“An efficient human resource management system model using web-based hybrid technique”

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AN EFFICIENT HUMAN RESOURCE MANAGEMENT SYSTEM MODEL USING WEB-BASED HYBRID TECHNIQUE

Abstract

The proliferation of international business activities drives organizations to expand their operations into new areas and propels human resource management (HRM) to ensure hiring and retaining competent personnel. Consequently, firms have been struggling to place qualified people in relevant roles and provide adequate training. This study utilized information technology to solve these challenges using a web-based system to interconnect the processes, receive the data from the job applicants via a web-based interface, and connect them with suitable employment. Firstly, the proposed model presented a hybrid technique of Convolutional Neural Network (CNN) with Long Short Term Memory (LSTM) Cloud Web-based Human Resource Management System (CLWHRMS) by recognizing distinct features and forecasts the candidate's potential under various classification tasks. For this, the study used a set of various software tools for web pages and database designing, including for the alteration of images. The hybrid model was executed using real-time data of 250 resumes, which were collected through an online database to validate the overall performance of the developed web-based system in terms of its accuracy, sensitivity, and specificity. Though the specificity was the same with all the techniques, the results illustrated CNN-LSTM technique was 91% accurate and 90% sensitive compared to the traditional methods. This CNN-LSTM model automatically estimates the suitability of a job candidate and projects his/her workability contributing to Saudi Arabian firms to ease and enhance their recruitment process.

Keywords recruitment, human resource management, convolutional neural network, Saudi Arabia organizations, candidate performance

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INTRODUCTION

HRM is an essential resource for the growth and functioning of any company, and its importance on enterprises has been steadily understood and brought to an unprecedented level. Management of human resources is the basic provision and strong assurance for company's survival, innovation, and growth, which is closely linked to the achievement of the company's strategic development objectives (Patel et al., 2018). HRM risks are caused by the worker's failure to use the relevant personnel reasonably or waste human resources tangibly or intangibly. Recruitment, training, performance, assessment, wages, and other critical human resource relationships are the main components of this risk (Rajib & Fan, 2015). When the riskier companies in such crucial links are not adequately managed, the company will suffer enormous losses and even decline. However, due to their specific characteristics, HRM hazards are more hidden than other company risks and are frequently ignored (Park et al., 2017). Therefore, for early risk prediction, building an early-warning model for HRM is vitally significant, and risk management plays a crucial role throughout the

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company's management scheme. Research studies have been carried out for a lengthy period in risk administration and have a considerable scope, and the methodologies of research are always new (Bader et al., 2015).

Human resources management focuses on effective human utilization to achieve corporate objectives and increase employees' dignity, contentment, and well-being. Although very few Saudi Arabian firms have been computerized, most other firms perform manually using conventional file systems to perform all these operations.

Akinyokun (2000) has also observed that both quantitative (structural) and quality (unstructured) data are used in HRM. Decisions mostly rely on institutions, principles, and knowledge. Now, the endeavor to make intelligence a computer system, by which vast volumes of quantitative and qualitative data can be processed for decision making, has become a reality. In general, resource professionals carry on numerous equal activities as they did decades before, for example, training, recruitment, management, retention, and pay. However, the internet has had an enormous impact on how HR workers complete these responsible tasks. Therefore, it is not unusual nowadays to discover firms that use the computing system in their recruitment and, in some respects, selection procedures, especially in industrialized countries. With this technology, the candidate only feeds his CV into the PC.

According to Akinyokun and Uzoka (2000), the conventional formless interview style is acknowledged as highly strategic and vital to the company's general performance. Due to its efficiency, speed, precision, reliability, mass processing, costs, and safety, the computer, which remained one of the best tools in recent years, has assisted in decision-making. A new awareness of computer use in administrative and qualitative information is currently ongoing. The use by organizations of the MIS and Decision Support Systems (DSS) has also been confirmed in the decision-making process, making it a web-based HRM system on the internet platform. With its advanced solution for users and technology, past research studies emphasized modeling human performance to predict human performance at work using various approaches like statistical analysis, text mining, data mining, HRIS, correlation analysis (Bal et al., 2011; Chien & Chen, 2008; Barrick & Mount, 1991; Brachnata & Wening, 2021; Borman & Motowidlo, 1997; Uzialko, 2019; Abdullah et al., 2020). The latest technologies like deep learning (Hinton & Salakhutdinov, 2006; LeCun et al., 2015) and artificial neural networks (ANN) demonstrated exceptional performance in the field of HRM. Correlation analysis has demonstrated a significant association between personal data of personnel and stated their personality traits could be used to predict their future job performance (Borman & Motowidlo, 1997; Barrick & Mount, 1991). In addition, the deep learning system has stimulated the HRM tasks efficiently and effectively. Most commonly known deep learning systems like CNN have a significant understanding of distinct features of classification tasks (LeCun et al., 1998). However, CNN lacks to capture dependency among these characteristics. Therefore, it is necessary to define an alternative model in human resource management.

1. LITERATURE REVIEW

Bojārs and Breslin (2007) introduced the Resource Description Framework (RDF) ontology to model the RDF data. Resume RDF describes the resume with its extensive class and characteristics. Bojars (2004) has supplemented the friend of a friend (FOAF) with resume information for a better information description. Taking into account the semantic relations with the other words, Turney and Littman (2022) have proposed a plan that would deduce the semantic appeal of a word. Marjit et al. (2012) proposed another technique that used linked data to reclaim information to allow the web to share information with various sources so that multiple types of information are discovered. Finally, Fazel-Zarandi and Fox (2009) proposed an ontological approach to match employee skills with the assistance of a deductive ideal that determined the combination of a job seeker's skills and those necessary by the employer.

Human resources support the assignment, objectives, and plans of organizations. Human resource objectives and strategies also need to be defined to achieve the organizational goals and support their plans by the deployment of various tools and techniques to introduce strategic changes. Organizations can use different projects to introduce dynamic changes and strategic implementations (Richardson & Jackson, 2018). An HRM division of a firm also provides or trains its employees to stimulate productivity, efficiency, and contentment of the employees and support the company's overall success (Pinto, 2013). The project management includes various tools and techniques, human resource development and training, tracking and controlling project schedules, and data repositories. The personnel department announces job vacancies, and such advertisements have weaknesses that have the elements contributing to the study of these research projects, a web-based model of human resources management system for the Deep Learning Networks. Such deficiencies include:

- Inability to access all possible applicants due to the failure to access the chosen media for the advertising. As a result, only a restricted number of job-suitable candidates would be applicable.
- Currently, most advertisements in several organizations are merely formal, as families of senior managers fill jobs before advertising.
- Because of the high cost of advertising, job accounts, and conditions, potential applicants are not always adequately defined because the requirements, duties, and remuneration related to their employment are misleading.
- Applicants expend more money creating several copies of the letters and summaries of their applications in response to internet advertisements.
- Many applications are used to be lost in transit because of the postal services' performance and the applicants in cases where a selection process is conducted.

The weaknesses outlined above create a situation where the organization's quality and quantity of employees do not meet the available vacancies. Therefore, for an effective recruitment process to address these weaknesses of the previous system, the web-based human resources management system is imperative. Such a system shall have an existing database of employment openings for various organizations and the accompanying web bank of information received from potential applicants. The study's primary purpose is to construct a recommended model that will:

- Increase the productivity of staff for human resources personnel (HRP) and, consequently, enhance the productivity of the corporate organization they serve.
- Lower the waste of time for gathering, sorting, and collecting job applicants' applications.

A noticeable increase in the use of organizational behavior theory has been determined within the organizations. The reason underpinning the use of organizational behavior theory is because it provides vital means for firms to move away from the macro-institutional level of the key stakeholders toward the micro-level of the individual employees (Xiao & Cooke, 2020). Furthermore, different studies have also been reviewed that describe technology that has significantly transformed HR practices. It has been determined that different HR portals are being used within the organization. This centralized means of HR portal by which each individual has customized access, and the issues related to the HR department can be addressed in the desired manner. These studies further highlight that the use of technology in HR practices has significantly reduced the dependency on the HR individuals within the organization. It has been determined that this approach provides vital means by which employees can easily maintain their HR data, and they can easily use different technologies to access different HR materials. Furthermore, the use of different technical means also provides vital means for the managers or leaders to perform different operations without any involvement of the HR department and the complexities associated with the HR tasks can be mitigated accordingly, which will ensure we have results within the minimum time (Rana & Sharma, 2019; Jia et al., 2018). Numerous authors have also reported regarding the use of technology

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in HR practices for effective decision-making. The use of Human Resource Information Systems is significant. After all, it provides a vital means for managerial decision-making because it significantly enhances the compliance of the reporting requirements. The data can be analyzed significantly by which effective decision-making can be obtained. Moreover, the real-time data can be accessed accordingly to have prompt decision-making, and the information can be examined in the desired manner (Safaâ & Mohamed, 2020; Wibawa et al., 2018).

Furthermore, different studies have also been examined to determine the use of information systems that could be used for decision-making in human resource management. The findings of these studies show that HR uses an intelligent decision support system. This has been recognized as one of the vital aspects of HR individuals integrating various modeling tools based on human knowledge. The implication of an intelligent decision support system is sufficient because it provides sufficient means to address the uncertainties present in the decision-making process, and the issues associated with incomplete information can also be addressed in the desired manner. Moreover, the risks associated with human bias are also mitigated because decision-making is being done based on the data present in the system (Armstrong, 2006; Bumblauskas et al., 2017). On the other hand, different studies also highlight the use of different techniques in the intelligent decision support system for the human resource department. As a result, numerous applications have been introduced based on intelligent techniques where different applications are based on knowledge-based systems, neural networks, and fuzzy sets by which learning capabilities can be developed accordingly and they could be used accordingly in HR practices (Jiang & Messersmith, 2018; Cooke, 2018).

It has been further reviewed that an intelligent decision-making system provides a pivotal means for the HR department to evaluate employee behavior. This is based on different applications, which provide vital means to the HR department. The data is gathered accordingly, and domain knowledge can be integrated by which reasonable outcomes can be obtained. All these aspects provide sufficient means where different opportunities can be provided for the employees, and effective decision-making can be obtained (Wuryani et al., 2021; Ma & Wang, 2020; Mkrttchian, 2020). Several studies have also highlighted the provisions of using HRIS (Human Resource Information System). The application of this system has significantly reduced the workload of the human resource department by which a systematic procedure is adopted to collect, maintain, and access the employee data, which will result in effective decision making within the organization (Brachnata & Wening, 2021; Abdullah et al., 2020).

On the other hand, various studies have also determined that HRIS plays an essential role in shaping human resource management practices. This system has been determined with various benefits by which all the organizational managers have all the information regarding the HR decision-making process. This provides a vital means by which all real-time information can be obtained from any instant, and there is no such aspect required by which a continuous track should be implemented to monitor one's performance. These studies have further highlighted that a human resource information system provides sufficient grounds by which a noticeable increase in the overall efficacy of the HR department can be obtained. It has been determined that HRIS is significant by which effective recruitment methods are integrated accordingly, and different benefits are also obtained by which effective organizational communication is obtained. Moreover, all the employees are integrated into different decision-making processes in an organization (Haddara, 2018; Qaisar et al., 2018; Uppin, 2017; Quaosar & Rahman, 2021). HR is liable to have all the updated information by which an employee's track record can be obtained. It has been analyzed that the use of different technical means in human resource practices and all the employee operations can be handled in the desired manner. Moreover, this approach provides vital means by which all the HR functions can be executed properly and streamlined management functions by which all the HR operations can be performed with maximum efficacy (Shrivastava, 2019).

A text mining-based hiring method has been proposed by Uzialko (2019). It facilitated recruiters to acquire and analyze a large number of resumes

from job boards. For Chinese resumes, the entire system was created specifically for them. They have considered the candidate's training and work history. To ensure a fair comparison, the study compiles information on all the candidates. As of 2018, the recruiter resume ranking algorithm was created by Ivana (2021). Information is extracted from resumes and saved in a database using Natural Language Processing (NLP). Firms may find the best fit for their needs using a candidate ranking algorithm by matching them with resumes. In their study, they advocated a resume-based system of ranking. The resume was evaluated using Natural Language Processing techniques in this system. Scores were calculated using information from GitHub and LinkedIn profiles. Using the resumes as a starting point, they have developed visual reports for each prospect. Social data has been used by Chou et al. (2019) for resume job matching. They grabbed data from social media sites like Facebook and LinkedIn for their project. Once the data was compared to the job specifications, they were able to recommend a suitable candidate. These methods assist human resources staff in determining the strengths and shortcomings of a candidate while providing little assistance in evaluating technical aspects.

In addition to all of the previously described models, several new attributes have been added to the resume evaluation process in this new proposal. Another thing to consider is that the candidate's practical expertise was determined by visiting technically based websites. The aim of this study is to attempt to propose a hybrid web-based HRM system by combining CNN model with LSTM to focus on the features and predict the performance of the job candidates. The proposed methodology is presented in this study.

2. RESEARCH METHODOLOGY

The study is basically emphasized on the qualitative database. Therefore, numerous recruiting organizations in Saudi Arabia were visited, where personal interviews were carried out with human resource employees. The system was designed using HTML for the web pages, and for the database tables design, the Microsoft Access Database was used. For production and HMTL page editing, ASP running on the IIS was used. For manufacturing and altering photos and images, CorelDraw and Corel photo paint were used. On the client-side, the internet explorer was utilized as a browser for interpreting the contents received from the webserver. The web was designed as a network operating system on Windows 10. Real-time data was used to test the scheme to guarantee that the design objectives were met.

2.1. Proposed system

The paper provides a relational form of the conceptual objects for HRM. The statistical process was applied to analyze the functioning of the effective human resources management system and implementation. The design of the system aimed at efficient and effective online management of human resources. Figure 1 illustrates the worldwide chart of the database design. Knowledge base, databases, inferences, decisions support system are the main components of the framework.

The basis of knowledge offers special understanding of the subject (facts and regulations) acquired by field experts. It is based on rules combining quantitative and qualitative know-how with data that is the information store for operational data processing. It provides information about the potential applicant for a job and the employment requirements given by companies hiring the employment office services. The CLWHRMS knowledge base includes two interrelated databases: job requirements, applicant databases, and additional databases.

The whole knowledge base is conceivable as a network of relationships in the database. A relationship is a two-dimensional table with several lines and columns. This concept is synonymous with the 'file' concept in the conventional data processing. The objects in the database are designed with a relational database ideal. A relation is comparable to the usual file and is usually signified by a number of tuples. Each tuple is the record of a file, and the attributes match the fields of a record. The general form of a relation is given by

$$R\left[A_1, A_2, \ldots . A_K, A_{k+1} \ldots . . A_n\right]. \quad (1)$$

where R represents the relationship name, and $\{A_i\}$, i = 1, 2, 3 ..., n, the relationship R attributes. The

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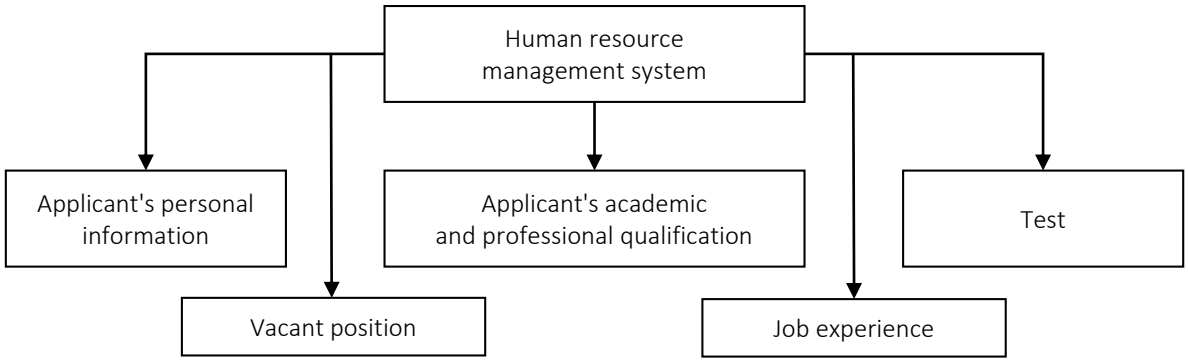

Figure 1. Global chart of the database design

system incorporates a roll-based mechanism for specifying the database system access privileges.

Six links in the knowledge base of the web-based human resources management system. The first five relationships provide structured information, but the subsequent relationships contain unstructured information modeled on a performance indicator. Table 1 includes the relational system-supported database.

Table 1. Relational database supported by the system

Description	Elements of database
APPLICANT QUALIFICATION	Applicant number, date of award, minor subject, certificate, main subject, name, status, date of award
APPLICANT PERSONAL INFORMATION	Applicant number, names, date of birth, sex, next of kin, age, nationality, state of origin, marital status, address, e-mail
APPLICANT JOB EXPERIENCE	Applicant number, date employed, date disengaged, promotion, progress, leaves, name, health, minimum year
ORGANIZATION	Organization number, address, line of trade, phone number
JOB REQUIREMENT	Job code, grade, status, years of experience, gender, time of life, nationality, organization, job status
JOB VACANCY	Organization number, vacancy, job code, job role, e-mail
PERFORMANCE	Applicant number, job code, intelligence test, physical test, aptitude exam, score

The inference engine (IE) offers the rationale for the expert scheme to draw inferences from certain facts and regulations on the topic delivered by the information base. The requests server would accept requests/summaries from diverse applicants and submit them for heavy processing activities to the corporate server. This module searches the applicant's information and qualifications and matches them against the job application. The CLWHRMS approach is used to make inferences for backward chaining. The proposed system examines a specific job appeal and then searches for the set of applicants who meet the requests. The results are then distributed by e-mail to qualifying applicants. Table 2 shows the knowledge about the applicant and job composition. Each of the phases was defined in Table 2; the inferences are drawn matching a new phase, where the diagrammatic representation is shown in Figure 2.

Table 2. Knowledge about applicant and job composed

Knowledge about an applicant is composed	Knowledge about the job is composed
Personal data	Applicants' registration
Academic and professional qualifications	Job and organization requirements
Job history	Job vacancy

The IE gives the reasoning capacity to draw inferences from exact facts and rules concerning the topic delivered by the database with the associated choice variables of the knowledge required for the work and produces a list of the candidates picked for certain specific occupations. The Decision Support System (DSS) contains two subsystems, namely cognitive and emotional filters.

In the information contents of a list of applicants appointed to a certain work by the inference engine, the cognitive filter provides a sequence of arguments, including inductive and deductive arguments. Some steps, for example, may be made in deciding which qualifications are most suited and additional skills may be required for a specific job, working restrictions, work experience in the sectors of work, places where candidates are employed, gender, status, married or not, male or female, etc. This

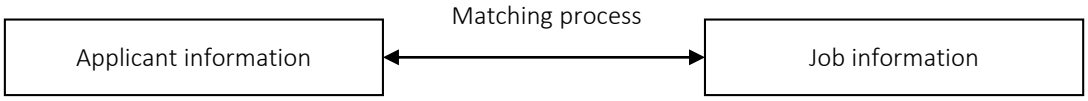

Figure 2a. Stage I: The system studies applicants and jobs

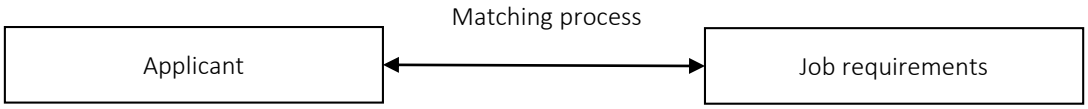

Figure 2b. Stage II: Matching of applicants to job necessity

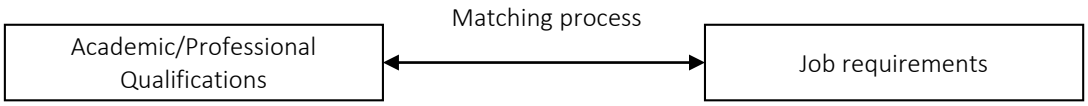

Figure 2c. Stage III: Matching of qualifications with job necessity

Figure 2. Design of the matching scheme

can serve as the basis for the cognitive straining of the system engineer's list of selected applicants.

In the context of information on the list of applicants nominated for a particular position created by the inferential engine, the emotional filter carries out several reasoning, including inductive and deductive reasoning. For example, because of their relations with authoritative people, a candidate may be preferred, a candidate may be ineligible because of bad conduct, a male applicant could be preferred to the female counterpart for the reason of the stress involved, a candidate may be disqualified on a health level, or a candidate may be disqualified on a tribe basis, etc. All this might form the basis for the emotional screening by the system engineer of the list of selected applicants.

A user interface is provided by the proposed system based on an interactive web browser called an internet explorer. Usernames and passwords help to restrict access to the website are provided with access. The inference procedure is interactive, and it guides intelligently to supply appropriate information. The inference technique is interactive and cleverly steers the provision of information. The expert will be offered alternate decisions on picking any of the menus. Lastly, the system administration will have the option of applicants, and the personnel department of the concerned organization will receive recommendations.

2.2. Decision-making model

It is believed that the same group of workers have the same mass range. There are also a set of identical companies with the same type of work, etc. Organizations, including signposts to aid, advertisements for television, local and national journals, employ local formal procedures. Workers walking around the city, listening to TV and radio announcements, or reading local advertisements find the openings information randomly. This means that workers with jobs and unemployed have the equal opportunity to hear of a job vacancy. He/she takes the job if the person is jobless. The study assumes that if one is employed, one communicates the information to social networks. Therefore, unemployed workers can get jobs either directly or indirectly through their working friends. The system can be modeled accordingly:

Let $(c_1, c_2 ..., c_k)$ is the applicant for jobs; U_n is the qualifications and experience required for the position, and J_m is the possible candidate s_j, such that $k = 1, 2, 3, ..., n$. Therefore, s_j, U_n and J_m could be represented as matrices:

$$S_j = \{S_1, S_2, S_3, \ldots . S_k\}, \quad (2)$$
$$\text{where } \{k = 1,2,3,\ldots .., j\},$$

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$$U_n = \{U_1, U_2, U_3, \ldots U_t\}, \quad (3)$$
$$\text{where } \{t = 1,2,3,\ldots..,n\},$$

$$J_n = \{J_1, J_2, J_3, \ldots..J_x\}, \quad (4)$$
$$\text{where } \{x = 1,2,3,\ldots..,m\}.$$

The minimum supplies for the job c_k, is a row vector $U_{kt} = [u_{k1}\, u_{k2} \ldots\, u_{kn}]$ and $U_{kt} \subseteq U_n$, t = 1, 2, 3, ..., n; and let a = 1, 2, 3, ..., p represent an extra condition of which candidates should be reviewed for each of the possible applicants who applied for the task c_k. The prospective applicants for the job c_k is also a row vector $j_{ip} = [j_{i1} j_{i2} \ldots j_{im}]$ and $j_{im} \subseteq J_m$, p = 1, 2, 3, ..., m.

In this case, a model is utilized to tune and assess the coefficients for the limitations of the functions f_1, f_2, f_3, f_4. The respective dependent chance of the job to be offered is

$$l' = P(decision = 1 \mid w) = g(w^L f), \quad (5)$$

$$f(a) = \frac{e^a}{1+e^a}, \quad (6)$$

where g is the logistic function assessed at activation a. Let w mark the weight vector and f the important column vector: f_L [f_1, ..., f_5].

Deep learning can be used to modify the weight vector w. There is one input and one output layer in the simplest example. This corresponds to the generalized logistic model. The weights estimated meet equation (7):

$$\sum_i w_i = 1, \quad 0 \le w_i \le 1. \quad (7)$$

The linear weight combination with inputs f_1, f_2, f_3, f_4 is a monotone function with a conditional probability that may be monitored by altering the weight combination to inputs f_1, f_2, f_3, f_4, as indicated in equation (5) and equation (6). The best threshold with the highest assessed possibility from group data can be used to classify the choice. The prediction of class x from group y was resolute by

$$C(x) = \arg\max_k \Pr(x \mid l = k). \quad (8)$$

To select the appropriate threshold, the study utilized the recipient operating function (ROC) to accurately classify and misclassify the percentage of detections. Several thresholds were used with [0.1] range for this purpose. In addition, the deep CNN-LSTM was used to improve generalization and attain the best quality.

Such as for each c_k and each S_j has applied for:

$$v = \sum W_{k2} \quad iff_{sj}. \quad (9)$$

Job vacancy:

$$F(f_1) \to V(f_1),$$
$$\text{where } f_1 = \{c_k\}, \quad 1 \le k \le 4, \quad (10)$$
$$v_k = \frac{\sum w_k}{T} iff, \quad c_k = w_k,$$

where T is the total point

Personal data:

$$F(f_2) \to V(f_2), \quad (11)$$
$$\text{where } f_2 = \{S_j\}, \quad 1 \le j \le 4.$$

$S_j = P_j \;\; iff S_j$ is true

$$v_j = \frac{\sum w_j}{T} iff \;\; S_j = W_j,$$

where T is the total point.

Academic requirement:

$$F(f_3) \to V(f_3), \quad (12)$$
$$\text{where } f_3 = \{j_m\}, \quad 1 \le j_m \le 4.$$

$j_m = p_m$, iff j_m is true

$$v_{jm} = \frac{\sum p_m}{T} iff \;\; j_m = p_m, \quad (13)$$

where T is the total point.

Job history:

$$F(f_4) \to V(f_4), \quad (14)$$
$$\text{where } f_4 = \{u_n\}, \quad 1 \le n \le 4.$$

$u_n = p_n \;\; iff \;\; u_n$ is true

$$v_n = \frac{\sum p_n}{T} iff \;\; u_n = p_n$$

where T is the total point.

Note that s_j, c_k, $j_{m,}$ and un are inputs; and p_n, p_k, p_m, $p_n = p_0$ are points, y_n, y_k, $y_{m,\ and}$ $y_n = y_i$ are bias; v_i = weighs; o_i = outputs.

Let t equals total jobs applied for. If $I_m \neq U_n$ and not end of file, then process s_j. Otherwise, $X_r = \mathrm{M}(J_m)$, $r = 1, 2, 3, ..., n$, where M represents the function that returns the list of short registered applicants s_t.

Therefore, get $X_r = \mathrm{M}(J_m)$.

$$\text{If } \sum_{t=1}^{r} \gamma(t) < p$$

select next γ other wish access the next candidate.

The final qualified is stated as:

$$f_{shorlisted} = \begin{cases} 1, \ provided & \sum_{r=1}^{n} X_r = p \\ 0, & otherwise \end{cases}, \quad (15)$$

where $\sum_{r=1}^{n} X_r$ represents the total candidates s_t that are qualified for the job c_k and the $f\_shorlisted_i$ signifies the qualified candidates, and p signify the maximum condition for the job k, where $J_m U_n$.

The CNN-LSTM is described and architectured. The adjustment of soft constraints coefficients is an analytical technique to handle the problem of decision-making. The architecture will substantially be simplified, and the time and memory will be saved. It can also be seen as a classification issue, for which CNN-LSTM has shown itself to be a very appropriate method. CNN-LSTM can learn to make human choices and, when changes to the environment naturally follow, it would remove the burden of reconfiguration of the data. This paper uses the following network architectures: Vanilla LSTM, 2-Stacked LSTM, and 3-Stacked LSTM, as shown in Figures 3a, 3b, and 3c, respectively. The initial LSTM model (or Vanilla LSTM network) contains a single hidden LSTM layer with a common output layer. Stacked LSTM networks are improved to many hidden layers of the original model. A multiple memory cell contains each layer in the Stacked LSTM network. Technologically, a Stacked LSTM structure may be distinct from an LSTM model consisting of many LSTM layers to benefit from the temporal extraction of each LSTM layer.

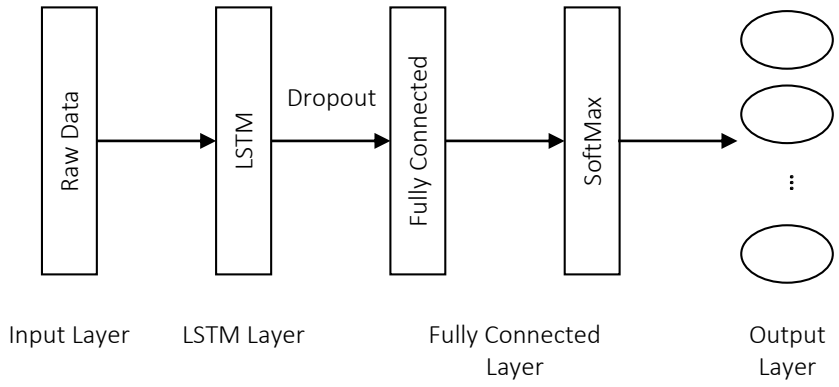

Figure 3a. Vanilla LSTM network design

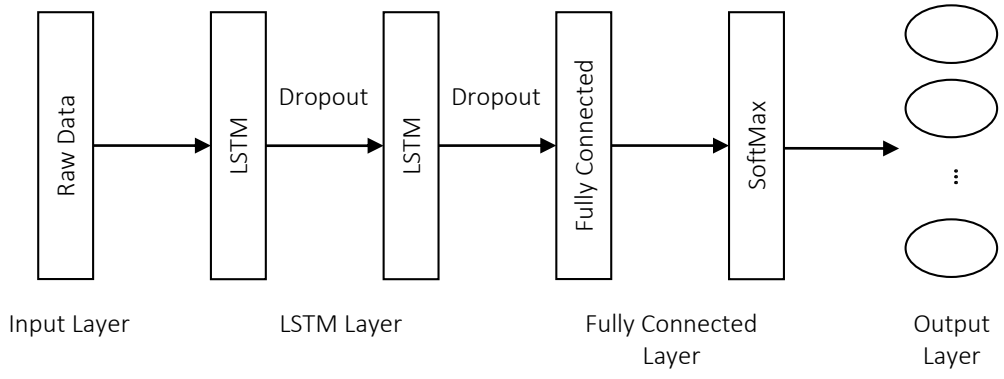

Figure 3b. Stacked LSTM network design

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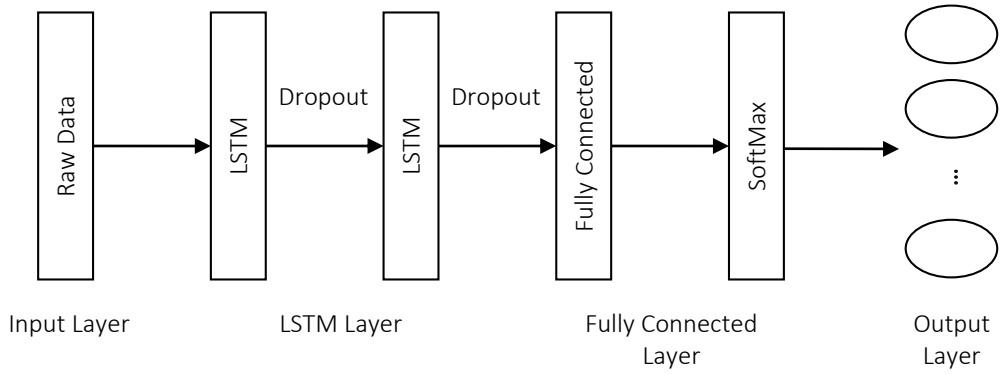

Figure 3c. Stacked LSTM network design

2.3. CNN-LSTM architecture

CNN-LSTM design utilizes CNN layers to provide sequence prognosis throughout the feature extraction process of LSTM-based input data, as Figure 4 shows. The CNN-LSTMs are created to resolve visual time series and applications forecast difficulties in order to provide textual picture descriptions. This design is suitable for problems involving a timely input or requiring a temporary structure output generation.

The aim of this effort will be to increase the performance of the LSTM network termed 4-layer CNN-LSTM. Four one-dimensional convolutionary layers have been employed for the activation feature in Rectified Linear Unit (ReLU) to derive feature maps from the input layer. A max pooling layer is also added to the proposed network to summarize the functional maps produced by the convolution layers and reduce computational expenses. Their dimensions also need to be reduced after reducing the size of the function maps to allow the LSTM network to operate. For this reason, the flattened layer converts each function map's matrix representation into a vector. In addition, several dropouts are inserted on top of the pooling layer to decrease the risk of overfitting. The output of the pooling layer is processed by an LSTM layer after the dropout function is applied. This models the temporal dynamics to trigger the feature maps. A fully connected layer, followed by a SoftMax layer to return identification, is the final layer. The next section shows the validation of both proposed segmentation and classification techniques with existing techniques.

3. RESULTS AND DISCUSSION

The internet has advanced to a more complex and dynamic usage, such as e-commerce, e-government, and e-enterprise from the previous static view and download of information. Any working website includes server-linked customers via network resources. The clients are equipped with a browser that displays all the data from the server. Furthermore, information is uploaded to the

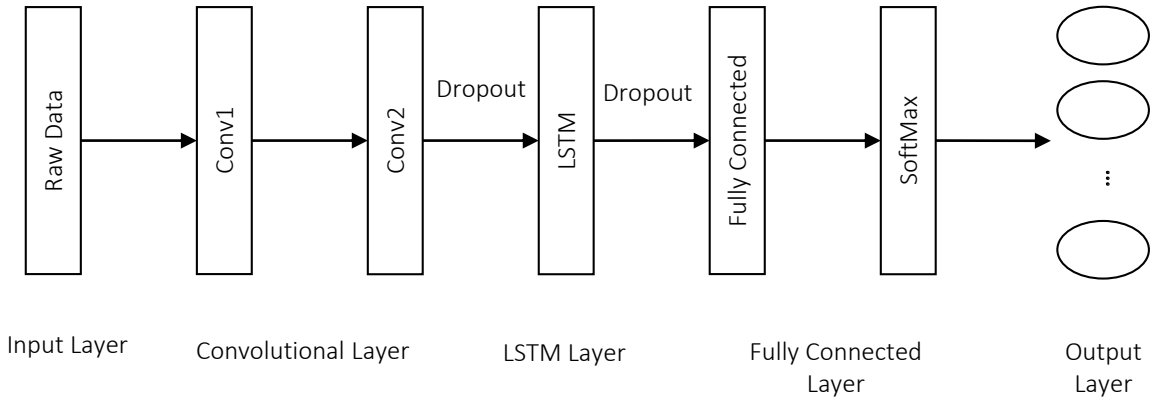

Figure 4. CNN-LSTM network architecture

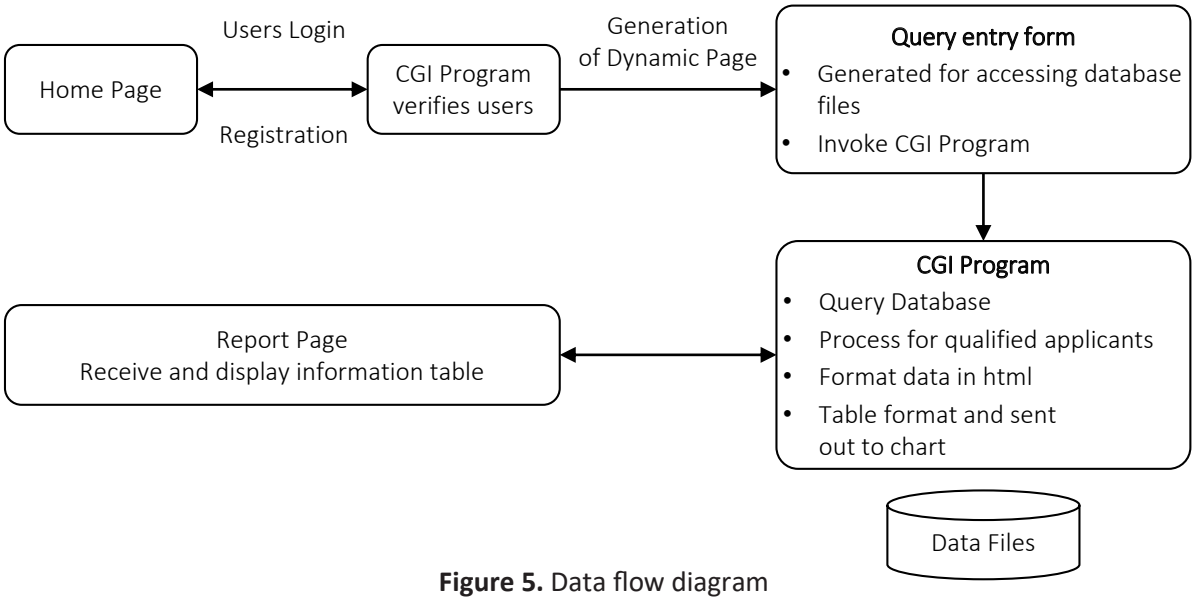

Figure 5. Data flow diagram

server for suitable processing through clients. In this context, a website is made that might help any company obtain its applicant's data via the internet. The applicants can search for positions and their addresses through this website. The flow diagram, which has one HTML static homepage (which includes login forms) and two CGI authentication programs and database access definitions, is shown in Figures 5-7. This graph also provides the diagram of the web delivery.

After any relevant company of interest, it is possible to complete and submit job forms, which are then uploaded to the server computers of the organizations. Then separate companies can be associated with their server computers and collect the processing data for applicants via an application developed on Internet Information Server. The system is implemented as a typical web-based application due to enormous flexibility in the distribution of information through the internet. On the applicant side, the core application functionality on the server side is provided by the typical internet browser on a local computer. Figure 6 shows the fundamental component of the system infrastructure.

Figure 7 provides a three-layer internet design that includes presentation, content management, and data services. A single point entry to the system

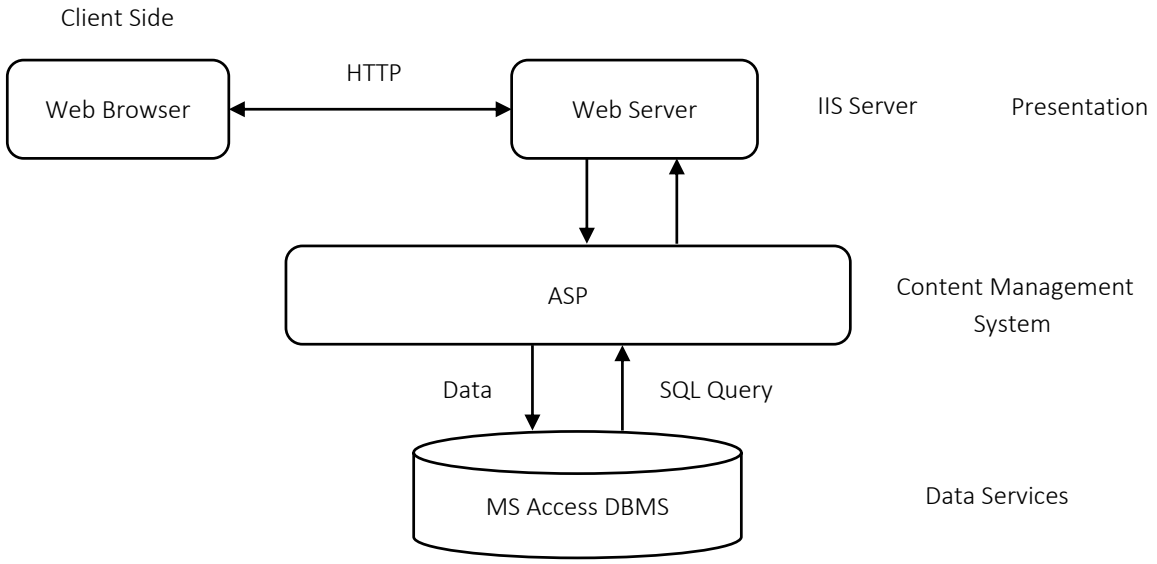

Figure 6. Conceptual diagram of the CLWHRMS

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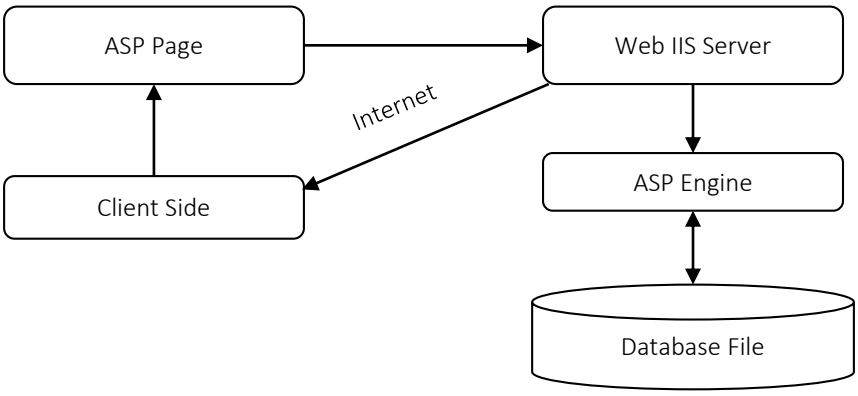

Figure 7. System conceptual architecture

is provided through URL by the common content management gateway. The presentation is comprised of two main elements from the diagram below. The first section is the system's user interface. The UI is built on HTML, therefore the client (applicant) side needs simply a browser, such as an internet explorer. The second part is the web server of the Internet Information Server. The content management system the user's request is converted to an organized query language for content management systems where active server pages (ASP) scripts are necessary. Data services represent database management, and Microsoft Access employs the essential capability. The system generates and returns dynamically an HTML page with operating results that the user specifies on the browser.

3.1. Security

In order to guarantee the security of the system against unauthorized use, the system presented must be carefully protected from abuse and facilities established. The system will not enable transactions or inquiries without logging on and entering the correct username and password to ensure that fraudulent transactions are not undetected. Unauthorized users who are logged out after a default amount of trials will be refused access. A unique user name and password are allocated to each structure or personnel, which is stored in a database management area. This inhibits unlicensed system access. The system's main menu will be loaded after successful authentication. Each application using the site is registered, and the username and password will be communicated following registration by the applicant's e-mail address. Physical access should also be restricted to authorized personnel to the computer system, diskette, and auxiliary devices. Adapted programmed controls on system maintenance facilities are available. For instance, if certain data are outdated and occupy space in the system unnecessarily, the removal of these data is made provision. However, this is done only by authorized users.

3.2. Evaluation metrics

The evaluation metrics are used for evaluating the performance of our method. For the classification, the evaluation criteria include specificity (SP), sensitivity (SE), and accuracy (AC). The performance standards are defined as:

$$SE = \frac{tp}{tp + fn}, \tag{16}$$

$$SP = \frac{tn}{tn + fp}, \tag{17}$$

$$AC = \frac{tp + tn}{tp + fp + tn + fn}, \tag{18}$$

where *tp, tn, fp* and *fn* denote the number of a true positive, true negative, false positive, and false negative.

3.3. Performance evaluation of system model

The above system model is manually developed in this research study to test the working efficiency of CLWHRMS. Initially, 250 resumes were collected from online databases as input data and

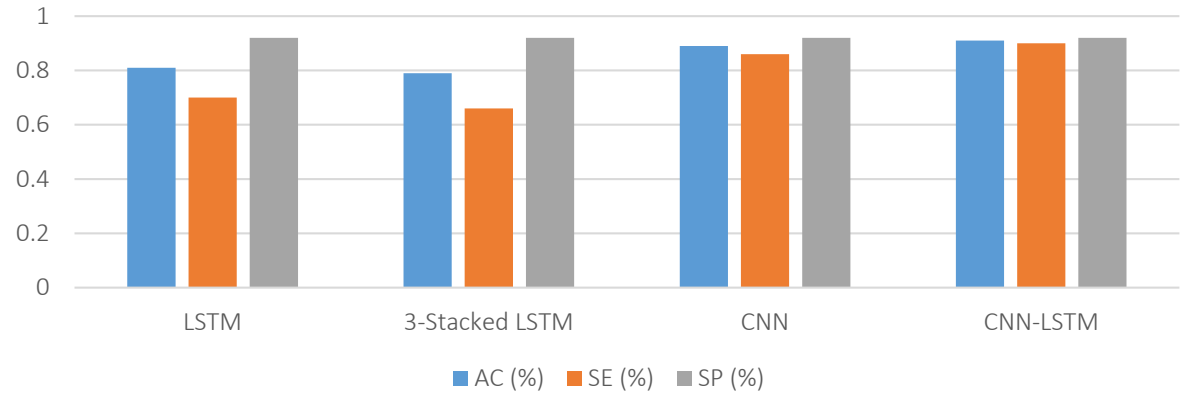

Figure 8. Overall system performance evaluation in terms of various parameters

validated its overall system performance in terms of Accuracy (AC), Sensitivity (SE), and Specificity (SP), which is shown in Table 3 and Figure 8.

Table 3. Overall proposed system validation

Method	AC (%)	SE (%)	SP (%)
LSTM	81.00	70.00	92.00
3-Stacked LSTM	79.00	66.00	92.00
CNN	89.00	86.00	92.00
CNN-LSTM	91.00	90.00	92.00

Table 3 shows that the CNN-LSTM achieved higher accuracy (i.e., 91%) than other models, including LSTM, 3-stacked LSTM and CNN, where these models achieved nearly 79% to 89% of accuracy. In the experiments of SE, the LSTM achieved 70%, 3-stacked LSTM achieved 66%, CNN achieved 86%, and CNN-LSTM achieved 90%. All techniques achieved the same SP, i.e., 92% of SP, which shows that the CNN-LSTM achieved better performance than other techniques.

The findings of this study argue that past studies developed many decision-making models of HRM that primarily focused on human performance (Karahoca et al., 2008; Gobert et al., 2012). Wang et al. (2009) applied a hybrid feature selection method to deal with human resource selection. Traditional HRIS systems addressed multiple administrative tasks to access HRM data easily, minimize human errors, reduce manual file work, and generate timely HRM recruitment reports. Rule-based framework of data-mining presented by Chien and Chen (2008) suffers from limitations in overall performance, as the technical experts need to manually predesign based on various features to establish a meaningful pattern. However, all these efforts and traditional machine learning-based models have poor generalization and lack learning ability. Hence, the proposed hybrid system of CNN with LSTM would be quite appropriate to help human professionals solve such challenges related to employment procurement. This statement is also consistent with the findings of Gupta (2013), who stated that there is a rigorous need to develop a dynamic model to holistically mitigate the recruitment and hiring needs and predict the future performance of job applicants by considering various attributes of the personnel. Therefore, to decide effectively and timely, this model has absolutely replaced the previous manual background research components with an automated data recovery procedure. On the other side, this CNN-LSTM model has high security for HRM purposes with separate user credentials, high performance in terms of accuracy, sensitivity, and specificity.

CONCLUSION

The study aimed to present a web-based hybrid HRM model to predict job candidates' performance in the future and assist in HRM decision-making process during hiring the most talented applicants. This approach eliminates the unnecessary struggles and other hassles encountered in the conventional unstructured interview and knowledge-based technique of corresponding candidates to job positions. This study has produced a web-based CNN-LSTM human resource management model that has solved

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earlier researchers' issues. The findings demonstrated that this hybrid technique is most feasible with accuracy, sensitivity, and high security of HR data. This would enable the website to construct a web system to help the human resources department acquire personnel without necessarily experiencing the rigors and challenges linked to the usual manual procurement process. Furthermore, this hybrid model differentiates various job candidates based on discriminative tasks and provides the expected level of candidates' performance before even recruiting him/her for a job. The study contributes to providing practical implications to HRM professionals, avoiding the possible risk factors, reducing unnecessary costs that are caused due to the traditional and unsecured methods of the HRM recruitment process, and gaining an effective and efficient candidate for various job positions.

AUTHOR CONTRIBUTIONS

Conceptualization: Sania Khan.
Data curation: Sania Khan.
Investigation: Sania Khan.
Methodology: Sania Khan.
Project administration: Sania Khan.
Validation: Sania Khan.
Writing – original draft: Sania Khan.
Writing – review & editing: Sania Khan.

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