A SURVEY ON TYPES OF 3D SCANNERS, THERE APPLICATIONS AND VISUALIZATIONS

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Abstract:The 3D Scanner is a device which is used to convert the physical data into digital data. 3D scanners digitize the photographic projection of an object, its shape, and its dimensions. 3D laser scanning developed during the last half of the 20th century in an attempt to accurately recreate the surfaces of various objects and places. The technology is especially helpful in fields of research and design. The 3D scanner plays important role in the areas of Virtual reality, Industrial design, Orthotics, Prosthetics, Games, Reverse Engineering, Art, Entertainment, Archaeology, Quality Control /Inspection, 3D mapping of underground environments, wood defect and specious detection

This Paper is discussed about various 3D Scanners, there applications & Challenges in visualization of the above fields.

1. INTRODUCTION

A 3D scanner is a device that analyzes a real-world object or environment to collect data on its shape and possibly its appearance (i.e. color). The collected data can then be used to construct digital three dimensional models. There are several different kinds of 3D laser scanners, with prices ranging from the couple thousands to the hundreds of thousands. That can be useful for a wide variety of applications. The first 3D scanning technology was created in the 1960s.

The starting time three types of optical technology were available in 3D scanner:

- **Point**, which is similar to a physical probe in that it use a single point of reference, then it repeated many times. This was the slowest approach as it involved lots of physical movement by the sensor.
- **Area**, which is technically difficult. This is demonstrated by the lack of robust area systems on sale.
- **Stripe**, the third system - was soon found to be faster than point probing as it used a band of many points to pass over the object at once, which was accurate too. Therefore, it matched the twin demands for speed and precision.

But now the available technologies are:

- Accurate
- Fast
- Truly three dimensional
- Capable of capturing colour surface
- Realistically priced.

There are several different kinds of 3D laser scanners,

- Airborne laser scanner
- Terrestrial laser scanner
- Hand-held laser scanner

2. WOOD DEFECT AND SPECIOUS DETECTION

Wood species and wood defects are two key issues in the wood quality assessment so as to judge the physical property and commercial value of different wood products (e.g., wood veneer, lumber, or board) correctly. Some visual image characteristics have been used in the wood species recognition and can be divided into two general categories: wood surface's texture analysis and its color analysis. Researchers also have proposed some schemes for detecting wood internal defects by using X-rays, gamma rays, microwaves, and longitudinal stress waves.

Simultaneous investigations on wood species and wood defect detections are scarcely performed to make an objective wood quality assessment. In fact, wood species detection and wood defect detection are usually performed with different instruments or technologies. Even if the same instrument or technology such as spectral analysis may be used for wood species and defect detection, the mutual disturbance exists so that the detection accuracy is low. For example, the wood species recognition accuracy is not good for wood veneer if there are many defects on wood surface by using spectral reflectance features. To solve this hard issue, we use a 3D laser scanning instrument to make qualitative wood species recognition and a quantitative wood defect measurement (i.e., the precise measurement of surface area and volume of every external defect such as cavity, worm tunnel, and crack on the wood product's surface) simultaneously. Therefore, the wood detection efficacy is improved by using our scheme and it can provide a better basis for the subsequent wood quality assessment.

Figure:1 Portable Artec 3D laser scanner

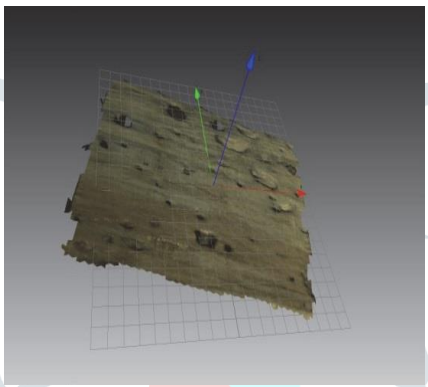

Figure2: Scanned wood surface in the Artec Studio 9.

3D Scan. The3D scan is a nondestructive detection technology based on laser processing with a fast scan speed and high scan accuracy. Therefore, it is usually used in the object's 3D reconstruction. In our scheme, a portable Artec 3D laser scanner is used to get the wood surface's 3D point cloud, as illustrated in Figure 1.This scanner is small and portable with an adjustable flash lamp and with 3D scan resolution of 0.5 mm. It is used conveniently with a number of data storage formats. This scanner is equipped with software system Artec Studio 9 to read the scanner data and then display the scanned object's surface. The object's surface is calibrated with the instrument's *XOY* plane automatically by this software and then the object's surface is stored as a file with OBJ format. For example, Figure 2 illustrates the scanned wood surface in the Artec Studio 9. Each scanned point contains its X, Y, and Z coordinate and its RGB color information. The point's X, Y, and Z coordinates are used in the defect detection, while its RGB information is used in the species recognition.

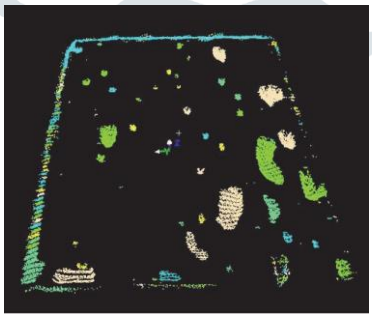

Figure3: The segmented defects displayed with different colors.

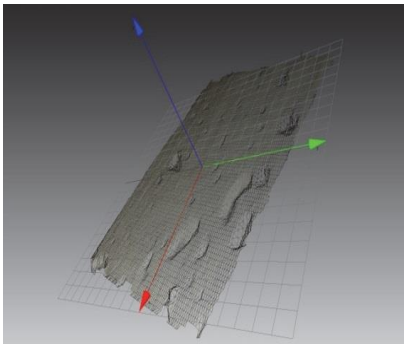

Figure 4: Wood surface's grid graph in the Artec Studio 9 without color information.

Figure 5: The detected wood specimen.

3. 3D MAPPING OF UNDERGROUND ENVIRONMENTS

The development of several instruments and techniques for reality-based 3D survey provides for new effective and affordable solutions for mapping underground environments. Terrestrial laser scanning (TLS) techniques demonstrated to be suitable for recording complex surfaces in high resolution even in low ambient lightning conditions. TLS approaches allow to obtain millions of 3D points and very detailed representations of complex environments, but these normally required a very high number of stations. The investigation and deployment of a hand-held laser scanning system, the GeoSlam Zeb1, for the fast 3D digitization of underground tunnels.

The GeoSlam Zeb1 is a hand-held active device equipped with a 2D infrared laser scanner profilometer and an inertial measurement unit (IMU) mounted on a spring. The UTM-30LX laser scanner emits pulses at a high frequency that reflect off surfaces and return to the sensor where signals are converted into range measurements based on the time of flight principle. The IMU measurements of angular velocities and linear acceleration, combined with laser data, allow to estimate the device's trajectory. A three-axial magnetometer records magnetic interferences common in underground environments. Laser scanner and IMU are connected to a micro-computer/battery unit which fits in a backpack. This very low-weight instrument acquires up to 43,000 measurement points per second, within a field of view of 270° and with a maximum range of 30 m (15 m outdoor). The device has a range precision up to 3 cm, conditioned by the distance, the incidence angle and the surface reflectivity. The scanning field of view is increased by the swinging mechanism due to a spring that allows to generate three-dimensional profiles of the environment roughly scanned every second. The instrument head can oscillate (or nod) in the front-back/walking direction or side by side (i.e. orthogonally to the advancing direction).

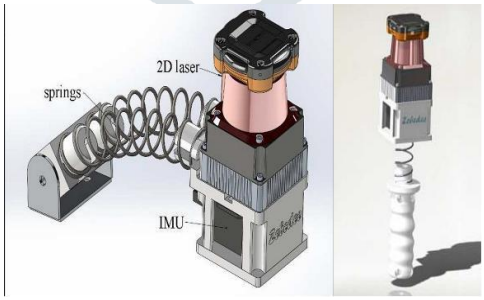

Figure 2. GeoSlam Zeb1 hand-held system.

3D data are acquired simply walking through the environments and keeping the device in one hand. Every dataset has to be acquired in an average range suggested of 20-30 minutes. Once followed the desired path for data acquisition, the device has to be placed on the ground for some seconds, so as the IMU can indicate the micro-computer to stop the acquisition and to terminate the logging process. In order to merge all the acquired profiles (by estimating 3D scanner positions and orientations), the device uses a simultaneous localization and mapping (SLAM) algorithm. This solution requires to observe the same features several times. The Zeb1 device acquires the local scene roughly once per second. Local views of the scenes, obtained through the swinging of the instrument, contain position and normal direction of every element recorded. By matching pairs of surface

elements acquired in different times, the trajectory is estimated through the relation between surface geometries. 3D point clouds and followed trajectories are provided in standard point cloud file formats.

4. QUALITY CONTROL/ INSPECTION

Digitization can be costly, take time, and can mean extensive handling of original materials, which may be fragile. For these reasons the goal of any digitization project should be to create high-quality master images, audio, or video files from which many derivative images can be created for access and other uses. Quality control (QC) is an important part of any digitization project. QC includes procedures and techniques to verify the quality, accuracy, and consistency of digital files. Quality control should be conducted throughout all phases of the digital conversion process to ensure that the material is only needs to be digitized once, then used and shared many times.

With the new MetraSCAN 3D, unexpected costs, production and approval delays are a thing of the past. Easily handle reverse engineering and inspection of tools, jigs, fixtures, assemblies or even final products from 1 to 3.5 m (3.3 to 11.5 ft.) with an accuracy of up to 0.064 mm (0.0025 in.). With its extendable measuring volume, high speed, shop-floor accuracy and impressive capabilities on challenging materials, the MetraSCAN 3D represents the most complete metrology-grade 3D scanner on the market.

Figure: MetraScan 3D

New Features:

- 1.5x more accurate
- 12x faster with 7 laser crosses
- 25% lighter
- Scan any material, even black, multicolored & shiny surfaces
- Greater volume of 16.6 m^3 (586 ft^3)
- Sturdy design for shop-floor hardware reliability
- Multi-function buttons for easier interaction with the software
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5. SOME OTHER SCANNERS

5.1. Matterport

Matterport is motorized, tripod-mounted 3D camera that uses PrimeSense chips. Their accuracy has been evaluated in . 2D and 3D sensors capture high-dynamic-range (HDR) images and depth image data; The camera system spins in place and transfers the data to the 3D Capture app on an iPad in 30 s. 3D Capture app is also used to visualize scanning progress and edit scans on the fly. The distance between neighboring stations is within 1–3 m, and the 3D Capture app stitches transferred scans together automatically. Captured projects can be uploaded to to Matterport's cloud servers for more complete and detailed post-processing. The Matterport Cloud creates a 3D model that combines HDR-quality imagery with dimensional geometry. Polygonal meshes can be streamed to the Matterport 3D Showcase media player. Furthermore, users can view the 3D models through their web browsers using the Unity multimedia plug-in. It is possible to move through the interior and then zoom out to a dollhouse or floor plan view of the model. The virtual reality (VR) 3D scene can be experienced by using VR platforms like the Samsung Gear VR headset. As an alternative to the VR, 3D files (.obj) of the scanned scene are downloadable. These 3D files can be transferred to point clouds, as we have done.

Figure: Matterport

5.2 NavVis

The NavVis 3D Mapping Trolley was first released in 2014 . NavVis consists of six 16 Megapixel cameras and three laser scanners with a 30-m range installed on a trolley chassis. The total weight of the trolley is about 40 kg. One scanner on top of the system is positioned horizontally and is used for SLAM positioning, while two tilted scanners are installed on the trolley arm for point cloud acquisition. A touch screen is used for the operation, and NavVis has real-time processing and viewing of collected point cloud data. Post-processing is carried out by automated software by NavVis. The post-processing has two main steps: point cloud processing and web processing. In the point cloud processing, the raw data are processed into the point cloud, and images from individual cameras are stitched into panoramas. Individual datasets (for example, different floors) are combined manually using NavVis software. In the web processing, the material is optimized for a walkable model in the web browser. Sticker markers that are automatically detected in the data can be used for automatic registration of the datasets and also for georeferencing if the location of these markers is available. User interaction with respect to data processing is limited to the selection of the point cloud density. The default is 0.02 m, with optional 0.005 m or 0.01 m.

Figure 4. Data acquisition using NavVis.

5.3 Leica Pegasus: Backpack

Leica Pegasus: Backpack is a commercial mapping system for indoor documentation, see Figure. The system incorporates two Velodyne VLP-16 scanners: one mounted horizontally for localization in GNSS-denied environments and one to perform vertical scanning for 3D reconstruction. The system uses NovAtel IGM-S1 for GNSS-IMU positioning when available. The scanners operate at a 10-Hz frequency, and as they cast 16 profiles simultaneously at a 30_ field of view, the scene is covered with 160 scan lines per second each with an angular resolution of 1.7 mrad. Beam divergence of the scanner is about 3 mrad, and the ranging accuracy is 30 mm. The system is also fitted with five cameras for 2-Hz image data capture covering a 360 _ 200_ field of view. According to the manufacturer, the absolute position accuracy for an indoor scene (SLAM based without control points) is 5 cm–50 cm after 10 min of walking, with a requirement of a minimum of three loop closures or double pass conditions. A variety of factors are listed, which may negatively influence the accuracy of trajectory. These include small rooms or hallways, the need to pivot while walking, stairs and uneven pavement, extremely smooth or blank surfaces, surfaces too far from the scanners and fast vertical movement.

5.4 Würzburg Backpack

The backpack features a horizontally-mounted SICK LMS100 profiler; see Figure . In addition, it comes with a low-end IMU, the Phidget IMU Precision 3/3/3. The 2D profiler and the IMU are used to build a 2D grid map of the environment using the state-of-the-art in 2D SLAM, HectorSLAM. It represents the environment as a 2D occupancy grid, which is a very well-known representation for maps in robotics. The 2D laser scanner performs six DoF motion while the backpack is carried. First, the scan is transformed into a local stabilized coordinate frame using the IMU-estimated attitude of the LIDAR system. Then, in a scan-matching process, the acquired stabilized scan is matched with the existing map, which is updated. The information of the 2D SLAM solution is exchanged with the navigation filter, which is an EKF (extended Kalman filter) in a bi-directional fashion, and thus, fused with the values of the Phidget IMU to produce six DoF pose estimates. The 2D mapping and the navigation module are not synchronized, and the EKF usually runs at a higher update rate. HectorSLAM uses this EKF for the pose estimation, and the EKF values are projected onto the xy-plane and are used as the start estimate for the optimization process of the 2D scan matcher. In the opposite direction, covariance intersection is used to fuse the SLAM pose with the full belief state of the navigation system.

Figure . Mapping the hallway test site with Leica Pegasus: Backpack.

The central sensor of the backpack system is the 3D laser scanner RIEGL VZ400. The VZ400 is able to freely rotate around its vertical axis to acquire 3D scans. Due to the setup, however, there is an occlusion of about 100 deg due to the backside of the backpack and the human carrier. The VZ400 is programmed to scan back and forth to avoid this blind spot. The data of the VZ400 are initially registered using the HectorSLAM trajectory. Then, it is split into segments and introduced to a semi-rigid six DoF SLAM . The resulting continuous-time SLAM algorithm and a more precise description of the backpack are given in and the references therein.

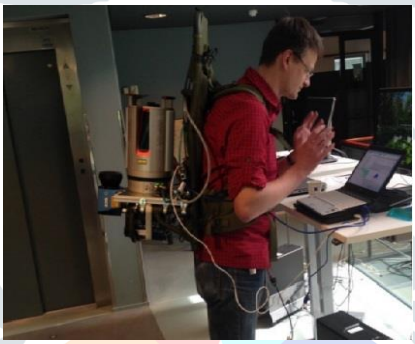

Figure: The Wurzburg backpack consisting of a SICK LMS100 profiler, a low-end IMU and spinningRIEGL VZ400.

6. CONCLUSION

3D laser scanning equipment senses the shape of an object and collects data that defines the location of the object's outer surface. This distinct technology has found applications in many industries including discrete and Process manufacturing, Utilities, Construction, Archaeology, Government, and Entertainment. In this paper discussed important role of 3D Scanners in some fields that are Ente Wood defect and specious detection, 3D Mapping of underground environments, Quality control/Inspection and also many 3D Scanners available every scanner have some difference from others that can be comport for various fields.

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