

Motion control and data capturing for laser scanning with an industrial robot

Sören Larsson*, J.A.P. Kjellander

Örebro University, Department of Technology, SE-701 82, Sweden

Received 31 May 2005
Available online 20 March 2006

Abstract

Reverse engineering is concerned with the problem of creating computer aided design (CAD) models of real objects by interpreting point data measured from their surfaces. For complex objects, it is important that the measuring device is free to move along arbitrary paths and make its measurements from suitable directions. This paper shows how a standard industrial robot with a laser profile scanner can be used to achieve that freedom. The system is planned to be part of a future automatic system for the Reverse Engineering of unknown objects.

© 2006 Elsevier B.V. All rights reserved.

Keywords: Reverse engineering; 3D measurement systems; Laser scanner; Path planning; Industrial robot

1. Introduction

1.1. Reverse engineering

In the development of new products, computer aided design (CAD) systems are often used to model the geometry of the objects to be manufactured. The reverse engineering (RE) of geometry is the reverse process where the objects already exist and the CAD models are created by interpreting geometric data measured directly from the surfaces of the objects. One application of RE is to create a three-dimensional (3D) CAD model of some object A and use that model to manufacture new objects that are partly or completely copies of A.

An introduction to RE that is often referred to is a paper by Varady et al. [1]. In this paper the RE process is divided into the following four steps:

- (1) Data capture.
- (2) Preprocessing.
- (3) Segmentation and surface fitting.
- (4) CAD model creation.

Step 1 is closely related to measurement technology. Optical systems such as laser scanners, in combination with

mechanical devices for orientation, are often used to measure the coordinates of large numbers of points from the surface of an object in three dimensions.

Step 2 is used to take care of the point cloud created by the measurement system and prepare the data for segmentation and surface fitting.

Step 3 can be described as a way to subdivide the point cloud into regions, each one small enough to be fitted with a single smooth surface.

The last step in the RE process is the actual assembly of information into a CAD model. Surface data and data representing the topology of the object are then merged into a single model.

1.2. Automatic data capture

Step 1 in the RE process can be manual or automatic. Manual measuring enables full control over the measurement process and an experienced operator can optimise the point cloud to produce the best possible result. Automatic measuring can produce good results if optimised for a specific class of objects with similar shape. For unknown objects, however, it is our opinion that automatic measuring has not reached the state where it can compete with manual measuring as far as the quality of the point cloud is concerned.

One reason for this is that automated processes do not adapt the density of the point cloud to the shape of the object. Planar regions need fewer points than sharp corners or edges to be

* Corresponding author.

E-mail addresses: soren.larsson@tech.oru.se (S. Larsson),
johan.kjellander@tech.oru.se (J.A.P. Kjellander).

URL: <http://www.oru.se/tech/cad> (S. Larsson, J.A.P. Kjellander).

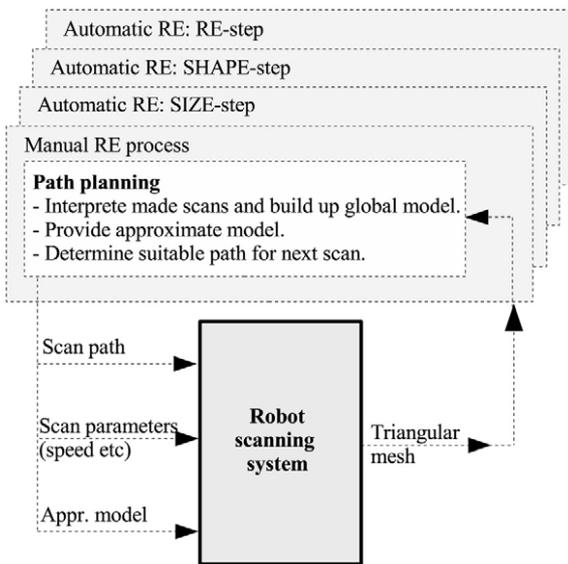


Fig. 1. The robot scanning system as a part of an iterative RE process.

interpreted correctly in steps 2 and 3. For optical measurement systems like laser scanners, it is also important that the angle between the laser source and the camera in relation to the normal of the surface is within certain limits or accuracy will drop dramatically.

A simple system is achieved by combining a scanner with a turn-table. See [2] for a description of such a system. A more flexible system is described in [3], where a coordinate measuring machine is used in combination with a profile scanner. A recent development by the same author is presented in [4]. In [5], a system based on a laser range camera mounted on the arm of an industrial robot in combination with a turntable is presented. The robot moves the camera to view the object from different positions and the camera scans the surface of the object.

1.3. Automatic reverse engineering

In [6], we proposed an automatic RE procedure based on three steps: SIZE, SHAPE and RE. The SIZE step should establish the overall size of the object in terms of its bounding box. The SHAPE step then scans the object more closely and creates a better approximation of the object. The RE step, finally, would use the intermediate model to plan further more precise measurements used to create the final CAD model (see Fig. 1). It will then be possible to scan a freeform surface while keeping the scan direction optimal or follow edges or other interesting features and scan them with higher density.

In order to optimise the accuracy of the resulting model, scanning should be adapted to the shape of the object. One way to do that is to use an industrial robot to move a laser profile scanner along curved paths. This makes it possible to control the distance and the angle between the scanner and the object and also to control the density of the point cloud. Furthermore, it makes it possible to view the object using



Fig. 2. The robot scanning system comprises an industrial robot, a turn-table and a laser profile scanner.

arbitrary orientation of the profile scanner and this increases the possibility of eliminating problems related to occlusion.

We have implemented the SIZE step using the equipment described in [6] and work is now being carried out to finish the implementation of SHAPE and RE. A key issue in both steps is the possibility of orienting the scanner freely and scanning along curved paths without collision. This paper focuses on the details of those two issues. Future papers will describe the implementation of the SIZE, SHAPE and RE steps from a higher system level, and we will then show how the technology presented here is useful in the scope of automatic RE.

1.4. Our experimental platform

The hardware of our system, presented in [6], is based on a laser profile scanner mounted on an absolute positioning industrial robot ABB IRB140 with a turn-table and S4C controller. The laser scanner comprises a line laser and a camera. The laser beam defines a “laser plane” and the part of the laser plane that lies in the image view of the camera is denoted the “scanning window”.

The scanner records pictures at certain time intervals as it is moved by the robot along some planned path. The robot also serves as a measuring device to determine the scanning window position and orientation in 3D for each camera picture. Fig. 2 shows the equipment at work.

Our software platform is the Varkon CAD-system [7]. All functionality presented here is implemented using MBS, a geometrically oriented programming language included in the Varkon system. MBS programs communicate with the robot and the profile scanner through TCP/IP.

1.5. Goal and requirements

Our long term goal is to create an automatic system for RE, as described in [6]. This paper focuses on what we believe is a key requirement of such a system — the problem of scanning along arbitrary paths. Future papers will address the problems

متن کامل مقاله

دریافت فوری ←

ISIArticles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات