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Industrial 3-D Scanner with Low Cost to Create 3D Replicas of Real-Life Objects

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Abstract:

This paper describes the prototype of the 3d scanner made in proportion for the larger 3D scanner that would be utilized to scan humans and make a 3d model replica of them with the help of some software tools. The current prototype is made with respect to objects of 1feet size. The design of the system is made cost effective than the current 3d scanners available in the market. The system utilizes Rasperry-pi 4B and R-pi camera V2.0 as its primary components.

Keywords — ***R-pi,3D scanner.***

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I. INTRODUCTION

3D-scanning is the process used to create replica of real-life objects into digital 3D models. This technology has a significant impact on various fields, from dentistry, fashion, historical monuments etc. The process of 3d scanning involves collecting data of the real object in terms of pictures and distinct points using sensors like cameras and lidar to convert this data into a digitized model and then converting this into a physical structure, trying to create exact replica of the actual object.

Due to the complex operational process the available 3D scanners are quite expensive. In the proposed design we have tried to minimize the cost to the lowest and tried to create a miniature 3d scanner that can be later scaled to around 6-7feet size with the proportional calculations.

II. SYSTEM ARCHITECTURE

A. Component of a 3-D Scanner

There are multiple different ways to obtain 3D data. There is laser-based distance measuring with LIDAR and Time-of-flight systems, as well as image-based reconstruction with Feature Extraction, among others. Our goal of scanning humans in particular has several parameters that need to be met:

- Capture of all data around the subject at the same time to avoid artifacts from movement (even when standing still, humans move)
- Capture of colour with flat light (for use as 3D model)
- Cheap scanner cost

The capture of colour and the cheap scanner cost excludes exclusively laser-based methods, while the capture with flat lighting excludes the exclusively structured light approach. Mixing techniques is possible, especially the structured light and SfM processes, but was omitted due to cost and time constraints. We are left with SfM, which uses images captured from different angles and matches features between them to calculate depth and colour information along with camera position in 3D space. A SfM-based scanner has two basic components: one (or more) camera(s), and a computer to calculate the 3D data from captured images. We need to capture all the data at once to avoid motion artefacts need multiple cameras that all capture an image at the same time. Generally, more cameras is always better for SfM, since there is more data and bigger overlap between pictures (60% overlap and more is recommended by Meshroom documentation, whereas taking multiple images from the same position is bad).

However, computational load and camera cost rises significantly with the use of more (or higher pixel count) images.

To make the system cost effective we have tried to design a system with moving rig of cameras so that with just 5-6 cameras we can achieve the same results.

1]The cameras would require the following features:

• Higher resolution →− more detail in image

• Cheap cost →− more cameras → more overlap and detail

• Decent SNR →− lower noise → more detail

• Fairly wide-angle lens →more overlap →less cameras needed to cover all surfaces (but also less detail at the same image sensor resolution)

2] Requirements for computer that will process the data from cameras:

The intermediary computers should provide

• Small form factor

• Cheap price

• Interface(s) for camera(s)

• Fast network interface for transmission of control signals and images

• Good software support and documentation

One such computer is the Raspberry Pi 4, Model B ,, sporting a CSI interface for camera modules, two USB 3.0 and two USB 2.0 ports, Gigabit Ethernet, and a small footprint. Since the cheaper USB webcams usually don't provide good image quality or controls, the Camera Module V2.1 for the Raspberry Pi was chosen as a camera. It has a1/4" 8M P sensor, a lens with a diagonal FOV of about 80° and attaches to the Pi via the CSI interface. It's worth mentioning that there are splitter cables for these CSI ports, making it possible to connect more than one camera module to the Pi. Unfortunately, those do not seem very reliable from the reviews that were gathered from multiple different sources. Additionally, since they can't have long ribbon cables due to signal integrity, the attached modules cannot be apart very far. Although this results in more image detail in a specific spot, it captures little depth information.

3] Lightning:

The lightning conditions around the object or person is also an important factor so as to get the details of the object from all angles correctly and not miss any details. We use two ring lights one at the top and other at bottom to avoid any shadows and capture clear images with all the details possible.

I. Mechanical design of the system:

The system is made out of a stable circular platform with a moving rig using wheels at the bottom of the rig. The lights are stable, fixed at the top and bottom. As we need to take multiple images of the object, we make the rig move around the object and stop at every 30 degree, capture images and then send it to the server computer. To stop the rig at 30 degree we use an Encoder attached with the internal motor that is used to move the rig.

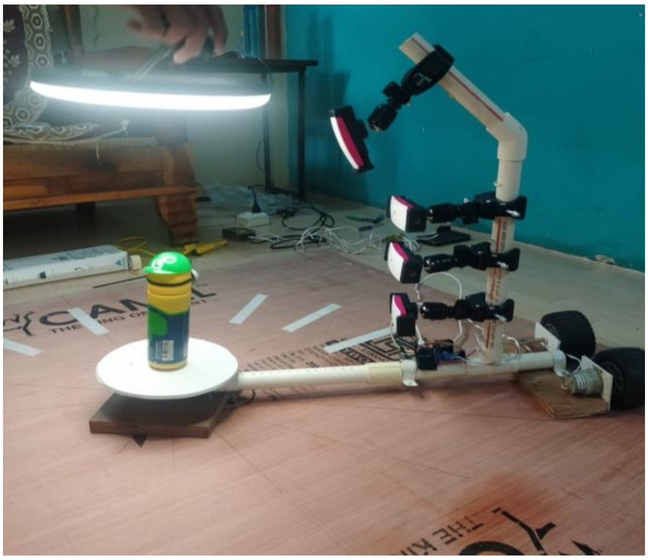

Fig 1 Mechanical arrangement of cameras and lights

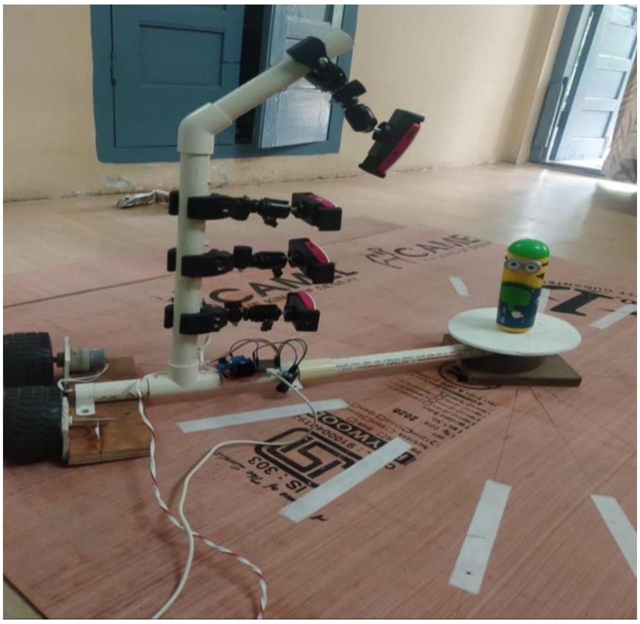

Fig 2. Example of 3D Scanning with a Doll.

The photogrammetry software needs significant overlap (above 60% is a good value) between neighbouring pictures. That means that the cameras can't be spread too thin in either axis. If the cameras are mounted on what is effectively a pole, getting a higher vertical camera density is trivial - just adding more cameras along the length of the pole will suffice. Yet to get the cameras closer in the horizontal axis, we need to stop the rig at a particular nearby angle.

From different experiments we observed that as decrease overlap by 5%, the cameras required to capture similar object was reduced to half. Thus, to capture a object of size 7 feet with 90% overlap we needed 10 cameras whereas with 85%overlap only 5 cameras were needed. Taking this scenario, we settled to overlap of 85% and used 5 camera structure to carry out our further testing.

III. SIMULATION WITH MESHROOM

The captured data is then provided to Meshroom and the respective plugins help us to convert the data to digital 3d model with just a few steps.

IV. CONCLUSIONS

Thus, we were able make a basic prototype of a 3D scanner by capturing the images of the real-time object and converting it into a digital model with minimal cost possible. With advanced cameras and processors, the quality of the data ie images of the target object can be improved thus making more detailed version of the 3d model. Also using more advanced software and plugins more advancement in the simulation process can be made.

