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Saad Motahhir  
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# Digital Technologies and Applications

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Saad Motahhir · Badre Bossoufi  
Editors

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*We are honored to dedicate the proceedings  
of ICDTA'24 to all the participants and  
committees of ICDTA'24.*

## Preface

This volume contains the fourth section of the written versions of most of the contributions presented during the conference of ICDTA'24. The conference provided a setting for discussing recent developments in a wide variety of topics including artificial intelligence, Internet of Things, embedded systems, chatbot, network technology, digital transformation and their applications in several areas as Industry 4.0, sustainability, energy transition, healthcare, etc. The conference has been a good opportunity for participants from various destinations to present and discuss topics in their respective research areas.

ICDTA'24 conference tends to collect the latest research results and applications on digital technologies and their applications. It includes a selection of 212 papers submitted to the conference from universities and industries all over the world. This volume includes a quarter of the accepted papers. All of the accepted papers were subjected to strict peer-reviewing by 2–4 expert referees. The papers have been selected for this volume because of their quality and their relevance to the conference.

We would like to express our sincere appreciation to all authors for their contributions to this book. We would like to extend our thanks to all the referees for their constructive comments on all papers; especially, we would like to thank Organizing Committee for their hardworking. Finally, we would like to thank the Springer publications for producing this volume.

S. Motahhir  
B. Bossoufi

## Acknowledgments

We request the pleasure of thanking you for taking part in the third edition of the International Conference on Digital Technologies and Applications (ICDTA'24). We are very grateful for your support, so thank you everyone for bringing your expertise and experience around the conference and engaging in such fruitful, constructive and open exchanges throughout the two days of the ICDTA'24 conference.

We would like to extend our deepest thanks and gratitude to all the speakers for accepting to join us from different countries. Thank you for being such wonderful persons and speakers. Again, thanks for sharing your insight, knowledge and experience.

Of course, this event could not be that successful without the effort of the organizing and technical program committees. Therefore, we would like to express our sincere appreciation to all of you who generously helped us.

We would like to especially thank all the participants for the confidence and trust you have placed in this conference. We hope we lived up to your highest expectations.

Our humble acknowledgement would be incomplete without thanking our sponsors and host. We would like to thank Mister Mohamed Bousseta, the General Director of Green Energy Park.

S. Motahhir  
B. Bossoufi



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# **Artificial Intelligence, Machine Learning and Data Analysis**



# Exploring the Impact of Artificial Intelligence on Human Resource Management

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**Abstract.** The purpose of this study is to explore the contributions of artificial intelligence (AI) to Human Resource Management (HRM) through a systematic review of the existing literature. To address the impact of AI in HRM integration, this study aimed to determine the current and potential AI implications at organizational and individual levels. It analyses the essence of the HRM practices transformation, such as planning, talent acquisition, performance evaluation, training, employee motivation, recruitment, and human-AI collaboration. This study ultimately examines and cross-relate 66 papers, published in journals indexed by Scopus and Web of Science databases over a period of 6 years (2018–2023). It is emphasized that although AI brings benefits for HRM such as data-driven decision-making and automatization, its potential impacts cannot be ignored, including job displacement, ethical, and legal challenges.

**Keywords:** Human Resource Management · Artificial Intelligence · Systematic Literature Review · Technological Transformation · HR practises

## 1 Introduction

The integration of AI technologies into HRM represents a significant transformation in organizational functions [1]. These technologies mark a pivotal point in the evolution of traditional HR practices [2]. AI tools can create opportunities to enhance organizational effectiveness and innovate HR practices, but it also introduces a spectrum of challenges, including ethical considerations, potential workforce displacement, and the necessity for new regulatory frameworks.

The exploration is guided by three pivotal research questions that form the enquiry's foundation:

RQ1: What are the scholarly contributions to AI in HRM, and what prevailing trends can be identified?

RQ2: What impact does AI have on HR practices and employment conditions, and how do these technologies reshape organizational dynamics and the nature of work?

RQ3: What future research trajectories are necessary, highlighting emergent issues and gaps that warrant further exploration?



Based on a thorough review of the relevant literature, this study identifies key areas where AI is applied in HRM, including recruitment, performance management, employee engagement, and training and development [3, 4]. Additionally, it evaluates the dual aspects of AI in HRM, highlighting its potential to enhance traditional HR practices while also posing possible legal issues.

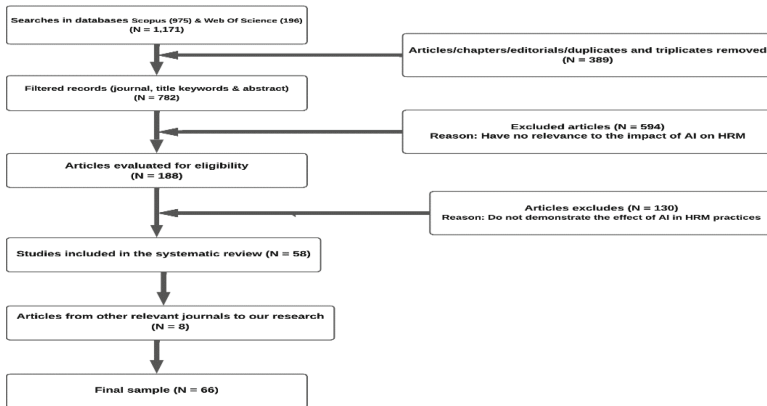
The remainder of this article is structured as follows. Section 2 describes the methodology employed to select and analyse the relevant literature. Section 3 presents the thematic findings of the review, discussing the implications of AI integration in HRM. Section 4 explores the legal implications of AI adoption in HR. Section 5 delves into the collective intelligence and human-AI collaboration. Section 6 provides a comprehensive discussion of the findings. Finally, Sect. 7 concludes the study, offering theoretical contributions and practical recommendations for HR practitioners navigating the evolving AI landscape.

## 2 Methodology and Article Selection Strategy

The research focuses on the research at the intersection of AI applications integrated in HRM, a systematic literature review was pursued, using databases of Scopus and Web of Science. The databases were specifically chosen for their sophisticated and multidisciplinary coverage of scholarly articles. The keyword search algorithm applied for this review is as follows: (“AI” OR “Artificial Intelligence” OR “Machine Learning” OR “Deep Learning”) AND (“HRM” OR “Human Resource Management” OR “HR” OR “Hiring” OR “HR Training” OR “Career Management” OR “Talent Acquisition” OR “Performance Management” OR “Recruitment” OR “Employee Integration” OR “HR Planning” OR “Employee Motivation”). we restricted the period of this review of the papers published between 2018 and 2023, document type, English language and by subject area.

Figure 1 encapsulates this process, depicting the methodical reduction of the initial 1,171 records from Scopus and 196 from Web of Science. Through using Bibliometrix package of language R for deduplication capabilities, the dataset was streamlined to 782 unique articles. These records were then subject to a granular evaluation based on article titles, keywords, abstracts, journals specialities and the alignment of their content with the central themes of AI impact on HRM. This refinement, undertaken with precision and scrutiny, resulted in 188 articles assessed for their empirical and theoretical contributions to the field. The intensive review process, informed by both the technological and HRM perspectives, ultimately distilled the body of work to 58 studies of significant relevance. This selection was complemented by 8 additional articles sourced from journals germane to the research aims, culminating in a final sample of 66 articles poised for in-depth review.

Thereafter, for a comprehensive analysis of the data extracted, Biblioshiny was leveraged to conduct science mapping through the primary functionalities of the Bibliometrix R package. This was further enriched by referencing the journal lists from notable studies by [5] and [6] given their interest in the role of AI in HRM. This step was instrumental in constructing Table 1, which catalogues the identified journals featuring articles on AI integration in HRM.



**Fig. 1.** Methodology for Article Selection (Source: Authors)

**Table 1.** List of academic journals found in this research (N = 40)

<p><b>General management journals (13)</b></p>	<p><b>HRM journals (9)</b></p>
<p>Academy of Management Journal Academy of Management Review Business Horizons Int. J. Business Innovation and Research International Business Review International Marketing Review Journal of International Business Studies Journal of International Management Journal of Business Research Journal of World Business Management International Review Management and Organisational Research Strategic Management Journal</p>	<p>Academy of Strategic Management Journal Asia Pacific Journal of Human Resources California Management Review Journal of Management Studies Human Resource Management Review The International Journal of HRM Journal of Management Strategic HR Review Human Resource Management Journal</p>
<p><b>Computer science &amp; engineering journals (8)</b></p>	<p><b>Information systems and management journals (6)</b></p>
<p>Artificial Intelligence in the Life Sciences Computers in Human Behavior Engineering Applications of AI Int. J. of Human-Computer Studies Computer Science Journal of Computer and System Sciences Journal of Information and Intelligence Int. J. of Engineering and Advanced Technology</p>	<p>Journal of Information Technology J. of the American Society for Information Journal of Strategic Information Systems Information Processing &amp; Management Information Systems Research Information &amp; Management <b>HR Development journals (5)</b> Advances in Developing Human Resources Employee Responsibilities and Rights J Journal of Management Development Personnel Review</p>

Moving deeper into the analysis, the R language was employed to link the extracted articles to their corresponding journals. This allowed us to deduce a distilled list of publications most pertinent to this research focus. Table 2, therefore, delineates the

relevant journals alongside the number of contributing articles, providing a snapshot of the core resources driving the discourse on AI within HRM.

**Table 2.** Journals by number of articles found relevant to this search (N = 23)

N°	Journal titles	Relevant articles
1.	Academy of Strategic Management Journal	1
2.	Asia Pacific Journal of Human Resources	1
3.	Business Horizons	1
4.	California Management Review	1
5.	Computers in Human Behavior	2
6.	Employee Responsibilities and Rights Journal	1
7.	Engineering Applications of AI	1
8.	International Journal of Speech Technology	1
9.	Journal of Business Research	5
10.	Journal of International Management	1
11.	Journal of Management	2
12.	Journal of Management Studies	1
13.	Humanities and social sciences communications	1
14.	Human Resource Management Journal	2
15.	Human Resource Management Review	6
16.	The International Journal of HRM	6
17.	Indonesian J. of Electrical Engineering and Computer Science	1
18.	Information & Management	1
19.	Information Processing & Management	1
20.	Int. J. Business Innovation and Research	1
21.	Personnel Review	1
22.	Procedia Computer Science	1
23.	Strategic HR Review	1

### 3 AI-Assisted HRM

Artificial intelligence is redefining HRM by automating complex tasks traditionally performed by humans, thereby enhancing productivity and strategic decision-making within organizations. AI's capability to predict and analyse human behaviour extends across various HR functions, transforming HR managers' roles from operational to strategic leaders [7]. This shift can streamline HR processes and improves accuracy in tasks such as performance management, employee engagement, and workforce planning, facilitated increasingly by sophisticated AI technologies like machine learning algorithms, neural networks, and blockchain [8]. These advancements allow HR professionals to minimise manual interventions and focus more on strategic initiatives that enhance organisational efficiency and employee satisfaction.

### 3.1 Planning

Effective HR planning leverages the predictive power of AI to enhance accuracy and efficiency in workforce management. AI's ability to synthesise extensive employee activity data significantly aids HR managers in navigating the complexities of HR planning [9]. Traditional methods often fall short due to imprecise data handling, making AI's role crucial in modern HR practises [10]. For instance, the implementation of the Fordful Carson Method (FCM) for HR allocation exemplifies AI's capabilities in optimising resource planning. This intelligent scheduling model accurately forecasts staffing needs with a high accuracy rate (99.12%), showcasing how AI can significantly reduce the time and effort required in traditional HR planning processes [11]. Advanced prediction algorithms streamline HR planning, aligning it closely with organisational goals and ensuring HR meet future business needs effectively [12].

### 3.2 Talent Acquisition and Management

AI is revolutionising talent acquisition and management by automating candidate evaluations, thereby increasing efficiency, and reducing biases [13]. Using natural language processing, AI tools swiftly sort through applications, ensuring candidates match job specifications precisely [14]. For instance, AI has significantly optimised talent acquisition strategies, exemplified by its use in Pakistan's manufacturing industry, where it enhances the matching process between candidates' skills and job requirements. This application can speed up hiring and improves the quality of hires by eliminating human biases [15]. AI's predictive analytics help manage talent more effectively by forecasting turnover rates and identifying potential leaders, thus informing development and retention strategies [16]. Furthermore, AI facilitates tailored onboarding processes, improving employee retention by aligning new hires with organisational goals and culture [17]. However, human oversight is crucial to ensure these technologies are applied ethically and transparently [18].

### 3.3 Performance Evaluation

HR managers oversee performance management, a critical process for monitoring employee performance aligned with organisational goals. Traditional metrics may lack granularity in assessing factors like productivity and efficiency comprehensively. AI offers promise in enhancing evaluation accuracy and detail by analysing extensive datasets, uncovering patterns and correlations that may elude human observation [16], and assisting in the rapid comparison of performance outcomes with initial goals [13]. AI facilitates continuous, and real-time updating of performance evaluation processes, moving beyond traditional periodic assessments. It enhances data accuracy and precision, enabling managers to make informed decisions when evaluating employee performance [19].

### 3.4 Training and Development

In HRM, the advancement of employee skills and career progression is pivotal, necessitating continual training that goes beyond mere technical skills to include soft skills like

stress, and conflict management [20]. The use of AI tools in training enhances this development process by customising programmes to meet individual needs, thereby improving job satisfaction and operational productivity while reducing absenteeism [21]. Intelligent AI agents, for example, offer real-time, personalised training and career coaching, improving engagement levels, which are often low with traditional training methods [22]. These agents not only suggest targeted training opportunities but also provide career guidance tailored to individual profiles, as demonstrated by IBM's use of algorithms to recommend suitable training for employees based on similar profiles [8, 23]. While AI does not replace human trainers, it significantly bolsters the training process by supporting the delivery and effectiveness of developmental programmes.

### 3.5 Employee Motivation and Engagement

Poor managerial practises, such as inadequate communication and unrealistic goal setting, can lead to employee stress and demotivation [24]. In response, HR departments are employing "emotional analysis" techniques, which utilise AI to analyse data from employees' activities, including social media usage, to gauge their emotions and identify any bias. This approach helps categorise emotional expressions into positive or negative sentiments, allowing organisations to better respond to their employees' well-being [25].

### 3.6 AI-Based Recruitment

The influx of job applications demands sophisticated methods for efficient management. AI-driven systems are at the forefront of revolutionising recruitment by optimizing the processing of CV data, thus enabling prompt assessment of candidates [26]. The integration of ML enhances the selection's objectivity, reduces manual bias, and promotes fairness across the recruitment process [27]. Chatbots, with their capacity to analyse audiovisual cues, offer a nuanced understanding of candidates' suitability for roles, marking a significant step towards personalised recruitment [28].

AI's role extends to enabling HR managers to review past applications and formulate fair compensation strategies [29]. Recruitment platforms powered by AI, such as LinkedIn and Indeed, utilise ML algorithms to personalise job recommendations, significantly improving the efficiency of matching candidates with suitable positions [30]. Additionally, chatbots facilitate stress-free interview experiences through their impartial and user-friendly interfaces, supporting remote interviewing processes [31]. This innovative approach not only simplifies candidate evaluation but also liberates HR managers to concentrate on strategic initiatives, thereby streamlining organisational communication and operational efficiency [32]. Notably, HireVue, a platform that employs AI for recruitment, underscores AI's transformative capabilities. Adopted by over 700 companies, including Unilever, Vodafone, PwC, and Oracle. HireVue has revolutionised recruitment by shortening recruitment time by 90% identifying ideal candidates for diverse roles and boosting employment diversity by 16% [33].

## 4 Legal Implications of AI Adoption in HR

Integrating AI into HR functions carries significant legal and ethical challenges, particularly concerning discrimination and privacy issues in employment decisions [34]. For example, Amazon had to abandon its AI recruiting tool because it showed bias against women, highlighting the risks of unintentional discriminatory outcomes when AI analyses sensitive attributes such as gender or ethnicity [35]. These challenges are compounded by AI's role in performance evaluations and other HR processes which might utilise psychometric testing and predictive analytics, raising serious concerns about privacy and the handling of personal data [36]. Furthermore, the delegation of decision-making to AI could potentially erode human dignity and fairness in employment practises [37]. However, Employers must ensure responsible AI use that upholds ethical standards and enhances workplace diversity, actively preventing discrimination based on race, gender, or other protected characteristics [38]. They need to implement robust oversight and continuous review processes to align AI applications with legal and ethical requirements.

## 5 Collective Intelligence and Human-AI Collaboration

AI's advancement stirs concerns about job displacement, particularly for those lacking advanced skills, fuelling unemployment fears in developed economies due to automation [39]. However, AI also presents opportunities for human-AI collaboration and decision-making support, enhancing productivity and agility through process optimisation and leveraging Big Data [40–42]. Establishing trust and clarity in AI's role is essential for a synergistic human-AI relationship that boosts collective intelligence and business efficiency [43].

## 6 Discussion

### 6.1 Comprehensive Implications of AI in HRM

Using AI in HRM makes the process of recruitment, performance management, and employee engagement more efficiency. What AI does is speeding up the act of analysing information about potential prospects and assessing productivity in a way that rids the process of prejudices. All these benefits that come with the use of AI do not come without introducing new problems, including higher costs, organizational change, AI use complexities. Taking such issues of technicality, ethicality and operationality is unavoidable even though AI has a lot of benefits.

### 6.2 Limitations of This Research

This review employs a rigorous methodology to select and analyse relevant articles on AI applications within HRM yet acknowledges certain limitations, such as the exclusion of diverse sources like books, reports, and websites, which might offer additional insights into the rapidly advancing ins this subject. Additionally, the keyword search used may not

have captured all pertinent studies, potentially omitting valuable information. Despite these constraints, this review provides a comprehensive synthesis of existing reviews on AI in HRM, meticulously discussing each practice along with the legal and ethical considerations involved.

### 6.3 Recommendations for Future Research

This paper finds a gap in the literature on AI use in HRM, which is the consideration of the wider influences of AI, other than employment and productivity evaluation. It is, therefore, recommended that AI be investigated for its effect on the well-being of workers. Another gap identified is the lack of intercultural research when it comes to AI integration in HRM. Future research is recommended to also utilize various informational sources.

## 7 Conclusion

In this paper, a review of the relevant pieces of work on the use of AI in HRM was conducted. Throughout the review, several different themes were discovered, including the use of AI in HRM, the collaboration between humans and AI, and the effect of AI on recruitment. In addition, the literature shows the importance and limitation of AI in HRM. Gaps in investigating the operation process of AI, group intelligence, and issues of ethicality and legality of the use of artificial intelligence in HRM emerged as well. Dealing with such deficits, the paper proposes ideas on the strategies to use in the implementation of AI, its effect on productivity and the betterment of collaboration between AI and its users. What the paper recommends is to make use of a wide array of informational sources to capture different insights.

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# Sentiment Analysis in Maghrebi Arabic Dialects with Enhanced BERT Models and Big Data Processing

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**Abstract.** Sentiment analysis in Maghrebi Arabic presents significant linguistic difficulties because of resource constraints. Among these difficulties are the several dialects spoken in the Maghrebi area and the peculiar grammatical systems. We introduce a complete framework that uses the Bidirectional Encoder Representations from Transformers (BERT)-mini and BERT-base models, improved with large data processing capabilities offered by Apache Spark, to improve scalability and performance. Selecting a variety of datasets, sophisticated preprocessing methods like tokenization, normalization, and keeping special characters and emojis are used, and several model architectures are carefully explored. Our method works; BERT-mini reaches accuracy rates of up to 0.885 and BERT-base reaches 0.899. Conventional machine learning techniques are much outperformed by these outcomes. This paper shows how well BERT models may be integrated with big data technology and points up areas that need more investigation. Our framework offers important insights and useful applications in many domains, including social media monitoring, market analysis, and customer feedback evaluation. It does this by tackling the linguistic complexity of Maghrebi Arabic.

**Keywords:** Sentiment analysis · Maghrebi Arabic · BERT · mini · BERT · base · Natural Language Processing · Deep Learning · Big Data · Apache Spark

## 1 Introduction

Identifying the attitude expressed in a text—positive, negative, or neutral—is the goal of sentiment analysis, sometimes referred to as opinion mining, a key component of Natural Language Processing (NLP) [1]. Applications in social media analysis, marketing, customer service, and politics are just a few of the sectors where it has drawn a lot of attention [2].

Analyzing text in languages like Maghrebi Arabic dialects with intricate structures and few linguistic resources, however, is quite difficult [3]. Sentiment analysis is hampered by the particular grammatical subtleties of these dialects [4]. While Maghrebi Arabic dialects are similar, precise sentiment analysis is hampered by their unique grammatical characteristics. Developing efficient sentiment analysis systems for these dialects is hampered by the lack of particular linguistic resources and techniques, which complicates this work even more [5].

We describe a complete framework to solve these problems, based on enhanced Bidirectional Encoder Representations from Transformers (BERT) models and sophisticated NLP methods designed for Maghrebi Arabic dialects. Strong natural language processing (NLP) tool BERT can extract contextual information and subtle semantics from text [6]. We propose to enhance BERT models especially for Maghrebi Arabic in order to better understand sentiment in this linguistic setting.

We furthermore use Apache Spark big data processing methods to manage and examine the enormous amounts of text data that are usually involved in sentiment analysis assignments [7, 8]. Sentiment analysis methods are made more precise and scalable by this connection. We also add a special layer to our model to capture linguistic intricacies unique to each dialect, hence enhancing the accuracy of sentiment interpretation [9].

This work introduces a framework to increase sentiment analysis in Maghrebi Arabic dialects by combining large data processing, improved BERT models, sophisticated NLP approaches, and a bespoke layer. We want to improve sentiment analysis capabilities in this environment and provide new paths for applications across many fields by tackling the particular linguistic issues and using big data technology [10].

## 2 Related Work

Multiple methods have been created in the field of Arabic sentiment analysis to capture the grammatical subtleties unique to Maghrebi dialects. We summarize recent methods in this field below:

Convolutional neural network (CNN) methods, two Long Short-Term Memory (LSTM) layers, and Support Vector Machine (SVM) on a multi-domain corpus were combined by Ombabi [11] to propose a hybrid deep learning model for sentiment analysis in Arabic. With precision gains as high as 90.75%, their approach outperformed earlier research using FastText word embeddings. But this method was restricted to one kind of word embedding and binary classification.

Comparably, Heikal [12] created an ensemble model for sentiment analysis on Arabic tweets by combining CNN and LSTM with pre-trained AraVec word embeddings. Their model was limited to a single vector representation of words even if it performed better than current methods with a precision of 65.05%.

For sentiment analysis of Arabic tweets, Altaher [13] suggested a hybrid deep learning-based method that combines deep learning methods with feature weighting algorithms. With 90% accuracy and 93.7% precision, their model outperformed conventional methods including SVM, Decision Tree (DT), and Neural Network (NN). But this method ignored how text in Arabic tweets is semantically structured.

On the AraSen corpus, Al-Laith [14] classified attitudes in Arabic using recurrent neural networks (LSTM). With precisions of 87.4% and 85.2% for binary classification on the SemEval 2017 and Arabic Sentiment Tweets Dataset (ASTD) datasets, respectively, their algorithm surpassed previous techniques. This work did not, however, investigate the application of various pre-trained dialects or vector representations.

Omara. [15] focused only on character-level characteristics in her application for sentiment analysis in Arabic utilizing two deep CNNs. With a precision of 94.3%, their model outperformed naive Bayes, SVM, and logistic regression among other machine learning techniques.

While underlining ongoing issues including the representation of Maghrebi dialects and the use of balanced and representative data corpora, these current approaches demonstrate the variety of ways utilized to handle sentiment analysis in Arabic. Our work investigates how to employ big data processing and improved BERT models for sentiment analysis in Arabic dialects spoken in the Maghreb. Combining these technological developments, we want to demonstrate the robustness and accuracy of sentiment analysis systems in challenging linguistic contexts like Maghrebi Arabic dialects. Our goal is to suggest a novel methodology that may be used in many situations, thereby providing fresh and encouraging viewpoints for useful sentiment analysis applications in the Maghreb area.

### 3 Lexical Exploration of Maghrebi Arabic Dialects

French and English terms are used in the Maghreb countries because of their colonial past, when France and the United Kingdom imposed their languages and traditions. This effect caused a lot of French and English words to be used in daily life. These words are ingrained in the legal, commercial, educational, and technological sectors long after independence. Examples of frequently occurring Maghrebi terms translated into Modern Standard Arabic (MSA) and English are given in Table 1.

**Table 1.** Examples of Common Maghrebi Words Translated into Modern Standard Arabic (MSA) and English.

MAGHREBI	MSA Translation	English Translation
Rwa7	تعال	Come
5rejt	خرجت	I went out
Malak	بك ما	What's wrong with you
Chna7welek	الحال كيف	How are you

Local vernacular dialects are also influenced by the French and English languages. For example, in Moroccan and Algerian Darija, the word “3lach” uses the “3” to represent the Arabic letter “ع”, which translates into English as “why”. In the Tunisian dialect, “why” is “3lah”. In addition to this, several letters in Arabic are replaced by numbers. For

example, in Maghreb dialects, “5” means "خ,kh" and “7” represents the letter "ح". Table 2 presents the distinctive North African characters as well as their Arabic equivalents.

**Table 2.** Unique Maghrebi Characters and Their Corresponding Arabic Equivalents.

ARABIZI	ARABIC
2	ا
8 or 9	ق
4 or gh or 8	غ
3	ع
\$ or sh or ch	ش

In the Maghrebi nations, where native dialects of Arabic coexist alongside French and English borrowings, this linguistic phenomena demonstrates an intricate integration of dialects and culture. The influence of colonial history and continuous cultural connections that continue to mold the linguistic environment of the region mean that the use of French, English, or Spanish terms endures despite attempts to maintain the originality of the Arabic dialects. Table 3 displays comments in Maghrebi together with their English translations.

**Table 3.** Positive and negative Maghrebi remarks translated into English.

MAGHREBI	English	Polarity
ما قيش حد مهتم بمشاكلنا	Nobody cares about our problems	Negative
هدا المأكلة شحال واعرة	How delicious is this food	Positive

## 4 Materials and Methods

For this work, datasets were carefully chosen in several phases with an emphasis on their applicability and representativeness to Arabic sentiment analysis. Quality of the annotations, size of the dataset, and diversity of the sources were selection factors. Key features of the datasets used in this work are listed in Table 4. Key procedures in the data cleaning process to guarantee best quality and accuracy were text normalization, stop word and special character removal, and tokenization.

BERT-mini is a compact model with four hidden layers, four attention heads, 256 hidden dimensions, and a total of 11 million parameters. The design of this product is focused on performance and is well-suited for contexts that have limited computing

resources. The basic BERT-base model is considered enormous because to its configuration of 12 attention heads, 12 hidden layers, a hidden size of 768 dimensions, and a total of 110 million parameters. While it demands increased processing power, it is capable of capturing more comprehensive text representations.

It becomes feasible to compare the effectiveness and performance of BERT-mini and BERT-base in the framework of sentiment analysis of Arabic dialects spoken in Maghrebi. BERT-mini is evaluated for efficiency of resources and speed, whereas BERT-base is used for advanced modeling capabilities and exceptional performance.

Now, the BERT models have a special layer to better represent the subtleties of Arabic language and culture. Working with Python 3.9 and many modules like scikit-learn, PyTorch, and Transformers, the work was done in Jupyter Notebook inside the Anaconda environment. Because of this configuration, our results are transparent and repeatable.

#### 4.1 Data Collection

To enhance the representation of data in the data collection section, a summary table detailing the key characteristics of the datasets mentioned is presented:

#### 4.2 Insight into Transformers Mechanics with BERT

One very successful NN architecture in natural language processing is transformers. Unlike recurrent architectures that analyze sequences sequentially, they are built on an attention mechanism that enables the model to consider relationships between all portions of the input sequence concurrently [16]. Transformers can more successfully capture long-term dependencies in sequences thanks to this attention capability. The Transformer model's design is illustrated in Fig. 1 by emphasizing its encoder and decoder parts. Within the Transformers framework is a pre-trained language model called BERT. By use of a training task called token masking, it is excellent in capturing bidirectional contextual information in text. Multiple self-attention mechanisms are housed in each of the stacked encoder levels that make up BERT.

Fundamental to Transformers is the self-attention process, which helps them to comprehend the connections between various pieces in a sequence. Unnormalized attention and normalized attention are its two main operations.

The unnormalized attention operation computes the attention score between query (Q), key (K), and value (V) matrices, represented as:

$$\text{Attention}(Q, K, V) = Qk^T \quad (1)$$

The normalized attention operation, on the other hand, applies the softmax function to the attention scores, followed by a weighted sum of the values, given by:

$$\text{Attention}(Q, K, V) = \text{softmax}\left(\frac{Qk^T}{\sqrt{dk}}\right)V \quad (2)$$