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Article

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

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Article

A Hybrid Method to Predict Human Action Actors in Accounting Information System

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Abstract: Recent literature shows that adopting an accounting information system (AIS) can lead to better decision-making, planning, efficiency and on-time management control, and organisational functionality. However, the impact of AIS implementation on role creation in the organisation is unclear. With the digital transformation of AIS and daily advances in machine learning and other innovative technologies, it is also unclear how these changes interact with human roles in organisations and which AIS components are considered essential. This paper addresses the above issues by applying the actor-network theory to examine the impact of deep machine learning modules in predicting the human actor roles in accounting information systems in organisations. We targeted 120 human actors and examined the influence of deep machine learning modules in predicting 11 personnel and professional features of human actors, based on multivariate statistical analysis. Our findings show that two human factors (familiarity with accounting information and time spent on becoming familiar with it) are the most influential elements that can predict the human actor roles in accounting information systems in organisations. So, human and non-human actors are both essential parts of an integrated AIS that must be considered. The current literature has focused on the AIS structure with less on the interaction between human and non-human actors. One of the main contributions of this study is providing evidence that AIS heavily relies on its human and non-human actors to form a coherent and united AIS network to promote AIS management strategies. The practical implication of the results is that investing in either technology or human resources alone is not enough to achieve the best productivity and performance in organisations. Instead, there must be a balance between human and non-human actors.

Keywords: accounting information system; actor-network theory; data mining; artificial intelligence algorithms; human actors



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1. Introduction

Accounting information is critical for all significant organisational decisions (Askarany 2018; Spraakman et al. 2018; Oesterreich and Teuteberg 2019; Namakavarani et al. 2021; Daryaei et al. 2022; Pouryousof et al. 2022; Shandiz et al. 2022; Zadeh et al. 2022). The accounting information system (AIS) and its functionality in representing organisational objectives has been and is of significant concern (Oesterreich and Teuteberg 2019; Goftwan 2022). The recent literature shows that adopting the AIS could lead to better decision-making, planning, efficiency, on-time management control, and organisational functionality (Wilkin and Chenhall 2010; Prasad and Green 2015; Shen and Han 2019). However, the impact of the AIS implementation on role creation in the organisation is unclear. With the digital transformation of the AIS and daily advances in machine learning and other innovative technologies, it is unclear how these changes interact with human roles in organisations (Christensen and Rocher 2021; Izzo et al. 2021; Leitner-Hanetseder et al. 2021).

Several factors (such as construction companies, designers, project owners, BIM vendors, governmental bodies, etc.) can affect the AIS (Oesterreich and Teuteberg 2019). However, the AIS literature suggests that the human factor is the leading actor in the AIS, which contributes to forming a coherent body of united human and non-human actors in the AIS, thus improving its functionality (Latour 1999; Jeacle 2016). The institutionalised view of the researchers towards the human contribution to the AIS is superficial, where too little attention is paid to humans' complex nature and features. It seems that the current human role in the financial structure of organisations is observed as a non-human actor, resembling an accounting institution with personal interests that defines the organisational and systematic operations and the optimisation therein (Callon 1993).

The AIS is indebted to managers for their unique features, expertise, and experiences, which become prominent character features for the AIS in accomplishing organisational objectives (Uyar et al. 2017).

The AIS is the core of the financial department, consisting of a broad network connected to the Informatics and Socioeconomics departments, and it provides valuable information as to coherency, interdependency, and harmony among human and non-human actors. The AIS must describe the realities while supporting more unity among the actors therein. In this context, one of the significant challenges in applying the AIS and having success in an organisation is selecting and using expert human resources for the system (Alewine et al. 2016). The AIS literature suggests that this selection cannot be appropriate if all features of the human actor are not revealed (Alcouffe et al. 2008). Otherwise, there will be a waste of money and time and sometimes heavy losses to the system (Stroehmeier 2007). Therefore, the selection and employment of human resources in AIS should be a serious concern among the top management—that is, realising their innovative role in analysing and predicting the organisational improvement due to better AIS performance (Ngai and Wat 2006). To our knowledge, as of now no study is reported in the literature that applies the AI algorithms on the 11 selected human features in this study to predict human actor behaviour in the AIS. So, we believe our study is a contribution to the literature.

Given the above, this paper concentrates on the AIS performance concerning human actors in the system and its interaction with other human and non-human actors to promote and expand the sociological concept in the accounting field (Teo et al. 2007). Relying merely on human actors would constrain the study dimensions, while in actor-network theory (ANT), both the human and non-human actors are involved and interpreted. This allows the researchers to focus on human role creation, in specifics, by re-describing the AIS performance; this would increase our understanding of AIS performance and the actors.

According to Latour (1999), ANT focuses on social structure and describes humans and other actors in the system. According to ANT, what is considered IS a network of heterogeneous elements and methods which, as individual entities, lack identity. When ANT is adopted in broader organisational relations, it forms the AIS and its functionality and creates a role. According to Hermans and Thissen (2009), considering anthropologic approaches to achieve accurate and correct interpretations of human and non-human interactions in the AIS is inevitable (Jeacle 2016). By adopting ANT, the human factor is usually not considered the initiator of realities in accounting studies but is overshadowed by concrete facts. In many cases, the elements that form human actors consist of a complex network of relations, connections, and role creations that fills all the management time. Every human actor is viewed as a mini-network consisting of features like education, experience, skills, performances, and unique thoughts that perform the action assigned to them by the management.

According to Cahnman (1969), managers should always be concerned with the definitions that human actors give to their acts, in addition to the fact that nothing is more important than knowing the deep purpose of anthropology and the extent to which it is interpreted and claimed that the formalisation of other symbolic systems must be actor-oriented (Latour 2004).

Like other natural phenomena, human action is unpredictable because it is subject to change. The theorists believe that like natural phenomena where physicochemical laws prevail, human relations are subject to some specific rules in the realm of social science. If found and defined, the relations of role-creating individuals in any system can be predicted and controlled (Hermans and Thissen 2009). According to ANT, if the human actor is not analysed in the AIS, it would resemble a Black box, which is ambiguous until it is opened. The data inside are correctly interpreted, which would exist in the context of a whole network of complex relations ready to be revealed and analysed. According to Tatnall (2005), if the network is viewed as an entire mass with all its details, it would disappear and be replaced by its own act.

The AIS management can consider each identity as an actor without ignoring the fact that every actor's behaviour reflects a set of individual features and hidden properties processed in the Black box, which appears as human behaviour in the system. In this context, the accounting numbers can be interpreted with a sociological approach in its specific sense (Miller 1991; Robson 1991; Preston et al. 1992; Chua 1995). Suppose the AIS management (when choosing and employing human actors) applies appropriate tools to predict their functionality in the system at a low error rate. In that case, the management could contribute to a remarkable evolution in its IS's improvement.

The focus of the available studies on the AIS is merely on information structure and less on an individual's personal and professional features as an actor in the AIS (Larsen 2003; Lee et al. 2005). However, there is evidence in the literature that the lack of human actor perception in AIS is one of the main reasons for fraud and cheating (Ghaemi et al. 2012; Arab et al. 2017). Khajavi and Etemadi (2010) found that the human factor is third among the 23 influential factors involved in bankruptcy.

An attempt is made in this study to overcome this drawback. In this context, due to the multidisciplinary nature of the AIS, one of the appropriate methods that is extraordinarily strong in predicting and classifying the related data contributing to managerial decision-making is data mining. According to Kirkos and Manolopoulos (2004), the data mining method is one of the four priorities applied by the Institute of Internal Audit Association. Data mining is universally used in finance, including bankruptcy, risk estimate, financial functionality prediction, operational consistency, and management fraud predictions and studies.

Boyacioglu et al. (2009) applied the data mining method and designed a model to predict banks' bankruptcies. By using the genetic algorithm, Shin (2009) developed a model that identifies and ranks the factors leading to a financial crisis in organisations. Huang et al. (2004) assessed the credit risk of two Korean and American companies by applying the Vector Support Machine, a learning machine, where five types of ranking are of concern (Huang et al. 2004). Kirkos and Manolopoulos (2004) applied the ANN method to predict bank bankruptcy by assessing the effects of nine financial variables on financial health and demonstrated a 93% prediction strength.

However, to the best knowledge of the authors of this paper, no study is reported in the literature to identify and prioritise individual human actor features at the beginning of employment to predict their actions and behaviour in the AIS. To contribute to the above gap in the literature, the current study aims to address the following question:

Is it possible to predict human actors' acts in AIS, at high accuracy, by adopting a deep learning-based multi-model ensemble method?

To answer the above question, this study focuses on 11 personal and professional features of human actors in AIS to determine which feature/s would be more influential. In doing so, we implement four data mining algorithms separately and combine them in a deep learning-based multi-model ensemble method format to serve the purpose.

The rest of this paper is structured as follows: Section 2 presents a literature review on the fundamentals of ANT and AIS and their components. It further develops the theoretical framework, which discusses the importance of the ANT formation process in AIS. Section 3 describes the research method, and Section 4 presents the results. Sections 5 and 6 focus

on the discussion and contribution and implications of findings. Section 7 presents the conclusions and Section 8 provides recommendations for future studies.

2. Materials

Accounting information is a crucial factor in business decision-making. A computerised accounting system (accounting information system, or AIS) facilitates accurate reporting, processes large-scale transactions, and generates meaningful reporting for subsequent evaluation (Lutfi et al. 2022a, 2022b, 2022c). The literature suggests that the AIS can contribute to organisational and operational improvement (Williams-Jones and Graham 2003; Kozinets et al. 2010). The AIS can be considered a social concept (Alcouffe et al. 2008) that communicates with various organisational actors (Hermans and Thissen 2009). Indeed, the AIS can be regarded as a network of human and non-human elements in a vaster organisational setting and can be explained reasonably by actor theory (Czarniawska and Hernes 2005). So, it can be assumed that the AIS capacity is subject to human factors and non-human factors such as applied tools and technologies (Lee and Kim 2001; Justesen and Mouritsen 2011; Alewine et al. 2016; Eze and Chinedu-Eze 2018). However, it is argued that in anthropologic perception as to sociological theories, the non-human components in the AIS cannot create a role and therefore have little or no effect on predicting the human actor roles in accounting information systems in organisations (Latour 2011). Nevertheless, the non-human components in the AIS can be used as practical instruments by a human to achieve the objectives of organisations (Masquefa 2008; Justesen and Mouritsen 2011). The main point is that in any system, the human is the vital actor who applies the available instruments and technologies to accomplish the main objectives of an organisation via A.

For a better understanding of an IS, the actor's professional performance, the type of relationship, and the role creation aspects should be clearly described (Williams-Jones and Graham 2003). The basis of sociology is the concept that the human has priority over the material (non-human). The group of people in an AIS interaction; consequently, running assessments and studies on corrective approach, allows the researchers to reveal the cumulative chronology of relations between the social human and material (non-human) (Justesen and Mouritsen 2011). According to Law et al. (1986), the description of social sociology concerns the humanitarian world in society, where social structures of human activities are the subject of constant study and assessment. In such a situation, the actors are aware of their conduct, and the observer should learn what they do and how and why they do it (Callon 1989). Given the above, Orlikowski (2007) emphasises the necessity of studying the AIS and human actors to better understand the mixture of humans and instruments in practice and the mutual interaction between the human actor and organisational effects. So, we need to consider all actors in the AIS that keep it coherent (Kim et al. 2017).

What keeps the AIS coherent is the mixture of social and material actors, where usually, the individual actor's identity is not outstanding (Hermans and Thissen 2009). According to this view, the individual actors' identities are generally ignored, and only their cumulative power is considered (Law et al. 1986). It is also argued that human beings that form the AIS obtain a higher practical capacity than they had before, due to having related connections in the AIS (Granlund 2007). According to the ANT, the human and non-human actors could lead to a system balance and stability, though the human actors are the main factors in the system's flow. Note that this network is subject to change (Eze and Chinedu-Eze 2018).

Formation of ANT in Accounting System

According to Law et al. (1986), the main factor that holds a system together is the frame, where acts are performed through heterogeneous (human and non-human) elements. To realise and interpret social or material correlations between humans and non-humans (e.g., instruments) in the AIS, this frame should be viewed outside the system (Callon 1989; Alcouffe et al. 2008). Moreover, the various human acts in a correlation network named the AIS should be assessed and verified (Justesen and Mouritsen 2011). This correlation would affect the system's patterns and introduce a bilateral correlation that could positively impact

the AIS. However, the AIS may not be a pre-structural and practical system. It consists of correlated actors like human instrumental technologies continuously shaping and changing when engaged with different aspects. According to Hermans and Thissen (2009), a set of elements such as perceptions, objectives, and resources are involved in shaping the action of the actors. Figure 1 shows the effective parameters of the actors' actions in AIS. Focusing on the correlation type among human actors in the AIS without considering their identities could mean that everything is explainable.

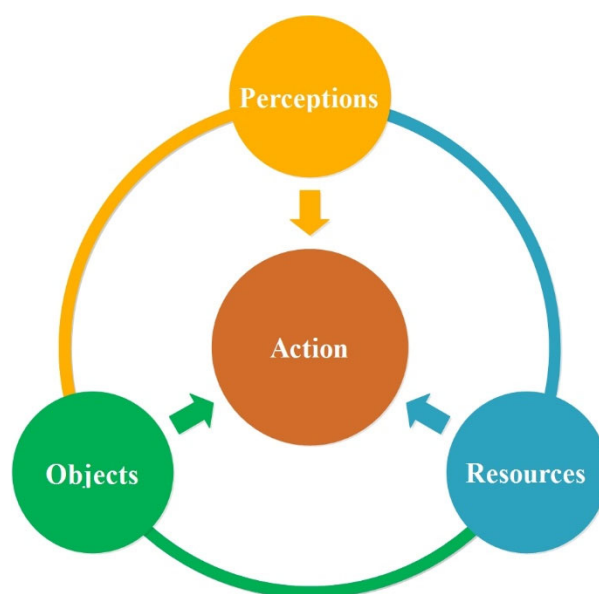


Figure 1. The effective parameters of the actors' actions.

The AIS comprises fundamental actors who make the spread of comprehensive information applicable to economic decision-making possible. The correlation among these actors consists of various tools and resources, such as communication, consulting, social and professional support, and material sources (like products and goods or financial support) (Uyar et al. 2017). Accordingly, every actor can form an AIS according to their objectives. Changes in the accounting information context, the encompassing information area, etc. are some examples of the acts conducted by the actors (Vinnari and Dillard 2016). According to ANT, the AIS is considered a network consisting of actors, actions, production, and technology, as well as the flourishing application information mechanism whereby, by promoting the scientific process, the relationship between knowledge and the environment is improved (Zawawi 2018). These actors consist of human resources such as a manager, accountant, and auditor, and non-human resources such as technical, social, and political aspects, etc. So, examining the performance of an AIS requires assessing the actor's nature and act, the nodes and connections of networks, the centres and sub-sets of production, and specifying how these elements perform to increase the system knowledge. Given the above, we may want to know if the human actor is recognised and identified beforehand in an AIS (Uyar et al. 2017). However, the literature suggests that the human involved in any system (as an ontological factor) has no stable features and reacts differently based on their adapted roles (Latour 2011).

It is argued that ANT is an appropriate lens to provide a clear view of the AIS role interpretation as a mega-network with ideal objectives and standards, which consists of human and non-human factors (Worrell et al. 2013), especially where the AIS unifies the actors further by overcoming the potential difficulties in the management system. So, we can use ANT to predict the human actions of actors in an accounting information system. Accounting is not what it seems to be. The accounting information is somehow finicky and may depend on the actor's role and conditions, and when interpreted may reveal new reactions directly affecting the decision-making process among management and

the AIS functionality. This issue is essential in AIS, as it affects the reactions, judgments, evaluations and decision-making regarding the structure and functionality of the AIS (Prasad and Green 2015). Given the above, our findings are expected to provide a unique pattern in identifying the AIS's actors' roles and justify this narrative framework, indicating that the human role with all its features should be of concern, considering all its complexities and interactions with all relevant elements in the AIS. We agree that AIS should realise its role in these interconnections and their performances (Dillard et al. 2016).

We believe the AIS's internal and external features should be defined to accomplish the above task. It should then be followed by assessing the AIS functionality and network expansion patterns during the system operation. We know that the AIS contains many elements and communicational networks, where each piece (according to its role and spatial position) could be expressive of its influence, making the AIS an independent actor (Tatnall 2005; Ngai and Wat 2006). An excellent network of internal and external organisational relations should be analysed to realise what the AIS could do. We agree that the interpretation of the AIS (instead of focusing on its formation and its movements as a linear and predictable process) should be based on the correlation between networks and their elements (yield from non-linear interactions among the human, scientific, technical, social, economic, and political actors) (Hopwood 1994; Worrell et al. 2013; Kim et al. 2017).

According to the ANT concept, the AIS role creation is subject to human and non-human actors' interactions with related information (Jeacle 2016). The AIS provides interpretation and role creation to financial entities through correlations and interactions between internal and external environmental factors. In ANT, the network scope is determined through actors who promote presence in other occurrences. Identification of each actor through other actors depends on their role in the AIS and their effect on the prediction process.

According to ANT, AIS managers are less likely to have a deep understanding of accounting information generation and evaluation unless they study the human actor's features and skills (Alcouffe et al. 2008). To explore the role creation in AIS, the participant's role in the system must be controlled constantly; that is, the manner of AIS formation must be of concern not merely as a ready mode system (Ruggeri and Rizza 2017), but to allow the analysis of the practical activities therein as to developed correlations (Callon 1993). By doing so, all the complexities, variations, and misunderstandings humans encounter in the system would be assessed, and each actor in AIS would be considered a network (Ruggeri and Rizza 2017). This requires more concentration on all elements of the AIS as an integrated system when it becomes a harmonised, appropriate, and wise/conceptual network pattern. According to Latour (2011), AIS managers' identification and prioritisation of personal and professional features of human actors in AIS can provide an answer to the following questions:

- Which feature/s of human actors is the most influential?
- How do interrelations among human actors work?
- What are their accounting information requirements, and in what frame?
- How can the communicative structure among the available actors in the AIS be organised effectively and efficiently?

Though many actors may become involved in promoting the practicality, development, and applicability of the information, the management (due to complexities in relations and connections and the actors' count) may overlook human and non-human actors' roles in task creation and the interactions therein.

In this context, a perceptive parallel is drawn to interpret what sociologists seek to find and its direct counterpart in the AIS context.

3. Methods

The method adopted in this article is a new strategy that applies deep learning to an ensemble approach that incorporates multiple machine learning models (Xiao et al. 2018).

The main question is: Is it possible to predict human action in the AIS at high accuracy through a deep learning-based multi-model ensemble method?

To select the relevant attributes of human actors for this study, we performed a brainstorming activity with an academic group of 44 staff in our university. A total of 35 personal and professional characteristics of human actors were identified in the brainstorming activity. Further screening steps revealed that 11 (out of 35) personal and professional attributes of actors were considered adequate to capture the overall characteristics of human actors in an AIS. The participants were asked to rate the impact of these 35 characteristics on the AIS with a score of 0 to 5 (see Appendix A). The number zero indicates a lack of influence, and the number 5 suggests the feature’s highest level of impact. The characteristics that were given a score of 5 or 4 and were shared among more than 80% of the respondents were identified as personal and professional characteristics affecting the AIS. The selected 11 characteristics identified in this stage are age, gender, level of education, the field of study, age group, service history in general, service history in a middle management position, service history in a senior management position, organisational function, degree of familiarity with accounting information systems, and the duration of using accounting information systems.

Table 1 provides additional descriptive information regarding 11 selected features of human actors (suggested by 44 AIS specialists and accounting professors) as follows:

Table 1. Detailed information on the considered variables.

	The Features of Human Actors	Variable Description
1	Gender	Male/female
2	Education	High school diploma/BA or BS/MSc/PhD
3	Field	Accounting/Finance/Management/Technical-Engineering/Others
4	Occupational record	Numerical variable
5	Mid-management record	Numerical variable
6	Top-management record	Numerical variable
7	Age	Numerical variable
8	Organisation position	Accountant/Auditor/Senior Auditor/Finance Manager/Auditing Manager/Directing manager
9	The years with AIS	Numerical
10	The period’s AIS is applied	Daily/Weekly/Bi-Weekly/Monthly/Never
11	Familiarity rate with AIS	Very low/Low/Medium/High/Very high

We targeted the senior managers of the audit organisation of Iran, with 230 members at the time of this study in 2020. The organisation’s website address is <https://audit.org.ir> (accessed on 25 January 2021). We obtained the list of all members and used Cochran’s formula with an error level of 5%, which resulted in the selection of 144 people from the list. The main reason for selecting the above members was their familiarity with accounting and the AIS.

A hard copy of the survey questionnaire was mailed to 144 selected members, followed by an email questionnaire (as an attachment in the form of an electronic questionnaire) after two weeks. We received a total of 123 completed questionnaires back after sending the emails (of which 42 questionnaires were received via mail and 81 via email attachment). After reviewing the received questionnaires, we identified 11 questionnaires with missing information and removed them. So, a total of 120 questionnaires were finally reviewed and analysed.

An attempt was made to apply a deep learning-based multi-model ensemble method, which included data mining methods and AI classification algorithms (as the strategy in GBDTs, SVC and K-NN formats) in answering the following question:

Can the human actor’s actions be predicted in AIS through its 11 selected features?

If yes, which are the most influential features?

We applied the KNN, SVM, RF and XGBoost to answer our research question. The above models are highly accurate and are assessed as follows:

The KNN is a non-parametric classifier applied when the data or distribution is low. This classifier converts the samples into a metric space, where the distances are determined. This new classification system has three stages: (1) The sample distance is tested and compared with all the training samples. (2) According to the distance, K counts of the NNs are formed from the training sample. (3) The test sample is classified according to the most common class in the nearest training sample. SVMs place the impact vectors into two groups. The gap between these groups is vast. The new samples are then drawn in the same space to allow the prediction as to which group they belong to, according to the results showing which gap has the higher reliability (Kassani et al. 2018). RF is a group learning method containing a set of decision trees. It combines the tree’s predictions in that each is sampled according to the volume of one independent random vector with similar distribution (Zhu et al. 2007). The result is the most common class with the highest consent from the FT, thus can suggest the best pattern. The XGBoost is a machine learning method that combines/converts a set of decision trees with a robust prediction model.

3.1. Process and Workflow of Research

In this paper, the deep learning-based multi-model assembly method consists of selecting and evaluating the features, measuring the importance of each selected element, presenting and implementing different classification models, and finally, presenting and analysing the results. Figure 2 shows the workflow of the experiment.

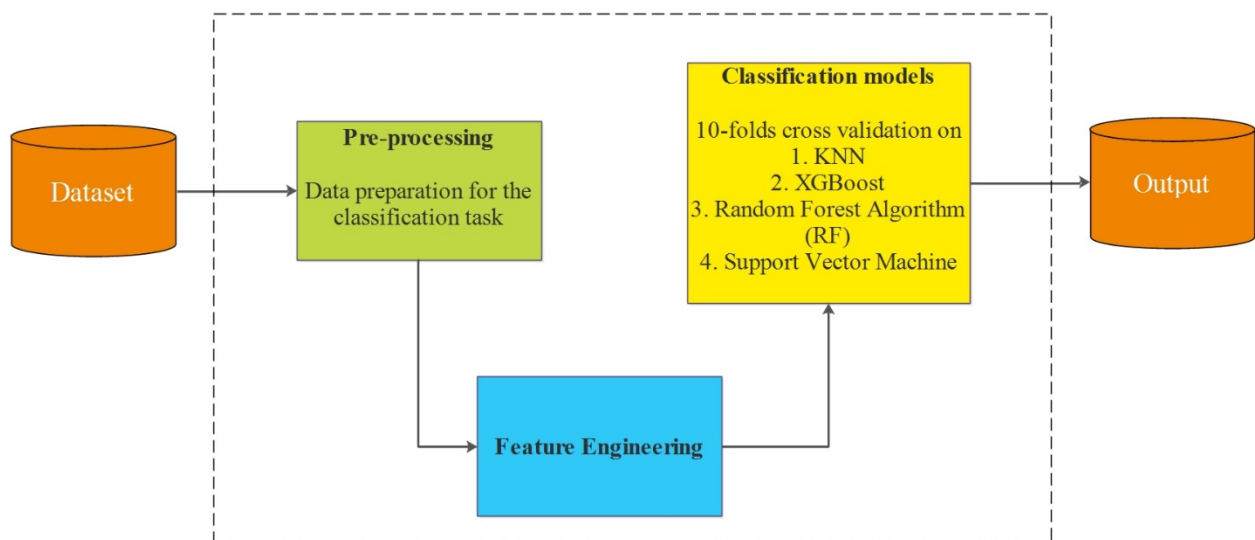


Figure 2. Schematic illustration of the carried-out procedure.

The first step is to select the data and find the various and influential characteristics of human actors that align with the objectives of the subject and should be used as input in the classification process. The 11 examined features are described in Table 1.

Stepwise regression is used at the error level of 5% in the second step for data cleansing. Before any analysis, the underlying regression assumptions, including the homogeneity of variances, the normality of the residues, the independence of the residuals, and the absence

of the same linear, are checked. Afterwards, the research model is used to determine the influential variables. In Table 2, the significance of the model has been proven.

Table 2. The total frequency and percentage of data.

Feature under Assessment	Variable under Assessment	Frequency	Frequency Percentage
Gender	Female	30	25.0
	Male	90	75.0
		120 people	100%
Education	High school diploma	2	1.7
	Associate Degree	17	14.2
	B.A or BS	68	56.7
	MSc	28	23.3
	PhD.	5	4.2
		120 people	100%
Field	Accounting–Finance	76	63.3
	Management	29	24.2
	Technical–Engineering	5	4.2
	Other	10	8.3
		120 people	100%
Occupational record	Less than 5	18	15.0
	5–10	25	20.8
	10–15	30	25.0
	15–20	29	24.2
	20–25	11	9.2
	More than 25	7	5.8
	120 people	100%	
Mid-management record	Less than 5	23	19.2
	5–10	28	23.3
	10–15	43	35.8
	15–20	14	11.7
	20–25	8	6.7
	More than 25	4	3.3
	120 people	100%	
Top-management record	Less than 5	10	8
	5–10	16	13.3
	10–15	35	29
	15–20	39	32
	20–25	20	17
	120 people	100%	

Table 2. Cont.

Feature under Assessment	Variable under Assessment	Frequency	Frequency Percentage
Age group	18–30	48	40.0
	31–45	49	40.8
	46–55	20	16.7
	More than 55	3	2.5
		120 people	100%
Organisation position	Accountant	13	11
	Auditor	30	25
	Senior Auditor	26	22
	Financial Manager	28	23.3
	Auditor Manager	16	13
	Directing Manager	7	6
	120 people	100%	
The years with AIS	Less than 5	23	19.2
	5–10	28	23.3
	10–15	43	35.8
	15–20	14	11.7
	20–25	8	6.7
	More than 25	4	3.3
	120 people	100%	
The period AIS is applied	Daily	59	51/2
	Weekly	25	20.8
	Bi-weekly	18	15.0
	Monthly	15	12.5
	Never	1	0.5
	120 people	100%	
Familiarity rate with AIS	Very low	5	5
	Low	8	7
	Medium	45	37.5
	High	47	40
	Very high	15	12.5
	people	100%	

After determining the input variables, a K-fold cross-validation strategy is used to train data and evaluate algorithm performance on the test set. The evaluation method determines how statistical analysis results on a dataset can be generalised. This method is primarily used to determine how useful the model could be in practice (Zhu et al. 2007).

Each dataset is divided into three independent subsets: training, validation, and evaluation. Training data is used for training the model. The validation data is used to determine the suitability of the parameters obtained from the model and avoid over-learning. The evaluation data is used for calculating the algorithm’s error rate (model prediction accuracy) on data that has not been seen so far (Kassani and Kim 2016). For this study, the data should be divided into two categories: training data and test data.

The training data itself includes the training set and validation set. For this purpose, the repetitions are used in the cross-validation method (Cigizoglu and Alp 2006).

For this research, we targeted 120 human actors and examined the impact of deep machine-learning modules. We divided 120 human actors into two groups: 90 samples were randomly assigned to the model training section and 30 samples to the test section. These samples have been randomly selected among the human actors of the population under investigation. Data is randomly extracted in which x_i is the dependent and y_i is the independent variable of the i th sample. In this method, the data set is randomly divided into K equal parts.

For this study, we selected 10-fold cross-validation, and in the first run of the first part of the 10-fold cross-validation, i of each piece is used for evaluating and the remaining $k - 1$ for learning. From $k - 1$ aspect/s of learning, one part is used for validation data and the remainder for training data. Another aspect of the k is used for evaluation, and $k - 1$ is the remaining part for training (training-validation). K repetitions of the algorithm are run in the same way. Every repetition calculates an error rate for training and evaluation data. Finally, the average of the obtained error rates is assigned as the error rate of training and evaluation data.

After data collection, data preparation steps including refinement, and data transformation and integration are performed to ensure the achievement of appropriate data. In the next step, a prototype model is constructed using modelling and data mining techniques. After each implementation stage, they are carefully validated to assess the quality of the model. If the selected model does not have the appropriate rate, the parameters should be changed, and the model should be revalidated to obtain a qualified model. The objective of cross-validation is to minimise the error rate and achieve a model with a better-generalised ability (Hosseinzadeh Kassani and Deters 2018).

After pre-processing the data set, we used data mining techniques in the form of four models to evaluate the prediction and prioritisation of the features and the assessment of the power of the appropriate model.

Some studies suggest that computational intelligence models are more efficient than classical ones (Cruz-Reyes et al. 2013). However, there are multiple computational intelligence models, and each actor's behaviour in accounting information is different (Shen and Han 2019). Therefore, it is necessary to use a wide range of artificial intelligence models in AIS to evaluate and compare the performances of these models with each other. This study compared and assessed four candidate models, including XGBoost, SVM, RF, and K-NN, to predict the model's accuracy and identify the most effective human actors.

3.2. Data Collection

To measure the questionnaire's reliability, a pilot study was carried out. The questionnaire was given to 30 out of the 120 participants randomly. After their response, the Cronbach coefficient was used to examine the validity of the questionnaire. Four AIS specialists and professors approved the results.

The obtained data were grouped, and their normalisation was assessed. The demographic data are tabulated in Table 2.

4. Results

The descriptive statistics of human actors (11 features addressed in this study) are tabulated in Table 2, and Figure 3a,b, where 90 participants are male and 30 are female.

The two criteria of correlation coefficient and RMSE were applied to evaluate the models and scale the inputs and outputs before entering the AI models. Given that the entry parameters contained different scales, they were standardised within a specific -1 and $+1$ range. The dispersion of each variable is shown in Figure 4. The correlation coefficient of the 11 features were tested through the human actor variable in Figure 5, indicating appropriate reliability.

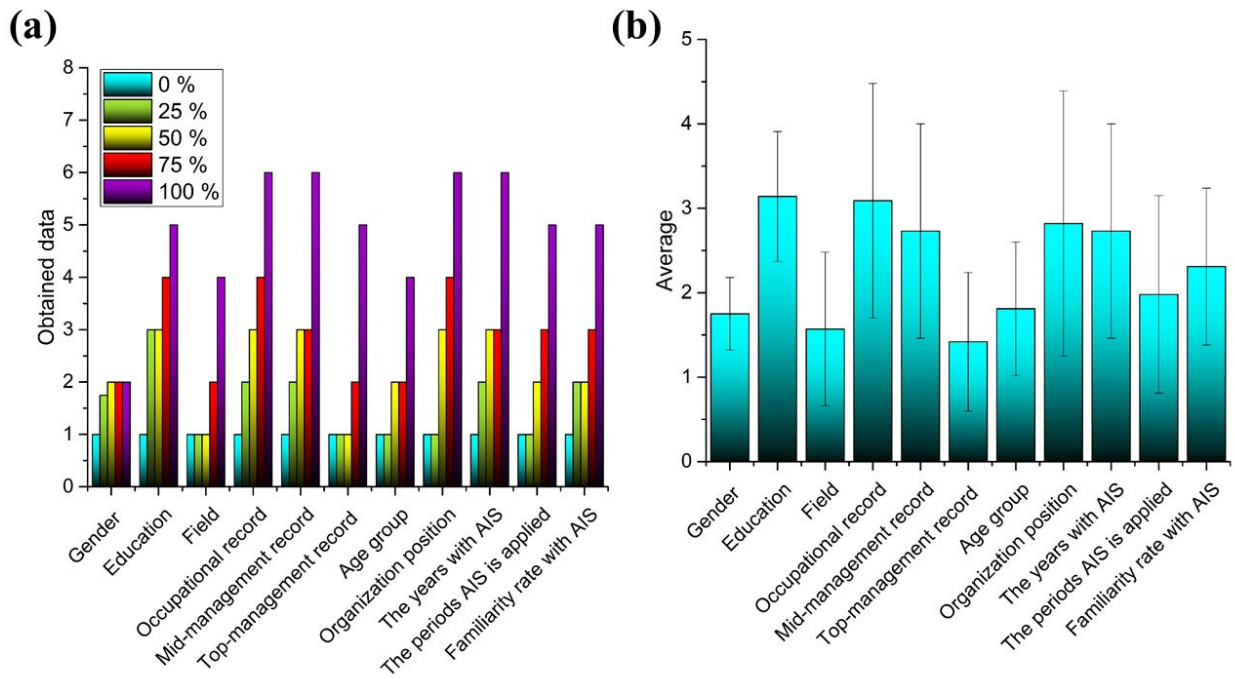


Figure 3. (a) The obtained data and (b) their calculated average for 11 evaluated features.

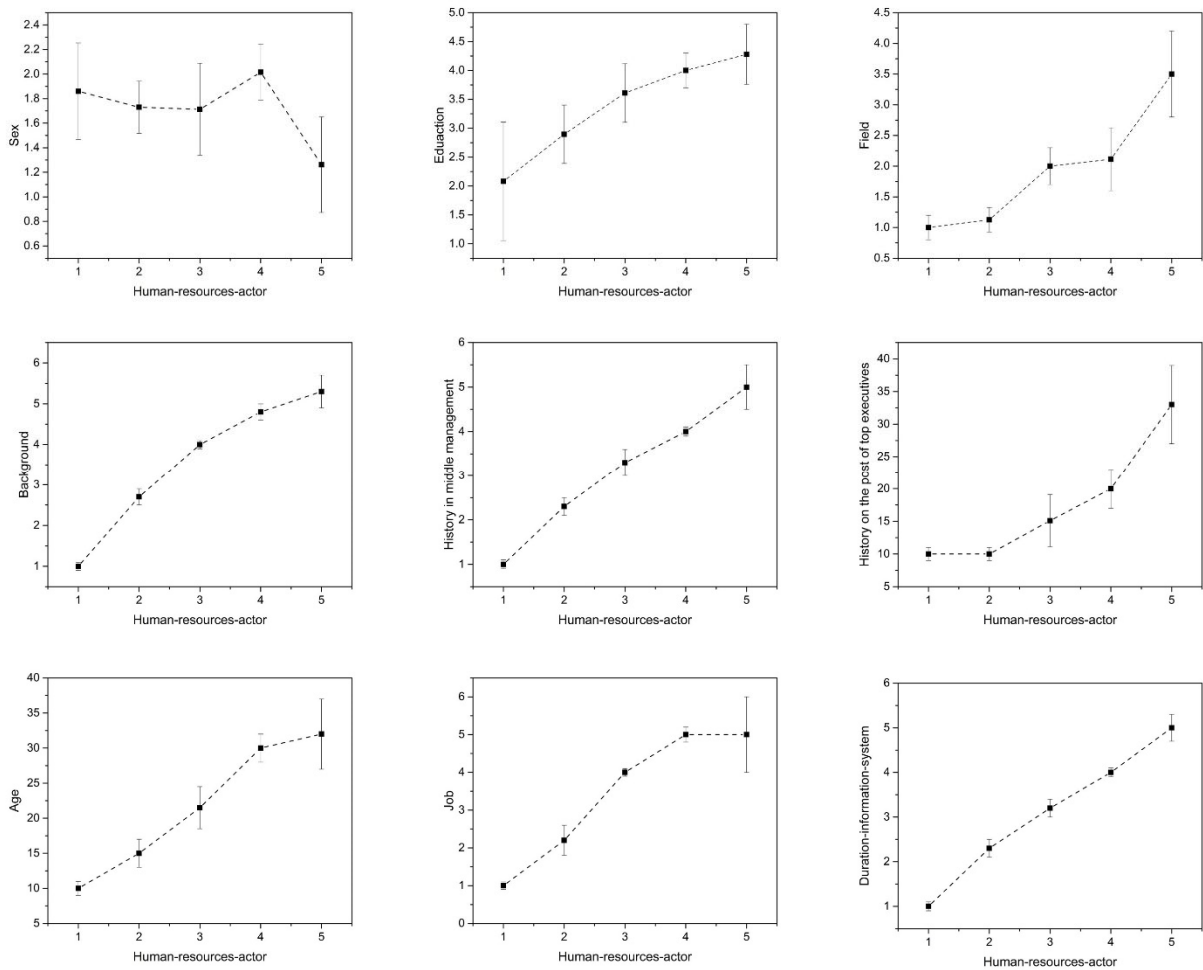


Figure 4. The Graph curvatures of various evaluated features vs. human actors.

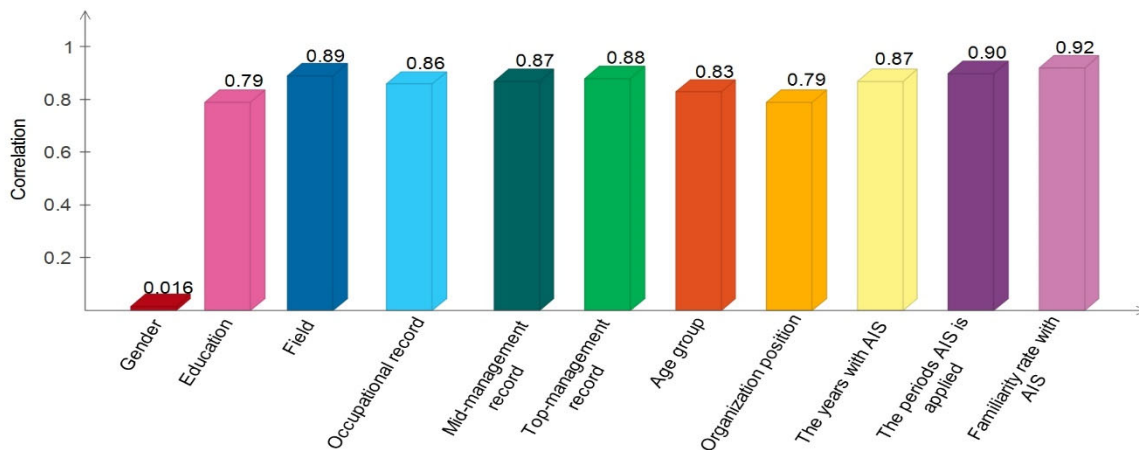


Figure 5. The correlation coefficient of the various characteristics.

The findings show that the dispersion and correlation coefficients for Education and Job is 0.79 and for History in middle management and the duration and information system is 0.87, which are similar.

The findings indicate that the human features named “familiarity with AIS” (item 11 in Table 1) and “the period of AIS application” (item 10 in Table 1) have the highest frequencies when the XGBoost algorithm is applied (please see Figure 5). Also, based on the RF model prediction, the level of “familiarity rate with AIS” and “the period of AIS is application” (items 10 and 11 in Table 1) are the most influential factors in predicting human behaviours in AIS (please see, Figure 6).

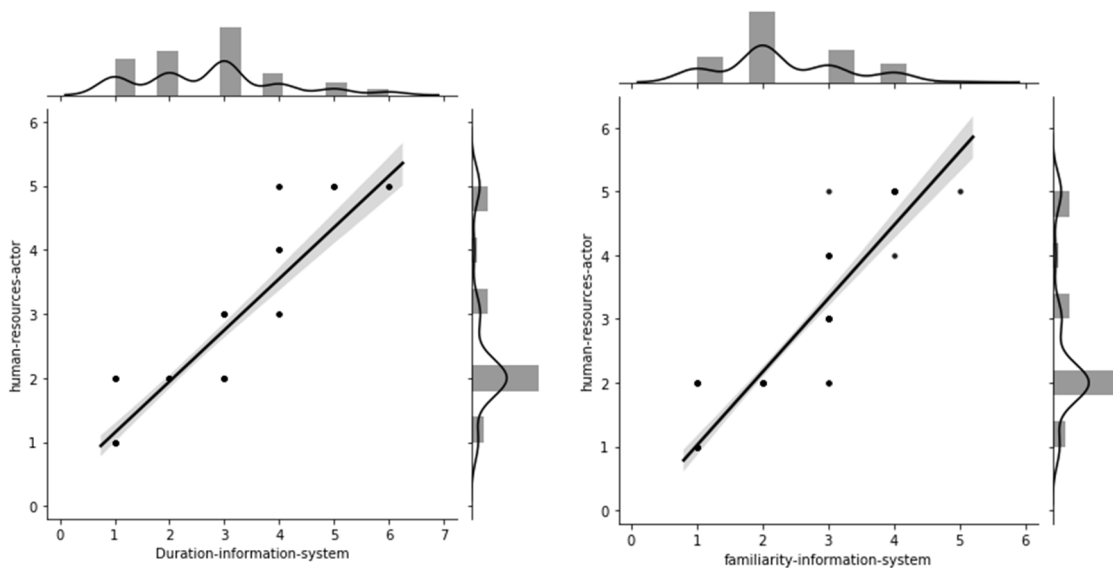


Figure 6. RF models performed for more significant features of human actors, including the period of AIS application and familiarity rate with AIS.

Though XGBoost and RF models are time-consuming, they yield validated results. Now the four algorithms applied in AI are measured and ranked based on the selected human features in this paper. The prediction accuracy is tested using a deep learning-based multi-model to identify and introduce more accurate models. The obtained results are tabulated in Figures 7 and 8.

Following this stage, the predicting accuracy of these four algorithms is measured and ranked according to the selected human features in this paper.

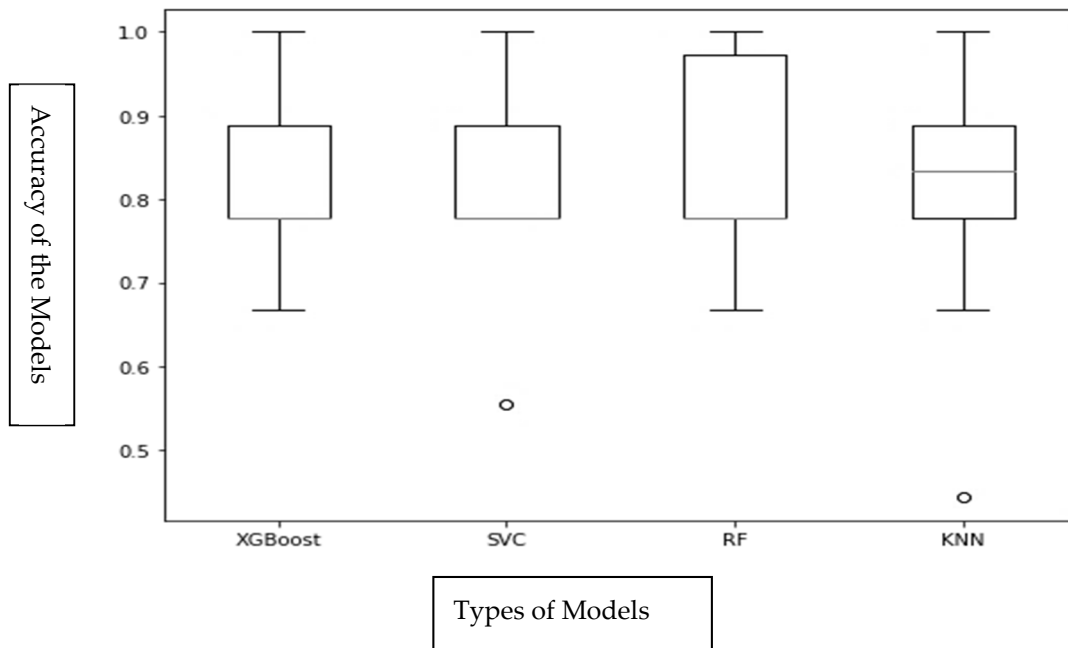


Figure 7. Boxplot of the four various models used for data analysis.

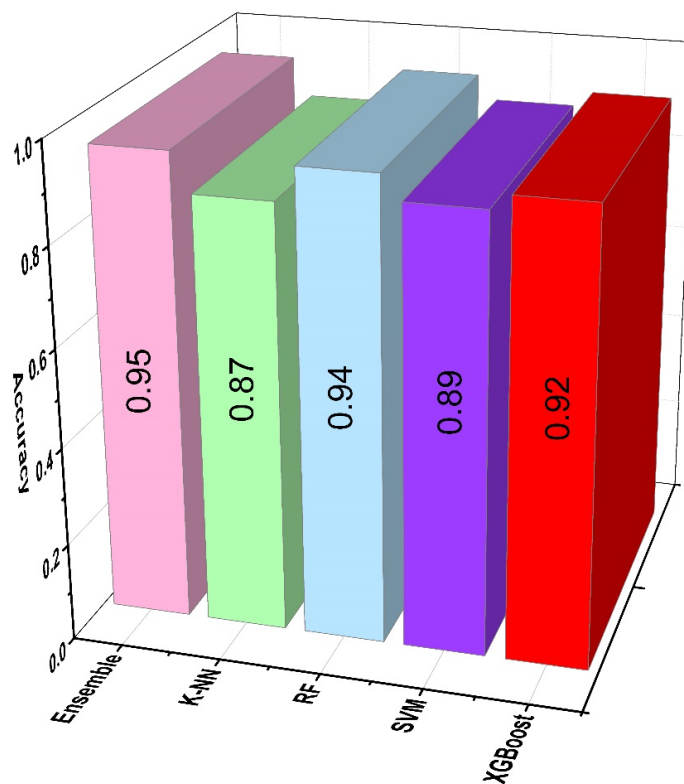


Figure 8. The calculated accuracy obtained through data mining models.

The results indicate that by applying the human actor’s personal and professional parameters (among these few algorithms), the RF, with 0.94% accuracy, is the most effective predicting model therein, followed by the rest (please see Figure 7). The prediction results of the deep learning-based multi-model ensemble method indicate that compared to each of these algorithms, the combined model has the highest accuracy, of 0.95 (please see Figure 8).

The findings suggest that predicting human actors’ behavioural activities through this proposed learning-based multi-model is effective. Among 11 personal and professional

human actors' personal and professional features, "the period of AIS application" and "the familiarity rate with AIS" indicates the highest correlation and prediction power (through RF at 94% accuracy).

5. Discussion

In this study, we tried to study the AIS from a scientific point of view based on the interpretative framework of innovation, which is interpreted as "actor-network theory" (ANT) in related texts. Therefore, to achieve this goal, we have found it essential to create a conscious understanding in the audience's minds about the role of actors in an information system to develop a coherent, coordinated, mutual and spontaneous relationship between them to make decisions. It can be said that the first step in creating the structural and institutional aspects of accounting information system management (based on the theory of actor networks) is to know the existing situation between active actors and their roles in an information system. Our argument, in line with the explanation and understanding of the innovative interpretive framework for AIS based on ANT, is that the actor-network theory (as a selective approach) can create and use the accounting information system logically. It can also explain the interaction between the social network production process and the application of the accounting information system. So, we can argue that the development of the accounting information system can result from how actors interpret their interests. In this way, the successful interpretation of the communication and interests of human and non-human actors leads to the formation of a coherent body of allies and the acceptance and effective implementation of the accounting information system. On the other hand, the accounting information system is a platform where the foundation of accounting is formed. Managers and users, as human actors, can make decisions by communicating with AIS actors and the presented financial statements.

Also, we tried to create a scientific perspective to explain and understand the innovative interpretive framework of the AIS based on ANT. We studied how to design and present a model through which the future actions of human actors can be predicted in AIS. We checked how it would be possible to accurately predict future actions in AIS based on human actors' personal and professional characteristics. To our knowledge, no study (especially in developing countries) has been reported to predict the future performance of human actors in AIS by using artificial intelligence algorithms. Given the above, this study helps to take an essential step towards providing a suitable model for predicting human role-playing in organisations.

We intend to predict future actions and performance in AIS for the first time through man's personal and professional characteristics, considering the interdisciplinary nature of the AIS from data technique. We used Kavi, which has great power in data prediction and classification and helps the manager's decision-making process. We performed a deep learning-based multi-model ensemble method that includes data mining techniques and artificial intelligence classification algorithms in the form of gradient-boosted decision trees (GBDTs), SVC, and RF models. We tried to answer whether it is possible to predict the future actions of AIS human actors through auditors' personal and professional characteristics. And if yes, which features are more effective in this prediction? And which one has the highest predictive power among the four used algorithms?

Selecting and applying a proper workforce considering their role in all potential organisational crises is essential; consequently, improving accuracy in predicting the human actors' behaviour using AI methods would contribute to the organisation's functionality. This study indicates that our proposed learning-based multi-model ensemble method, which includes data mining methods and AI classification algorithms in the GBDTs, SVC, RF and KNN form, can predict human actor acts in the AIS based on personal and professional features of the workforce.

We used machine learning-based multivariate statistical analysis on 120 human actors. Five data mining steps were followed to perform and present a combined classification model. The first step was to collect the data and find the influential characteristics of human

actors. Accordingly, 11 demographic features of human actors were identified and studied as input variables in the classification process.

Stepwise regression was used at a 5% error level for data cleansing in the second step. Before any investigation, the underlying assumptions necessary for regression analysis were checked; they included the homogeneity of variances, the normality of the residues, and the independence of the residuals.

The third step was to determine the extent to which the results of the statistical analysis on a dataset could be generalised and be independent of training data. This was verified by datasets and using 10-fold cross-validation. Consequently, in each part, 90 samples (among the 120 human actors under investigation) were randomly assigned to the model training section and 30 samples to the test section. Afterwards, data refinement, preparation, conversion, and integration were performed to ensure the achievement of appropriate data.

A prototype model was constructed in the next step using modelling and data mining techniques. After each implementation stage, the quality of the model was assessed using two criteria: the correlation coefficient and root mean square error. The obtained results indicated that the human actors' personal and professional features, based on their correlation therein, can be ranked; the higher these features' correlation, the better the predictions of their conduct in the future.

The applied instruments are highly essential in this context. These four AI algorithms are tested here due to their high measuring abilities. It is found that among them, the RF is the strongest in prediction at 94% accuracy in the AIS area and its components.

Another important finding is that this learning-based multi-model ensemble method has the highest efficiency at 95% accuracy compared with its four counterparts. Only RF, with 94%, is the best among the others as a particular method. As observed, the difference between this proposed and RF error rate is only 1%. We should mention that [Xiao et al. \(2018\)](#) found that a combined method is more robust than an individual algorithm predicting cancer.

The results here can be attributed to the fact that the equations are assumed to be linear. When the variables are given coefficients, different factors are of no concern; that is, for all, the coefficient is the same. One of the features of this newly proposed method is learning the complex and hidden structures and the non-linear equations and considering them in assigning coefficients. This method is promising in organisations' AIS concerning human actors' acts prediction.

6. Contribution and Implications of Findings

Previous studies show that humans are the main actors of the AIS. However, a suitable AIS depends on forming a coherent body of united human and non-human actors, which has received less attention in the literature. Our findings suggest that with the help of ANT, the human factor (usually not seen as the creator of facts in the significant part of accounting research) should be considered the leading actor of the information system (as a complex network of relationships, connections, and roles). The basis of ANT is to pay more attention to the social structure to understand and explain the activities of humans and other actors in each system. Our findings can be a starting path for researchers to address the role of humans in the accounting information system.

According to ANT, an information system is a network of heterogeneous elements and methods that does not have an identity. Instead, this network forms the information system and its performance when placed in broader organisational relationships and with the actors interacting and playing roles within this network. Given the above, the role of the information system in the organisation can be interpreted.

Implications

One of the practical implications of this research is that it provides a guideline for the selection and employment of appropriate human resources in the AIS by managers with the help of a new strategy. By using a deep learning-based multi-model ensemble method (suggested by this study), managers can predict their future performance (with less

error) in the system when hiring and employing human actors. This practical implication is essential, mainly because (to our knowledge) no study has been reported to predict the future actions of human actors based on their personal and professional characteristics. If successful, it will represent a massive evolution in the field of selecting a workforce.

Other implications of this study can be stated as potentially changing the simplistic view of the AIS researchers towards humans in organisations. Because based on ANT and its components, the AIS can be considered the leading network of the financial field, which should explain not only the facts that the system provides but also the role of creation and relationships between actors in the information system. Based on ANT, for as long as the human actor in the AIS remains analysed, it can be considered like a black box that cannot be translated and correctly interpreted in the information system. Still, when the lid of the black box is opened, and the so-called human actor is analysed, it will be seen as a complete network of complex relationships that researchers and managers in organisations should carefully study.

Another implication of this research is to remind the management of the AIS that the behaviour of each actor is derived from a set of individual characteristics and hidden traits that are processed together in the actor's black box and manifested in the form of human behaviour. Therefore, these personal characteristics and traits lead to human action in the system. Thus, each identity cannot be considered only an actor. This actor is a set of components, behaviours, and roles that should be treated as a whole, as all characteristics are added together and then analysed and interpreted.

According to the actor-network theory, an information system is a network of heterogeneous elements and methods that does not have an identity. Instead, this network forms the information system and its performance when placed in broader organisational relationships and with the actors interacting and playing roles within this network. Therefore, it is with such a view and attitude that the role of the information system in the organisation can be interpreted. The main implication of this study for theory development and management is that balanced attention should be given to both human and non-human actors to form a coherent and united AIS network to promote the AIS management strategies. This study suggests that human and non-human actors must be considered essential parts of an integrated AIS. The practical implication of the results is that investing in either technology or human resources alone is not enough to achieve the best productivity and performance in organisations. Instead, there must be a balance between human and non-human actors. The basis of the theory of actors is to pay attention to the social structure to understand and explain the activities of humans and other actors in each system. Therefore, conducting this research can provide a starting path for researchers to address the role of humans in the accounting information system.

7. Conclusions

The available studies on accounting have merely focused on the AIS structure with less focus on the role generators. At the same time, the human role as a role generator in AIS has received little attention. One of the main implications of this study is that the AIS heavily relies on its human and non-human actors to form a coherent and united AIS network to promote the AIS management strategies. So, human and non-human actors are essential parts of an integrated AIS that need to be considered. The practical implication of the results is that investing in either technology or human resources alone is not enough to achieve the best productivity and performance in organisations. Instead, there must be a balance between human and non-human actors. Given the above, an attempt is made in this study for the first time to equip the managers with a model to help them select and employ the most experienced and professional workforce in AIS to prevent irreparable damage to their systems in general. Managers equipped with a model which can predict their workforce's behaviours in the future (of course, not absolutely) are usually in better positions than those without such a prediction tool.

The findings indicate that the human features named "familiarity with the AIS" and "the period of AIS application" have the highest frequencies when the XGBoost algorithm

is applied. Also, based on the RF model prediction, the level of “familiarity rate with AIS” and “the period of AIS application” is the most influential factor in predicting the AIS’s human behaviours (please see Figure 7). The results indicate that by applying the human actor’s personal and professional parameters (among these few algorithms), the RF, with 0.94% accuracy, is known as the most effective predicting model, followed by the rest. The prediction results of the deep learning-based multi-model ensemble method indicate that compared to each of these algorithms, the combined model has the highest accuracy, of 0.95 (please see Figure 8).

The findings suggest that predicting human actors’ behavioural activities through this proposed learning-based multi-model ensemble method is successful. Among 11 personal and professional human actors’ personal and professional features, “the period of AIS application” and “the familiarity rate with AIS” indicate the highest correlation and prediction power (through RF at 94% accuracy).

As noticed in this article, sociology and other related disciplines have played their roles in expanding the field of accounting, where the AIS not only reveals the human and non-human actors but also shows the interaction among the actors in the system. This highlights the importance of an AIS as an integrated system that depends on all its components (e.g., human and non-human factors).

There are some similarities and differences between current research and previous studies reported in the literature. Both the present study and those reported in the literature emphasise the roles of human and non-human actors in information systems. However, previous studies place more emphasis on the information system as a whole or on non-human actors and less on human actors (Adeoti-Adekeye 1997; Ismagilova et al. 2019; Koivisto and Hamari 2019; Crawford 2020). Indeed, studies following actor-network theory (ANT) look at information systems as integrated systems and do not place a particular emphasis on the human actor. Nevertheless, while endorsing the integrity of an information system, our study suggests that non-human actors are subordinates of human actors in an information system. That is why our study indicates that organisations need to pay particular attention to selecting and employing human actors in every organisation.

8. The Limitations and Suggestions for Future Research

As with any survey, this study has suffered from some limitations. The first limitation is related to using survey mail questionnaires and, therefore, the lack of face-to-face interactions with respondents to understand their views better. The second limitation is the timing of captured data. The study was carried out in 2019, which was the pre-Covid era. So, we are unsure if the findings remain the same for the Covid period and after. Furthermore, the targeted populations are from non-Western countries with less access to advanced technologies. So, the findings may not be the same for Western countries.

In this research, we tried to examine the role of human actors in the AIS from a conceptual perspective, considering that the AIS is a network of human and non-human elements placed in broader organisational relationships and collectively forming the information system. Further studies are suggested to understand the impact of AIS on human and non-human actors—or to investigate the simultaneous effects of the AIS and human and non-human actors on each other.

In this research, we have looked at the human actor as the only AIS actor, while the actor in the AIS is considered a network. Therefore, further studies are suggested to explore the whole network’s role in shaping the interactions between human actors. Further studies are also recommended to replicate this study in Western countries to see if the results hold and if Covid and advanced technologies affect the findings.

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Appendix A. Initial Questionnaire Regarding the Prioritization of 35 Personal and Professional Characteristics

Dear Respondent: In your opinion, How effective are the following actors in explaining Accounting Information System (AIS)?

No	Feature under Assessment	Never	Very Low	Low	Medium	High	Very High
1	Gender						
2	Age group						
3	Blood type						
4	Education						
5	Field						
6	Appropriate field of study with the type of work						
7	Location						
8	Workplace						
9	Marital status						
10	Number of children						
11	Spouse’s employment						
12	working hours						
13	Income level						
14	Individual ethics						
15	Job Satisfaction						
16	Character type						
17	Risk-taking						
18	Self Confidence						
19	Years of service						
20	Occupational record						
21	Organization position						
22	Mid-management record						
23	Top-management record						
24	The years with AIS						
25	The period AIS is applied						
26	Familiarity rate with AIS						
27	work planning						
28	Professionally speaking						

Dear Respondent: In your opinion, How effective are the following actors in explaining Accounting Information System (AIS)?

No	Feature under Assessment	Never	Very Low	Low	Medium	High	Very High
29	Participation in AIS training classes						
30	The thinking about AIS						
31	Work Quality						
32	Learning a second language						
33	Having organizational skills						
34	Time Management						
35	Career independence						

Dear Colleague, The questionnaire you have in your possession has been prepared to carry out a research project with the title of investigating the impact of personal and professional characteristics of human actors on the accounting information system. Please answer the following questions. The results of this questionnaire will be confidential in general. Thanks.

1. Gender

- a. Female
b. Male

2. Education

- a. High school diploma
b. Associate Degree
c. B.A or B.S.
d. MSc
e. PhD

3. Field

- a. Accounting–Finance
b. Management
c. Technical–Engineering
d. Other

4. Occupational record

- a. Less than 5
b. 5–10
c. 10–15
d. 15–20
e. 20–25
f. More than 25

5. Mid-management record

- a. Less than 5
b. 5–10
c. 10–15
d. 15–20
e. 20–25
f. More than 25

6. Top-management record

- a. Less than 5
b. 5–10
c. 10–15
d. 15–20
e. 20–25

7. Age group

- a. 18–30
- b. 31–45
- c. 46–55
- d. More than 55

8. Organization position

- a. Accountant
- b. Auditor
- c. Senior Auditor
- d. Financial Manager
- e. Auditor Manager
- f. Directing Manager

9. The years with AIS

- a. Less than 5
- b. 5–10
- c. 10–15
- d. 15–20
- e. 20–25
- f. More than 25

10. The period AIS is applied

- a. Daily
- b. Weekly
- c. Bi-weekly
- d. Monthly
- e. Never

11. Familiarity rate with AIS

- a. Very low
 - b. Low
 - c. Medium
 - d. High
 - e. Very high
-

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