Intelligent Human Resource Information System (i-HRIS): A Holistic Decision Support Framework for HR Excellence

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Abstract: *Nowadays, Human Resource Information System (HRIS) plays a strategic role in the decision making process for effective and efficient Human Resource Management (HRM). For Human Resource (HR) decision making, most of the researchers propose expert systems or knowledge-based systems. Unfortunately, there are some limitations in both of expert system and knowledge-based system. In this paper, we have proposed a framework of Intelligent Human Resource Information System (i-HRIS) applying Intelligent Decision Support System (IDSS) along with Knowledge Discovery in Database (KDD) to improve structured, especially semistructured and unstructured HR decision making process. Moreover, the proposed HR IDSS stores and processes information with a set of Artificial Intelligent (AI) tools such as knowledge-based reasoning, machine learning and others. These AI tools are used to discover useful information or knowledge from past data and experience to support decision making process. We have likewise attempted to investigate IDSS applications for HR problems applying hybrid intelligent techniques such as machine learning and knowledge-based approach for new knowledge extraction and prediction. In summation, the proposed framework consists of input subsystems, decision making subsystems and output subsystems with ten HR application modules.*

Keywords: *HRIS, KDD, DSS, framework.*

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1. Introduction

Human Resource Information System (HRIS) is an indispensable instrument for achieving competitive advantages in organizations [32, 33]. It saves time and resources by accomplishing Human Resource (HR) tasks more quickly and more accurately [1]. The radical changing nature of today's business establishes a novel postulation that HRIS is not a traditional cost driven partner, but a strategic partner in an organization [8]. Researchers reported that usually data are collected without human intervention, precisely summarized, correctly generated, properly disseminated, and transformed into specific formats in automation feature enable HRIS to fit different requirements of Human Resource Management (HRM) practitioners. Besides, HRIS consisting of friendly user interface, powerful analytical tools and reporting tools for information sharing. As an analytical tool, Decision Support System (DSS) is used for HR strategic planning, predicting HR needs, and appraising HR's policies and practices [23, 25, 29]. Unfortunately, DSS has some limitations for providing the better decision. Conventional DSS is frail in articulating and integrating the knowledge. Therefore, in that respect is a complexity for DSS in providing solution of complex semi structured and unstructured problems. To get rid of the drawbacks of DSS, Intelligent Decision Support System (IDSS) is initiated. That is integrated with Artificial Intelligent (AI) techniques, especially agent and machine learning, in DSS technologies. Machine learning concerns the construction and study of systems that can learn from data to adjust machine behaviour [24]. Most researchers have proposed Knowledge-Base System (KBS) [9] or expert system [2] approaches for specific HRM field, such as employee recruitment, selection, training, and performance appraisal [5, 6, 28, 38]. Researchers state that KBS is more static, less expensive, documented without human interference, and easier to duplicate [4]. Merely, it is really hard to capture informal knowledge in KBS as knowledge is difficult to verbalize and it has not been correctly documented. For these drawbacks of KBS, some intelligent approaches such as data mining approach [13, 45, 48] and neural network approach [30] are proposed for personnel selection in the HR DSS. On the other hand, HR expert systems have also some problems such as sometimes erroneous knowledge is extracted since acquiring knowledge from appropriate experts is very difficult task [10]. Not only that, representation of models with that knowledge in a computer is very complex task having incapability of the system to learn [25]. For limitations of expert system and knowledge-based system, hybrid

intelligent techniques (combination of more than one AI techniques) are proposed in this study. Hybrid intelligent techniques could be most effective for HR IDSS for solving HR problems [23, 24].

This paper seeks to propose a framework of Intelligent Human Resource Information System (i-HRIS) consists of input subsystems, decision making subsystems and output subsystems with ten software modules to manage human resource activities efficiently and effectively. In decision making subsystem, we have proposed a knowledge-based advisory system [11]. It includes artificial intelligent tool-IDSS and knowledge mining tool- Knowledge Discovery in Database (KDD) with some potential Artificial Intelligence techniques. These would serve to improve semistructured and unstructured decision making process to provide accurate, consistent, and reliable decision for HRM. The HR functions such as strategic HR planning, new employee selection, planning for employee training and career paths, forecasting future employee needs, predicting employee performance and others could be solved using this framework.

2. Previous Works

The concept of HRIS commences from an employee payroll system. An automated system was developed and employee data were used for the first time in the late 1960s [39]. Observing that, manual actions for managing employee data were replaced by automated computer having the faster data storage capability and data processing capacity. The incessant advancement of HRIS, especially in network engineering and DSS, helps HR staff and managers for effective HR activities capturing, analyzing and forecasting information [8]. Researchers proposed several helpful models or frameworks of HRIS. They tried to enrich HRIS research by suggesting advanced engineering sciences such as artificial intelligences, data mining, IDSS and so forth. This paper will briefly go over the previous HRIS frameworks and its recent development.

The first conceptual model of HRIS was introduced by Hyde and Shafritz [21]. The model comprises sixteen database modules with data exchanging capability. To carry out the planning function of HRIS, it receives both personal, and position data of employees from different modules. This model produces organized reports with accountability for modules. This model is a closed loop system. It has with input module, processing module, output module, and feedback loop. The aims of each module may be modified observing the actual execution of that module [21]. Later on, Simon proposed an HRIS model that consists of error correction, data validation, and some common features of database in 1983 [36]. Manzini and Gridley [34] proposed an improved model than earlier to produce HR reports as a form of hardcopy in response of an ad hoc request of the manager. Here a user interface was used to operate the HRIS for online PC or a terminal. Afterwards, nine major application modules for HRIS were suggested by Fisher *et al.* [15]. McLeod and Anctis [36] developed Resource-flow HRIS model. This is a pioneer for present models. This model consists of three devoted subsystems such as input subsystem, database subsystem, and output subsystems with six application modules to transform data into information for users. Here, intelligence system as a HR Intelligence Subsystem is introduced for the first time. Input data are received from both internal sources as well as external sources. After twelve years, McLeod and Schell slightly modified the Resource-flow HRIS model. They incorporated Transaction Processing System (TPS) instead of Data Processing Subsystem in the component of Input Subsystem [35]. At last, Wickramaratna [52] aimed to merge the McLeod and Schell model of HRIS with the Expert system. She proposed Intelligence-based expert system integrated with an HRIS to solve semistructured and unstructured HR problems in the managerial decision making process. There are also some studies on HR functions such as recruitment, selection, performance evaluation, and others using different types of AI tool and techniques. It is mentionable that we have not found any comprehensive HRIS model integrating AI technologies for semistructured and unstructured HR problems.

The findings of the study show that previous models are suitable to solve only structure and semi-structure problems of HRM. They are incapable to solve unstructured problems except Wickramaratna [52]. But, she has not provided any comprehensive model to achieve this expert system, although there are many tools and techniques for artificial intelligence. It is very important that, among different tools and techniques of artificial intelligence, we have to select the right one for the specific task in HRM. As there are some limitations of the expert system [25], in this work, an alternative knowledge-based system is proposed to improve HR operational activities and decision making process for HR activities.

3. Knowledge Extraction for HRM

3.1. Data Mining and KDD

KDD is a widely used term in intelligent data processing. Fayyad [14] defines KDD is a nontrivial process of identifying potentially useful, valid, novel, and ultimately logical patterns in a data set. The term KDD describes the entire process of extracting information from a data warehouse. Moreover, data mining is one of the steps of the KDD process. Besides, doing the actual data mining is the most challenging step of the KDD process. Data mining

consists of "discovery driven techniques" for analyzing a big quantity of data. It reveals meaningful hidden patterns to identify trends, relationships, and association among the data measurement. And so, this extracted useful information is utilized to achieve the specific business objective [41]. There are four key techniques of data mining problems such as association, clustering, classification, and prediction. Among the four techniques, classification and prediction are widely applied for future planning and knowledge discovery. In data mining approach, several AI techniques are implemented for classification and prediction. By examining past events, system can make a prediction about uncertain outcomes. More to the point, statistical and intelligent techniques are two approaches for prediction technique. Intelligent techniques approach is focused in this study. The most popular intelligent techniques for prediction are Artificial Neural Network (ANN), Decision Tree, Bayesian Belief Networks, Genetic Algorithm, Fuzzy Clustering, Support Vector Machine (SVM), fuzzy logic, Extreme Learning, deep learning, reinforcement learning, Conditional Random Field (CRF) and hence onward. Moreover, a number of researchers agree that hybrid intelligent technique such as fuzzy data mining [48], Fuzzy Artificial Neural Network [42], Neural Networks and Support Vector Machines [16], Genetic Algorithm and Data mining [47] can produce better results instead of single AI technique.

3.2. Data Mining in HR Applications

In HRM, there are many occurrences where HR decision depends on a variety of factors, such as knowledge, human experience and judgment. These factors can be cause of inaccurate, inconsistent, unfair and unanticipated decisions. For this reason, data mining techniques may be used for its reasoning characteristics. This study gives attention to data mining techniques, keying out the patterns that concern to HR issues. The matching of HR managers' needs and data mining problems is very critical. So, determining the appropriate data mining techniques is very important. Numerous studies refer applying data mining to different HR functionalities, such as recruiting and selecting employees [13, 45, 48] and predicting employee turnover [3, 19, 46] in staffing function; determining employee competencies [20, 28] and career planning [30] in HR development function; forecasting the receiving of severance pay [42] and planning HR costs [25] in HR compensation function; and assessing employee performance [19, 53, 54] in HR performance management function. In brief, previous literature shows a booming new area of data mining research that present ample insights in how to produce advanced information and decision support within the HR field.

4. Intelligence in HR Decision Making

4.1. Decision Support System

At present, HR managers depend on DSSs use to take the best decisions in the shortest possible time. In DSS, data and models are used to solve managerial semi-structured and unstructured problems [55]. Gorry and Morton [18] introduced the term "decision support systems" in a research paper for the first time. DSS does not supervise the decision and never replaces human decision makers, but it supports user and helps them to make better and consistent decisions [17]. Moreover, DSS includes knowledge-based approach. A properly designed DSS is an interactive software-based system intended to assist decision makers. It collects useful information from a combination of raw data, documents, business examples and personal knowledge to discern and solve problems and arrive at determinations. It has a robust reporting facility that contains ad hoc reporting capabilities, pre-built analysis functions, and multidimensional analysis. Unfortunately, DSS has some limitations for taking the best decision. DSS is frail in articulating and integrating the knowledge. As a consequence, there is a complexity for DSS in providing solution of difficult semistructured and unstructured problems. Furthermore, the lack of a combination of internal and external data may also cause to ineffective application of traditional DSS.

4.2. Intelligence Based DSS

To overcome the drawbacks of DSS, IDSS is used as a decision support technology [12]. IDSS is a new type of DSS that is integrated with AI techniques. This system is a combination of basic function models of DSS and knowledge reasoning techniques of AI. It solves complex, imprecise and ill-structured problems [43]. IDSS also uses human judgment and preferences for uncertainty or incomplete data in the decision making process. There are some superior characteristics that distinguish IDSS from other DSSs. IDD has improved consistency in decisions, timeliness in making decisions, enhanced explanations and rationalizations for specific recommendations, and formalization of organizational Knowledge [40]. The efficiency of IDSS depends on all AI techniques that embed with DSS. ANNs, fuzzy logic, genetic algorithm, and expert system are widely implemented AI techniques in IDSS. ANNs can act brain-like function such as prediction, categorization, and pattern matching [7]. Moreover, Deep Belief Network (DBN) is also suitable technique for decision modelling. In machine learning, a DBN is a generative graphical model, or alternatively a type of deep neural network, composed of multiple layers of latent variables, with connections between the layers but not between units within each layer [31]. Genetic algorithms are search

procedures that involve intelligent trial and error, which aspire to determine a global optimal. They use techniques found in nature, such as replication, gene crossover and mutation to determine optimal solutions to mathematical problems [7]. Expert system incorporates human expert knowledge in its knowledge-base component. It is able to mimic the decision ability of human expert to help them with their routine tasks, even their absence. Fuzzy Logic is used in conjunction with expert system to amplify its reasoning ability, thus get better the quality of decisions [26]. Figure 1 shows that an IDSS incorporates many AI techniques in its working steps on the basis of problem nature.

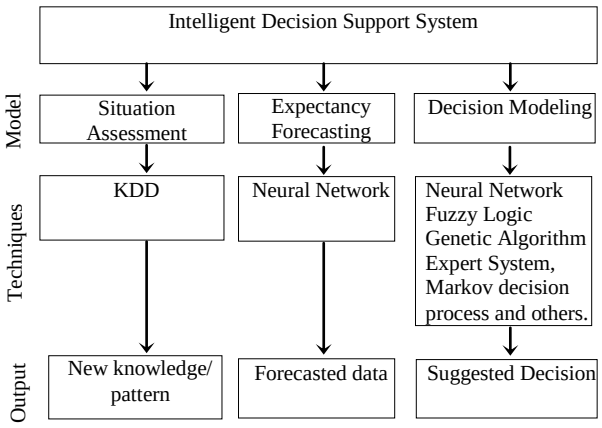

Figure 1. A typical working steps of IDSS.

Researchers state that more effective results can be obtained when hybrid AI techniques are employed for semi-structured and unstructured problems [27]. Each combination of AI techniques has an aim to decrease the limitation of one method. We have found that hybrid approach is adopted in IDSS applications by integrating the intelligent techniques, such as ANN and data mining are combinedly used for weather forecasting [50] and, Fuzzy Neural Network along with Genetic Algorithm are used to measure the outcome on the stock market [30], Fuzzy Logic and Neural Network for speech recognition [37], Rule based and Model based are used to measure enterprise performance [51]. For machine learning and reasoning, most of researchers have found hybrid intelligent techniques (e.g., ensemble learning) are more suitable. But, in some instances, a single intelligent technique can provide the same result as hybrid techniques. The selection of single intelligent technique or hybrid intelligent techniques depends on the characteristics of the problems that to be worked out. We have concentrated our discussion on IDSS applications for HRM domain.

4.3. IDSS for Human Resource

These days, HRIS is integrated with analysing the ability to create different types of report for HR professionals. They can take better decision for semi-structured and unstructured problems in respect to accuracy and uncertainty. There are a few studies where IDSS is applied for HRM such as for staffing [5, 6, 20, 25, 29, 42, 44], training and development [5, 22, 24, 38], performance appraisal [44, 49] and HR administration [16]. Most researchers used KBS or expert system approaches for HR IDSS. Due to some limitations of expert system and KBS, hybrid intelligent techniques may be preferable for HR IDSS. Knowledge based system with machine learning can be more effective hybrid intelligent technique for HR IDSS. The HR activities can be executed using this approach, for examples, matching people to jobs, selecting new employees, planning training needs for new and old employee, planning career paths, predicting future employee and employee turnover, predicting existing employee performance, and others. For prediction task, some machine learning approaches produce more honest outcome. In this study, we have focused on IDSS using machine learning approach for HR decision support.

5. Proposed Model of i-HRIS

The intelligence based HRIS model consists of three segments: input subsystem, decision making subsystem, and output subsystems to provide any HR related report and to suggest solutions of structured, semistructured and unstructured HR problems and making it available to users. Figure 2 illustrates the proposed i-HRIS model for HR functionalities. The description of the suggested model is presented below:

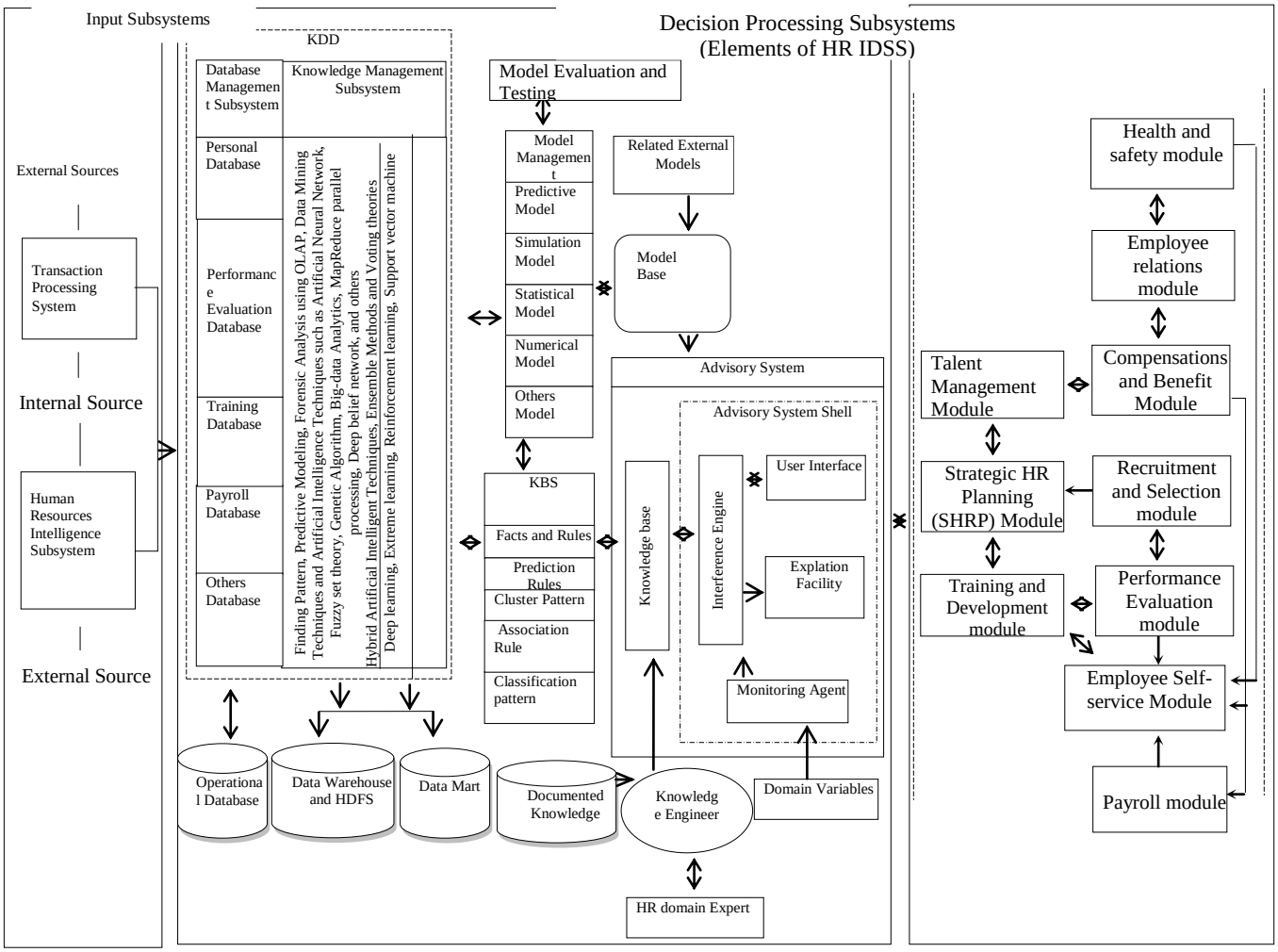

Figure 2. Model of intelligence based HRIS.

5.1. Input Subsystems

HRIS input subsystems consist of Transaction Processing Subsystem (TPS) and HR Intelligence Subsystem. The input subsystems section takes HR related data into operational database. This part also includes software or other external databases that transform input data into the mandatory format for storage.

- *TPS*: TPS gathers firm's day-to-day activities, as data, into database. It transforms data into accurate information. It provides useful information to mid-level managers and executives. For example, TPS update employee data, such as name, birth date, gender, address, phone, emergency contact information, e-mail address, department code, work status (full-time, part-time, or contract), salary, post titles, employee work history, and benefit information. The TPS would gather the data from both internal and environmental sources using the Internet, intranets, extranets, and other networks for online transaction processing.
- *HR Intelligence Subsystem*: HR intelligent subsystem is an interface. It collects HR data related to stakeholders of organizations, such as government, suppliers, financial institutions, labor union, and competitor intelligence. These intelligent data could be obtained from commercial databases.

5.2. Decision Making Subsystems

A typical IDSS includes five major components, such as database system, knowledge-based System, model base system, inference engine, and user interface [24]. For decision making process, the proposed IDSS contains four major components, such as KDD, Model management Subsystem, KBS, and Advisory Subsystem.

a. KDD can extract knowledge from old data and decisions. This component is used to determine the possible patterns and rules from existing database system to develop a predictive model for the HR problem. Database management subsystem includes databases that hold data that are relevant to the class of problems for which the DSS has been planned and it manages the databases. It would be interconnected with data warehouse, Hadoop Distributed File System (HDFS) and/or data marts of the organization. In knowledge management subsystem, knowledge is extracted from existing databases by different instruments and techniques

including Big-Data Mining, OLAP, and AI techniques. Since all knowledge is not relevant to the business operations, these instruments and techniques do filter the unnecessary and non-relevant knowledge. Here, possible pattern and rules are found, and predictive models are developed for HR problems using traditional and hybrid AI techniques along with machine learning and reasoning. In addition, genetic algorithms and ANNs are the most popular techniques used for machine learning.

b. Model management subsystem stores constructed models, existing simulation models, and related models of financial, statistical, management science, and others. These models can be applied in the suitable decision making process. The model-base component is used to convert data, which are stored in databases, into information/ knowledge by applying these models. In model analysis and evaluation process, the model must be evaluated and tested before using the predictive model.

c. KBS comprises a set of facts and rules. In the recommended model, this component will include information about association rules, patterns, and any related facts and rules. Consequently, HR domain experts will evaluate and interpret these rules, and patterns.

d. Advisory subsystem provides iterative support in the decision making process. Applying KDD, knowledge is acquired by knowledge engineers from the experts and the documents of rule and regulations. The cognition is inferred by the inference engine. This component has a monitoring agent to see the requirement for identifying unstructured decisions that need to be addressed. And so, it will start the iterative decision-making process by offering a suggested path of activity. Sometimes, if demanded, this component will instruct KBS to update the existing knowledge. Decision maker uses the user interface to communicate with the system. There exists an explanation facility to display the arguments of any decision or suggestion.

5.3. Output Subsystems

The output subsystem consists of diverse characters of software modules that could provide reports or solutions for HR problems using a variety of models. It will also show flexible suggestions or solutions to solve complex, imprecise and ill-structured problems by decision making subsystem. In this proposed model, output subsystems represent the ten groups of HR applications.

- *Strategic HR Planning (SHRP) Module*: The vital role of this module is matching the right people to the strategic requirements of the organization. It may follow both short-term and long-term approaches to predict future demand of HR based on HR inventory, supply and demand analysis of HR, and so onward. SHRP will use HR IDSS for knowledge extraction from an operational database.
- *Recruitment and Selection Module*: This module will aid to get a recruitment plan and to monitor its success by compiling and processing different types of information of potential candidates. HR IDSS approach will apply prior experience from model based, knowledge-based or machine learning to select expected employees consistent with decision-making criteria.
- *Training and Development Module*: It will behave as an expert system comprising artificial intelligent techniques for knowledge management training courses. In this system, association rule mining may be used to find training strategies and learning map for personal learning. Moreover, rule-based expert system may be applied to infer the learning type for employees.
- *Performance Evaluation Module*: This module will offer a total performance index, considering all criteria, for an employee. This process is very complex as there are many rules for each criterion with different priority. This problem may be worked out by fuzzy rule-based decision making approach. Because, fuzzy logic takes different criteria as input and performs aggregated calculation based on given rules which is complex to do in the conventional method. Moreover, we found that, among the data mining functions, classification methods (e.g., neural networks, decision trees, support vector machines, and discriminant analysis) are frequently used for employee performance prediction.
- *Compensations and Benefits Module*: In this module, statistical and financial models will be used for estimating the amount of compensation and benefits (insurance, pension, profit-sharing, and stock option, and other benefits). HR IDSS may use ANN, for special cases, where compensation and employee benefits are strategic decision for competitive advantage.
- *Health and Safety Module*: It will maintain employee information about accidents (number and types), health and safety complaints, workers' compensation claims, and others health and safety related issues.
- *Employee Relations*: In this module, employees and their managers will have access to relevant information on employee work policies, rules, regulations, employee related issues like illegal discrimination, grievances, privacy, work diversity, and others. Management may offer online surveys and "suggestion box" for allowing express their satisfaction or dissatisfaction from the work environment. As a consequence the management will be informed about the atmosphere among the

employees.

- *Payroll Interface Module*: This automatic payroll module will include information on salary, wages, and benefits. It will be developed using financial or accounting models for timely and accurate structured decision of payments. This module may incorporate the information necessary to calculate attendance, any leaves of absences (paid or unpaid), vacation time, and any other events that interrupted service.
- *Talent Management Module:* This module will assist managers to assign the right person at the right place at the right times. The module will identify existing talent (current employee) by forecasting their performance. HR IDSS approach will apply previous experience from knowledge-based or machine learning to predict the most skilled employees consistent with decision-making criteria.
- *Employee Self-Service Module*: In this module, employees will be able to view or update their own, some basic, information without communicating with HR managers to act thus. Using this module, they can enjoy accessing of personal contact information, payroll and pension information, pay slip, provident fund statement, loan statements, assessment reports, training related information, career planning, wellness and safety incidents.

6. Conclusions and Future Work

From previous literature, it is observed that different types of artificial techniques are used for HR domain problems, for example, selection and recruitment, performance evaluation, talent management, and thus onward. But, we did not find any logical connection among the studies of HR domains. Udani proposed Artificial Intelligence-based expert system as a module of HRIS for HR activities. But, she did not offer any comprehensive model to achieve this expert system. In this paper, we have proposed an intelligence based HRIS with some essential features such as IDSS for decision making, KDD for knowledge extraction, and others model using knowledge base and model base. The model has reasoning capability using past experience for solving complex, ill structured HR problems. The model consists of three parts: input subsystem, decision making subsystem, and output subsystem with ten modules of HR functions. In decision making subsystems, we have suggested use of machine learning approach in HR IDSS for HR problems. Thus uncertain and incomplete data can be transformed into useful knowledge. We have also found that researchers agree that hybrid intelligent techniques are the best approach to support unstructured or semistructured decision making process. As an inference from this fact, we have suggested to integrate hybrid techniques (e.g., Knowledge-based system and machine learning approaches) with HR IDSS in this proposed HRIS model. For future work, in HR problem domains, data can be tested using some of the AI techniques such as prediction techniques to determine the suitable techniques. The scope of this proposed i-HRIS model can be broader through wireless protocol and web-enable tools, Group Decision Support System (GDSS), which can spread out the inter-activities and perverseness decision support technologies.

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