Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 33 (2015) 245 – 250

www.elsevier.com/locate/procedia

9th CIRP Conference on Intelligent Computation in Manufacturing Engineering - CIRP ICME '14

Using of a uncertainty model of an polyarticulated coordinates measuring arm to validate the measurement in a manufacturing processsus

Fékria ROMDHANI[a], François HENNEBELLE[a], Patrick JUILLION[a], Richard COQUET[b] Jean-François FONTAINE[a]*

Le2i, Laboratoire d'électronique, informatique et image , Burgundy University, 89 000 AUXERRE,France
CETIM, 52 av Felix LOUAT, BP 80067, 60300 SENLIS, France

* Corresponding author. +33 03 86 49 28 26; fax: +33 03 86 49 28 29.*E-mail address*: jffont@iut-dijon.u-bourgogne.fr

Abstract

Coordinates Measuring Arms (CMA) are increasingly used to control industrial parts and are often an alternative to CMM controls that require conditions of laboratory measurement and involve significant costs. However, the control of uncertainties is often not guaranteed because the measurement process is complex and there is no standard for setting a framework qualification process of the measurement process.

The proposed study, in this paper, is a first approach to model the measurement uncertainties of a CMA with contact sensor. The problem is complex because there are many sources of uncertainty, largely due to variability in the handling carried out by the operator.

A model, based on Denavit-Hartenberg description, has been developed taking into account the measurement conditions (i.e.: the influence not only of the temperature, of the encoder error, of the deformation of different parts of the arm, of the noise of external vibrations, but also of the calibration parameters). The Monte Carlo method is used to estimate the obtained uncertainties. This method allows to take into account of the covariance when factors cannot be considered independent.

The resulting model was validated for the measurement of the location of different points of the working space of a CMA Sigma 2025 (ROMER®), then for the measurement of an industrial part in comparison with a measurement carried using a CMM.

Selection and peer-review under responsibility of the International Scientific Committee of "9th CIRP ICME Conference"

Keywords: Metrology; Uncertainty; CMA Modelling; Monte Carlo Method

1. Introduction

Coordinates Measuring Arms (CMA) are increasingly used in business for various tasks ranging from reverse engineering of products to the control of their compliance with pre-defined geometrical specifications In metrological applications, they are less efficient than measuring machines but can be used for with lower tolerances, but also in a workshop atmosphere for fastest specifications controls. The arms are generally constituted by a mechanical assembly with 6 and 7 pivot links [see **Erreur ! Source du renvoi introuvable.**]. They carry out measurements using static or dynamic contact sensor or laser contactless sensors. The measuring principle consists in performing the acquisition of the position (X, Y, Z) of a fixed point at the end of the arm by means of the indication of angle encoders of each liaison and the length of different elements The actually measured points are obtained by the knowledge of the characteristics of the probe attached to the tip or of the laser sensor. The measurements made by the arms depends on many parameters

Selection and peer-review under responsibility of the International Scientific Committee of "9th CIRP ICME Conference"
doi:10.1016/j.procir.2015.06.044

and estimation of measurement uncertainty is not controlled. It is therefore necessary to improve this area to provide solutions to estimate the uncertainties. The objective is to develop a model for estimating measurement uncertainties of a CMA that can be directly used by the manufacturers and the users of these devices. The estimation of uncertainties will be in accordance with GUM Supplement 1 [1]. The most influential parameters are explained and then their influence is assessed, including the stresses due to the manipulation by the operator on the deformations of the structure, the temperature, the encoder resolution and vibrations. The studied arm is an arm SIGMA 2025 ROMER® that has 6 rotations. The model is built from a wire geometry description with the Denavit Hartenberg method and verified by a more realistic determination of deformation modeling with FEM. Measures with strain gauges are used to validate the model on four specific configurations of the arm. The comparison with measurement results repeatability of the position of a point in these configurations allows to validate the model. Finally, the model was applied to the determination of the uncertainties of measurements of the diameter of a ball bearing.

Fig. 1 Sygma Romer CMA

2. Modelling of measurement with coordinates measuring arm

2.1. State of art

There is no standard for the estimation of measurement uncertainty by CMA. Only a few recommendations as ASME B89.4.22 [2] or VDI 2617-9 [3] address the practical problem of evaluating the measurement performance of polyarticulated arms. Les quelques travaux qui ont été mis en œuvre restent des approches partielles. Multiba et al. [4] applied the recommendations of the ASME B89. Some works concern the calibration Santolaria et al. [5-7] or A. Sultan [8] which take into account the influence of temperature.

Sladeck et al. [9] address the problem of theoretical modeling of the arms measurement error. They propose a correction by a compensation matrix (Articulated Arm Computer Aided Accuracy). Finally, some authors have incorporated the influence of the deformation of different parts of the arm. Li et al. a type arm scara. [10] and Hamana et al. [11] with a more current arm but by coupling the end of the arm at the head of a CMM with a double ball-bar, which changes the mechanical behavior of the arm. It is therefore not under normal conditions of use. The results also indicate a low influence of deformations.

2.2. presentation of the model

The strategy is to carry out a Monte Carlo model at several levels, it has already proven itself in a COFRAC accreditation for french technical center for mechanical Industries (CETIM). This strategy provides a simulation closer of the physics of the measurement: a first level corresponding to the carrier device and a second level applied to the evaluation of the measurand. The first level consists to determine by simulation, for all configurations possible CMA, the variability depending on external constraints (temperature, user handling, vibrations ...). This simulation allows to estimate the changes of the structure and, ultimately, to obtain the variations of the position of the "reference point of the CMA". This level 1 is complex and can be divided into sub-levels of Monte Carlo simulations: the level 1.1, to know the positioning error of a point, the level 1.2, for identifying errors calibration from the level 1.1 and the level 1.3 for determining the fluctuations of the reference point [12].

2.2.1. Geometrical modelisation

The metrological behavior of the arm must be developed from a geometric model. The constitution of the arm is similary to that of the robots, the methods developed for modeling the control thereof can be used. The commonly used method is the one introduced by Denavit-Hartenberg [13]
The model parameters are defined as follows:

- A reference frame is noted R_i when applied to solid i (z_i the axis is carried by the joint I; see figure 2);
- x_{i-1} -axis is supported by the common perpendicular to z_{i-1}-axis et z_i-axis. ;
- α_i is the angle around x_{i-1} -axis between z_{i-1}-axis and z_i-axis;
- d_i is the distance, counted on x_{i-1} –axis, of z_{i-1}-axis and z_i-axis orthogonal projections;
- θ_i is the variable around z_{i-1} -axis between x_{i-1}-axis and x_i-axis;
- *and,* r_i is the distance, counted on z_i-axis, of x_{i-1}-axis and x_i-axis orthogonal projections;

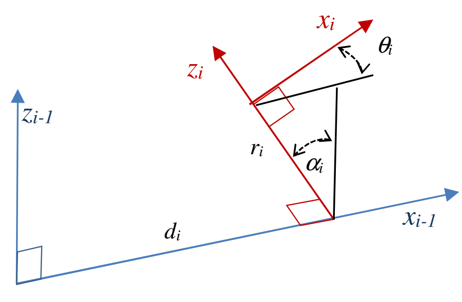

Fig. 2 Denavit Hartenberg parameters