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Mini review

Development of artificial intelligence algorithms for estimating the implementation status of E-management based on virtual survey results in Colombian SMEs

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Abstract

Business dynamics continuously and naturally evolve in response to technological advancements, whether to implement or enhance continuous improvement initiatives, productivity, or competitiveness all aimed at maintaining market presence and increasing profitability. As a result, the concept of E-management has gained strength and is being increasingly adopted across various business sectors. This study aims to develop a model by training AI algorithms using data collected through surveys administered to mid- and senior-level managers of small and medium-sized enterprises (SMEs) within a specific sector of Colombian industry, in order to assess the level of E-management implementation.

Keywords: E-management, artificial intelligent, productivity, competitiveness, entrepreneurs, Mipynes Colombia

Introduction

The concept of e-Management refers to the use of technologies, especially advances in telecommunications, and how communication is facilitated via the internet. Various collaborative platforms enable interaction with teams in new ways, transforming organizational management practices. As noted on Inese's website, through e-Management, directors and middle managers can monitor objectives and oversee their teams as if they were physically present in the office (1 - 2024).[1] New leadership models are emerging continuously to adapt to current times. To keep pace, e-management combines traditional management practices with digital tools to achieve more efficient and effective administration. This approach aims to improve employees' quality of life through flexible schedules while simultaneously increasing productivity and competitiveness.[2]

With telecommunications advancements and their widespread adoption, especially following the COVID-19 pandemic between 2020 and 2022- many companies continued operations by utilizing tools like TEAMS, MEET, Skype, among others.[3] These tools enabled virtual meetings, digital file sharing, and presentations, facilitating clearer decision-making and minimizing contagion risks.As a result, organizational management fundamentally changed during this pandemic period, leading many companies to adopt hybrid work modelspartly remote, partly on-site. When the pandemic subsides and economic reactivation begins (around 2022-2023), many firms revert to traditional management practices, leaving behind pandemic-era adaptations that contributed to the rise of e-Management.[4]

According to Vilkaite-Vaitone & Povilaitiene[1]and Alsulmi[2] e-management has significantly improved the efficiency of labor processes that do not require physical presence. The adoption of ICT solutions has optimized execution times and reduced costs across various tasks Tabatoni.[3] In today's rapidly evolving business environment, organizations face multiple challenges demanding exceptional management to ensure survival and success. Excellence in management, driven by technological progress in digital communication and increasing competition, has become a key concept in modern management Alsulami.[4]

Another major advantage of technological advances, particularly the Fourth Industrial Revolution (4IR) is the massive volume of data that must be stored, analyzed, and retrieved to make effective decisions and gain a competitive edge. This data volume has given rise to a powerful technological tool: machine learning.

Machine learning, a branch of artificial intelligence, focuses on optimizing processes with minimal or no human intervention. It analyzes patterns and extracts valuable insights from large datasets, supporting decision-making in areas such as production, quality, finance, marketing, supply chain, and human resources. It facilitates quality pattern recognition, data forecasting, and promotes growth by transitioning physical data into electronic formats, enhancing memory, and supporting financial and operational decisions.[5] This excellence is crucial for meeting customer expectations and adapting to a constantly changing global market.

Traditional performance management has proven inadequate for current business development demands, especially in public companies, where motivating employees and fostering innovation are vital.[6] Optimizing performance management and creating value networks that facilitate cooperation and co-creation among companies are essential for adapting to industrial dynamics and fostering innovation through emerging technologies like machine learning and the Internet of Things (IoT). In this context, AI plays a significant role in sectors such as agriculture and consumer goods.

Theoretical framework

The internet has become the main channel for innovative technologies, essential in today's organizations. It allows managers to access key information about their business anytime and anywhere, eliminating travel downtime and enabling them to actively manage even outside the office. This context forms the basis of e-management, which provides the necessary support for companies to achieve their goals in a clear, measurable, and predictable way. According to Murray Murray,[7] we are in an information and knowledge society, which has transformed the productive sector and led to electronic management or e-management. This approach enables greater efficiency in processes thanks to the potential of Information and Communication Technologies (ICT). Taba Toni defines e-management as the integration of all administrative processes with ICT, optimizing the completion, organization, animation, and control of technological opportunities and challenges.

Peter Drucker, a pioneer in management education and the connection between practice and research, highlighted the importance of e-management in the cultural, structural, and operational transformation of organizations. This transformation has solidified electronic businesses as an operational alternative to improve organizational benefits.[8]

E-management takes organizational processes to a new level, centralizing data and interconnecting systems and clients through software tools, which facilitates making appropriate decisions.[9] In this environment, mass customization is a key strategy, transforming relationships with employees, shareholders, suppliers, and partners.[10] The stakeholder theory, which defines stakeholders as any actor with direct or indirect interests in the organization, is fundamental in the study of corporate social responsibility.[11] E-stakeholders, defined by their symbolic capital, interact with the virtual organization through data networks and web interfaces, removing barriers to consumption and access.[12,13] Technology has strengthened organizations, facilitating flexibility, knowledge creation, and exchange (Snowden). Digital migration is an irreversible process that transforms all organizational levels, shifting from an industrial era to a digital one, enabling greater interaction and a diversity of services.[14,15] In summary, information systems management is essential in modern management, and e-management, driven by the information society and the internet, is indispensable for improving business management capacity and gaining economic advantages (Corneliu).

Methodology

Data collection

Data was collected using a Google Forms survey sent to SME entrepreneurs in the manufacturing sector of Antioquia. The company data was obtained from the Medellín Chamber of Commerce database.

The questions with their answers were as follows:

Data preprocessing

An exploratory data analysis process is carried out, where the distribution of data and labels is visualized. The goal of this process is to perform a multi-class classification, where there is an ordinal label from 1 to 5. The processing protocol proposes the following: (Figure 1)

Initially, a data quality assessment is performed, verifying the data types of the survey, nominal and ordinal categorical variables, and numerical variables. Characteristics that do not enter the machine learning process, such as acceptance of personal data processing and IDs, are eliminated. The selected characteristics are variables correlated with the survey result, considered in its formulation. Data cleaning is then carried out, verifying empty fields in the survey and outliers; in this case, there is no data presenting such behaviors.

To transform the data into the desired training format, textual variables are converted into nominal categories, converting each response into a binary option of whether or not the virtual technology with which they work was selected (see methodology table), among others. The transformation result is applied by counting binary variables as True and False, and for responses with multiple selections, a feature is created in a column for each response, and if selected, it is described as True or False. For the target variable, an expert labeler in the subject decides at what level of E-management implementation each company has, with the following criteria:

A. **Basic level (1)**
   - Daily frequency of digital technology use: Less than 3 hours
   - Perception of productivity improvement: Not clear or negative - 1
   - Perception of quality-of-life improvement: Not clear or negative
   - Efficiency in resources and competitiveness: Evident
   - Use of digital technologies: Email and occasionally Whatsapp.

B. **Initial level (2)**
   - Daily frequency of digital technology use: Less than 3 hours
   - Perception of productivity improvement: Some perceived improvement-2
   - Perception of quality-of-life improvement: Slight perceived improvement
   - Efficiency in resources and competitiveness: Evident
   - Use of digital technologies: Email, WhatsApp, and some meeting platforms (meet).

C. **Intermediate level (3)**
   - Daily frequency of digital technology use: Between three and five hours
   - Perception of productivity improvement: Significant perceived improvement - 3
   - Perception of quality-of-life improvement: Notable perceived improvement.
   - Efficiency in resources and competitiveness: Evident

- Use of digital technologies: Meeting platforms, information systems, E-mail, WhatsApp, and data analysis technologies.

D. **Advanced level (4)**

- Daily frequency of digital technology use: between 3 and 5 or more than 5 hours
- Perception of productivity improvement: Substantial perceived improvement-4
- Perception of quality-of-life improvement: Perceived.
- Efficiency in resources and competitiveness: Evident
- Use of digital technologies: Wide range including meeting platforms, information systems, data analysis technologies, email, WhatsApp, Internet of Things.

E. Optimal level (5)

- Daily frequency of digital technology use: between 3 and 5 or more than 5 hours
- Perception of productivity improvement: Exceptional perceived improvement - 5
- Perception of quality-of-life improvement: Perceived.
- Efficiency in resources and competitiveness: Evident
- Use of digital technologies: Integral use of meeting platforms, information systems, data analysis technologies, email, WhatsApp, Internet of Things and knowledge about e-management.

Once labeling is done, input data is normalized with a MinMaxScaler that scales within a determined range, in this case by default from 0 to 1 for all features as a good normalization practice so that each feature value is represented numerically in magnitude equally without affecting the classifier model in subsequent stages. The selection of Artificial Intelligence algorithm models for classification are as follows with their respective hyper-parameters for Grid Search CV:

Support vector machine classifier

- RBF Kernel, Numbers generated on logarithmic scales for (Gamma=-4,4,9 and C=-4,4,9) within mentioned ranges.
- Sigmoid Kernel, Numbers generated on logarithmic scales for (Gamma=-4,4,9 and C=-4,4,9) within mentioned ranges.
- Linear Kernel Numbers generated on logarithmic scales for (Gamma=-4,4,9 and C=-4,4,9) within mentioned ranges.

Ridge classifier

- Alpha: 1e-3,1e-2,1e-1,1e0,1e1,1e2,1e3.
- Tolerance: 1e-3,1e-2,1e-1,1e0,1e1,1e2.

Decision tree classifier

- Decision selection criterion: Gini entropy Log Loss.
- Maximum tree depth levels: 12 24 36 48 no depth limit.
- Minimum individuals per leaf: 1 2 4 8 16

Random forest classifier (RF)

- Number estimators: 1 2 4 8 16 32.
- Decision selection criterion: Gini entropy Log Loss.
- Maximum tree depth levels: 12 24 36 48 no depth limit.
- Minimum individuals per leaf: 1 2 4 8

Multilayer perceptron classifier

- Optimizer Adam SGD.
- Alpha Numbers generated on logarithmic scales within space (-4 ,4 ,9) one number per value.
- One hidden layer: 10, 20, 30, 40, 50.
- Activation functions ReLuTansig Logsig.

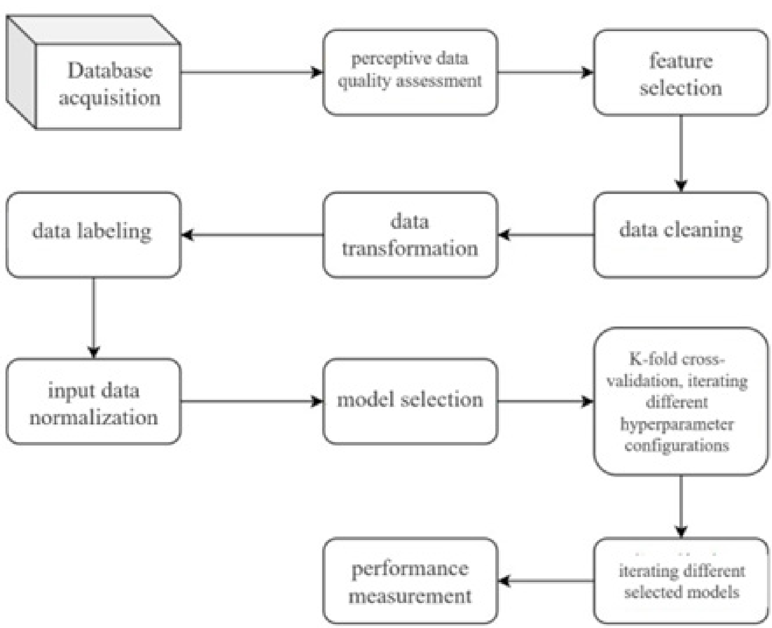

Figure 1 Preprocessing, training, validation, and performance flow pipeline

The training validation process behaves performing SKFold divisions each training model per subdivision performing KFold hyperparameter configuration subdivisions thus cross-validation grid search method Performance indicator used verifying best model Roc-Auc Receiver Operating Characteristic then verifying F1 score precision accuracy recall best model indicators normally used classification tasks machine learning Results each model best hyperparameter selection K-fold subdivisions best model indicators shown results section.

Results

The surveys were conducted and with 29 responses from entrepreneurs, the analysis was carried out. The data were processed as described in the methodology section and increased to 118 data points as a result. The efficiency indicators in the GridSearchCV process are reported to the K-fold process within each of the selected models with the best hyperparameters within the established ones, behaving as follows: (Tables 1–5**)**

The tables present different results with the best highlighted in each fold. A result of 100% does not mean better results but points to overfitting in validation for each fold. The percentage of results is normalized from 0 to 1.

Table 1 Results within the K-fold for the Decision Tree model with the specified configuration in the table, which was selected as the best among the candidates

Questions	**Possible Answers**
To continue the survey, it is necessary to read and accept the informed consent statement.	Accept / Do not accept
Preliminary Concepts	
There are concepts used in companies that operate in virtual environments such as:	Open-ended question
What is e-Management and e-Productivity?	
How often do you use digital technologies daily in your work?	Between three and five hours
	More than five hours
Do you consider that processes using digital technologies improve organizational productivity?	Yes
	No
Which of the digital technologies listed below do you use in your work?	Email
	WhatsApp
	Information systems (ERP, CRM, LMS)
	Meeting platforms (Meet, Teams, etc.)
	Data analysis technologies (Big Data, Artificial Intelligence, and others)
	Internet of Things (IoT)
Which of the digital technologies listed below do you consider applicable in your company?	Email
	WhatsApp
	Information systems (ERP, CRM, LMS)
	Meeting platforms (Meet, Teams, etc.)
	Data analysis technologies (Big Data, Artificial Intelligence, and others)
	Internet of Things (IoT)
Do you believe that productivity in your company improves by applying e-management?	On a scale of 1 to 5
According to the definition of e-management provided in numeral 1, do you think working under this model has improved your quality of life?	Yes
	No
Do you think an organization working under e-management is more efficient in its resources, showing better levels of productivity and competitiveness?	Yes
	No

Questions	Possible Answers
If your previous answer was positive, select the resources	Technological Human resources Logistical Financial Others
Do you believe that working in virtual environments helps organizations grow their portfolio and become more competitive in the market?	Yes No
If you would like to share any opinion on the importance of e-management for your business, please write it below	Open-ended

	Criterion	max_prof	min_samples_leaf	F1	Accuracy	Precision	Recall
0	gini	12	1	0,861111	0,833333	0,916667	0,833333
1	gini	12	1	**1**	**1**	**1**	**1**
2	gini	12	1	0,916667	0,916667	0,916667	0,916667
3	gini	12	1	0,916667	0,916667	0,958333	0,916667
4	gini	12	1	0,861111	0,833333	0,916667	0,833333
5	gini	12	1	**1**	**1**	**1**	**1**
6	gini	12	1	0,888889	0,916667	0,875	0,916667
7	gini	12	1	**1**	**1**	**1**	**1**
8	gini	12	1	**1**	**1**	**1**	**1**
9	gini	12	1	0,939394	0,909091	1	0,909091

Table 2 Results within the K-fold for the Random Forest model with the specified configuration in the table, which was selected as the best among the candidates

	criterion	max_depth	min_samples_leaf	n_estimators	F1	Accuracy	Precision	Recall
0	gini	12	1	1	0,453704	0,583333	0,371212	0,583333
1	gini	12	1	1	0,65	0,666667	0,638889	0,666667
2	gini	12	1	1	0,794444	0,833333	0,760417	0,833333
3	gini	12	1	1	0,733333	0,75	0,722222	0,75
4	gini	12	1	1	**0,905556**	**0,916667**	**0,927083**	**0,916667**
5	gini	12	1	1	0,636218	0,666667	0,636111	0,666667
6	gini	12	1	1	0,455556	0,416667	0,597222	0,416667
7	gini	12	1	1	0,630952	0,666667	0,604167	0,666667
8	gini	12	1	1	0,556818	0,636364	0,494949	0,636364
9	gini	12	1	1	0,626446	0,545455	0,787879	0,545455

Table 3 Results within the K-fold for the Ridge classifier model with the specified configuration in the table, which was selected as the best among the candidates

	alpha	tol	F1	Accuracy	Precision	Recall
0	0,001	0,001	0,883333	0,916667	0,861111	0,916667
1	0,001	0,001	0,883333	0,916667	0,861111	0,916667
2	0,001	0,001	0,883333	0,916667	0,861111	0,916667
3	0,001	0,001	0,883333	0,916667	0,861111	0,916667
4	0,001	0,001	0,883333	0,916667	0,861111	0,916667
5	0,001	0,001	0,888889	0,916667	0,875	0,916667
6	0,001	0,001	0,888889	0,916667	0,875	0,916667
7	0,001	0,001	0,883333	0,916667	0,861111	0,916667
8	0,001	0,001	**1**	**1**	**1**	**1**
9	0,001	0,001	**1**	**1**	**1**	**1**

Table 4 Results within the K-fold for the Support Vector Machine classifier model with the specified configuration in the table, which was selected as the best among the candidates

	C	gamma	kernel	F1	Accuracy	Precision	Recall
0	0,0001	0,0001	rbf	0,429825	0,583333	0,340278	0,583333
1	0,0001	0,0001	rbf	0,429825	0,583333	0,340278	0,583333
2	0,0001	0,0001	rbf	0,429825	0,583333	0,340278	0,583333
3	0,0001	0,0001	rbf	0,429825	0,583333	0,340278	0,583333
4	0,0001	0,0001	rbf	0,429825	0,583333	0,340278	0,583333
5	0,0001	0,0001	rbf	0,429825	0,583333	0,340278	0,583333
6	0,0001	0,0001	rbf	0,429825	0,583333	0,340278	0,583333
7	0,0001	0,0001	rbf	0,333333	0,5	0,25	0,5
8	0,0001	0,0001	rbf	**0,494949**	**0,636364**	**0,404959**	**0,636364**
9	0,0001	0,0001	rbf	**0,494949**	**0,636364**	**0,404959**	**0,636364**

Table 5 Results within the K-fold for the Multilayer Perceptron classifier model with the specified configuration in the table, which was selected as the best among the candidates

	Activación	alpha	Capas ocultas	solver	F1	Accuracy	Precision	Recall
0	relu	0,0001	(10,)	adam	0,833333	0,833333	0,833333	0,833333
1	relu	0,0001	(10,)	adam	0,883333	0,916667	0,861111	0,916667
2	relu	0,0001	(10,)	adam	0,916667	0,916667	0,916667	0,916667
3	relu	0,0001	(10,)	adam	0,883333	0,916667	0,861111	0,916667
4	relu	0,0001	(10,)	adam	0,75	0,75	0,75	0,75
5	relu	0,0001	(10,)	adam	**1**	**1**	**1**	**1**
6	relu	0,0001	(10,)	adam	0,916667	0,916667	0,916667	0,916667
7	relu	0,0001	(10,)	adam	0,916667	0,916667	0,916667	0,916667
8	relu	0,0001	(10,)	adam	**1**	**1**	**1**	**1**
9	relu	0,0001	(10,)	adam	0,939394	0,909091	1	0,909091

Improvements

It is important to consider from the beginning of the project, the participation of business associations or chambers of commerce, as the main point to improve is the availability of entrepreneurs to respond to surveys and have reliable data to apply different processing methodologies and subsequent creation of Artificial Intelligence algorithms.

Conclusions

- The survey methodology used proves to be a valid tool for obtaining company data to estimate e-management implementation status.
- The data processing procedures carried out prove to be an adequate strategy for subsequently developing artificial intelligence algorithms.
- The five applied artificial intelligence models, DecisionTreeClassifier; RandomForestClassifier; RidgeClassifier; SVM; MLPClassifier can be applied for e-management level classification.
- The algorithms that work best for e-management classification were Random Forest and MLP.
- The work establishes the possibility of classifying e-management implementation status in a company, where depending on how the respondent answers, a category from 1 to 5 is delivered, where we can interpreted as low implementation level and 5 as advanced state.

Recommendations

A project involving a greater number of SMEs is recommended to obtain more data; this could be achieved by linking an association, as it is difficult to obtain a good amount of data for artificial intelligence methods.

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Conflicts of interest

Authors declare that there is no conflict of interest.

References

1. Vilkaite-Vaitone N, Povilaitiene K. **E-Management as a Game Changer in Local Public Administration**. *Economies,* 2022;10(8):1–16.
2. Alsulami AN. The Impact of E-Management on Organizational Excellence: Case Study on King Abdulaziz University. *Indian Journal of science and Technology.* 2023;13(18):1–12.
3. Tabatoni P. Integrating ICT in E-Management Practices*. Journal of Management Studies.* 2023;60(3):567–580.
4. Sujith AVLN, Qureshi NI, Dornadula VHR. *et al.* Comparative Analysis of Business Machine Learning in Effective Financial Decisions Using Structural Equation Model (SEM*). Journal of Food Quality*. 2023.
5. Murray R. E-Management in the Information Society. *Journal of Information Technology*. 2023;38(1):45–58.
6. Lee J, Chen S. E-Management and Digital Transformation in SMEs. *International Journal of Information Management*. 2023;63:102–115.
7. Maiorescu I. Centralizing Data in E-Management Systems. *Journal of Information Systems*. 2023;37(2):234–245.
8. Gârjoabă A. Mass Customization in E-Management. *Journal of Business Research*.2023;146:123–135.
9. González R. Corporate Social Responsibility in E-Management. *Journal of Business Ethics*. 2023;178(3):567–580.
10. Wang Y. Deep Learning-Based Framework for Social Data Sensing and Fusion for Enterprise Managemen*t. Mathematical Problems in Engineering*. 2023.
11. Chellappa S. Performance Management in the Future of Work. *Forbes*. 2022.
12. MacDonald A. The 10 Most Popular Articles in 2022 (So Far). *MIT Sloan Management Review*. 2022.
13. Zhang X, Luo Y. The Role of AI in Enhancing E-Management Practices. *Journal of Business Research*. 2023;146:123–135.