and used slices to provide the client or constructor to determine construction quality in coordination with point clouds. It not only lets wall finish workers understand the result of construction quality with accurate analysis, but also let the client determine wall finish inspection standards before construction as well as let

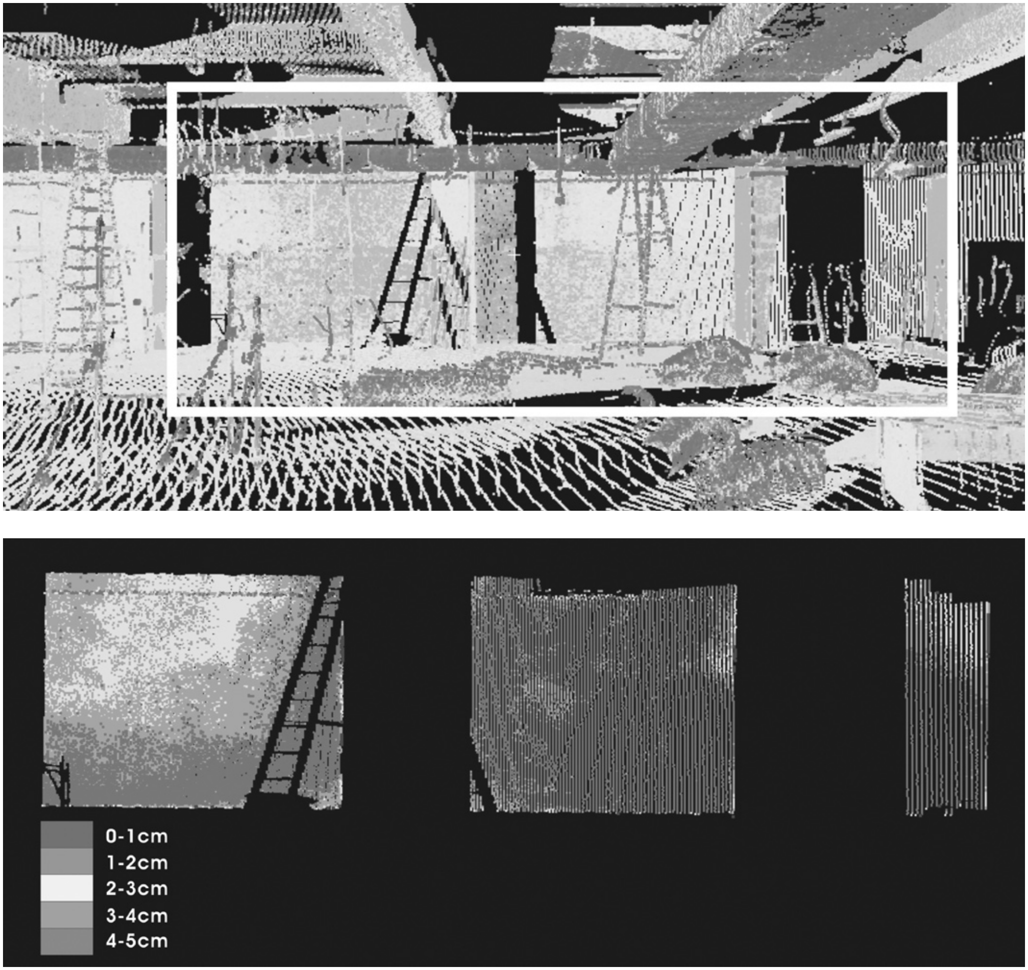

Figure 3
Used different colors to define different layer point clouds to produce wall smoothness dimension. The top is original point cloud of wall.

the wall finish worker understand the requirement of wall smoothness in advance. Afterward, it has an objective standard to inspect for acceptance. Therefore, the client will receive higher quality wall finish, and for follow-up interior decoration worker can reduce much needless operations in coordination with reconditioned walls. This will improve construction quality and efficiency.

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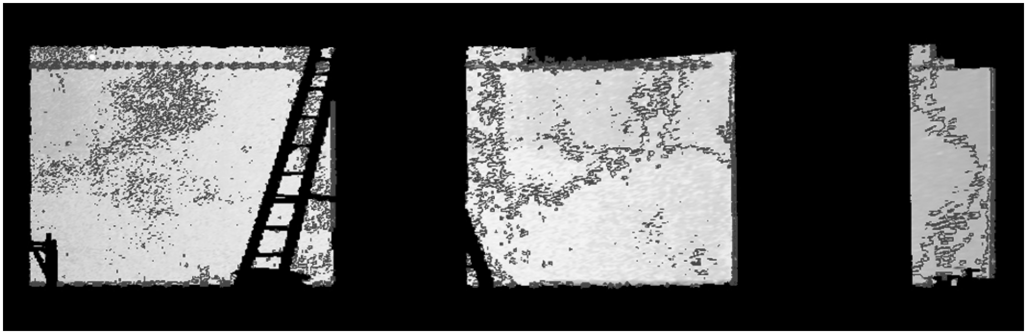

Figure 4
Used every slice point cloud connect contours.