Chapter 5
Integrating Linear Physical Programming and Fuzzy Logic for Robot Selection

Mehmet Ali Ilgın
Manisa Celal Bayar University, Turkey

ABSTRACT

An increasing number of companies are using robots to perform a variety of repetitive and hazourdous tasks. Existence of many different robot alternatives force companies to consider several conflicting criteria before determining the most suitable robot alternative. Researchers have developed various multi-criteria decision making based methodologies in order to assist the decision makers in robot selection process. However, those methodologies require decision makers to assign physically meaningless weights to evaluation criteria. This article eliminates this weight assignment process by proposing a robot selection methodology based on linear physical programming. In addition, fuzzy logic was integrated into the proposed approach in order to determine the preference values of subjective robot evaluation criteria. A numerical example is also provided in order to present the applicability of the proposed methodology.

1. INTRODUCTION

Rapid developments in numerical control technology stimulated the use of automation in industry. One of the most widely used forms of industrial automation is the use of robots for the execution of hazardous, repetitious and difficult tasks. Robots can achieve a wide variety of tasks in a production facility including spot welding, material handling, spray painting, machine loading and assembly. Since they are controlled by computers, they can be connected to the other computers systems in the production facility to achieve computer integrated manufacturing. In addition, a robot can perform a task with a consistency and repeatability that can not be achieved by a worker (Groover, 2008).

Due to the above-cited advantages, robots can provide significant improvements in product quality and production efficiency. However, a company should determine the most suitable robot alternative for a particular task in order to fully experience the benefits provided by a robotic system. That is why

DOI: 10.4018/978-1-7998-1754-3.ch005

robot selection is a crucial process affecting the competitiveness and profitability of a company. Decision makers must consider various objective and subjective criteria during this process. Objective criteria can be defined in numerical terms while the subjective criteria can be defined qualitatively. Table 1 presents the objective and subjective robot selection criteria commonly employed in the literature.

Researchers developed various multi attribute decision making (MADM)-based methodologies for the evaluation and selection of robots. Goh (1997) developed an AHP-based robot selection methodology which considers objective as well as subjective criteria. Bhattacharya, Sarkar and Mukherjee (2005) integrated AHP with QFD in order to relate customer requirements and design characteristics of a robot. Chatterjee, Manikrao Athawale and Chakraborty (2010) applied both VIKOR and ELECTRE to a robot selection problem and stated that the rankings obtained by those two MADM techniques match significantly. Bhangale, Agrawal and Saha (2004) compared the performance of TOPSIS with some graphical methods while Parkan and Wu (1999) compared the performance of TOPSIS and a performance measurement tool called OCRA. Sen, Datta, Patel and Mahapatra (2015) used PROMETHEE in order to obtain the complete ranking of robot alternatives. The robot selection methodologies proposed by Braglia and Petroni (1999), Karsak and Ahiska (2005) and Mondal and Chakraborty (2013) employed data envelopment analysis (DEA).

In order to incorporate the uncertain judgements of decision makers into the robot selection process, fuzzy logic was integrated with MADM techniques in many studies. Fuzzy AHP (Ic, Yurdakul and Dengiz, 2013; Parameshwaran, Praveen Kumar and Saravanakumar, 2015), fuzzy TOPSIS (Parameshwaran, et al., 2015; Chaghooshi, Fathi and Kashef, 2012; Chu and Lin, 2003; Kahraman, Cevik, Ates and Gulbay, 2007; Koulouriotis and Ketipi, 2011; Bairagi, Dey, Sarkar and Sanyal, 2014; Rashid, Beg and Husnine, 2014), fuzzy VIKOR (Parameshwaran, et al., 2015; Bairagi, et al., 2014; Keshavarz Ghorabaee, 2015; Devi, 2011), fuzzy DEA (Karsak, 1998) and fuzzy COPRAS (Vahdani, Mousavi, Tavakkoli-Moghaddam, Ghodratnama and Mohammadi, 2014) were used to develop robot selection methodologies. Rao, Patel and Parnichkun (2011) developed a novel fuzzy multi-attribute decision making technique for robot selection.

The number of studies using multi-objective decision making (MODM) techniques (e.g., goal programming, fuzzy goal programming) in robot selection is limited. Imany and Schlesinger (1989) and Alinezhada and Mavib (2009) developed goal programming formulations for robot selection problem.

Besides MCDM and MODM techniques, various other techniques were employed to develop robot selection methodologies. Rao and Padmanabhan (2006) used digraph and matrix methods for the evaluation of alternative industrial robots. The methodology proposed by Kumar and Garg (2010) was based on a technique called "distance based approach". Kentli and Kar (2011) developed a robot selection procedure by integrating a satisfaction function with a distance measure technique. Karsak, Sener and Dursun (2012) employed fuzzy linear regression to develop a novel robot selection approach.

The literature review shows us that MADM techniques are the most frequently used techniques in robot selection methodologies. Because these techniques are less complex compared to the other quantitative techniques and the user follows well-defined steps while applying them. However, majority of those techniques require the decision maker(s) assign physically meaningless weights to robot selection criteria. This subjective weight assignment process damages the credibility of the results provided by them. Hence, there is a need for a robot selection methodology which allows decision makers to express their preferences about robot selection criteria in a natural and physically meaningful way.

In this study, a novel robot selection methodology integrating fuzzy logic and linear physical programming is proposed in order the fill the above-cited research gap. First, fuzzy logic is employed in order to determine the preference values of subjective robot evaluation criteria. Then, LPP is used to rank