Ultra-precision Manufacturing of XXL Parts

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An innovative solution for machining of parts with large dimensions (up to 50 m) was implemented in a prototype. The solution is more precise and more flexible as well as considerably cheaper than currently available machines. Target applications include manufacturing of windmill wings, parts for civil construction and aerospace industries.

Parts with large dimensions, in the range of several tens of meters long, are commonly found in a number of industries, including aeronautics, energy and others. Machining of parts with these dimensions is usually performed manually, with very low geometrical tolerance, or with very large and expensive CNC machines, with cost and error growing more rapid than linear rate with machine dimensions.

The European project Megarob [1] is developing an innovative solution for the manufacturing of such large parts based on standard industrial components: a three-axes overhead crane, a six-axes industrial robot arm and a laser tracker (see Figure 1). The robot is mounted upside down on the crane. The part to be worked on is placed under the area covered by the crane. Finally, the laser tracker is placed in the manufacturing hall so that the robot's end-effector is always in its field of view.

The use of only standard industrial components was a design decision. It lowers system development and operation costs while it increases acceptance and reliability. These components can be freely chosen by the end-user, avoiding technical restrictions emerging from commercial aspects.

Figure 1: The Megarob prototype with overhead crane, robot arm, and laser tracker.

Megarob uses two custom software components: a Robot Global Controller, implemented by CSEM, and a System Supervisor, implemented by project partner TeamNet International and CSEM.

The Robot Global Controller integrates the industrial robot arm with the laser tracker, enabling manufacturing large parts. The laser tracker gives the pose of the tool at the robot's end-effector. The difference between this position and the programmed robot pose is used to add an offset to the robot's target position. This cycle is repeated every milli-second on a real-time operating system running on a desktop PC.

The Robot Global Controller provides several features to the Megarob solution. Firstly, it continuously supervises the manufacturing process and minimizes all static and dynamic positioning errors of the tool. Since the correction is performed online, the Global Controller guarantees first-time–right execution of a robot program. Furthermore, the correction is performed at the robot's joint motion controller. In this way, the correction is transparent at the robot's programming level. This leads to an easy deployment of the Global Controller, even in legacy systems.

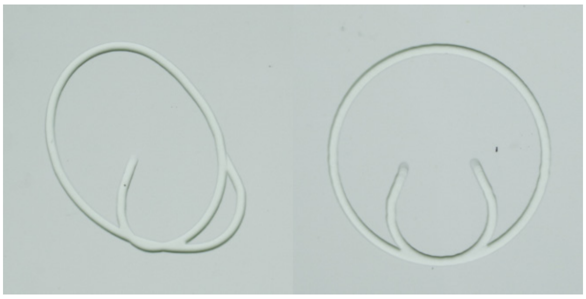

Figure 2: Milling a circle with large disturbance in the system without real-time position correction (left) and with correction (right).

The System Supervisor is another piece of software developed for the Megarob system. It provides an interface to manually control every component of the system. The software can also be utilized as a process planning tool by working as CAM (computer aided-manufacturing). It calculates the 3D machining path of the tool taking into account the kinematic model of Megarob, composed of the crane and the robot. Finally, the System Supervisor also controls the machining process. It executes a planned program by automatically operating the components of the system in a synchronized form. In this way, the machining of a part can be split into several regions. In each region, the crane remains stopped while the robot performs the machining motions.

The resulting system provides a number of attractive technical and commercial features. The system has a better precision than currently available machines. The use of standard physical components lowers the cost of maintenance. Other features include flexibility for machining of complex geometries thanks to its nine axes as well as minimal footprint. Finally, Megarob costs about half of current machines.

The results achieved during the Megarob project are promising. Companies outside the consortium have expressed interest in testing and commercializing the system. The main target industries are civil construction, energy generation and aeronautical production.

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[1] www.megarob.eu