The work was supported by the EU funded project: FP7-FoF.NMP.2010-1-026621
Plug-and-produce COmponents and METhods for adaptive control of industrial robots
enabling cost effective, high precision manufacturing in factories of the future – COMET

ARTIS MARPOSS

First metal cut at TEKS monitored with 500 kHz

ARTIS Genior Modular UM recorded the first metal cut at TEKS as part of the European Commission sponsored COMET project (www.comet-project.eu). Involving 14 technical partners across Europe and coordinated by Delcam plc, the COMET project aims to develop innovative robot machining systems that are flexible, reliable and predictable with an average of 30% cost efficiency savings in comparison to machine tools. Genior Modular UM (**U**niversal Sensor **M**odule) is normally designed to sample sensor signals and to provide the data via CAN Bus to the process monitoring component Genior Modular with 100 Hz. The Genior Modular UM unit was improved in the COMET project by an innovative Ethernet UDP export function, which provides raw acceleration data with sample frequency of 500 kHz. This helps to understand details of the cutting process and to find strategies for further improving (robotic) accuracy.

Test scenario to cut alloy with ABB robot

TEKS engineers were the first inside of the COMET project to mill alloy with a standard industrial robot. The cutting process in combination with a fixed 42000 rpm spindle running at 17000 rpm was monitored by ARTIS unit to record and analyze.

Picture 1) TEKS robot with ARTIS acceleration sensor VA-2-S in Z direction

To measure means to understand

Preparing process monitoring always starts with measurement. After measuring signals and assigning signals to events, the ARTIS developers are able to put a predictable and reliable behavior into a product. At the end, only this predictable behavior will lead to customer benefit, because only reliable decisions are sent to the controller, whether the process is identified as ok or whether to stop production.

ARTIS provides a smart and flexible measurement alternative

In research centers and universities high end measurement equipment is always necessary to develop new know how. The problem of the state of the art equipment is the lack of industrial robustness. ARTIS fills that gap with industrial standard measurement devices. They can be used firstly in the analysis phase and in production phase later as well.

Picture 2) Genior Modular UM with UDP export functionality

In case of the TEKS test scenario it was not practical to use large sized measurement equipment on the robot. So ARTIS developed a prototype of Genior Modular UM unit for measurement with a small form factor, yet very powerful in signal sampling with 500 kHz internal sample rate. A smart device to start research activities. The data points were transported each 4 ms to a UDP server, which can run on any PC with standard Ethernet capability. CSV is the common data format to be opened with standard programs like the open source statistical software solution R, see picture 5/6). Due to the amount of data it is not recommended to open data files in MS EXCEL, for example a second means half a million points, EXCEL diagrams can only handle 32.000 points.

INTELLIGIZE YOUR PROCESS.

ARTIS GmbH • Sellhorner Weg 28-30 • 29646 Bispingen-Behringen
Tel +49 (0) 51 94 9 50-0 • Fax +49 (0) 51 94 7825 • www.artis.de

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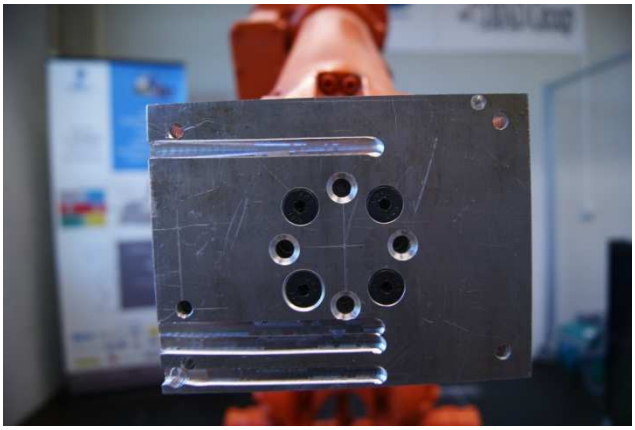
Genior Modular UM meets TEKS robot

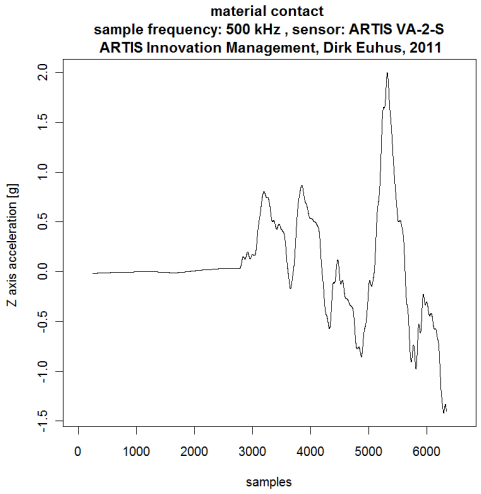
TEKS first used Genior Modular UM unit in combination with acceleration signals on the top of the robot in January 2011. The results shows the different (mis)behavior of the robot kinematics, see Picture 4). It is very obvious, that the cutting tool has a deviation in the –Z direction in the first half of the tool path. The second half is more stable and the surface on the bottom of the tool path is of better quality. Measuring and understanding this (mis)behavior is a key for improving robot accuracy while milling with the robot. The knowledge of that (mis)behavior is an important step for building different compensation models.



Picture 4) first 4 cuts with TEKS robot using genior modular UM

See the process details

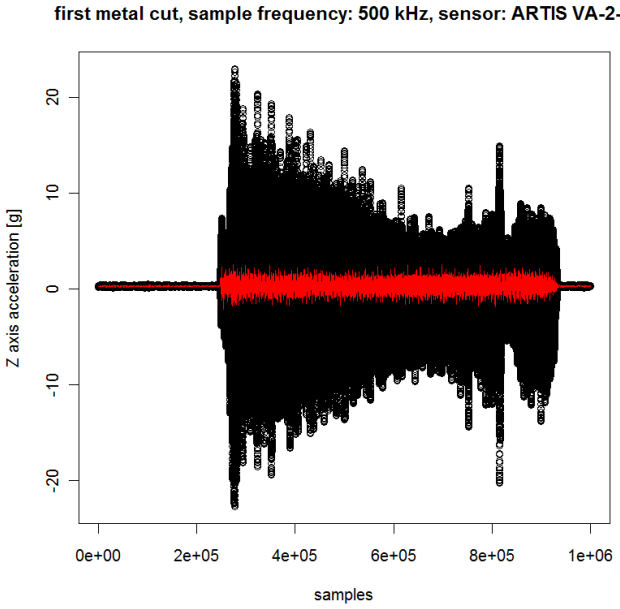
Running a tool path is always divided in two zones, before and after material contact. Without material contact there are no cutting forces to disturb the robot movement, see first half of picture 5. Each cutting edge produces an acceleration peek in the second half of picture 5. The average of the acceleration after material contact is negative, the tool has a constant deviation in the –Z direction, see picture 5).



Picture 5) first micro seconds of milling tool contact

Acceleration as accuracy indicator

One goal of the EC COMET project is to increase industrial robot accuracy. The ARTIS acceleration sensor VA-2-S is capable to indicate the stability of a milling process. The comparison of the 500 kHz acceleration signal in picture 6 and surface quality in picture 4 indicates a relation. In further project measurements the function will be caught in a regression formular, described in a signature file and used to improve surface quality. Knowing that best accuracy results would be expected where the amplitude in Z is a low as possible during milling process.



Picture 6) Advantage of 500 kHz signal (black) compared to 1kHz (red)

Outlook

Milling tests at TEKS were only the beginning of a wide range of necessary measurements inside the COMET project to understand the complexity of metal cutting itself and in combination with industrial robots. It simply shows the differences in cutting conditions, but in a new way which is not obvious to each robot user and at a very high speed which captures one 360 revolution of a tool in 1780 data points. These data can be used later in the project by the HDCM unit, developed by Fraunhofer IPA, to compensate the missing stiffness of the robot structure.

Without this knowledge it is impossible to develop improved data models describing the exact behavior of the cutting process. But even with improved data models the changes of the real process needs to be always monitored, as in practice there will always be unexpected situations, where the robot needs the helping hand from a monitoring system to decide about alarm situation.

Author:

Dirk Euhus, Manager Innovation, ARTIS GmbH, euhus@artis.de

Roland Krain, Manager R&D, TEKS

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ARTIS GmbH • Sellhorner Weg 28-30 • 29646 Bispingen-Behringen
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