Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 122 (2017) 346–353

Procedia Computer Science

www.elsevier.com/locate/procedia

Information Technology and Quantitative Management (ITQM 2017)

Selecting industrial robots for milling applications using AHP

Radu Eugen Breaz[a]*, Octavian Bologa[a], Sever Gabriel Racz[a]

[a]Lucian Blaga" University of Sibiu, Victoriei 10, Sibiu 550024, Romania

Abstract

Industrial robots are usually used for pick-and-place applications, which require only point-to-point motion control. However, the recent developments, both in robot technology and in Computer Automated Machining (CAM) software, allow the use of these equipment in applications which require continuous path control, such as multi-axis milling processes. However, the producers do not offer robots specifically developed for this kind of application, thus the user has to choose the most appropriate robot for this goal from a wide range of general purpose robot types. This research work proposes a method based upon Analytic Hierarchy Process (AHP) for selecting the industrial robot for milling applications. Several attributes of the robots are proposed as selection criteria, and a simulation study of the milling capabilities of the robotic structure is also taken into consideration.

Peer-review under responsibility of the scientific committee of the 5th International Conference on Information Technology and Quantitative Management, ITQM 2017.

Keywords: AHP, robot selection, multi-axis milling, kinematic model, simulation

1. Introduction

Industrial robots have a wide range of applications, such as assembling, welding and painting. These applications require only point-to-point motion control, being operations where the end-effector of the robot must move between a set of given points, without the need of following a certain trajectory. By contrast, milling applications demand continuous path control, because the accuracy of the toolpath influences the shape and dimensional accuracy of the machined part. Recent advances in robot technology and computer automated machining (CAM) software have opened this range of applications for serial industrial robots. Industrial robots are still designed and produced for general purpose applications, so selecting the best robotic structure for multi-axis milling could be a difficult task.

Several works are described when performing a literature survey, with regards of robot selection for a given task. The work presented in [1] applies for robot selection an extended VIKOR [2] method. Among the inputs

* Corresponding author. Tel.: +40-745-374-776; fax: +40-269-217-871.
E-mail address: radu.breaz@ulbsibiu.ro.

1877-0509 © 2017 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of the scientific committee of the 5th International Conference on Information Technology and Quantitative Management, ITQM 2017.
10.1016/j.procs.2017.11.379

taken into consideration were positioning accuracy, flexibility of programing system, HMI interface, quality and availability of service, cost of the robot and maximum load.

In the research presented in [3], a distance based approach method is introduced. This approach is based upon three criteria (performance, quality and cost), each criterion being characterized by attributes. No attributes for cost were defined. The attributes for performance criteria were defined as velocity, repeatability, load capacity, degrees of freedom), while for quality the attributes defined were stability, compliance and accuracy.

The approach from [4], based upon weighted sum decision model, divided the criteria in two categories: objective and subjective. The first one included velocity, maximum manipulated load, cost and repeatability, while the second one included quality of service provided by the producer and flexibility of programming.

Industrial robots were compared and identified by means of methods based upon digraph and matrixes, according to [5]. Finally, the selection between robotic structures was made based upon the overall cost, the manipulated load, velocity repeatability, degrees of freedom, and HMI interface.

A method based upon objective and subjective preferences is developed and presented in [6], which used as selection attributes load capacity, maximum tip speed, repeatability, memory capacity, manipulator reach.

The research presented in [7] uses methods based upon compromise ranking and outranking for selecting between the alternative robot structures.

Fuzzy approaches are also reported in the literature, consequently in the work presented in [8] a fuzzy decision support system is introduced. The method divided the selection attributes into objective attributes (cost, positioning accuracy, repeatability, reliability, load capacity, degrees of freedom) and subjective attributes (man-machine interface, programming flexibility, service, training, vendor reputation).

Systems for supporting the decision to select between different industrial robots, based upon Fuzzy Analytical Hierarchy Process (FAHP) are presented in [9-10].

An approach based upon Analytic Hierarchy Process (AHP) approach was developed in the research presented in [11]. Repeatability, cost, load capacity, velocity were the robot attributes selected as criteria.

An integrated model using AHP and QFD (Quality Function Deployment) is presented in [12]. The QFD method was introduced in the work presented in [13.] The approach from [12] have selected as robot attributes the following: actuation devices, dexterity (geometrical), motion feedback system, size of the robotic structure, material from which the main components are made, weight of robot, initial operating cost, manipulated load, positioning accuracy, life-expectancy, velocity of robot, flexibility of programming system and overal cost.

2. The analyzed systems

For this approach, medium-size serial industrial robots, which can perform milling operations were taken into consideration. The characteristics of the analyzed robotic systems (R1, R2, R3) are presented in table 1.

Table 1. The considered robotic systems

Characteristic	**R1**	**R2**	**R3**
Kinematic structure	Serial, 6 degrees of freedom (dof)	Serial, 6 dof	Serial, 6 dof
Load capacity [kg]	16	20	20
Reach [mm]	1611	1811	1550
Weight [kg]	235	250	380
Repeatability [mm]	± 0.05	± 0.04	± 0.03
Power consumption [KW]	8.8	1	0.67
Service points	One office, branch of a reseller from abroad	Only abroad (no offices in the country)	Two offices in the country, national reseller