In-Process Laser-Scanning Technology for Micro Assembly

S. Rathmann, A. Raatz, K. Schöttler, J. Hesselbach
Institute of Machine Tools and Production Technology, Germany

s.rathmann@tu-braunschweig.de

Abstract

To recognize edges of components in an assembly process, in particular of microelectronic or micro system components, nowadays vision systems are preferred. These systems are working fast but the results strongly depend on ambient conditions. In most sensor guided assembly systems laser displacement sensors are implemented additionally to vision systems. These sensors are used for detection of the components height. In this paper a scanning method is presented that detects edges by using a laser displacement sensor. These data can be used by robot assembly system for a sensor guided assembly process. Further by this technique is extended in order to gain 3D-information of micro components and a proposal of the field of application is outlined.

1 Introduction

The laser-scanning method used is a technology for the scan of surfaces or bodies by using a laser beam. In most applications the laser is deflected by a mirror unit. To generate relative movement either the laser or rather the object is moved. There are two different laser scanning technologies that are used for scanning micro components: confocal laser-scanning and 3D-laser-scanning. These technologies obtain exact models of investigated micro components reading sub micrometer accuracy. A disadvantage of the methods named is that there is no possibility to scan the object during a production process. However, in high precision assembly processes it is necessary to get exact in-process information about these micro components, for example their position and geometry as well as their deviation from their ideal geometry. One could think of employing vision systems for this purpose. But the disadvantage of such systems is their dependence of light settings. Especially when working with complex geometrical structures with different properties of surface reflection, which is often the case in micro systems, it is likely that wrong geometric properties can be detected. For this reason we propose the laser-scanning technology to get the desired information about position and deviation of micro components in an assembly process. In high precision assembly systems laser displacement sensors are often implemented. So it is possible to extend the existing assembly systems with a technology in following called "In-Process Laser-Scanning" (IPLS).

2 Method

IPLS uses a laser, which is mounted on a high accurate micro assembly robot parallel to the z-direction of the robot coordinate system (figure 1). The sensor is usually used to measure the height of components. In this case it will be used for the scanning process by moving the robot over the component. During IPLS the heights' information of the laser sensor is related to the robot position in x- and y-direction. The accuracy of the scanning process depends on the diameter of the laser beam. For experiments, a confocal laser displacement sensor (Keyence, LT-9000) was used. It has a laser beam diameter of 2 µm with a measurement range in z-direction of ±0.3 mm. Additionally to the measurement of the distance of a single point, the sensor described offers a line scan option. There integrated horizontal oscillating system deflects the laser beam ±550 µm in x-direction to get height information over the deflected range by an increment size down to 2 µm.

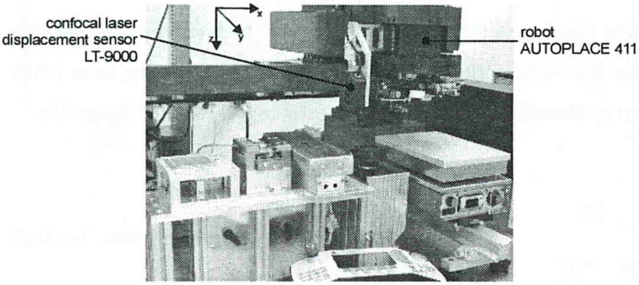

Figure 1: Assembly system with mounted laser displacement sensor (LT-9000)

The laser is mounted on a micro assembly robot AUTOPLACE 411 (Sysmelec). The robot offers a repeatability in x-, y- and z-direction of 1 µm [1]. The smallest step size is 0.5 µm. The laser is connected to the robot control via analog interface. The setup of the high accurate robot and the confocal laser displacement sensor offers a variety of scanning options. Figure 2 shows an overview of those different scanning options.

	In-Process Laser-Scanning (IPLS)			
Detection method	edge-point detection		surface-point detection	
Scan method	raster scan	line scan	raster scan	line scan
Data analysis	2D object recognition	2.5D object recognition	3D object recognition	
Application	in process: • recognition of geometric properties in the x-y plane • height calculation of compensation planes for plane surfaces	in process: > recognition of geometric properties in planes with different height ranges	system setup: > calibration of robot / measuring systems process setup: > calibration of process devices in process: > spatial recognition of geometric properties > error diagnosis	

Figure 2: Overview of In-Process Laser-Scanning options

The IPLS is classified in two detection methods: The simple edge-point detection and the detection of a surface-point of a component. With the edge-point detection and the two scan methods, raster scan and line scan, it is possible to get information about the components position and their deviation by using a 2 D or 2.5 D data analysis for object recognition. The raster scan method works with the point laser of the LT-9000 and the movement of the robot in x- and y-direction. The raster is defined either by a step size in x-direction or y-direction or both (figure 3a). The line scan method uses the line scan option of the LT-9000. The oscillating laser gives information in z_l- and x_l-direction while the robot moves in y-direction (figure 3b).

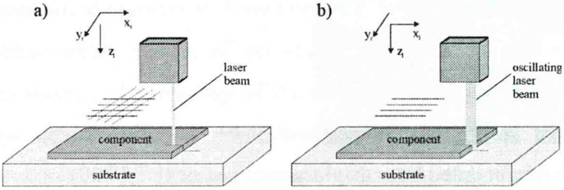

Figure 3: Illustration of the scanning process (a) point scan, (b) line scan

By using the raster scan method an edge-point is detected if the laser height signal is changing significantly during moving over the edge. The data analysis of several edge-points yields the construction of geometric properties of the component in the two dimensions x_r and y_r related to the robot coordinate system.

3 Application

In micro assembly a very important scenario is the recognition of micro components position in the workspace of assembly systems. Below the implementation of the edge-point detection from figure 2 is described. This method using raster scan and line scan method can be used for the simple recognition of geometric parameters of micro components, for example the recognition of rectangular or circular geometries, and the derivation of the components position in the assembly system workspace. Experiments at various velocities verify the high accuracy edge-point detection can achieve (figure 4). In this experiment the laser sensor was moved across to the component. When the laser beam crosses an edge the sensor signal will change significantly. This change was recognized and the actual robot position was marked as the position of the edge. The time to detect one point of the edge is depending on the distance from the starting point to the edge and the velocity. Its average was calculated to 1.5 seconds per edge-point at a velocity of 200 μm/s and a distance to the edge of about 300 μm. In this way the detection of a rectangle characterized by 8 edge-points needs about 15 sec.

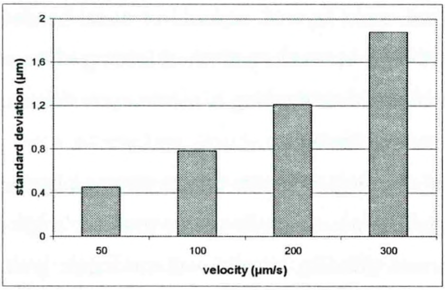

Figure 4: Standard deviation for different velocities

References:

[1] J. Hesselbach, G. Pokar, J. Wrege, K. Heuer, Some Aspects on the Assembly of Active Micro Systems, Production Engineering. Research and Development, issue 11, book 1 WGP e.V., Braunschweig, pp. 159-164 (2004).