Alignment with Leica Laser Tracker

Calibration of Perceptron sensors using the Leica Laser Tracker
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Perceptron inline measuring systems for industrial process monitoring

With its TRICAM™ sensors and recently the latest DIGITAL TRICAM™ digital sensor series, Perceptron provides reliable industrial measuring systems which have been used in the leading automobile manufacturing plants since their introduction in 1983. These sensors allow vehicle body components to be measured during the production process. Short measurement cycles mean a 100% measurement can be made. The data can be used straight away to implement corrections in the process, increasing the production quality and eliminating waste.

Principles of the measuring system

The Perceptron system works on the triangulation principle and uses powerful image analysis technology. The sensor consists of a Class 3A laser. An optic fans out its beam into a line, which is displayed on the object to be measured. A CCD camera in the sensor housing captures this line from a specific angle, so that the spatial position of the object can be calculated.

By using a special image analysis algorithm, the sensor can recognise a known object within its field of view and determine its position. Objects in this context are corners, edges, holes of various types, or touching points on surfaces. To recognise them, the system uses algorithms that e.g. simulate the touching process of a coordinate measuring equipment or allow the measurement of gap widths and flushing of alignments.

Measurements in the vehicle coordinate CAD system

Sensor coordinate system

The accurate calibration of the Perceptron measurement field is fundamental to obtaining precise measurements. Following the works calibration process, the sensor can express deviations from the nominal dimensions as absolute values. These measurements are then related to the sensor coordinate system.

Alignment using specimen vehicles (in exceptional cases)

For the first measuring systems, a known component was originally used to align them. This component had to be appropriately prepared, i.e. the measurement points were marked and measured using coordinate measuring machines. The sensor derives the relationship between this reference component and the vehicle coordinate system.

Alignment using Leica’s ECDS theodolite measuring system

An external measuring system was necessary to establish the relationship between the sensors and the CAD coordinate system. At first, Perceptron worked with theodolites. The alignment method developed out of this is known as VERISTAR™. Its accuracy is limited by the theodolite and the process is relatively time-consuming. However, this method was considered to be a success.

Time saving alignment with Leica Laser Tracker

The experience with VERISTAR™ led to the development of the TETRASTAR™ calibration system. This system works on the same principle as the theodolite based method, but employs a laser tracker as the external measuring system and makes use of the advantages of this new highly accurate measuring system.

The requirements of today’s manufacturers allow this method to be used only in exceptional circumstances. Specimen components are expensive and seldom available, particularly in the pre-production phase. There is always the additional problem of producing the first component to exact dimensions.

Several Perceptron sensors used in measuring the rear of the vehicle
Details of alignment using the TETRASTAR™ method

Coarse positioning of the sensors
The first step in the installation of a laser measuring system is to mount the sensors at particular positions in 3-D space. The feature to be measured should be in the centre of the field of view of a sensor. Installation takes place using the construction drawings and a system of steel tube components (Rose & Krieger), which provides flexibility in the set-up. Using this method, positions are established to an accuracy of a few centimetres.

Measurement using the laser tracker in the vehicle coordinate system
First the laser tracker must be incorporated into the vehicle coordinate system. This is done using reference points that are within the future field of view of the Perceptron system. By measuring these points and employing a subsequent 3-2-1 or best fit transformation, the laser tracker is transformed into the vehicle coordinate system. This ensures all further measured points are related to this coordinate system. The calculation and measurement data is provided by Leica’s industrial measurement software package Axyz.

"Visualisation" of the vehicle position
As the real component is not present, a substitute must be fabricated in order to adjust the sensor field of view correctly. This procedure is called "Virtual aiming".

The LTD500 Laser Tracker with the Axyz software offers the ideal tool for this procedure. The measurement point list is imported as a file using the measuring mode «Build points». Then the laser tracker can be aligned on to these points in 3-D space. The measured difference between the reflector position is continuously displayed. This ensures that the reflector can be easily positioned exactly at the measurement point. A 0.5 inch (1.25 cm) diameter tooling ball reflector is recommended for doing this.

The Perceptron sensor is aligned in such a way that the laser line cuts the tooling ball reflector across the middle and its image is located in the centre of the field of view. The position of the laser line can be adjusted to an accuracy of ±1 mm. This is a value which is not often achieved with a real component and is perfectly adequate for the correct recognition of the feature. The third step is the actual precise measurement using the sensors.

Quick and precise individual sensor measurement
The first step requires the high accuracy of the laser tracker. This is done by bringing an object into the field of view so that it can be measured by the sensors as well as by the laser tracker. The measurement uncertainty for both systems must not exceed 1⁄100 mm.

Laser tracker for aligning the sensors
Tetrahedron in the measurement position at the sensor
Tetrahedron with 0.5” reflector
Perceptron uses a calibrated tetrahedron, a tetrahedral body, which has a mount for the tooling ball reflector on its apex. The sensor measures the side edges of this tetrahedron and from these values calculates the centre of the reflector on the apex. At the same time, the laser tracker provides the position of the reflector in terms of the vehicle coordinate system. This measurement is carried out at four different points in the field of view of the sensor. A special rod, which is fixed to the sensor and carries the tetrahedron, allows quick movement into the various measurement positions.

The measurement data from the laser tracker is transferred over a serial interface to the Perceptron system controller. This is done automatically by the Leica software and speeds up the process considerably. The controller compares the measured data and calculates the transformation matrix from the sensor coordinate system to the vehicle coordinate system for each sensor. After calculation of this matrix the sensor is able to measure the vehicle coordinates.

**Up to 80% time savings with the laser tracker**

The Leica software provides several tools that simplify the task of calibrating into a jig. Other options include the measurement of locating pins or the measurement of bearing points. The radius of the reflector is taken into account in this. With open structure jigs using a known reference, measurement requires no longer than 40 minutes including a 20 minutes warm up period for the laser tracker. Four to five hours would be allowed for the same process using a theodolite system.

Normally the Perceptron sensor system would be mounted on a steel frame. With the laser tracker, the supporting structure can be checked in a relatively short time using the alignment holes. In the same way, these alignment holes allow the laser tracker to be repositioned and a new set of measurements to be taken within a few minutes. It may be necessary to do this repositioning up to four times for complicated jigs. The same task with a theodolite system would take several hours.

**Future applications**

The positive experiences throughout with the Leica LTD500 Laser Tracker has meant that this measuring system will be quoted as a reference for the location of Perceptron measurement stations and will also find further applications in the future.