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Innovative Applications of O.R.

Robust competence assessment for job assignment

Romain Guillaume [a], Raymond Houé [b], Bernard Grabot [b,*]

[a] Université de Toulouse, IRIT, 5 Allées A. Machado, F-31058 Toulouse Cedex 1, France
[b] Université de Toulouse, INPT, LGP-ENIT, 47 avenue d'Azereix, BP 1629 F-65016 Tarbes, France

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ABSTRACT

Allocating the right person to a task or job is a key issue for improving quality and performance of achievements, usually addressed using the concept of "competences". Nevertheless, providing an accurate assessment of the competences of an individual may be in practice a difficult task. We suggest in this paper to model the uncertainty on the competences possessed by a person using a possibility distribution, and the imprecision on the competences required for a task using a fuzzy constraint, taking into account the possible interactions between competences using a Choquet integral. As a difference with comparable approaches, we then suggest to perform the allocation of persons to jobs using a robust optimisation approach, allowing to minimise the risk taken by the decision maker. We first apply this framework to the problem of selecting a candidate within n for a job, then extend the method to the problem of selecting c candidates for j jobs ($c \geqslant j$) using the *leximin* criterion.

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1. Introduction

Human factor is now considered as a key point for industrial performance (Pépiot, Cheikhrouhou, Fürbringer, & Glardon, 2008). The link between a person and a task (or role, job, position, etc.) is usually made through the concept of "competence", now quite universally understood as the "ability" or "potential" to act effectively in a given working situation (Rozewski & Malachowski, 2009). As a consequence, the ISO 9000 standard version 2005 (ISO, 2005) requires the organisations to justify the competences of the human resources involved in the processes, defined as their "demonstrated ability to apply knowledge and skills". An efficient management of the operational performance of human resources therefore requires being able to allocate the right person to a task or role within a business process. This necessitates to address two problems:

- how to model and assess the competences (competences required by a process and competences possessed by an individual),
- how to allocate tasks or roles to actors according to their competences.

Two of the authors have developed a Competence Management software which has been implemented in several companies of different industrial sectors: railway industry (1 company), aeronautic (2 companies), petroleum (2 companies), construction (8 companies) and paper industry (1 company). In each case, the competences attached to a considered position or role have been identified and grouped in "types of competences". The number of levels of the competences has been defined, and the competences possessed by the actors have been assessed (self assessment plus evaluation by the supervisor). Tools have then been provided for comparing required and possessed competences, and to address the detected gaps using trainings.

The longest implementation of this framework has taken more than two years. Some lessons learnt from these experiments have been detailed in Grabot and Houé (2009), concluding on the following requirements which would in our opinion allow to better address the present industrial needs concerning the allocation of persons to tasks or positions:

- like many human characteristics, the competences required by a process, so that those possessed by an individual, can hardly be precisely assessed. Defining required competences is a matter of preferences, and could benefit from a flexible model, while there may be some uncertainty on the validity of the assessment of the level of a possessed competence. Therefore, a framework allowing to model the possible imprecision and

* Corresponding author. Tel.: +33 5 62 44 27 21.
E-mail addresses: Guillaum@irit.fr (R. Guillaume), rhoue@enit.fr (R. Houé), bernard.grabot@enit.fr (B. Grabot).

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uncertainty on the required and possessed competences would allow to cope with partial ignorance, often realistic in this domain;
- in real situations, the combination of competences required for performing a job may have to be modelled more subtly than using a classical "and" (e.g. "Competences X *and* Y *and* Z are required for performing job *J*"). Models denoting alternatives ("*X* or *Y*"), but also synergies or oppositions between competences may be useful for describing some real situations;
- allocating persons to jobs according to their competences may be done in different ways. The most classical one is to try to maximise the consistence between required and possessed competences. Nevertheless, if competences are imprecisely known, minimising the risk taken by an allocation, i.e. a "robust optimisation" approach, would express a more natural attitude of the decision maker (Kahneman & Tversky, 1979).

The first point has been addressed in several studies, especially using fuzzy logic for modelling imprecisely known competences. The state of the art provided in Section 2 shows that the two other points have not yet been fully considered in the literature. In order to address these requirements, we suggest to use the possibility theory for taking into account the imprecision on the competences, by defining the satisfaction level of the competences required for a job using fuzzy constraints. We suggest to assess as a second step the global level of satisfaction provided by the allocation of a person to a job using the Choquet integral, which allows to take into account interactions between competences (Section 3). In the context of resource allocation under the uncertainty modelled by possibility theory, "robust optimisation" consists in maximising the minimal expected value for each allocation. In that purpose, we maximise the *necessity* of satisfaction of each allocation, again using a Choquet integral. As an illustration, we first apply this framework to the problem of selecting a candidate within n for a job described in Barbera and Jackson (1988)), using the *leximin* criterion as a robust criterion (Section 4). We then address the problem of c candidates for j jobs ($c \geqslant j$) in Section 5.

2. Competence modelling: from crisp to fuzzy models

2.1. Modelling competence

The capacity of a person to perform an activity has first been considered using the *qualification* framework (Zarifian, 1994, chap. 6), which denotes the recognition of an aptitude. Nevertheless, listing all the activities that a person may perform in a given job is unrealistic; therefore the more generic concept of "competence" has been introduced. Competences are for instance defined in Peters and Zelewski (2007) as the ability of an employee to use his knowledge to achieve a predefined goal at a given level of performance. As pointed out in Boucher, Bonjour, and Grabot (2007), this concept may be covered by different words in the literature, especially "skills" (de Korvin, Shipley, & Kleyle, 2002; Otero, Centeno, Ruiz-Torres, & Otero, 2009; Valls, Perez, & Quintanilla, 2009), or to a lower extent "abilities" (Huang, Chiu, Yeh, & Chang, 2009) or even "suitability" (Yaakob & Kawate, 1999). Nevertheless, "skills" seem to be usually considered as close to "know-how", denoting a technical aptitude to perform some tasks, while "competences" are more generic: for most of the authors, competences are a fluid mix of knowledge, skills (possibly given by experience) and attitudes (Léné, 1999; Tobias & Dietrich, 2003). A close distinction is made in Warhurst, Keep, and Grugulis (2004), in which "skills" are distinguished from "generic skills", also called "competences". In what follows, we shall combine the previous definitions, by defining competences as "knowledge, know-how and attitudes used to achieve a goal at a required level of performance", this goal being associated to a role or activity of the actor.

Since companies have now the necessity to justify the competence of the human resources involved in their business processes, many Competence Management tools have recently been developed by software editors, as standalone applications, included in Human Resource Management modules, or as part of ERP (Enterprise Resource Planning) systems. Such tools usually allow to compare the competences required by a position and those possessed by a person. The competence levels are sometimes described using linguistic expressions (e.g. poor, adequate, average, good, very good and excellent) but they are always associated to integers for building graphics on which required and possessed competences are compared one by one, through radars or bar graphs. No aggregated score summarising the adaptation of a person to an activity or position is usually provided.

Industrial applications of such "crisp" competence models are for instance described in Grabot and Houé (2009), with the conclusion that defining precisely the level of a competence required by a process may be difficult in real cases. Similarly, assessing the precise level of competence of an individual is still more complex. A solution is to describe the available knowledge on required and possessed competences with its intrinsic ambiguity. This is for instance possible using fuzzy logic, allowing to describe categories with imprecise boundaries: fuzzy logic is known as providing an easy-to-use framework for expressing subjective knowledge, which is the case of required and possessed competence.

This idea has already been applied in the literature on skill/competence modelling: even if the term "competence" is not used, an early work dealing with fuzzy competence modelling is (Liang & Wang, 1992), in which decision-makers' fuzzy assessments about "personnel suitability ratings relative to various evaluation criteria" are aggregated using fuzzy arithmetic. In Wang and Wang (1998), competences modelled by fuzzy sets are used for finding an optimal process to expand a worker's competence set. Triangular fuzzy numbers are also used in Yaakob and Kawate (1999) to assess the "suitability" of workers for performing given jobs. In Huang et al. (2009), required and available competences are again modelled by trapezoidal fuzzy sets, and compared using a degree equal to the maximum of the intersection of the two sets: both over-competence and lack of competence are in that case penalised.

Other works are more precisely oriented on the process of evaluating competences: (Cannavacciulo, Capaldo, Ventre, Volpe, & Zollo, 1996) uses fuzzy logic for modelling the activity of competence evaluation. Pépiot et al. (2008) focus on the modelling of elementary competences, then on their aggregation in order to define a "global" competence on a given domain using fuzzy inference, while in Rozewski and Malachowski (2009), a fuzzy competence model is used for providing a detailed, behavioural description of the employee's characteristics required to effectively perform a task. In Suleman and Suleman (2012), a fuzzy approach is suggested to rank workers according to their competences, while in Zemkova (2008), a comparison between the fuzzy competences possessed by individuals and those requested by a "role" is suggested. Weights are often associated to elementary competences in order to express their relative importance. Korkmaz, Gokcen, and Cetinyoku (2008) and Huang et al. (2009) suggest to use AHP (Analytic Hierarchy Process; Saaty, 1980) for capturing the expertise on these weights. Aggregation may also be performed using more complex operators, like Hurwicz and OWA (Ordered Weighted Average) operators (Nasibov, 2007), both allowing to express a compromise between optimistic (the global index is the maximum of the elementary ones) and pessimistic (the global index is the minimum of the elementary ones) attitudes.

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