

# A Literature Review on the Use of Soft Computing in Support of Human Resource Management

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**Abstract.** Organizational Human Resource Management (HRM) presents complex problems, some of them difficult to aboard by traditional problem solving strategies, because of the necessity to face subjective or imprecise issues, such as the evaluation of knowledge or abilities of a candidate for a specific job. Because of the above, researchers and practitioners have used Soft Computing, or Computational Intelligence, approaches to aboard some of the problems faced in HRM. This paper present the results of a systematic literature review conducted to know how Soft Computing has contributed to solve the problems that exist in HRM. The research identified is classified according to the problems faced in the field of HRM, and the Soft Computing techniques used to aboard such problems.

**Keywords:** Soft Computing, Computational Intelligence, Human Resource Management, Systematic Review.

## 1 Introduction

Knowledge has become a very important factor for many organizations; in fact it is the main input in the development of the products or services provided by many organizations. The last has conducted to a growing interest in the field of knowledge management [1]. Several authors have observed that for knowledge management to be successful, such initiatives must focus on the human resources [1, 2]. As Drucker observed [3], human resources, and particularly those in charge of knowledge intensive activities, could become the most valuable resource for XXI century organizations.

Human resources (HR) are an essential and strategic part of every organization [4, 5]. Individuals who are members of an organization make decisions and define the goals and the road the organization will follow, they control and configure the technological systems, create and share the knowledge needed for the organization's growth, identify the problems that interfere with the performance of the individuals, and hence the whole organization, among many other things. By its nature, HR Management

(HRM) faces complex problems difficult to address with traditional problem solving strategies, for instance because of the need for using qualitative and quantitative multi-criteria to evaluate individuals. If we include the need for managing the knowledge of HR this becomes even more complex because of the subjective and imprecise nature of people's knowledge. These characteristics of HRM have taken researchers and practitioners to explore the use of Soft Computing or Computational Intelligence techniques into the different activities of HRM.

To know the manner in which Soft Computing techniques have contributed to the solution of some of the problems that HRM face, in this paper we present the results of systematic literature review on the use of Soft Computing to address the problems present in the HRM field. In this paper we describe the main results of such research; particularly the main problems addressed by Soft Computing techniques, and the main techniques used. The remains of this paper are structured as follows: first, section 2 introduces the basic concepts related to the research. In section 3, the methodology we followed for conducting the research is described. Section 4 presents the results obtained once the retrieved documents were analyzed and classified. The discussion of the observed in those results is in section 5, followed by our conclusions in section 6.

## **2 Theoretical Background**

The present work is based on the relationships of two main fields: Human Resource Management and Soft Computing. In this section, we shall develop on these two concepts in order to contextualize our research.

### **2.1 Human Resource Management**

HRM is about the efficient management of the working people in order to make them productive and satisfied workers [5]. Without HR, computer systems, payment plans, mission declarations, procedures or programs won't be needed. It is required that the members of the organization be harnessed in an efficient way, but taking care of their wellness and comfort. To maximize the use of human resources, different factors, either qualitative or quantitative, must be taken into account. These factors relate to the complexity of human nature and of the processes of an organization.

The traditional approaches in the field of HRM require personnel capable of following orders. Personnel is instructed on what they should do and how, they must follow established procedures. However, when jobs become more complex, they also become more intensive in the use of knowledge [2]. This requires people that not only know what to do, but people with abilities, skills, and capacities to make decisions about how to do their jobs, when to do it, under which conditions, and knowing why they should do it [3]. This last conducts to the necessity of not only follow the record of the academic information and the career path of individuals; it is required to go farther and get records of the skills, competencies, formal and informal knowledge, experience, values, culture, etc., in order to make a better adjustment of the candidates

to a job [6]. Hence, choosing the better HR for a vacancy in an organization, as well as maintaining them inside the organization could become a very complex task [7].

HRM include several activities such as staff planning, recruitment, selection, rewards management, job evaluation, performance management, capacitation planning, promotion, hygiene and security, among others [5]. These activities should be aligned to the factors that influence the organization's processes and personnel satisfaction to function correctly, in order to achieve the productivity and competitive success that the organizations pursue. The complexity of the individuals and processes of organizations, lead them to require the support of intelligent technologies to carry out their tasks in a better way, while making better use of their human resources. There is why Artificial Intelligence techniques have proven to be useful in support of HRM [8].

## **2.2 Soft Computing**

Soft Computing, or Computational Intelligence, represents a set of techniques for information processing, useful in cases where traditional algorithmic techniques could not exist, or be too complex [9]. These techniques process and interpret data (numeric, symbolic, binary, logic, images, etc.) in connection with a symbolic representation of knowledge, by imitating some of the aspects of intelligent human behavior.

Lotfi Zadeh defines Soft Computing as “a collection of methodologies that aim to exploit the tolerance for imprecisions and uncertainty to achieve tractability, robustness, and low solution cost” [10]. Soft Computing include the use of techniques such as artificial neural networks, fuzzy logic, genetic algorithms, rough sets, probabilistic methods, among others. In summary, Soft Computing provides intelligent mechanisms that may be useful to solve some of the problems faced by HRM activities.

## **3 Methodology**

The present study consisted on the realization of a systematic literature review following the procedure proposed in [11], where a systematic review is described as a mean to evaluate and interpret the relevant research related to a research question or phenomenon of interest, in order to get a reasonable evaluation by using a reliable, rigorous and auditable methodology [11].

The goals of the review were: to identify the problems associated to HRM in which Soft Computing has been used to provide a solution; to identify the Soft Computing techniques used to solve the problems faced in HRM; to identify how those techniques are being used to solve the problems of HRM.

Considering the above objectives, the review was carried out taking into account the following research questions: 1) In which HRM areas have been used Soft Computing techniques? 2) What HRM problems have been faced with Soft Computing techniques? 3) Which Soft Computing techniques have been used in support of HRM? 4) How those techniques have been used?

### **3.1 Planning the Review**

The literature review was conducted by searching in digital databases. We developed a list of terms related to HRM and Soft Computing. The initial selection of them was made with Brainstorming. This initial list of terms was used for a preliminary search where retrieved documents were less than expected. Because of these, we contacted with an expert in the field of HRM to improve the list of terms, this expert helped us to extend the list of terms, and provided us some relevant literature to improve the list. The same was made in the field of Soft Computing. The terms for the HRM field were 67, and 7 for the field of Soft Computing. Additionally we defined a list of 5 synonyms for the word “employee”, these synonyms were used to create new terms to get a wider search, for instance, “Employee Selection” and “Staff Selection”.

The digital databases used for the review were selected based on the fact that they include journals in the field of Soft Computing or related to it, and because access to them was available to us. The selected databases were: Thomson Reuters Web of Science, EBSCO, IEEE Xplore, and Elsevier sciencedirect.

To conduct the review, first we opted for creating one general query. This was because we wanted to avoid debugging duplicated documents in a same database, as well as reducing search time. To create this query, we grouped the terms into two groups: the first one was a set composed of the union of terms in the Soft Computing field, and the second one the set resulting of the union of the terms in the HRM field. The final query was the intersection of the two sets. The documents were filtered using three aspects of them: the title, the abstract, and the keywords.

While using this general query, we faced one big problem: the search engine of each database present technical differences that made it impossible for us to use the general query on all of them. Some search engines presented restrictions on the number of terms that can be used in a query therefore they rejected it. To solve this, it was necessary to remake the search method by dividing the general query into several queries; each query was made by the intersection of each term of the HRM field as the first part of the query, and the set of terms in the field of Soft Computing as the second one. Thus, there were 67 queries on each database, 268 totally. Additionally, it was necessary to use an additional filter in the IEEE database to reduce the documents retrieved by searching just in the range of time of 2004 to 2014. This was because the search engine was not filtering the documents correctly according to the query, and therefore it retrieved too much documents, most of them irrelevant.

### **3.2 Inclusion and Exclusion Criteria**

To establish the criteria to be used to determine the documents to be considered is an important part since it gives validity to results of the review [11]. The inclusion and exclusion criteria that were considered are the following:

- The language of the document must be English or Spanish.
- The title must include a reference to the HRM and Soft Computing fields.
- If the title does not include explicitly a reference to the HRM field, but it can be inferred that it is the application area of a Soft Computing technique, or it is not to-

tally clear, we will search for an explicit reference of the HRM field in the abstract or keywords.

- If the title does not include an explicit reference to the Soft Computing field, but it does with the HRM field, we will search for an explicit reference of the Soft Computing field in the abstract or keywords.
- If the title does not include an explicit reference of any of both fields, we will search for an explicit reference of both fields in the abstract and keywords.
- If none of the above criteria are fulfilled, the document is rejected.

## 4 Results

Table 1 shows the number of documents that were found and selected. The documents are organized using the HRM area where the Soft Computing techniques were applied as the rows, and the Soft Computing technique used as the columns. The column labeled others, groups the documents using combinations of the four techniques, as well as one document using Rough sets, and another that uses an imperialist competition algorithm. The row named others, groups the documents in which Soft Computing techniques were used in the areas of HRM with less than four incidences (most of them with just one or two).

**Table 1.** Results of the review (GA = Genetic Algorithms, FL = Fuzzy Logic, ANN = Artificial Neural Networks, NFN = Neuro-Fuzzy Networks).

Problem	GA	FL	ANN	NFN	Others	Total
Personnel Prediction			7	2	1	10
HRM Evaluation		1	3			4
Job Scheduling	8	2	1		3	14
Personnel Assessment	1	10	5	2		18
Personnel Assignment or Turnover	17				3	20
Personnel Selection		14	3	2	1	20
Others		5	5	1	4	15
Total	26	32	24	7	12	101

In the following subsections we briefly describe the problems of HRM faced with Soft Computing, and the techniques used to solve such problems.

### 4.1 HRM Problems Faced with Soft Computing

**Personnel Selection.** It can be observed on table 1 that personnel selection is one of the two most faced areas in the field of HRM. The problems faced are related to the selection of the best individual for the job. This problem uses to be addressed from a

multicriteria point of view, where the individuals are evaluated with respect to several essential capacities, abilities or attributes for a good performance into the specified job [12–14]. In these cases, fuzzy logic is used for addressing the uncertainty related to the description of the profile of a specific job, or related to the evaluation of the profile of a specific individual. Some times the selection is focused on determining the best of all the candidates [15]; others in searching for an ideal candidate [16]; and in other cases on defining a solution that helps avoid certain undesired behaviors [17]. Fuzzy Logic has also been used combined with neural networks to construct learning systems capable of identifying the better characteristics to describe a specific job [18].

**Personnel assignment and turnover** is the other most faced problem. Genetic algorithms have been used mainly in this area, where it is required to find the better combination of individuals within an organization, in order to maximize or minimize one or several characteristics, such as cost, time, quality, etc. [19, 20]. Personnel reassignment can help to eliminate repetitive tasks by using ergo-nomic, competencies, environment and physical abilities [21], in the search of a better performance, and to avoid diseases. Another use has been in the problem of fair payment with the use of personnel assignment, and evaluation and assigning projects to employees to avoid dissatisfaction because of an unfair payment or economic differences [22]. Additionally, in [23] a methodology for addressing the decreased efficiency caused by the “learning-forgetting” effect is proposed.

Personnel assignment can be also addressed as the formation of work teams. Selecting the better team for a job is a difficult task. One must take into account the abilities and the relationships of the candidates to fulfill a specific task: “good teams before good individuals” [24].

**Personnel assessment** looks for defining the value that individuals have for the organization [25–27]. For addressing this problem, it has been proposed the use of neural networks for talent discovery [28]. Fuzzy logic has been used to evaluate individual performance considering multiple sources [29], and to consider employee satisfaction, learning and performance in capacitation events [30]. Neural networks were also used to predict and optimize personnel efficiency by valuating its attributes in order to identify those that are better to determine the impact of the individuals into the organizational efficiency [31, 32]. Additionally, neuro-fuzzy networks have been used to evaluate the individuals that resigned to a job in order to predict absenteeism [33].

**Job scheduling** consists on assigning resources to a job, such as HR, considering different restrictions, criteria, and one or several goals. In [34], HR are assigned according to their skills, by searching for the best individual and the best moment to avoid delays in tasks and to reduce perturbations while inserting new preventive or corrective maintenance tasks. In [35] neural networks and genetic algorithms are combined to consider human factors in resources and activity scheduling, in this work, authors used past schedulings as a mean to obtain information to define new schedules using neural networks as the learning method.

There are also important works in other areas, such as the job classification according to risk of physical disorders by using neural networks [36], in order to take decisions that allow avoid such disorders. As well, in [37] authors used an imperialist competition algorithm to solve the problem of positioning HR in the adequate job to

obtain cost and time reductions. Neuro fuzzy approaches have also been used to discover implicit knowledge to allow predicting the future performance of employees, in order to select the best individual for a project or a position [38].

In summary, considering the Soft Computing techniques, the most used to face problems in the field of HRM seems to be fuzzy logic, which has been mostly used to address problems related to personnel selection and assessment. On the other hand, genetic algorithms have been mainly used for solving problems related to personnel assignment and rotation, and for job scheduling with different focus. Finally, Artificial Neural Networks have been the most widely used technique if we consider the number of different areas of the HRM where they have been applied.

From the results of the review we can observe that it is clear that Soft Computing has had a significant impact in the HRM field. It has proven to be a useful tool for solving complex problems presented in almost all the activities of the HRM process. Nevertheless, even though we conducted a wide review, we consider that the works found in literature are still a few, and more research should be carried out in order to exploit the benefits that Soft Computing could bring to solve many of the problems faced in HRM, an essential process for every organization.

## **5 Discussion**

In the literature we found that some of the main problems addressed with soft computing techniques in HRM are personnel assessment and selection, as well as the job assignment of personnel, using multicriteria approaches. In these problems it is common to search for the individual that better fits to an ideal to fulfill a specific job, by giving it a qualification from the best to the worst, or from 0 to 1. Fuzzy logic is the main mechanism used to assign those qualifications, since it is commonly needed the use of several attributes that are frequently subjective and imprecise.

However, we observed that the methods used do not allow to know if individuals are overqualified, an important issue to make the best decision while assigning personnel to a job. We also observed that most works reviewed use to consider all the criteria as if their where just one, since they sum them before making the match between the individual and the job, hiding the qualification of specific criteria.

Multicriteria approach is robust, however, it could be possible to obtain important information to make a better decision if we would be able to show the result using a multilevel approach, for instance, by creating a job profile based on the activities that should be performed, and describe these activities according to the competencies required to accomplish them. In this way, we could evaluate individuals according to their competencies, but at the same time know what activities or jobs can do in a satisfactory manner, and which ones do not.

In [39, 40] an approach to describe job and employees profiles is proposed. It allows realizing the description in a multilevel way, describing the abilities, knowledge, competencies, and values required for a job or role of an organization. This proposal has been defined following a knowledge representation approach based on traditional logic. Therefore, it does not allow facing the uncertainty that exists in a natural form

in the description of the necessities of a job, as well as on the description of the profile of a candidate for such a job. The systematic review conducted has helped us to identify the manner in which fuzzy logic can help us to aboard these limitations.

As a result of the above, and as a continuation of the present work, we will search for a more detailed review of the manner in which fuzzy logic has been used to solve the problems present in the activities of personnel selection, assessment and assignment, in order to adapt the proposal of [39, 40].

We expect that such adaptation will facilitate the use of a description of job and employee profiles to help the analysis and the matching of them in order to obtain a comprehensive solution for the several problems faced by HRM, including:

- Facilitate Job analysis.
- Select the best candidates for a job.
- Improve the assignment of personnel to a job.
- Improve the design of career plans for the employees of an organization.
- Improve capacitation programs and planning according to the specific needs of each job or employee.

Job analysis is an important activity for HRM. It allows obtaining information about the relevant issues of a job, giving as main result a description (summary) and specification (knowledge, abilities, competencies, skills, etc.) of it [5]. The above is essential to carry out in a better way the rest of the activities of HRM. There is why as part of our further work we will focus on providing a mechanism to facilitate job analysis through an approach based on fuzzy logic. As observed in the table 1, it is an area of research that has not been explored from this point of view in literature.

## **6 Conclusions**

Soft Computing has offered to HRM different alternative solutions to the problems that managers face while they work with the complexity of human resources. The use of fuzzy logic to represent the uncertainty given by the human complexity, genetic algorithms used in the combinatorial optimization problems present in job and tasks assignment, and neural networks to classify, evaluate, and predict conducts of individuals and organizations, within others, have demonstrated to be potent and efficient mechanisms to solve some of the most complex problems faced in HRM.

Most of the works found in literature focus on solving specific and particular problems. It is needed a more comprehensive approach capable of impacting in most activities of HRM. There exist important problems in HRM that have been not addressed yet by the use of Soft Computing techniques. We consider that one alternative to aboard these deficiencies is to provide a solution for the job analysis phase that facilitate the use of Soft Computing techniques in the rest of the HRM activities. Taking these into account, as a result of the present work we have proposed to adapt an approach to describe jobs and employees profiles, in order to such profiles to be described following a schema that facilitate the use of fuzzy logic in the analysis of



jobs. To accomplish this, we will make a more detailed analysis of the manner in which fuzzy logic has been used in the field of HRM.

Finally, it is important to mention that even though we consider that the result of the review is a good approach to what is reported in the literature about the use of Soft Computing in HRM, a more extended review could be made in order to consider other important sources, such as the digital database of Springer, ACM, and others that were not considered in our review.

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