Robotics and Computer–Integrated Manufacturing 49 (2018) 361–373

Contents lists available at ScienceDirect

Robotics and Computer–Integrated Manufacturing

journal homepage: www.elsevier.com/locate/rcim

An approach for applying STEP-NC in robot machining

Sasa Zivanovic*, Nikola Slavkovic, Dragan Milutinovic

University of Belgrade, Faculty of Mechanical Engineering, Kraljice Marije 16, 11120 Belgrade, Serbia

ARTICLE INFO

Keywords:
Industrial robots
STEP-NC
Programming
Simulation
Machining

ABSTRACT

This paper presents an approach for applying new machining standard ISO 10303-238 in machining operations by using industrial robots. The methodology developed according to this standard is proposed for executing programming, simulation and machining by industrial robots. A detailed description is given of a developed RoboSTEP-NC module which, being part of established methodology, translates the program according to ISO 10303-238 for 3-axis machining into a robot programming language. Programming verification has been realized, first, by simulation on virtual robots configured in STEP-NC Machine environment, and thereafter also by machining on a real available robot after translating machining program by applying the developed RoboSTEP-NC module.

1. Introduction

In manufacturing systems the key role of an industrial robot has been material handling and welding, but nowadays robots are increasingly taking part in the tasks of milling operations. Industrial robots are promising cost-effective and flexible alternatives for a certain multi-axis milling application. Compared to machine tools, industrial robots are cheaper and more flexible with potentially larger workspace. It is widely recognized that poor accuracy, stiffness, and complexity of programming are the most important limiting factors for wider adoption of robotic machining in machine shops [1,2]. The reason for the complexity of robot programming in machining application is in that each robot manufacturer uses, for the most part, its own proprietary robot programming language, because no industry standard exists. This fact was a strong motivation for both researchers and leading world robot and CAD/CAM software manufacturers to develop versatile software solutions, such as G-code translators, specific postprocessor solutions, etc. to make the robot programming close to the programming efficiency of CNC machine tools [1–5].

Robot languages are vendor specific and often even model specific. As a result, CAD/CAM software, generally, do not support post-processors for robots. Program exchange from one robot to another is often impossible and viewed from the small and medium sized enterprises (SMEs) the whole idea of using robots in machining applications is quite challenging [6].

Nowadays a new standard, informally known as STEP-NC (Standard for Product Model Data Exchange for Numerical Control) [7-10], is used as the basis for development of the next generation of CNC controller for new machine tools and robots. These new standards are ISO 14649 and ISO 10303-238, and are both co-existing and each of them has been implemented by different groups [10]. The ISO 14649 standard is more likely to be used in an environment in which CAM systems have exact information from the shop floor, whereas ISO 10303-238 is more suitable for a complete design and manufacturing integration.

However, industrial robots are getting more and more capable of taking onto machining operations and it is necessary to couple the robot for machining towards the new standard [6]. The new programming method, using standard known as STEP-NC, is an open challenge in the field of machine tool programming, but also for programming the robots for machining. The development of a new method of programming has started but is not yet completed. After more than a decade of investigation, the STEP-NC technology is still in its development stage [11].

Examples of the applications of robots programming for machining operations based on STEP-NC standard can be found in [6,12]. The STEP-NC based Robot CAM module for industrial robot machining operations is introduced in [6]. Experiments show that the suggested Robot CAM module, based on a STEP-NC input file, can interpret, translate and transfer the manufacturing orders to an industrial robot. The generated tool-path was drawn by the robot on a millimeter-scale paper, and experiments were carried out without any material cutting actions.

As stated in [12], the unified data models of industrial robots under the STEP standard, to exchange information between different CAx and robot off-line programming systems, will not only benefit the robot simulation systems, but also the improvement of traditional industrial robot controllers. All of these benefits of the STEP-NC technology are implemented in a virtual environment (like the function of ST-Machine).

* Corresponding author.
E-mail address: szivanovic@mas.bg.ac.rs (S. Zivanovic).

http://dx.doi.org/10.1016/j.rcim.2017.08.009
Received 20 July 2016; Received in revised form 19 June 2017; Accepted 10 August 2017
Available online 23 August 2017
0736-5845/

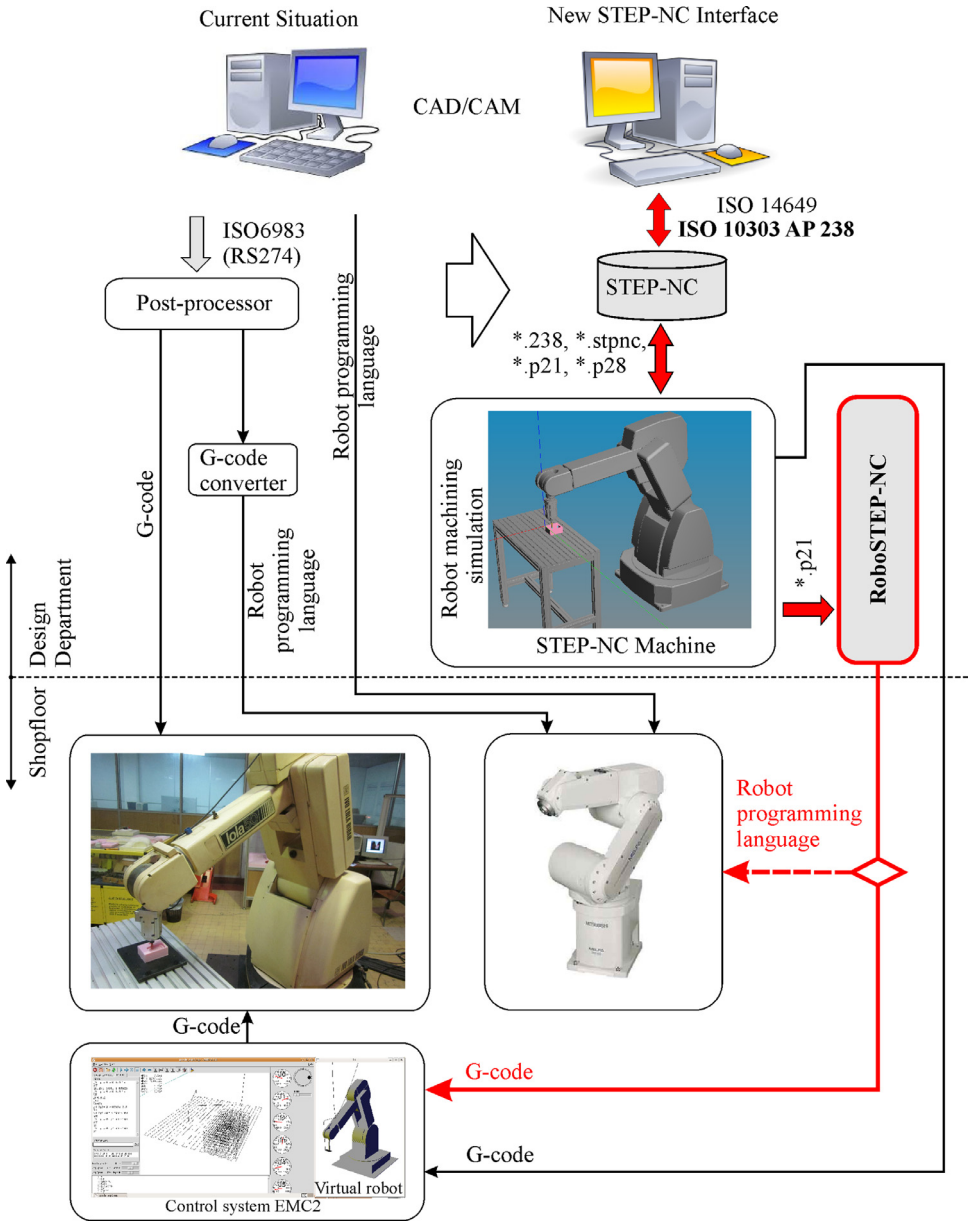

Fig. 1. Current ISO 6983 and new STEP-NC interfaces for programming the robot in machining tasks.

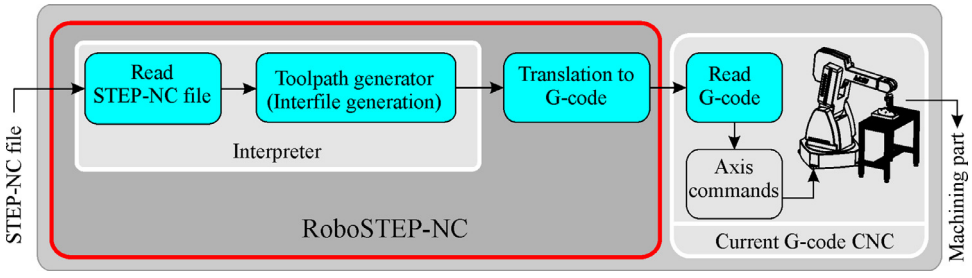

Fig. 2. Indirect STEP-NC programming.

As reported in [13], an interpreter for a numerical control (NC) language is defined as a software system that is able to read files in the language and produce commands to run a machine. The NC language (G-code) according to ISO 6983 (RS274) is line-based. That is, the program written in this language is intended to be executed line-by-line. The STEP-NC is intended to be executed workingstep-by-workingstep. A STEP-NC interpreter must read the entire program before starting execution because any data line in a STEP program may reference any other data line. Also, to a much greater extent than a G-code interpreter, a STEP-NC interpreter must be able to generate tool paths. Since building interpreters for the whole of STEP-NC would take too long, it is necessary to implement enough functionality to cut realistic simple parts.