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A review paper on artificial intelligence at the service of human resources management

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ABSTRACT

In the last few years, all companies have been interested in the analysis of data related to Human Resources and have focused on human capital, which is considered as the major factor influencing the company's development and all its activities at all levels of human resource policies. Data analysis (HR analytics) will significantly improve business profitability over the next years. We started with an extensive survey of different human resources problems and risks reported by HR specialists, then a comprehensive review of recent research efforts on computer science techniques proposed to solve these problems and finally focusing on suggested artificial intelligence methods. This review article will be an archive and a reference for computer scientists working on HR by summarizing the IT solutions already made in human resources for the period between 2008 and 2018. It aims to present clearly the issues that HR researchers face and for which computer scientists seek solutions. It summarizes at the same time the recent and different methods, IT approaches and tools already used by highlighting those using artificial intelligence.

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1. INTRODUCTION

Human Resources Management has undergone profound transformations as a result of a diversification of issues related to the HR function and a strengthening of its influence in the strategic decision-making processes of companies. Today, the HR function is moving more and more towards personalizing HR practices that take into account the specificities of each target. The goal is to help managers achieve a better intergenerational collaboration. Human Resources Analysis enables companies to make good use of their "employee" databases in order to make the best decisions and improve their operational performance [1, 2].

At a time when business leaders are preparing for a digital world that is gaining momentum, artificial intelligence based on the "machine learning" technology [3] promises to revolutionize human resources departments at different levels: recruitment, training, management of career, mobility, compensation and benefits in order to attract talent and high potential, treat and evaluate nominations as quickly as possible, check the suitability of the profile and position and predict the candidate's added value for the company, these are the major challenges of any Human Resources Department[4].

One of the most difficult situations of any company that wants to be modern and competitive is to lose one or more of its successful employees to one of its competitors [5]. Thanks to artificial intelligence, HRDs can implement performance indicators of their human capital, based on internal data analysis, cross-referenced with external market data and in particular competition. The results of these analyses will make it

possible to map the existing profiles according to each employee's productivity and effectiveness [6-9]. Inspired by the functioning of the human brain, this technology is the subject of a technological boom and it is increasingly bringing about convincing results in the giants of technology (Apple, Facebook, Google, Microsoft ...).

The treatment of the data is an intelligence that must be interpreted, mastered to make the best of it. And it is on the basis of this reflection and on its intuition that the HR function will be able to capitalize and to place its function at a higher strategic and decisional level. Some may think that data and algorithms could be a substitute for the intelligence of their decision when in fact; they allow a better expression of this intelligence. It is fundamental to understand that if data becomes unavoidable, it is not independent. All its value lies in the reading and interpretation of this information by human intelligence. Data does not replace the intelligence and courage of HR; it is at their service. HR, supported by the data, has the means to build their future. Challenging ready-made representations and preconceived ideas to induce propositions based on these observations is the challenge that accompanies the taming of data by HR [10].

2. LITERATURE SURVEY

Over the last years, there have been some researchers who have completed their work successfully on Human resources analytics. We have chosen to collect the various researches on this subject during the period between 2008 until 2018. The majority of articles dealing with topics related to the field of artificial intelligence and human resources were published in newspapers from 2015 to 2018, especially between 2015 and 2017. In 2018, the number of researches involved increased between the months of March until September and during the month of November.

Hundreds of articles have appeared in scientific journals related to computer science such as (Future Generation Computer Systems, International Journal of Interactive Multimedia and Artificial Intelligence, International Journal of Computing and Informatics, The Scientific World Journal, … etc) while others have appeared in human resources management journals (for example: Management : Journal of Contemporary Management Issues, Journal of Business Strategy, Business Horizons, … etc). Exponential growth of HR articles number from 2008 to 2018 as shown in Figure 1.

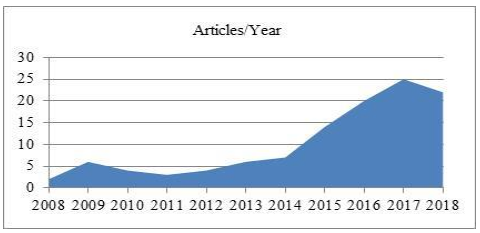

Figure 1. Exponential growth of HR articles number from 2008 to 2018

3. HUMAN RESOURCES RISKS

To achieve these HR goals several risks are arise [8, 11, 12, 69]. Human Resources risks as shown in Figure 2.

Figure 2. Human resources risks

3.1. The Social Dialogue:

A failure in the management of social dialogue following a lack of communication or precision of managerial objectives can generate strong tensions within the company: prolonged strike (absenteeism, demotivation, lack of trust between managers and employees ...).
Predict: Strike Extra / Absenteeism Rate [13].

3.2. Skills Management:

A lack of follow-up of the skills and talents of the company systematically leads to an accentuated departure of key employees of the company: increased demotivation of staff, lack of training, and stagnation of teams...
Predict: attrition rate / assisted awareness rate [14-18].

3.3. Well-Being and Motivation at Work:

Some managerial practices such as the setting of unattainable goals and the lack of communication between managers and employees can be considered as a trigger for stress, burn out or even suicide of employees.
Predict: Staff Satisfaction / Staff Involvement [19-21].

3.4. Employee Safety:

A lack of formalization of safety procedures and the absence of internal control in this area may lead the company to possible civil and / or criminal penalties following injuries or even deaths in the workplace (degradation of his image).

Predict: Operational risks related to the activity of the company [22].

3.5. "Malicious" HR Practices:

A calamitous social climate may be the result of an unsensitized management system based on excessive pressure on the part of management (pressure on objectives) and lack of control of managerial practices internally (harassment of staff, unequal treatment of situations).
Predict: Indicators to assess the social climate [23].

3.6. HR Costs:

A lack of control of HR costs may lead to additional costs and a structural increase in management costs, especially in the absence of management and HR management control: poor management of payroll, cost health insurance / provident insurance. The IT solutions for human resources issues as shown in Table 1.
Predict: Indicators to control HR costs and enhanced HR management control [24].

Table 1. The IT Solutions for Human Resources Issues

HR Risks	Problem	Prediction
The social dialogue	Absenteeism, demotivation, lack of trust between managers and employees…	Strike Extra/Absenteeism Rate
Skills management	Demotivation of staff, lack of training, and stagnation of teams...	Attrition rate/assisted awareness rate
Well-being and motivation at work	Stress, burn out or even suicide of employees	Staff Satisfaction/Staff Involvement
Employee safety	civil and/or criminal penalties following injuries or even deaths in the workplace (degradation of his image)	Operational risks related to the activity of the company
"Malicious" HR practices	harassment of staff, unequal treatment of situations	Indicators to assess the social climate
HR costs	poor management of payroll, cost health insurance/ provident insurance	Indicators to control HR costs and enhanced HR management control

4. IT SOLUTIONS AND ARTIFICIAL INTELLIGENCE FOR HUMAN RESOURCES PROBLEMS

4.1. The Different HR Issues Studied

According to our research, several HR issues have been asked to computer scientists to find the best possible solutions; most of the issues raised are concerning: Jobs, talents and skills management, candidature/ staff selection and recruitment, attrition, turnover, future human capital needs, HR performance and effectiveness, etc. The following graph shows the important HR issues raised and for which computer scientists have proposed different IT solutions. The important HR issues studied using IT solutions as shown Figure 3.

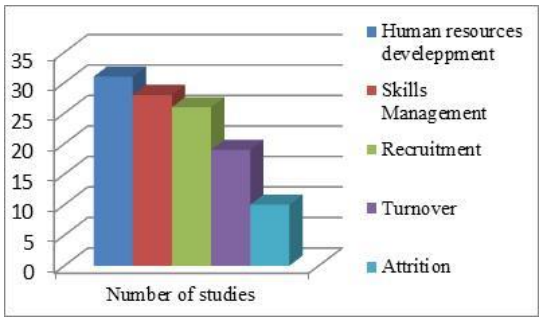

Figure 3. The important HR issues studied using IT solutions

According to the chart, most of the articles found concern HR development, followed by skills management, recruitment and turnover and attritions.

4.2. IT Solutions for Human Resources Issues

According to our quantitative research, several IT solutions have been proposed to solve the various problems related to human resources. Percentage of Use of IT solutions for HR issues as shown in Figure 4.

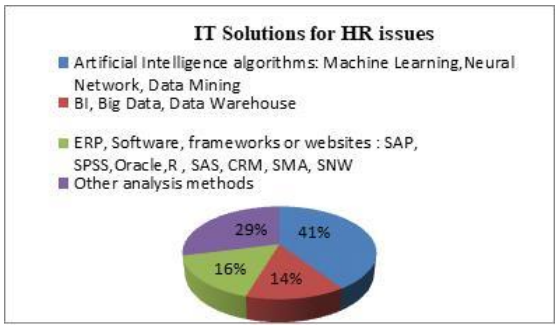

Figure 4. Percentage of use of IT solutions for HR issues

According to our detailed research, we have found that the solutions using artificial intelligence algorithms (Machine Learning, Neural Network, Data Mining) are the most used to solve the HR problems. They oversee the others by a use percentage of 41%, followed by 29% of other analysis methods or simple statistics, 14% of BI, Big Data and Data Warehouse solutions then 16% of simple analysis using software, ERP, frameworks or websites. The Table 2 summarizes the different solutions proposed for each HR problem.

4.3. Artificial Intelligence Solutions for Human Resources Issues

Abridged with the acronym AI, it is the science treating the production of the human knowledge, and offering to machines the ability to imitate human reasoning and intelligence. It simulates the execution of tasks similar to those handled by the human being: recognition, prediction, classification, understanding, dialogue, adaptation and learning.

The keyword Artificial Intelligence is quite the buzz in the virtual world in all domains today and since its appearance it has undergone a renaissance in the form of Machine Learning and subsequently the emerging of Deep Learning, which has boomed over the last few years ; thereby giving a new type with deeper examples and algorithms to Machine Learning. Furthermore, we cannot talk about these terms without mentioning the neural networks which represent the core of our research in view of their importance in all substantial items already mentioned. The most known artificial intelligence algorithms used to solve human resources issues as shown in Figure 5.

Table 2. The IT Solutions for Human Resources Issues

HR Issues	IT Solutions proposed	Publications
Recruitment, Jobs & Skills Management	Job Pruner, Single-label classifier, SVM Linear & RBF Kernel, RFs, ANNs, LMI Knowledge Graph, advanced SMA frameworks, SNWs, Cluster analysis, Genetic algorithms, Natural Language Processing, Speech and Image recognition, Regression Models, Sentiment Analysis, Signal Processing and Data Visualization, web scraping, Structural equation modeling (MSEM)/ Mplus software, AMO model, Access, SAP,IBM SPSS, Oracle, R, SAS, Visier Workforce Analytics, SharePoint, Workday, Excel, Big Data, Fuzzy Analytic Hierarchy Process (FAHP), Grey Relational Analysis (GRA), Centroid method, Fuzzy VIKOR method, Jobvite, Data Mining, C4.5 DTs, C 5.0 DTs, LDA, Tree J48, The stepwise weight assessment ratio analysis (SWARA), grey additive ratio assessment (ARAS-G), Multicriteria Decision-Making (MCDM), Grey Relational Analysis (GRA), Multi Criteria Decision Making (MCDM), ANCOVA, Naive Bayesian, BI, Social Recruiting (SR) technologies, On-line Evolute Helix application, Clusters, Rotation Forest, Mapping HR-Analytics-Strategy, Return on Investment ROI of HR Analytics, Giant Oracle, Online Analytical Processing (OLAP), Technology Acceptance Model (TAM), Standard Process for Data Mining (CRISP-DM), Waikato tool Environment for Knowledge Analysis (WEKA), Bayes Net, JRIP, MCDM, Web 2.0 technologies, Fuzzy Expert System (FES), Affinity Propagation,	[17], [25-51]
Employee Attrition Prediction	RFs, SVMs, KNNs, ANNs, DTs(C5.0, C4.5, REPTree,), Logistic Regression(Logit and Probit model), CART, discriminant analysis, CART, Naïve Bayes, Rstudio, WEKA data mining tool, C4.5(J48), REPTree, CART (SimpleCart) decision tree, logistic regression, neural network, SEMMA methodology, subset selection method, Taguchi method and Nearest Neighbour Classification, particle swarm optimization, Data Mining,	[14-18], [52]
Employee's Turn Over	DTs, RFs, SVM, MLP, KNN, Naïve Bayes, Sequential Backward Selection Algorithm (SBS), Decision Tree, Gradient Boosting Trees, Logistic Regression, Linear Discriminant Analysis, Polynomial Regressions, Cross-Classified Multilevel Analysis, MLP, Python, SPSS, weighted least squares (WLS), Linear Discriminant Analysis (LDA), Conditional semi-Markov (CSMK) model, self-organizing maps (SSOM), Extreme Gradient Boosting (XGBoost), dynamic regression, C4.5 Decision Tree, SPSS 12.0 software package, Cronbach's a and confirmatory factor analysis, Pearson's correlation, ANOVA and Scheffe´'s post hoc analysis, Taguchi Methods, Leader-Member Exchange (LMX) scale, the Minnesota Satisfaction Questionnaire (MSQ)	[20, 21, [53-69]
Improve human resources talents, productivity, effectiveness and performance	Multiple Criteria Decision-Making (MCDM), Analytical Hierarchy Process (AHP), iThink software, Back Propagation, HR predictive analytics (HRPA), Structural Equation Modelling (SEM), neuro-fuzzy approach, Data warehouse, ETL framework, CSV,CSVQL, BI, Data Mining: C4.5 classifier, J48, KNN, Apriori algorithms, Decision Tree, Random Forest, Neural Network (Multilayer Perceptron, Radial Basis function), Nearest Neighbor, Logistic Regression, SEMMA SAS, Global Business Services (GBS), Oracle Fusion Workforce Predictions, PricewaterhouseCoopers Human Resource System(PWC-HRS), k-means, Simple Addictive Weighting (SAW), Tahani fuzzy, Human Resource Information System HRIS, Knowledge Discovery in Database KDD, Intelligent Decision, Apriori algorithm, Support System (IDSS), Fuzzy Hybrid Multicriteria Decision-Making (MCDM), worst-case method, Modified Fuzzy VIKOR, Text Mining, Bayesian, Sequential Minimal Optimization (SMO), Neural Networks tools from Matlab, Backpropagation,),SVM, human capital management (HCM) software, Basic data analysis(Mean,Median Minimum & maximum range, Percentiles), Intermediate data analysis (Correlation, Statistically significant differences, Standard deviation), Basic multivariate models (ANOVA / ANCOVA, Regression, Factor analysis), Advanced multivariate models (Structural equations models, Hierarchical linear models, Bivariate / multivariate choice models, Cross level models, including adjustments for grouped and non normal errors), BI, Knowledge Discovery in Database (KDD), Intelligent Decision Support System (IDSS)	[70-99]

It is deduced that the search for IT solutions for HR issues are increasingly developing. Scientists have proposed different solutions to solve these HR problems. Artificial intelligence is not the exception. It also offers different algorithms and methods.

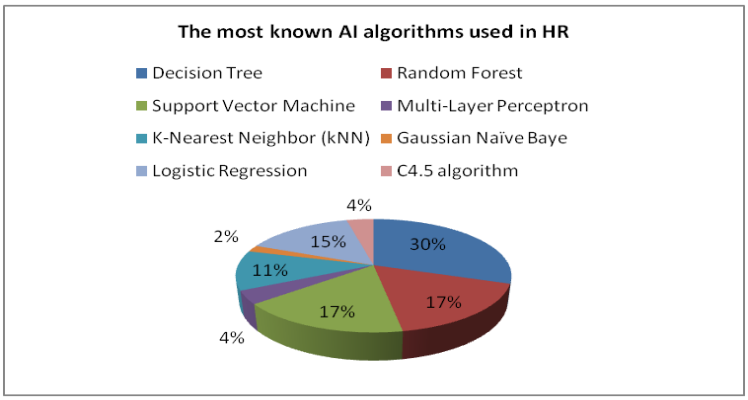

Figure 5. The most known artificial intelligence algorithms used to solve human resources issues

According to our quantitative research, several IT solutions have been proposed to solve the various problems related to human resources. Many Artificial Intelligence solutions have been applied, using different methods and algorithms. The most known Artificial Intelligence algorithms that have been used are: Decision Tree, Random Forest, Support Vector Machine, Multi-Layer Perceptron, K-Nearest Neighbor (KNN), Gaussian Naïve Baye, Logistic Regression, C4.5 algorithm… etc.

The most used Artificial Intelligence algorithm is Decision Tree with 30% of use, 17% using SVM and Random Forest, 15% for Logistic Regression followed by 11% for KNN, 4% MPL and C 4.5 and the less used are Naïve Bayes with percentage of use 2%.

5. CONCLUSION

From our research on the two axes : Human Resources and Artificial Intelligence, we were able, first of all, to highlight the different issues raised by the experts and the managers of the domain and to target the most posed problems, afterwards. We have tried to find all the solutions proposed by scientists and computer scientists for each problem and especially those using Artificial Intelligence techniques for the period between 2008 and 2018. We concluded from the number of articles found that several HR Analytics were proposed and most of them used artificial intelligence algorithms and methods, which shows the rapid and observed development and the increased interest and competition in applying this technology in HR field.

The most HR issues asked were about analyzing and predicting: Recruitment, Skills Management, Human Resources Development (employees talents, effectiveness, productivity and performance), attritions and turnover. Proposed solutions were concerning known technologies like Business Intelligence, Big Data, Data Mining & Data Warehouse, some known software, frameworks and ERP (SAP, SPSS, Oracle, SAS, CRM, SMA, SNW) and Artificial Intelligence algorithms(Machine Learning, Neural Network, Deep Learning…), others used or proposed other analysis methods and simple statistics combined with HR analysis and HR approaches. The most Artificial Intelligence algorithms known used were: Decision Tree (DT), Random Forest (RF), Support Vector Machine (SVM), Multi-Layer Perceptron (MLP), K-Nearest Neighbor (KNN), Gaussian Naïve Bayes (GNB), Logistic Regression (LR), C4.5.

The field of Human Resources is vast and constantly developing. The concern of each company is the management of its Human Resources by considering human capital the source of development and the pillar of success to increase productivity, attract talent and the customers in order to well cope with the competition. On the other hand, the field of intelligence is always evolving and new approaches and methods are always proposed.

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