Object Scanning Using a Sensor Frame

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Abstract. This paper focuses on object scanning using sensors. The objects are articles in daily use. Everyday objects, such as cups, bottles and vessels are good models to scan. The sensor scan represents the objects as 3D images on the computer monitor. Our research proposes a new device to scan real world objects. The device is a square frame, similar to a picture frame, but, except for the frame, is empty. The infrared sensors are arranged on the device frame. These sensors detect the object and extract the coordinates from the detected object. These coordinates are transmitted to the computer and the 3D creation algorithm represents these coordinates as a 3D image. The operating principle is simple, similar to scanning a person at a checkpoint. The user passes the object through the sensor frame to obtain the 3D image, creating the 3D image corresponding to the real object. Thus, the user can easily obtain the 3D object image. This approach uses a low-cost infrared sensor, rather than a high-cost sensor, such as a laser.

Keywords: Sensor frame, 3D image, Scanning, Infrared sensor.

1 Introduction

The ability to form a 3D image from a real object is valuable, creating a 3D image of an object in a short time, without drawing the object directly. This is especially important in 3D animation and 3D games. The general method to acquire a 3D image uses computer vision or laser sensors. Computer vision using a stereo camera is sensitive to light or color; it is difficult to obtain an accurate 3D image using a stereo camera. A laser sensor may be used to obtain the 3D image for the object, but this approach is uncompetitive, due to their high cost. Our research focuses on obtaining a 3D image from the real object using a low-cost device. We developed a sensor frame to do so. The sensor frame body is acrylic. Infrared sensors are installed on the frame circumference. These elements are cheap and readily available. Our aim is to obtain a 3D image from an object using this device.

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2 Related Work

A number of researchers have attempted to improve the performance of 3D object scanning. Bor-Tow Chen used a 3D laser scanning system. Generally, a 3D scanner needs two or more scanning processes to capture multiple layers to register and merge to a complete 3D object, since it is based on a 2-dimensional axis. He proposed an algorithm to decrease the number of scanned layers and to acquire the best-view data in the double-axis 3D scanner [1]. Masakazu proposed a portable 3D scanner system that combined narrow-baseline stereo camera and consumer video projector [2]. Georg introduced a 3D object detection approach with a geometric model description. Fast and robust object detection was achieved combining the RANSAC algorithm with a hierarchical subscale search [3]. Joseph P discussed the design and development of a 3D scanning system that includes a computing processor capable of handling large volumes of high-speed, high-resolution digital camera output data [4]. Kazuki proposed a method to recover valid 3D range data from a moving range sensor using multiple view geometry [5]. Beverly D focused on the laser light-sectioning method, an accepted technique for measuring the 3D shape of the target object [6].

3 The Creation Process the 3D Image from the Object

This section demonstrates the process to create a 3D image from an object. The sensor frame is a device to scan the object. The sensor frame extracts the coordinates of the object in three-dimensions. The sensor frame is square, like a picture frame. Its interior is empty, except for the frame. Infrared sensors are installed on the frame circumference. The user can hold the frame. The user passes the sensor frame over the object. This process scans the object top-down. When the sensor frame passes over the object, each infrared sensor on the frame detects the each distance between the object and the sensor.

However, this is insufficient to acquire the three-dimensional coordinates. Two coordinates must be acquired from the sensor position and the distance between the ground and the sensor frame. One sensor is installed at the bottom of the frame to obtain the distance between the ground and the frame. These values change the coordinates to three-dimensions. After scanning the object using the sensor frame, the coordinates are transmitted to the computer. Then the three dimensional coordinates are linked by our proposed algorithm. Finally, the 3D image can be obtained. In brief, we develop a novel device to create a 3D image from an object.

3.1 The Structure of the Sensor Frame

The infrared sensor consists of the transmitter and receiver that measure the distance between the sensor and the object. The device has twenty-four infrared sensors. Six sensors are arranged on each of the four sides of the frame (Fig. 1). The sensor board transmits the sensor data to the host PC as soon as it is switched on. The host PC stores the twenty-four sensors' data in a twenty-four variable array.

3.2 Object Recognition

The sensor zone is the space surrounded by sensors. Before the object enters the sensor detection zone, the initial values of all the infrared sensors are 15cm, since the detection zone is a 15cm square. Recognition begins at the top of the object. Our algorithm recognizes the object when more than three sensors have a reading of less than 8cm. Once the object is recognized, the sensor data are stored in the array variable. These sensor data are obtained from the twenty-four sensors on the sensor detection zone and one sensor on the bottom of the sensor frame. The sensor on the bottom of the device measures the distance between the device and the ground. The three coordinates are obtained using this method. Fig. 2 shows how the three coordinates from the sensor frame are obtained.

3.3 The Measurement, Compensation and Storing of the Sensor Data

Once the sensor frame recognizes the object, the sensor data are stored to the array variable. The sensor detection zone is two-dimensional space, thus the sensor frame cannot detect the three-dimensional coordinates simultaneously. Therefore, the object should be divided into layers. Fig. 3 shows the object layers.

The object section is formed on each layer. After the object is sensed, each section of the object layers is connected to make the three-dimensional object. However, the sensor information is unstable for each measurement and often has incorrect values. Our algorithm measures the sensor data ten times for each layer to resolve these problems. The mean values of the sensor data are used. dat_p[24][10][10] is an array variable to store the sensor position number, measurement count and the height of object layers. The mean value of ten sensor values is calculated. The mean values are stored in Data [24][10], a two-dimensional array, in which the first factor includes the sensor position number and sensor value. The second factor stores the height of each object layer.

```
dat_p[24][10][10]
  = Sensor Value[Sensor Num][Measurement Count][Height]

Data[24][10]
  = Sensor mean Value[Sensor Num][Height]
```

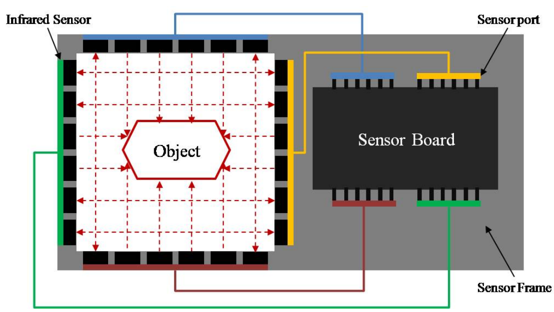

Fig. 1. The structure of the sensor frame

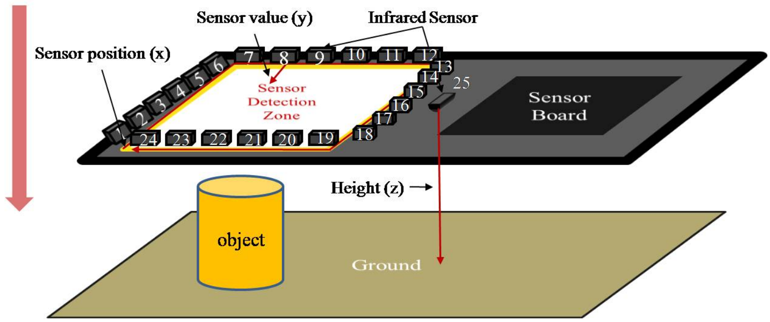

Fig. 2. The process to obtain three coordinates from an object

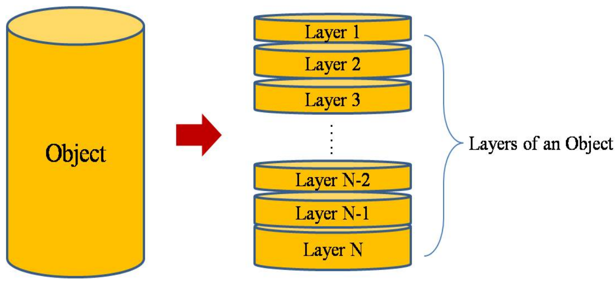

Fig. 3. The layers of the object

3.4 The Coordinate Generation of Three-Dimensional Space

This section describes how to generate three-dimensional space. Three parameters are required to generate the three-dimensional object. The parameters, x, y and z, represent the coordinates on a three-dimensional space. The method obtains these parameters in the three-dimensional array Data [24][10]. The three-dimensional array Data [24][10] stores the mean value of the twenty-four sensors and the height of the layers. The first factor is the sensor position used for the x coordinate; each sensor value is used for the y coordinate. The second factor, the distance between the device and ground, is the z coordinate.

3.5 The Formation of Object Section

This section describes how to create a cross-section of the object. Fig. 4 shows the process to form the object section. The row axis represents the x axis and column axis represents the y axis. The red points are the coordinates created by the sensor position and sensor value. These points have to be connected without crossing. The algorithm uses two pointers to detect the red points used to connect these points. The point detection order increases from bottom-left to top-right direction. If the first point is detected, pointer 1 indicates the point. If the second point is detected, pointer 2 indicates the point. Pointers 1 and 2 are thus connected. If the third point is detected, the nearest pointer of two pointers on the x axis is selected to indicate the third point. Therefore, pointer 1 moves from the previous point to the third point. If no point is

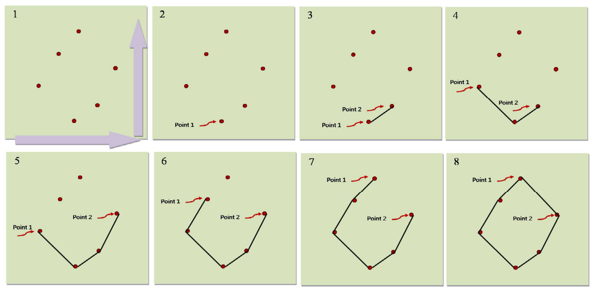

Fig. 4. The formation process of an object section

detected, pointer 1 and pointer 2 are connected and a section of the object is made in two-dimensional space. Our algorithm uses the extended scale of 300 x 300 x 10 for ease of computation. The original scale is 24 x 15 x 10. The first factor is the number of sensors, the second factor is the maximum sensor value. The last factor is the number of object layers. Fig. 5 shows the change from the original scale to the extended scale.

3.6 The Connection of Object Sections

Since the each section of the object is already formed, the next step is to connect those sections of the object. The upper sections are connected to the lower sections. Fig. 6 shows the connection process of object sections.

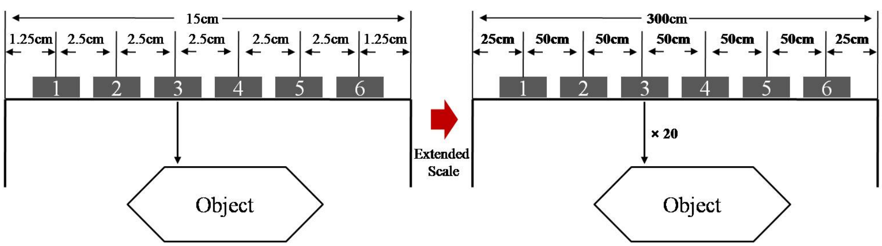

Fig. 5. The change from the original scale to the extended scale

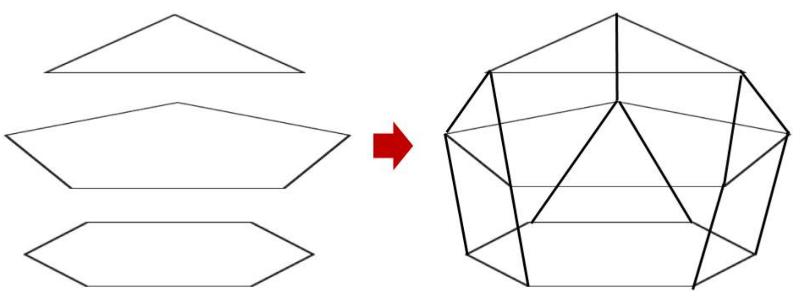

Fig. 6. The connection of object sections

4 Experiment Results

This section demonstrates the experimental results. We tested our object-sensing algorithm with three object of different type. The first object tested is a mug. This object looks like a cylinder with a handle on the side. We scanned this object using our object scanning algorithm and obtained the result shown in the figure on top of Fig. 7. This figure roughly depicts the shape of the mug. The second object tested is a triangular pyramid. The upshot of the scan was a similarly shaped triangular pyramid. As the height of 3D object decreased, its area became larger. The last object tested is a mini-fan. This shape is difficult to recognize. The mini-fan is divided into three parts: the pan, the cable and the prop. The test outcome represented a figure that has these three distinguishable parts.

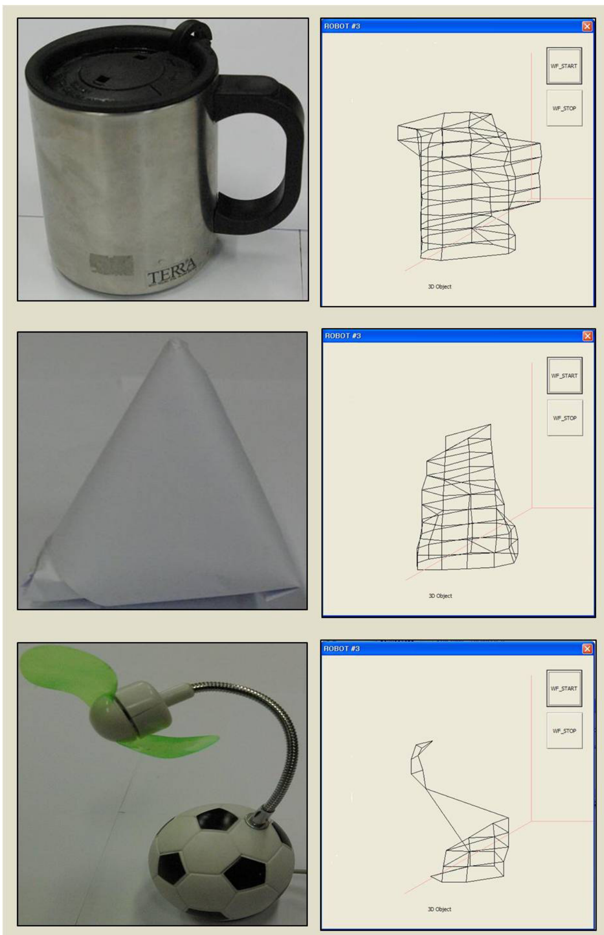

Fig. 7. The demonstration results of the experiment

5 Conclusion and Future Work

The object-scanning sensor frame uses infrared sensors to recognize an object. We used twenty-four sensors to detect an object. The number of sensors is too small to scan some objects. As shown in the experiment, the 3D objects form shapes similar to the real object, but were not exact. This can be solved by adjusting of the number of sensors and the interval between the sensors. The 3D object depicted becomes recognizably closer to the real object when the scanner has more sensors and the interval between sensors is lowered. This refinement will be achieved in future research.

Acknowledgments

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