Design evaluation of industrial robot under mixed information: A multi objective optimization design evaluation approach

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Abstract: An industrial robot is a manipulator designed to move materials, parts and tools, and perform a variety of programmed tasks in manufacturing and production settings. Industrial robots are reshaping the manufacturing industry. They are often used to perform duties that are dangerous or unsuitable for human workers. Design evaluation of industrial robot for any industrial application is difficult tasks in real time manufacturing. Many robot design evaluation problems are considered in the context of Multi Criteria Decision Making (MCDM) in present era. In the presented research work, the authors have designed an Multi Objective Decision Making (MODM) appraisement module, which has been solved by multi objective optimization design evaluation approach.

Key words: Robot, Module, Multi-objective optimizations, group decision making process, multi objective optimization design evaluation approach

I. INTRODUCTION AND LITERATURE SURVEY:

The industrial robot is a good fit for many applications. It is most often used for arc welding, material handling, and assembly applications. They are grouped according to number of axes, structure type, size of work envelope, payload capability, and speed. A robot controller provides the interface for programming and operating the industrial robot. A device called a teach pendant is used to plot the motions needed to perform the application.

Decision-making is extremely intuitive while considering single criterion problems, since we only need to choose the alternative with the highest preference rating. However, when decision-makers (DMs) evaluate alternatives with multiple criteria, many problems, such as criterion weight, preference dependence, and conflicts among criteria, seem to complicate the problems and need to be overcome by more sophisticated tools and techniques.

In order to deal with Multi-Criteria Decision Making (MCDM) problems, the first step is to figure out criteria/attribute listing. Next, we need to collect appropriate data or information in which the preferences of DMs can be correctly reflected upon and considered (i.e., constructing the preferences). Further work builds a set of possible alternatives or strategies in order to guarantee that the goal will be reached (i.e., evaluating the alternatives) (Sahu et al., 2012; Sahu et al., 2014; Sahu et al., 2015a,b). Through these efforts, the next step is to select an appropriate method to facilitate us to evaluate and outrank or improve the possible alternatives or strategies (i.e., finding and determining the best alternative).

The several relevant literature survey has been conducted (Koulouriotis and Ketipi 2011; Chu and Lin 2003; Olcer and Odabasi 2005; Bhangale, Agrawal, and Saha 2004; Bhangale, Agrawal and Saha 2004; Tansel, Yurdakul and Dengiz 2013; Karsak 2008, Chakraborty 2011). After carrying out the literature survey, it is found that there is necessity to develop a potential decision making appraisement structure, which can be used to evaluate the best design of industrial robot under multiple subjective or objective dimensions. It is also perceived that for making decision, there is indeed necessity to implement a potential a multi objective optimization design evaluation approach to solve appraisement structure.

II. RESEARCH OBJECTIVES:

It is found after conveying the momentous literature survey, there is need to construct and apply and robust Robot design evaluation approach on robot evaluation module to select design, the author developed a multi objective optimization design evaluation approach, which must handle mixed information.

III. DEVELOPED MODULE:

Module has been consisted of several dimension to choose proper design of robot such as Cost, INR, (C_1), Speed, m/s, (C_2), Load carrying capacity, kg, (C_3), Space requirement, (C_4), Cost, INR/Year, (C_5), Degree of Freedom, No, (C_6), Energy consumption, Unit/Hrs, (C_7) Effectiveness,(C8), Worker intention, (C_9) Flexibility against change in goods design , (C_{10}) ,Chances of failure, (C_{11}), Simplicity, (C_{12})

IV. ROBOT DESIGN EVALUATION APPROACH:

Ratio Analysis System:

Ratio System defines data normalization by comparing alternative of an objective to all values of the objective:

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}} \qquad (1)$$

Here X^{*}_{ij} denotes i^{th} alternative of j^{th} objective. Usually these numbers belong to the interval [0, 1].

Ratio Analysis System:

These indicators are added (if desirable value of indicator is maximum) or subtracted (if desirable value is minimum), thus the summarizing index of each alternative is derived in this way:

$$y_i^{*} = \sum_{j=1}^{g} x_{ij}^{*} - \sum_{j=g+1}^{n} x_{ij}^{*}, \qquad (2)$$

Here $g = 1,...,n$ denotes number of objectives to be maximized. Then every ratio is given the rank: the higher the index, the higher the rank.

Full Multiplicative Form

$$U_i^{'} = \frac{A_i}{B_i} \qquad (4)$$

Here $A_i = \prod_{j=1}^{g} x_{ij}; i = 1,2,...,m$ denotes the product of objectives of the i_{th} alternative to be maximized with $g = 1,2,...,n$ being the number of objectives to be maximized and where

$B_i = \prod_{j=g+1}^{n} x_{ij}; i = 1,2,...,m$ denotes the product of objectives of the i_{th} alternative to be minimized with $n-g$ being the number of objectives (indicators).

MOSRA:

$$U_i^{'} = \frac{A_i}{B_i} \qquad (4)$$

Here $A_i = \sum_{g}^{n} x_{ij}; i = 1,2,\ldots,m$ denotes the product of objectives of the i_{th} alternative to be maximized with $g = 1,2,...,n$ being the number of objectives to be maximized and where $A_i = \sum_{j=g+1}^{n} x_{ij}; i = 1,2,\ldots,m$ denotes the product of objectives of the i_{th} alternative to be minimized with $n-g$ being the number of objectives (indicators).

V. DEFUZZIFICATION:

It is applied to convert the fuzzy or subjective information in numerical data. The authors used.

VI. CONCLUSIONS:

Robot appraisement module (for evaluating designed of general robot), which could consider both, objective and subjective dimensions, corresponding to numerical data and fuzzy data, respectively, for evaluating design of robot design -5 has found best. table 1-6 dealt with subjective data, while table-7 dealt with objective data. Proposed module can be solved by multi objective optimization design evaluation approach, which must handle mixed information i.e. TOPSIS, Grey relational analysis (GRA), Inner product of vectors (IPV), Measuring Attractiveness by a categorical Based Evaluation Technique (MACBETH), Multi-Attribute Global Inference of Quality (MAGIQ), Multi-attribute utility theory (MAUT), Multi-attribute value theory (MAVT), New Approach to Appraisal (NATA). Presented module might assist the mangers of manufacturing firms towards electing the best design of industrial robot under multiple subjective or objective dimensions in extent of subjective or objective information. The outcomes of research work might help each manufacturing firm to improve their firm further profit.

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Table 1: Significances against design of objectives

Significances of C	DM1	DM2	DM3	DM4	DM5
C_1	H	H	M	H	H
C_2	VH	VH	VH	H	H
C_3	H	H	MH	H	MH
C_4	M	VH	H	H	H
C_5	VH	H	VH	H	H
C_6	VH	VH	VH	H	H
C_7	H	H	MH	H	MH
C_8	M	VH	H	H	H
C_9	VH	H	VH	H	H
C_{10}	H	H	M	H	H
C_{11}	VH	VH	VH	H	H
C_{12}	H	H	MH	H	MH

Table.2 Design of robot under subjective parameters, (C_8)

Evaluation of Robot design	robot under subjective parameters				
	DM1	DM2	DM3	DM4	DM5
Robot design-1	MG	F	G	MG	VG
Robot design-2	F	G	MG	F	G
Robot design-3	F	G	G	G	F
Robot design-4	F	G	G	G	G
Robot design-5	G	MG	F	VG	MG
Robot design-6	VG	VG	G	G	G
Robot design-7	MG	VG	G	F	G

Robot design-8	G	VG	MG	VG	VG
Robot design-9	MG	G	MG	G	VG
Robot design-10	F	VG	F	MP	VG
Robot design-11	VG	VG	G	G	G
Robot design-12	G	MG	MG	MG	G
Robot design-13	VG	MG	MG	MG	MG
Robot design-14	G	MP	MG	MP	G
Robot design-15	VG	G	MG	VG	VG

Table.3 Design of robot under subjective parameters, (C_9)

Evaluation of Robot design					
	DM1	DM2	DM3	DM4	DM5
Robot design-1	VG	VG	G	G	G
Robot design-2	MG	VG	G	F	G
Robot design-3	G	VG	MG	VG	VG
Robot design-4	MG	G	MG	G	VG
Robot design-5	F	VG	F	MP	VG
Robot design-6	MG	F	G	MG	VG
Robot design-7	F	G	MG	F	G
Robot design-8	F	G	G	G	F
Robot design-9	F	G	G	G	G
Robot design-10	G	MG	F	VG	MG
Robot design-11	G	MG	MG	MG	G
Robot design-12	VG	MG	MG	MG	MG
Robot design-13	G	MP	MG	MP	G
Robot design-14	VG	G	MG	VG	VG
Robot design-15	F	G	G	MP	MP

Table.4 Design of robot under subjective parameters, (C_{10})

Evaluation of Robot design					
	DM1	DM2	DM3	DM4	DM5
Robot design-1	G	MG	MG	MG	G
Robot design-2	VG	MG	MG	MG	MG
Robot design-3	G	MP	MG	MP	G
Robot design-4	VG	G	MG	VG	VG
Robot design-5	F	G	G	MP	MP
Robot design-6	MG	F	G	MG	VG
Robot design-7	F	G	MG	F	G
Robot design-8	F	G	G	G	F
Robot design-9	F	G	G	G	G
Robot design-10	G	MG	F	VG	MG
Robot design-11	VG	VG	G	G	G
Robot design-12	MG	VG	G	F	G

Robot design-13	G	VG	MG	VG	VG
Robot design-14	MG	G	MG	G	VG
Robot design-15	F	VG	F	MP	VG

Table.5 Design of robot under subjective parameters, (C_{11})

Evaluation of Robot design					
	DM1	DM2	DM3	DM4	DM5
Robot design-1	G	MP	F	F	MP
Robot design-2	G	G	VG	G	VG
Robot design-3	VG	VG	VG	G	G
Robot design-4	VG	G	VG	VG	VG
Robot design-5	VG	MG	G	G	G
Robot design-6	MG	F	G	MG	VG
Robot design-7	F	G	MG	F	G
Robot design-8	F	G	G	G	F
Robot design-9	F	G	G	G	G
Robot design-10	G	MG	F	VG	MG
Robot design-11	VG	VG	G	G	G
Robot design-12	MG	VG	G	F	G
Robot design-13	G	VG	MG	VG	VG
Robot design-14	MG	G	MG	G	VG
Robot design-15	F	VG	F	MP	VG

Table.6 Design of robot under subjective parameters, (C_{12})

Evaluation of Robot design					
	DM1	DM2	DM3	DM4	DM5
Robot design-1	G	G	VG	VG	G
Robot design-2	MG	VG	MG	VG	MG
Robot design-3	MG	VG	MG	G	VG
Robot design-4	G	G	F	MG	MG
Robot design-5	G	G	MG	VG	MG
Robot design-6	MG	F	G	MG	VG
Robot design-7	F	G	MG	F	G
Robot design-8	F	G	G	G	F
Robot design-9	F	G	G	G	G
Robot design-10	G	MG	F	VG	MG
Robot design-11	VG	VG	G	G	G
Robot design-12	MG	VG	G	F	G
Robot design-13	G	VG	MG	VG	VG
Robot design-14	MG	G	MG	G	VG
Robot design-15	F	VG	F	MP	VG

Table. 7: Technical and Cost information for polar robots

Evaluation of Robot design	(C_1)	(C_2)	(C_3)	(C_4)	(C_5)	(C_6)	(C_7)
Robot design-1	16000000	0.60	11	49000	51000	5	10
Robot design-2	15000000	0.50	10	50000	52000	6	11
Robot design-3	17000000	0.60	12	50000	50000	5	10
Robot design-4	18000000	0.49	13	47000	53000	6	12
Robot design-5	19000000	0.70	14	50000	50000	6	13
Robot design-6	19000000	0.60	15	50000	50000	6	14
Robot design-7	12000000	0.80	9	52000	54000	5	10
Robot design-8	10000000	0.60	8	50000	50000	6	11
Robot design-9	18000000	0.56	8	52000	50000	6	9
Robot design-10	18000000	0.60	10	50000	42000	6	11
Robot design-11	19000000	0.57	12	48000	43000	6	10
Robot design-12	19000000	0.60	13	50000	42000	6	8
Robot design-13	12000000	0.62	14	55600	58000	4	8
Robot design-14	18000000	0.61	10	50000	50000	6	7
Robot design-15	19000000	0.63	12	40000	50000	6	9