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The Current State of Information Security Policies

Matthew Paulson

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Abstract: This paper provides an overview of the current state of information security policies, including adherence to policy frameworks and compliance challenges. A review of existing scholarship highlights the importance of organizational culture in shaping employee behavior and the need for effective policies that align with top management support and user buy-in. The discussion also covers the evolution of information security policies, current trends, and future directions. Additionally, the paper identifies key problems with non-compliance to information security policies and opportunities for further research on reasons for non-compliance and strategies for encouraging compliance. This paper examines the current state of information security policies, including adherence to policy frameworks and compliance challenges. We review existing scholarship highlighting the importance of organizational culture in shaping employee behavior and the need for effective policies that align with top management support and user buy-in. We also discuss the evolution of information security policies, current trends, and future directions. Overall, this paper contributes to the ongoing discussion of information security policy development, implementation, and evaluation, highlighting the need for a comprehensive framework that incorporates both technical and non-technical controls.

Keywords: Information Security Policies, Policy Compliance, Organizational Culture, Risk Management Frameworks.

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Introduction

This paper discusses the current state of information security policies. Adherence to information security policies and policy frameworks is discussed. Current scholarship regarding information security policies and policy frameworks is presented, as well as current problems with policy compliance. Finally, research problems and opportunities are considered.

Current State of Information Security Policies

Before considering the current state of information security policies, a definition should first be offered. Alotaibi et al. (2016) defined a security policy as "…a formal document that specifies what constitutes acceptable and unacceptable behaviour of users in relation to dealing with information assets in a secure manner." Given this

definition, several different types of policies can be considered security policies. Policies ranging from acceptable use policies to privacy policies to application updating policies to data retention policies can all be considered security policies under this broad designation.

The current state of information security is fluid and currently dominated by ethical and social issues (Brookshear & Brylow, 2015). The fluidity occurs, in part, due to the constantly changing nature of the threat environment. New technical and non-technical threats appear often and must be addressed or mitigated (Joint Transformation Task Force (JSTF), 2012). When responding to the challenge of mitigating technical and non-technical risks, many organizations look to an information security framework that can assist them in selecting, implanting, and assessing various security controls (JSTF, 2012). Information security can be defined as assuring the confidentiality, integrity, and availability of information that is in the stewardship of a particular organization (Young, 2009).

Additionally, there are loose standards and little consensus on what exactly an information security policy is and what it should cover (Paananen et al., 2020). This uncertainty and lack of consensus add to the fluidity just mentioned. Each organization is more or less left to determine the information that is important to them and design security policies to protect that information (Johnson & Easttom, 2022). Some standards do exist, such as the international ISO 27000 series (ISO/IEC, 2018) and the Cybersecurity Framework published by the United States National Institute of Standards and Technology (NIST) (National Institute of Standards and Technology [NIST], 2024), but many of these standards are industry-specific. There are other general frameworks, such as the Critical Security Controls (CSC) (Center for Internet Security, 2024). However, unless organizations are aware of these standards, they are often confused and potentially protecting the wrong information (Paananen et al., 2020).

One area of information security that focuses on non-technical security deals with information security and organizational culture. Tang et al. (2016) and Young (2008, 2009) authored studies that examined the phenomenon of ensuring the use of effective information security policies in an organization. Tang et al. (2016) studied how organizational culture impacted adherence to information security policies. Research showed that compliance with security policies depended on various organizational cultural identifiers, such as being process-oriented, employee-oriented, tightly controlled, and normative. When these dimensions exist, employee compliance with information security policies tends to be greater (Tang et al., 2016).

Another aspect of information security and organizational culture that Young (2009) addressed is the use of policies to ensure compliance with applicable laws and regulations. If an effective information security management methodology is adopted, effective policies will naturally follow. Young (2009) also noted that if information security policies are to be of any use, they must be supported by top management and have buy-in from the users. If only one of these groups backs the information security policies, they may be less effective. In a separate study, Young (2008) examined the relationship between the maturity of an organization and maturity of the organization's information security posture; research showed that as an organization's processes and

procedures matured, so did information security, even down to the level of hiring specialized workers in information security. A further study in corporate culture and information security was completed by Da Veiga (2016). Research showed that employees who had read or were otherwise familiar with the organization's information security policies were more likely to be mindful of information security practices. This conclusion may seem obvious; however, the conclusion is fundamental to the efficacy of an information system program in an organization.

The current scholarship also includes determining whether information security frameworks are useful in an organization. Da Veiga and Eloff (2007) created an information security framework that incorporated elements from the Capability Maturity Model for organizations and from ISO 17799, which is an international standard for information security. Da Veiga and Eloff's proposed framework contained several planks which included governance, security management, and technical security controls. Any security policy proposed by an organization should fit into one or more of these planks. If these planks are supported and mandated at the highest management level possible, employees should understand where a policy fits into the general structure of the security organization.

Grohmann (2018) proposed using an existing security framework to assist United States federal and non-federal organizations in shoring up existing policies: the cybersecurity framework from NIST. The NIST framework centers around activities an organization can do to improve the security posture: identify, protect, detect, respond, and recover. If information security policies fall into one or more of these activities, the policies will be viable and effective.

Evolution of Information Security Policies

Information security policies have existed since the very creation of the field, but have existed for specific purposes, such as conformance to laws and regulations (Grohmann, 2018). Most of the frameworks were created to comply with government regulations, such as Security Technical Implementation Guides (STIGs) (Grohmann, 2018). A STIG is a guide created by the United States Department of Defense (DoD) to provide a consistent standard of security throughout the entire DoD ecosystem (Defense Information Systems Agency, 2024). Other configuration guides have come into existence over the last ten years, notably the Critical Security Controls published by the Center for Internet Security (CIS) (Center for Internet Security, 2024). All these configuration guides help form technical security policies for organizations.

The lack of effective security policies has allowed security breaches to go unnoticed (Doherty & Fulford, 2005). Research has shown that if security policies are not enforceable, too complex, too general, and not specific to an organization or a division in the organization, or not publicized, data breaches will occur and likely remain unreported (Doherty & Fulford, 2005). Security policies had germinated and remained in the realm of managers until managers realized that users also have a stake in security; after this realization, users and managers worked together to ensure the effective creation and use of security policies (Doherty & Fulford, 2005).

Current and Future Trends of Information Security Policies

One current and future trend of information security policies is to select and adhere to a framework for security control selection, implementation, and assessment. The selected framework can either be brand new or a previously verified framework. An example of a new framework was created by Atoum et al. (2014), where a new holistic framework was proposed. This new framework consisted of taking stock of the organization's current security posture and transforming that posture into a new and improved security level through technical and non-technical security controls, taking into account an overall information security strategy (Atoum et al., 2014).

An additional new framework was proposed by Da Veiga and Eloff (2007), which combined elements from ISO 17799 and ISO 27000 and other non-governmental frameworks to create a best practice framework. The new framework considered components such as corporate governance, privacy, ethics, user security awareness, incident management, business continuity planning, and others (Da Veiga & Eloff, 2007). When a policy is created that adheres to the information security components noted in the framework, the new policy will be useful and effective.

Information security frameworks currently available do not only focus on technical or non-technical security but encompasses elements from both. Cayirci et al. (2016) proposed using a questionnaire to assist cloud service customers to select an appropriate cloud service provider based on the provider's answers to security questions and other previously published risk assessments. Woods et al. (2017) created a system where potential cyber insurance clients would have their organization evaluated by using the CIS Critical Security Controls. The CIS Critical Security Controls contain both technical and non-technical security controls to ensure the organization has tight control and is aware of all network, server, and workstation activity that happens in the system boundary (Center for Internet Security, 2024).

Regardless of the framework that an organization eventually chooses, the framework needs to make sense from both an implementation standpoint and a financial standpoint (Radziwill & Benton, 2017). If the framework creates more cost and work, then it may not be the correct framework to choose. However, if a particular framework is mandated for use by a government or other authority, the organization has the responsibility to execute the framework in the most efficient way possible, while minimizing fraud, waste, and abuse of the system (Radziwill & Benton, 2017).

Current Problems and Opportunities

The main current problem with information security policies is non-compliance (Harrison & Jürjens, 2017; Hwang et al., 2017). Most companies of any size recognize the need for formal security documentation and have created libraries of various policies (Alotaibi et al., 2016). There is general agreement that security policies need

to be truthful, clear, and applicable to the organization for there to be any chance that employees will follow the policies (Stahl et al., 2012). Information security policies are not followed because people are involved; security is not just left to automated machinery to carry out (Harrison & Jürjens, 2017). Hwang et al. (2017) looked at this question and found that there were several reasons for employee non-conformance to policy; first among these reasons was perceived work impediments, along with anxiety regarding the security system and peer behavior regarding policy non-compliance.

An opportunity for research around compliance with information security policies exists. Research can take place for further investigating reasons for non-compliance with information security policies. Research can further take place regarding how to encourage, reward, and mandate compliance with policies. Research can also be further narrowed down to compliance strategies with information security or risk management frameworks.

Conclusion

This paper considered information security policies. The current state of scholarship regarding policies and associated frameworks was presented, along with current problems of non-compliance to information security policies. An opportunity for further research was presented, which included examining reasons for non-compliance to policies along with positive reinforcement when policies are followed.

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Time Delay Controller for Tele-Operated Vehicles

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Abstract: A military vehicle, which transports soldiers to an unsafe region, may be a target for terrorists' attacks. During this transportation, a bomb may be placed on road to explode the military convoy. To reduce the impact of the explosion, a remote vehicle, which does not include any humans, could be used as the leader vehicle. This leading vehicle could be either controlled directly by another driver or by the GPS system. In this study, a remote vehicle was controlled by varying time delays. The bomb on the road could be assumed as an obstacle. The originality of this study is to introduce the benefit of the usage of a tele-operated vehicle during a strike avoidance maneuver. The controller design was prepared in MATLAB/Simulink interface with IPG/CarMaker simulation environment. A fuzzy logic controller was used to determine the correct steering input depending on the time delay and vehicle speed during a strike avoidance maneuver. The simulations were established in IPG/CarMaker multibody simulation environment with a four-wheel vehicle model including nonlinear tire characteristics. According to the simulation results, the steering angle of the remote vehicle was controlled successfully by the proposed fuzzy logic controller.

Keywords: Advanced driver assistant systems, Autonomous control systems, Fuzzy logic controller, Strike avoidance, Tele-operated vehicles

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Introduction

Advanced Driver Assistance Systems (ADAS) have been commonly introduced in market during development of autonomous vehicles. Collision avoidance is a significant topic for automated vehicles. The vehicle control is being surrounded by artificial intelligence which led the industry to open doors to autonomous vehicles. The aim of the driver assistant systems to reduce or avoid possible collisions. The operation principle of the driver assistant systems could be implemented in remote vehicles in varying cases. Tele-operated Vehicles (TOV) are also a part of autonomous vehicles (Ge et al., 2019). The military tele-operated vehicles could be one of the cases for the implementation of driver assistant systems. An avoidance maneuver from an obstacle can be assumed as an avoidance maneuver from a bomb placed on the road. Therefore, an obstacle on road could be assumed as a bomb. The communication between the remote vehicle and the host vehicle typically includes time delays (Almutairi et al., 2001; Smith & Jensfelt, 2010). There are varying communication delays described in the network control which have been significantly mentioned in literature, such as stochastic and deterministic

(Liu et al., 2007; Wang et al., 2010; Witus et al., 2011; Ware & Pan, 2011; Boukhnifer et al., 2011; Tümerdem, 2021). The delay could be controlled by handling the suitable parameters. The system dynamics are predicted during this delay simultaneously according to the prediction model (Boukhnifer et al., 2011; Tümerdem, 2021). The driver assistant systems may be used to support the control of the time delay in the TOV. In the driver assistant systems, collision avoidance is the main purpose as discussed in (Jansson & Johansson, 2002; Choi et al., 2012; Eidehall et al., 2007; Benderius, 2014; Ruscio et al., 2015; Fieandt et al., Itoh et al., 2010). TOV hasn't been used in cooperation with collision avoidance maneuvers so far. Therefore, the originality of this study is to introduce the control of the time delay of the remote vehicle during a strike avoidance maneuver. The bomb was assumed as an obstacle during this study. The obstacle detection could be done with various sensors in the vehicles such as Lidar, Long-Range Radar (LRR) and Camera (Ruscio et al., 2015; Fieandt et al., Itoh et al., 2010). In this study, a LRR was installed in the remote vehicle for the detection of the possible obstacle. The steering maneuvers were proposed to avoid a possible collision to the obstacle. The delay compensation for these maneuvers were examined with a fuzzy-logic controller (FLC). The rule based FLC was designed in the MATLAB/Simulink interface. The corresponding design was implemented in IPG/CarMaker multibody simulation environment. The vehicle model in the IPG/CarMaker simulation environment includes non-linear tire characteristics. Therefore, the simulations in the avoidance maneuvers represent the realistic results by observing non-linear load transfers. Steering wheel angle, lateral vehicle position, vehicle body side slip angle, vehicle speed, longitudinal acceleration and load transfers were observed during the corresponding simulations.

Method

Vehicle Design

A rear-wheel drive vehicle was modeled in the IPG/CarMaker multibody simulation environment. In the vehicle model, longitudinal and lateral load transfers were also taken into consideration. The proposed vehicle contains two-axles. The main parameters of the TOV are presented in Table 1. It is also possible to use ADAS features in the TOV. Therefore, a Long-Range Radar (LRR) was installed into the TOV to detect obstacles in front of the vehicle.

Table 1. The remote vehicle parameters in IPG/CarMaker

Vehicle Mass	2300	kg
Center of gravity	0.66	m
Anti-Roll Bars	30000/30000	N/m
Springs (front/rear)	25000/30000	N/m
Dampers	2500/3000	Ns/m
Tire model	235 55 R16	[-]
Range of the LRR	240	m

Initially, a set of simulations were performed during a strike avoidance maneuver to create suitable cases. To perform a successful steering maneuver, the distance to the obstacle was measured from the LRR as shown in Equation (1) where w is the width of the proposed steering maneuver, d is the longitudinal distance to an obstacle to perform an emergency steering maneuver, ay is the lateral acceleration of the vehicle, (Wong, 2001; Rajamani, 2006).

$$d = \sqrt{\frac{2*w}{a_y}} v_{vehicle} \tag{1}$$

If the distance to the obstacle is sufficient depending on Equation (1), the trajectory of the maneuver could be calculated. x is the longitudinal position and y is the lateral position as presented in Equation (2) (Wong, 2001; Rajamani, 2006).

$$y(x) = w\left[10\left(\frac{x}{d}\right)^3 - 15\left(\frac{x}{d}\right)^4 + 6\left(\frac{x}{d}\right)^5\right] \tag{2}$$

The visualization of the Equation (1) and Equation (2) are presented in Figure 1. As illustrated, yend represents the width of the steering maneuver and xend represents the longitudinal length of the steering maneuver at 32 km/h vehicle speed with 4.5 seconds of time delay. After defining the steering maneuver for the TOV, a set of experiments were done in IPG/CarMaker simulation environment.

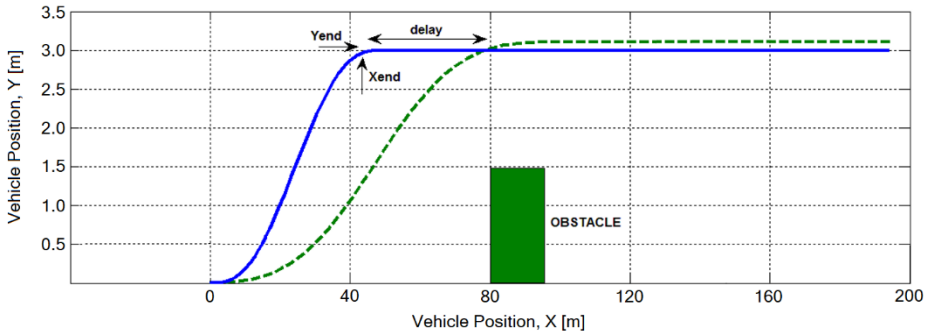

Figure 1. The design of the visualization of a strike avoidance maneuver

The FLC design for time delay

In this case, the vehicle model adopted into the defined trajectory in Equation (2). During the constructive simulations, a proper time delay (td) introduced into the model in Equation (3). As presented in Equation (3) α is the tuning parameter, t is the actual time and x, xd are the actual, desired longitudinal coordinates of the TOV respectively (Tandon & Puneet, 2011). By the usage of the delay compensation, a rule based FLC design was constructed in MATLAB/Simulink interface as presented in Table 2. By implementing the Equation (3) with the Equation (1) and (2) the steering maneuver was performed to observe the effectiveness of the time delay.

$$\dot{x}\,(t) = \dot{x}_d\,(t - t_d) - \alpha\big(x(t - t_d) - x_d\,(t - t_d)\big) \quad (3)$$

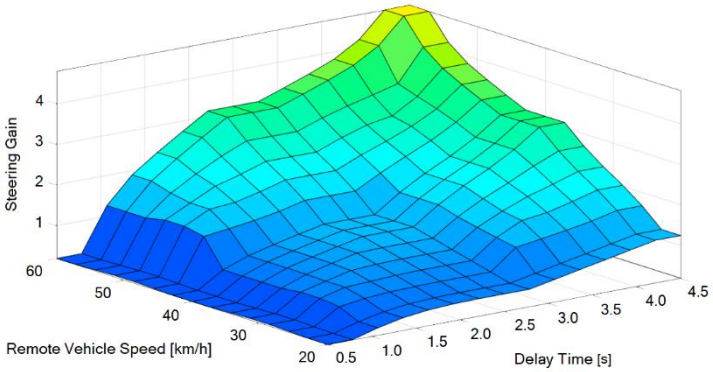

Figure 2. The visualization of the membership functions of the FLC

Depending on the time delay and speed of the TOV, the appropriate gain of the steering wheel angle was optimized with the rule-based design in Table 2. As shown in Table 2, Z is for a zero value, PB is for a positive big value, PS is for a positive small value and PM is for a medium value. The visualization of the rule-based design is illustrated in Figure 2. The aim is to find out a correct steering wheel gain to maintain the stability of the TOV.

Table 2. The-rule based design of the FLC

	Time delay (0-4.5 s)			
TOV speed (20-60 km/h)	Z	PS	PM	PB
PS	Z	PS	PS	PS
PM	Z	PS	PS	PM
PB	Z	PS	PM	PB

As illustrated in Figure 2, the steering gain is prortional to the delay time. The overlapping regions of the membership function represents the maximum limit of the small value (S) as 3, and the minimum limit of the big value (B) as 3. The medium (M) value is between 0.2 and 6. The zero (Z) value is zero in all cases. Increasing delay time resulted with higher steering gains. Moreover, the vehicle speed dramatically effects the rate of the steering gain. Especially after 40 km/h, the relationship between the steering gain and the delay time turns from proportional rate to exponential rate. The fuzzification method was selected as Sugeno type fuzzy modeling, in which fuzzing of input variables and fuzzy logic operations are the same as Mamdani fuzzy modeling (Wang & Chen, 2014; Rhung et al., 2009).

Results

To perform a simple verification of a four-wheel vehicle model in IPG/CarMaker, an introduction case was designed. In this case, the remote vehicle speeded up to 60 km/h starting from zero on a dry asphalt in a straight-line. Immediately, a full-braking maneuver was done as shown in Figure 3. The vehicle speed was 60 km/h at the 10th second of the simulation. The acceleration and deceleration values are also illustrated in Figure 4. The load transfer between front-left and rear-left tire is illustrated in Figure 5. Depending on the simulation results, the load transfer between the tires and the acceleration-deceleration values are compatible.

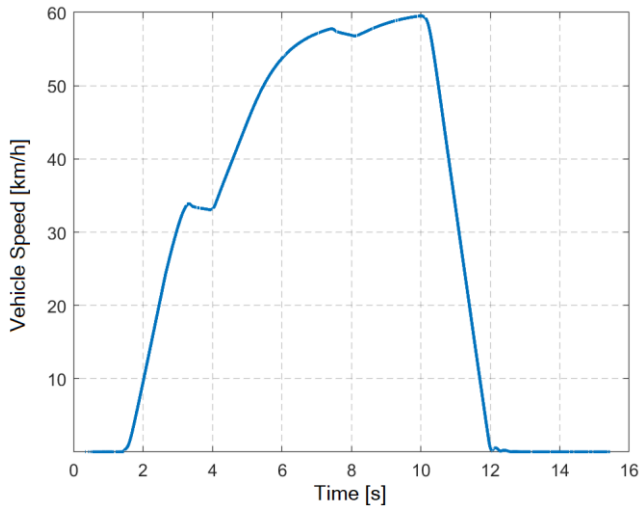

Figure 3. Simulation Scenario for the four-wheel model verification (vehicle speed)

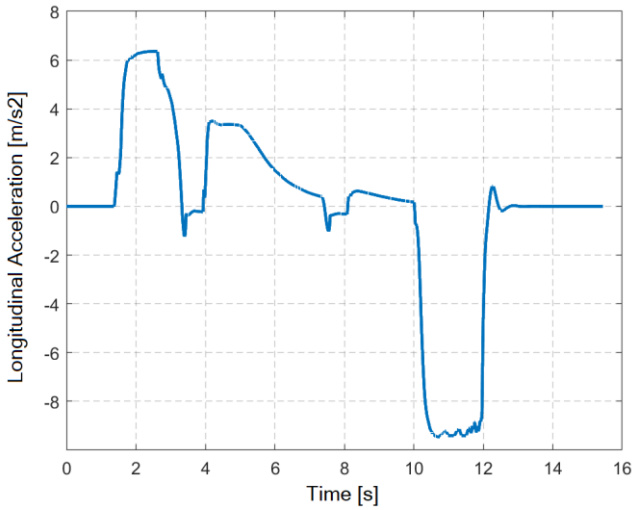

Figure 4. Simulation Scenario for the four-wheel model verification (vehicle longitudinal acceleration)

In the construction of the main simulation results, a critical strike avoidance maneuver was introduced in IPG/CarMaker environment as presented in Figure 6. The obstacle is illustrated as a stationary truck which represents a possible bomb carrier. For this case, the remote vehicle was selected as a Van which represents a transport vehicle for soldiers. In Figure 6, in the 1st position, the obstacle was detected by the LRR of the TOV.

According to the distance and relative velocity, the strike avoidance maneuver was calculated. In the 2nd position, the emergency steering maneuver was introduced to perform the strike avoidance maneuver. In the 3rd position, the recovering steering maneuver was applied. In the 4th position, the host vehicle completed the proposed strike avoidance maneuver successfully depending on the rule based FLC design.

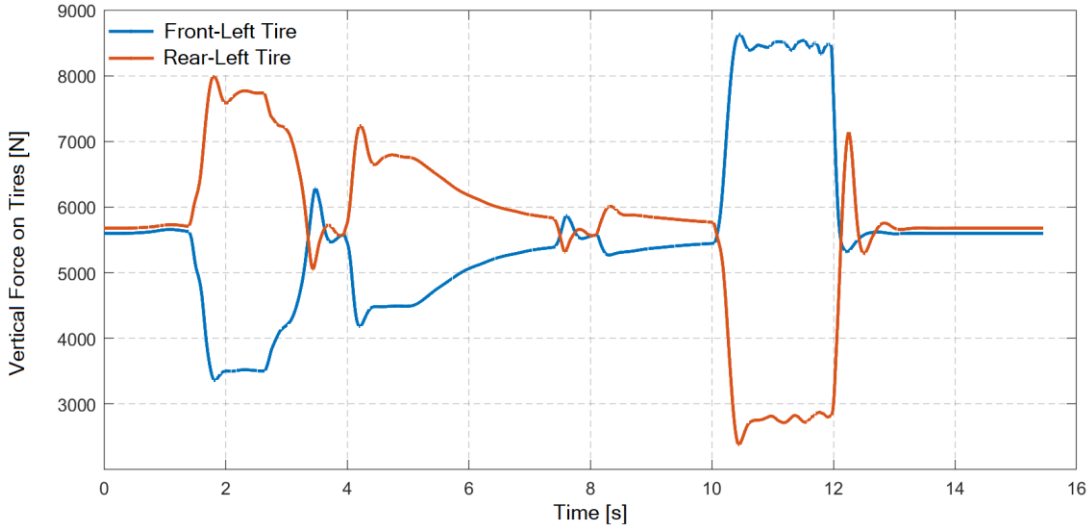

Figure 5. Simulation Scenario for the four-wheel model verification (load transfers)

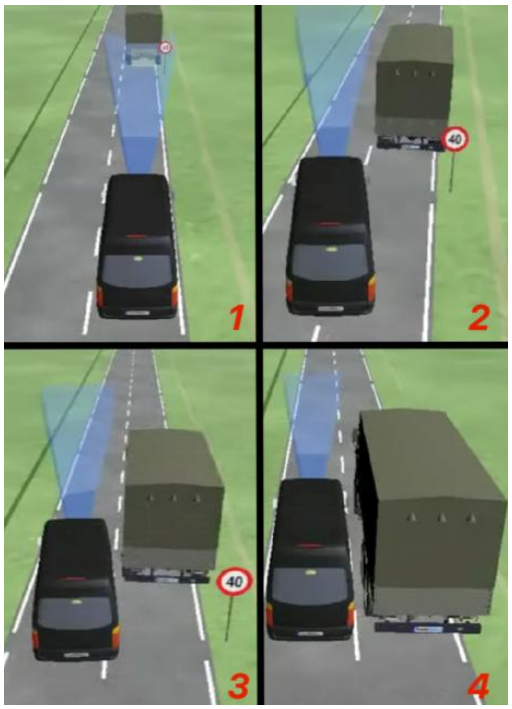

Figure 6. The strike avoidance maneuver of the TOV with the FLC

During this case, the road friction coefficient was same as on the dry asphalt. The time delay was selected as 4.5 seconds, and the remote vehicle speed was defined as 32 km/h. The aim of this case was to perform a strike avoidance maneuver successfully. By the usage of the FLC controller, the steering wheel angle gain was

optimized for 4.5 seconds time delay as presented in Figure 7. At around the 5.5th second of the simulation the steering angle was 70 degrees. Moreover, the steering angle was 155 degrees around the 10th second of the simulation. The time delay resulted in a steering gain which was offered with the proposed FLC. In Figure 8, the steering wheel angle rate is observed. The delay resulted in an increase of 100 degrees/s in the steering wheel angle rate. In Figure 9, the vehicle body side slip angle is illustrated. The delay resulted in an increase of 3 degrees in the body side slip angle. Moreover, the delay could be observed in the lateral vehicle position as presented in Figure 10.

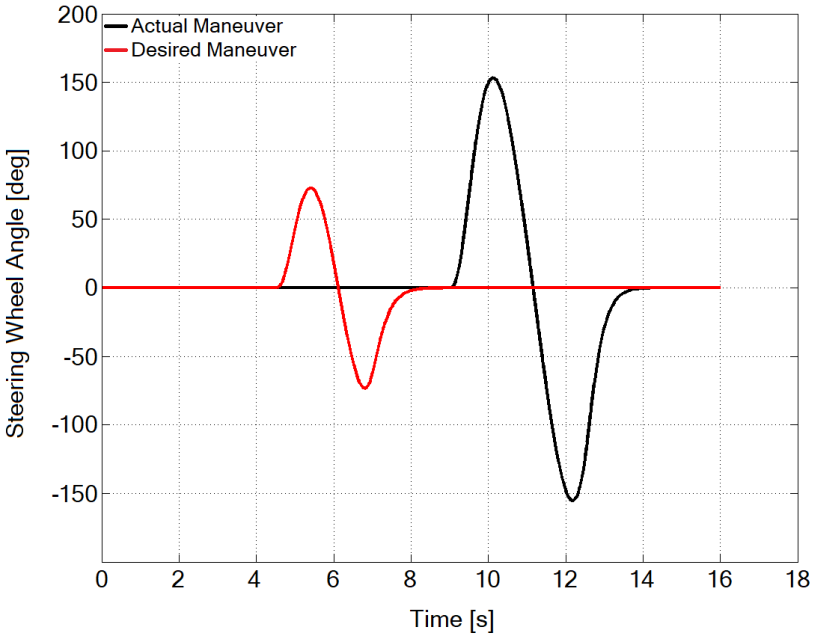

Figure 7. Steering Wheel Angle of the Remote Vehicle

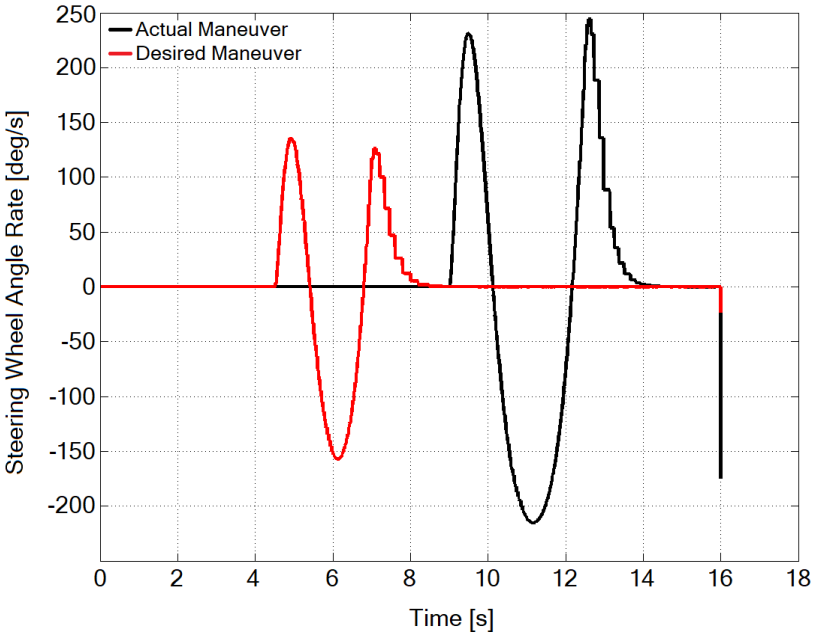

Figure 8. Steering Wheel Angle Rate of the Remote Vehicle

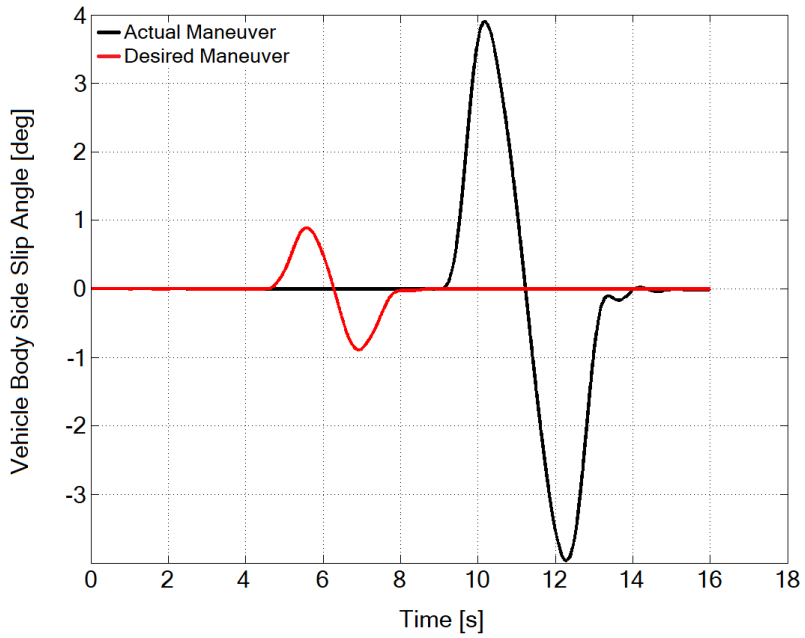

Figure 9. Vehicle Body Side Slip Angle of the Remote Vehicle

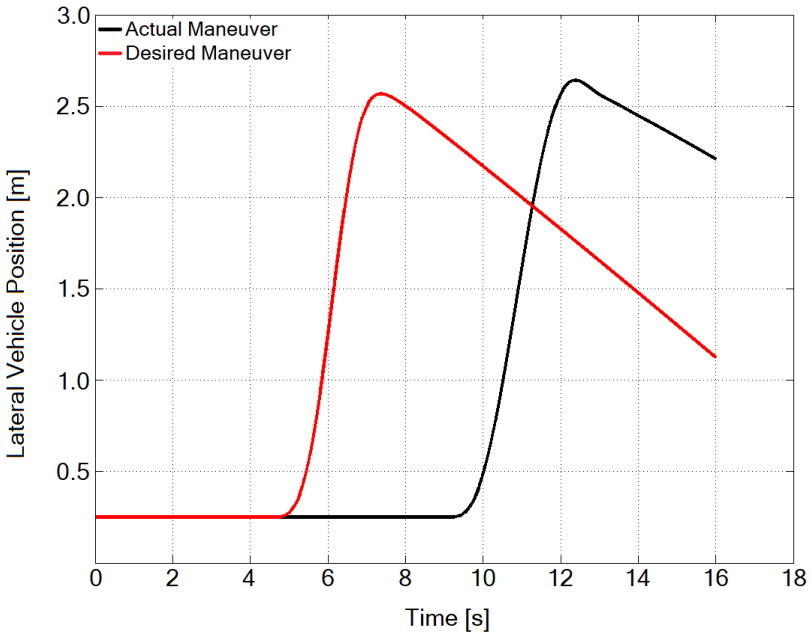

Figure 10. Lateral Vehicle Position of the Remote Vehicle

Discussion

During the construction of the proposed FLC, varying sets of experiments were performed. The usage of the FLC controller provided valid solutions for the adaptation of the TOV in different vehicle speeds and time delays. The relationship between the steering angle gain and the relative velocity was introduced on a dry asphalt. The construction depends on the correct definition of the path calculation. The path calculation

including the time delay represents the original perspective of this study. The transient motion of the load transfers was also taken into consideration in the IPG/CarMaker simulation environment. The varying time delays up to 4.5 seconds were examined. The remote vehicle was assumed to be controlled through the GPS system or by another vehicle in the corresponding convoy. Results show that the proposed steering gains calculated by the harmony of the relative velocity and time delays successfully keep the remote vehicle on track.

Conclusion

In this study, the effectiveness of the Fuzzy Logic Controller (FLC) on the compensation of the of the time delay was investigated. In the construction of the FLC, varying vehicle speeds and time delays were taken into consideration. The design of the controllers was completed in MATLAB/Simulink interface. The design of the controllers in a four-wheel vehicle model was verified with a dynamic simulation environment in IPG/CarMaker. To observe the benefit of the time delay control, an emergency steering maneuver was introduced to simulate a strike avoidance maneuver. The FLC controller provided successful results on the dry asphalt. Therefore, a tele-operated vehicle (TOV) may be an option in military for the critical environments which may include bomb set-ups by the terrorists. Although, the detection of an obstacle and a bomb is quite distinguishing, the strike avoidance maneuver could be similar with an emergency steering maneuver. The combination of the time delay and vehicle speed was successfully handled in this study. The proposed steering wheel angle was calculated to be performed on a dry asphalt. As a future study, the proposed steering wheel angle should be investigated on varying road surfaces such as ice, snow, and rain. On the other hand, the instruments for the detection of a possible bomb are beyond the range of this study.

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Identifying Bias in AI Image Generation

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Abstract: In this research, we explore the pervasive issue of bias within AI image generation, a challenge that persists despite AI's rapid development and increasing relevance in various fields. Specifically, the study focuses on detecting biases related to gender, race, and age in images produced by free AI image generators. Bias in AI often originates from imbalanced and non-diverse training data, leading to prejudiced outcomes. To examine this, five free AI image generation tools—NightCafe, Leonardo, Craiyon, Microsoft Designer, and Playground—were chosen for their diverse AI models and ease of access. Each tool was tested with prompts reflecting social situations, workplace environments, and home life. The resulting images were analyzed to identify any biases. Among the tools tested, Microsoft Designer was found to have the least bias while maintaining relevance and accuracy, whereas NightCafe exhibited the highest level of bias, along with frequent image deformations. This study highlights the critical need for addressing and mitigating biases in AI to ensure the development of more equitable and inclusive AI systems.

Keywords: Artificial intelligence, Image generator, chatbots.

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Introduction

Artificial intelligence (AI) technologies are increasingly embedded in everyday life, impacting diverse fields such as healthcare, finance, creative industries, and education. Among these applications, AI-driven image generation tools have gained substantial traction, finding use in areas like digital art, advertising, gaming, and virtual reality. This expansion of AI's influence has driven researchers and developers to continuously improve its functionality, accessibility, and reliability. However, even as AI becomes more relevant and widespread, its rapid development has not resolved all its inherent challenges. One of the most pressing issues facing AI today is bias—a flaw that can have significant social implications, especially in technologies like AI image generation that directly shape visual and cultural perceptions.

Bias in AI, particularly in AI image generation, has garnered critical attention in recent years. When AI systems

are biased, they risk reinforcing stereotypes and producing outcomes that lack fairness, inclusivity, or accuracy. This bias often originates from imbalanced or non-diverse training data. For instance, if an AI model is trained primarily on images that do not adequately represent a broad range of gender identities, ethnic backgrounds, or age groups, it is likely to produce biased results, underrepresenting or misrepresenting certain groups. Such biases can not only distort individual identities but also perpetuate existing social inequalities and reinforce harmful stereotypes, particularly when AI-generated images are used in influential public contexts.

The objective of this research is to examine whether AI image generation tools exhibit bias and to encourage increased awareness and caution among users and developers of these tools. By identifying biases related to gender, race, and age, this study seeks to reveal how AI image generators may unintentionally reinforce stereotypes and impact social perceptions. Addressing this issue is critical, as the widespread use of biased AI could have lasting implications on how various groups are represented across media platforms. This research underscores the need for developers to incorporate more diverse data into training processes and to develop mechanisms for detecting and correcting bias in AI systems.

To examine bias in AI image generation, this study evaluated five popular, accessible AI image generation tools: NightCafe (Nightcafe Studio, 2024), Leonardo (Leonardo AI, 2024), Craiyon (Craiyon AI, 2024), Microsoft Designer (Microsoft Designer, 2024), and Playground (Playground AI, 2024). These tools were chosen based on their accessibility, popularity, and diverse AI models. Each was tested using prompts designed to reflect typical social scenarios, workplace dynamics, and home environments, allowing for an in-depth analysis of how each tool responded to varied contexts. Through this approach, we assessed whether the AI-generated images exhibited any apparent biases.

In the following sections, we provide a review of relevant research on AI bias, detail the methodology for evaluating bias in AI image generation, and present an analysis of the results. By contributing to the broader discourse on ethical AI practices, this study serves as a resource for developers and users alike, offering insights that encourage the development of more inclusive and fair AI tools. Ultimately, this research aims to advance our understanding of AI bias and highlights the importance of vigilance and accountability as AI technologies continue to evolve.

Background

For our experiments, we utilized 5 free AI image generator, NightCafe, Leonardo, Craiyon, Microsoft Designer, and Playground. In the following we provide brief background about the five tools.

NightCafe is a user-friendly AI art generator that empowers users to create stunning visual masterpieces simply by providing text prompts. It offers a diverse range of artistic styles, from classic oil paintings to modern digital art, and provides customization options for adjusting image parameters like aspect ratio, color palette, and style.

Leonardo AI is a cutting-edge AI art generator renowned for its ability to produce highly detailed and realistic images. It excels in generating images based on specific artistic styles and techniques, such as anime, oil painting, and photography. Leonardo AI also offers advanced features like image inpainting and outpainting, allowing users to modify and extend existing images.

Craiyon is a versatile AI image generator that offers a quick and easy way to bring your imagination to life. While it may not produce the highest quality images, it's a great tool for generating creative ideas and brainstorming. Craiyon is ideal for users who want to quickly visualize concepts without the need for advanced technical skills.

Microsoft Designer is an AI-powered design tool that simplifies the process of creating professional-looking designs. It offers a range of templates and design tools, such as automatic layout suggestions, color palettes, and font pairings. Microsoft Designer is particularly useful for non-designers who want to create high-quality visuals without the need for extensive design expertise.

Playground AI is a powerful AI platform that offers a variety of tools, including an image generator. It allows users to experiment with different AI models and techniques, such as text-to-image generation, image editing, and style transfer. Playground AI is a great tool for developers and researchers who want to explore the capabilities of AI in creative applications.

In the following table (Table 1) we compare the different services and options provided by the image generators.

Table 1. Comparison of the AI Image generators

Services	Free	Registration Required	Free Credits	Image Storage
Nightcafe	Yes	Yes	5 daily	Yes
Playground	Yes	Yes	50 daily	Yes
Leonardo	No	Yes	150 daily	With plan
Microsoft	Yes	Yes	15 daily	Yes
Craiyon	Yes	No	N/A	Yes

Methodology

The AI image generators require users to input a prompt, which the model then uses to generate an image. In Craiyon and Playground, a negative prompt is also required to optimize the results. Each service was tested for three types of bias: gender, race, and age. The AI models were given prompts designed to reflect social situations, workplace settings, or home environments. After generating each image, we analyzed it to assess whether any bias was evident in the AI model's output.

Once the desired prompts were entered, the image generator typically produced one or multiple images relatively quickly. These images were then analyzed and compared against others generated from the same prompt. To facilitate easy viewing and comparison, the images were organized into slides. After collecting all images, they were ranked overall based on the presence or absence of bias.

One notable observation was that NightCafe struggled to generate an accurate image of a Black man in a workplace setting, requiring several prompt revisions to produce an acceptable image. This limitation affected NightCafe's ranking, as no other service encountered similar issues when generating images for specified races or ethnicities. Additionally, when a particular race or ethnicity was specified, the AI models occasionally included stereotypical elements in the background, which reinforced certain cultural assumptions. For instance, when an individual was specified as Asian, the background sometimes featured traditional Asian architecture. Similarly, when Hispanic was specified, background elements occasionally included older-looking buildings associated with Hispanic culture.

This methodology enabled a comprehensive assessment of how each AI image generator responded to prompts involving diverse social and demographic scenarios, helping to identify patterns of bias in their outputs.

Figure 1. Leonardo output for prompt "Hispanic/Asian men hanging out"

Figure 1 shows the output for Leonardo when the prompt was "Hispanic/Asian men hanging out". Figure 2 shows different output version for Nightcafe, when the prompt was "Black man working". From left to right, it displays output for the original prompt, modified prompt and successful prompt. To find the correct image the prompts needed to be updated and modified until a meaningful image was generated.

Figure 3 demonstrates a possible age bias that exists in Leonardo where the girls are typically portrayed as older than the boys, unless specified.

Figure 2. Nightcafe output for prompt “Black man working” (Original prompt, modified prompt, successful prompt)

Figure 3. Leonardo output for prompt “Girl/Boy”

Image Prompts

The image prompts were designed to focus 3 types of biases, Sex/Gender, Age, and Race/Ethnicity. For each category, the following properties were evaluated attire, activities and facial expressions. The following (Figures 4, 5 and 6) are some of the sample prompts and generated images.

Socialization

(What kind of toys does the AI give them? Does it follow stereotypes?)

Prompt 1: Two young girls/boys playing with toys, photography style

Prompt 3: Girl/Boy in school. Teenage Girl/Boy in school.

Prompt 3.1: Teenager in school socializing.

Prompt 3.2: Teenager in school studying.

Prompt 4: Group of women/men hanging out together and socializing

Figure 4. Girl in School Prompt (In order: Microsoft, Craiyon, Nightcafe, Playground, Leonardo)

Work Situation

CEO, Janitor, Teacher, Secretary, Scientist, Nurse

(What type of work are they doing, what are they wearing, what expressions are they making?)

Prompt 1: Woman/man getting ready for work, early morning, photography style

Prompt 2: Woman/Man going to work, morning, photography style

Prompt 3: Woman/Man working

Employee giving presentation on company stocks

Assistant delivering coffee to the meeting room

Prompt 4: Employee talking to their boss

Boss talking to their secretary

Figure 5. Nurse Prompt (In order: Microsoft, Craiyon, Nightcafe, Playground, Leonardo)

Homelife Enviroment

(Are the subjects male or female?)

Prompt 1: Parent cooking dinner for child

Prompt 2: Person fixing car in a garage/home repair

Prompt 3: Parent nurturing children

Prompt 4: Parent playing game with children

Prompt 5: Parent arriving home after work

Person mowing the lawn

Adult folding laundry

Individual cleaning the house

Figure 6. Cleaning the house Prompt (In order: Microsoft, Craiyon, Nightcafe, Playground, Leonardo)

Experimental Results

Based on our observations using a variety of prompts designed to test for bias across the three primary categories—gender, race, and age—we ranked each AI image generation service on a standardized scale of 1 to

5, with 5 representing the highest level of fairness, relevance, and accuracy in response to the prompt. This ranking process involved evaluating how each tool responded to prompts within social, workplace, and home-life contexts, noting instances where bias was evident or where the tool produced balanced, representative images. Each service's score reflects its performance in generating images free from noticeable bias or stereotypes and its ability to accurately interpret and represent the prompt provided. The following table (Table 2) presents the summarized results of our assessment, allowing for a clear comparison of each tool's effectiveness in minimizing bias while maintaining prompt fidelity.

Table 2. Comparison of the AI Image generators ranks

Services	Gender	Race	Age	Relevance	Accuracy	Deformation	Average
Nightcafe	3	2	3	3	4	2	2.8
Playground	3	3	3	5	5	5	4
Leonardo	2	4	3	5	5	5	4
Microsoft	4	4	3	5	5	4	4.2
Craiyon	4	5	3	3	4	2	3.5

Based on the average scores across all criteria, Microsoft Designer emerged as the top-performing tool in terms of bias, relevance, and overall accuracy. Microsoft Designer consistently produced images that exhibited lower levels of observable bias compared to the other tools, while also demonstrating strong alignment with the prompt's intent. This balance between reduced bias and high-quality output made it the most effective tool among those tested. Microsoft's ability to generate diverse and realistic images with minimal stereotypical portrayals across gender, race, and age further solidified its position as the preferred tool, especially in contexts where inclusivity and representation are crucial.

In contrast, NightCafe was the least effective tool in the study, displaying the highest levels of bias across multiple prompts. It frequently produced images that deviated from the intended diversity goals, often struggling to accurately represent certain demographics without introducing stereotypical elements. Additionally, NightCafe encountered frequent image deformations, further diminishing the quality and usability of its outputs. This high level of bias and repeated technical issues with image generation made NightCafe the lowest-ranked tool among the five, underscoring the need for substantial improvements to enhance both its representational fairness and technical reliability.

Conclusion

In conclusion, this study reveals that all five AI image generation tools tested—NightCafe, Leonardo, Craiyon, Microsoft Designer, and Playground—demonstrated varying levels of bias when given prompts to reflect social situations, workplace environments, and home life. While all tools exhibited some degree of bias across gender,

race, and age, significant differences emerged, with Microsoft Designer displaying the least bias and achieving the highest overall relevance and accuracy in image production. On the other hand, NightCafe frequently exhibited the highest levels of bias, alongside a notable number of image deformations, which affected its overall reliability and quality. These findings underscore the critical need for continuous improvement in AI model development, particularly regarding the elimination of entrenched biases that may impact inclusivity and fair representation.

Looking ahead, future work in this area could expand upon the present study by testing a broader range of AI image generation tools, including newer models and those leveraging distinct algorithms or data sources. This approach would provide a more comprehensive understanding of how different platforms handle demographic representation and bias across various scenarios. Additionally, exploring other types of bias beyond gender, race, and age—such as socioeconomic or cultural biases—could offer deeper insights into how these tools reflect and sometimes reinforce societal stereotypes. Finally, conducting a longitudinal analysis to track improvements over time in specific AI tools and evaluating how interventions (e.g., updates to training data) reduce bias could further support the development of more equitable, inclusive, and user-sensitive AI systems in image generation and beyond.

Acknowledgements

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Harnessing Deep Learning for Cryptocurrency Price Forecasting

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Abstract: Digital assets have surged in popularity, evolving from having niche market value to coming mainstream. Some notable examples include Bitcoin, Ether, Ripple etc. However, the market is characterized by its high volatility and potential for significant returns, often described as a "high risk, high reward" environment. As the cryptocurrency market experiences an impressive annual growth rate of 200%, accurate price prediction becomes essential for stakeholders like regulators, investors and venture capitalists who wish to participate in this market. This paper involves a comprehensive study on predicting cryptocurrency prices using deep learning models, specifically the Long Short-Term Memory (LSTM) algorithm. These recurrent neural networks are capable of learning order dependence in sequence prediction problems. Our model utilizes historical price data including opening, closing, high, and low values, along with trading volume—to forecast future price movements. By employing the LSTM architecture, we effectively address the long- term dependency problem inherent in time series data, optimizing the accuracy of our predictions. Additionally, this model has been compared to comparable deep learning models like random forests, SVM and more. This study aims to keep exploring accuracy of different prediction techniques.

Keywords: Blockchain, Deep learning, Artificial intelligence, Data science, Fintech

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Introduction

Machine learning (ML) has been around for quite some time now. At the same time, we've seen its diverse and wide range of applications, which include, but are not limited to, chatbots, large language models, healthcare, finance, etc. One of machine learning's most sought-after subsets is deep learning (DL), which is being extensively practiced these days. Well-known firms like Blackrock and Fidelity Investments have already deployed quants for stock-price forecasting. These high-frequency trading assistants enable these firms to execute billions of dollars' worth of trades based on future stock price predictions. The cryptocurrency market, however, differs from traditional financial instruments as there is more volatility and risk in the price action of digital assets.

That means there is room for high profit margins if intelligent strategies are taken. The global market capitalization of cryptocurrencies in the likes of Bitcoin, Ethereum, and such has been reported to exceed values

of $2.34 trillion. Although there are still regulatory hurdles towards its mass adoption, there are still billions of dollars' worth of daily transactions conducted in perpetual trading of crypto assets. Additionally, exchanges such as Coinbase and Binance have helped onboard millions of users on their trading platforms. Further, it is not uncommon in this market to see 10X-100X returns in a very short time [1]. This has led to the rise of a new type of trader called "degens." These traders execute high-risk, high-reward strategies that reward them based on their leverages and volatility.

This paper focuses on predicting the prices of cryptocurrencies based on several factors, such as price action, user engagement, tech, and consensus factors. The main and top assets of the crypto space are Bitcoin (BTC) and Ethereum (ETH). Bitcoin is an asset with only 21 million supply in total. There are no more bitcoins than 21 million. Think tanks and billionaires predict bitcoin could be worth $100,000 by 2025 [2]. Bitcoin being the main asset and the driving force in crypto, there will be more new people coming into crypto amid rising popularity, which will eventually make crypto trading among the top 3 investment options [3].

To state it rather blatantly, back in 2011 Bitcoin (BTC) was worth $10, and today in 2024 it is close to $73,000 as of today. We really don't want to miss the next moonshot, but we don't know when that will happen. We firmly believe that machine learning and deep learning can help us in this answer. By training and testing real time crypto data and predict the price using neural networks and machine learning, we will be predicting the price of Bitcoin which is the main asset of the crypto space. We'll also be evaluating more currencies such as Ethereum and YFI. Finally, we will examine various machine learning models and choose the one which suits our needs and requirements, also some traditional algorithms which support prediction of gold and stocks using machine learning.

Literature Review

Cryptographic softwares date back to the 1980s when a computer scientist and cryptographer, David Chaum, suggested a new scheme to build a cryptographic architecture when a sender sends a message that is blinded in such a way that the content of the message cannot be interpreted by the signer. These blind signatures, such as digital signatures, have been used to validate material. Chaum proposed such a view that a third party could not track the contents of the message in any way. In 1998, Wei Dai, a Computer Engineer proposed an anonymous and distributed cash system known as B-money [4]. It is often said that if Bitcoin is today's Cryptocurrency, then B-money can be considered its draft. In his work, he stated a model where two protocols exist in the network that cannot be traced, where only their public keys can identify the senders and receivers, and each message sent is verified by those keys. A dying light in the line of the new generation cryptocurrency network, which laid the foundation for future study, known as Hashcash [5], a network that relied on cryptographic hash functions to extract evidence of computational work to authenticate the systems, was proposed by Adam Back.

Finally, we have our most common digital currency, Bitcoin [6], which was developed by a pseudonym

developer known as Satoshi Nakamototo, which eventually became the first decentralized cryptocurrency. Around 2008 and 2009, the first Bitcoin whitepaper was also published. It is now one of the most highly valued holdable asset, with current price being at $73,000.

Related Work

Several machine learning models have been used to predict future prices for the crypto-asset class. Greaves et al proposed using Logistic Regression, Support Vector Machine (SVM) and analysis using graphs to predict cryptocurrency prices [7]. But only 55% accuracy was achieved with this method because it did not take into account the exchange behavior which affects the prices of cryptocurrencies directly. A later research paper strongly recommends considering the exchange behavior which directly affects the prices of these digital currencies. Almeida et al proposes artificial neural networks for this purpose. The models were generated from Theano library from MATLAB [8]. This model was applied for 2 years in a real time scenario and yielded a profit of $8000. Shah et al represented Bayesian regression algorithm for generation of source models, using the algorithms was able to register a 67% gain with a sharp immediate prediction ratio [9]. This model was better for immediate prediction, but long-term position strategies couldn't have been taken in the market.

McNally et al presented various models that were based on Recurrent Neural Networks, and Autoregressive Integrated Moving Average (ARIMA) [10]. The models were generated using traditional datasets containing high price, low price, opening and closing data. The results forecasted a 52.78% accuracy. ARIMA networks are ideal for short term data forecasting, and it works better when the data we are trying to predict has a stable or consistent pattern over time. But this is tedious with real time cryptocurrency price data when the data being processed is volatile while depending on many complex factors as the data fluctuates violently. Taking accuracy and performance consideration of the above models, we are going to analyze and predict the prices using a LSTM network.

Long Short-Term Memory

The Neural Network which will be used in this paper is the LSTM (Long Short Term Memory) neural network It is widely used in machine and deep learning and has many advantages. It is a recurrent neural network (RNN) and unlike the standard networks, it also possesses feedback connections [11]. They also have the ability to process data sequences (like speech and video) in addition to processing singular data points (like images). The LSTM network, while similar to RNNs, also consists of modules with recurrent consistency. RNNs and LSTMs have a comparable structure, with the memory cell of the secret layer being the only difference. Fig. 1 shows a schematic diagram of the LSTM module. It consists of the three special gates, which is useful in solving gradient problems. The biggest advantage of LSTM over a common recurrent network is it's memory cell unit which has the ability to encapsulate part of the previously stored information and also add part of the new information available. This means that it is suitable to avoid long term dependency problem which is often the case in traditional recurrent neural networks.

Unlike standard networks, LSTMs possesses feedback connections. They also can process data sequences (like speech and video) in addition to processing singular data points (like images). That is why it is widely used in recognition of expression and associated handwriting. Based on time series data, LSTMs find application in classifying, processing, and making predictions, as time series may have lags between significant events. This made it unique as an architectural RNN [12].

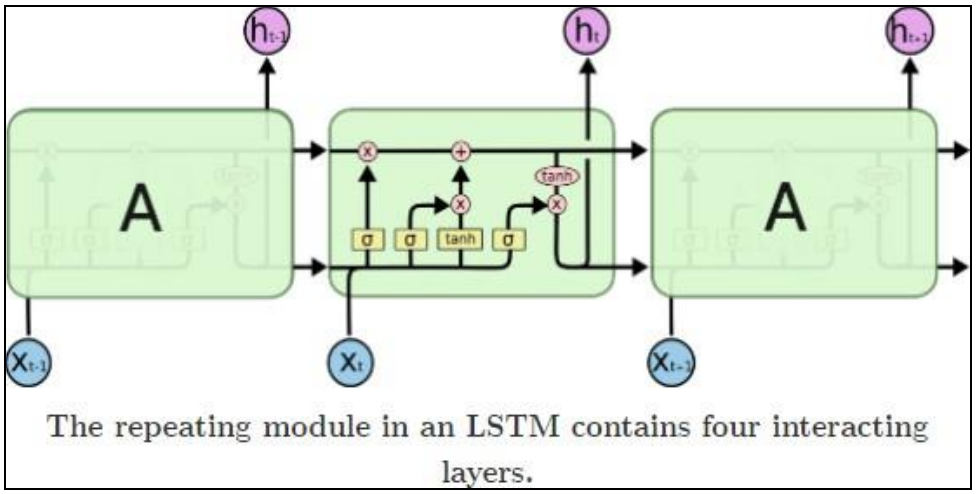

Figure 1. LSTM Layer Representation

Fig. 1 shows a schematic diagram of the LSTM module. It consists of the three special gates, which is very useful in solving gradient problems. The biggest advantage of LSTM over a common recurrent network is it's memory cell unit which has the ability to encapsulate part of the previously stored information and also add part of the new information available. This means that it is suitable to avoid long term dependency problem which is often the case in traditional recurrent neural networks.

Method

Data

There are many cryptocurrencies available in the crypto market; these include Bitcoin, Ethereum, Tether, Ripple, Cardano, 1inch, Solana, etc. In this paper, the currencies taken for research are Bitcoin, YFI, and Ethereum. The historical price data for experimentation and processing are taken from YahooFinance.com. The parameters in the dataset include date, open, close, high, low, adj (adjusted close) price, and volume.

Features of the datasets are as follows:

Table 1. Dataset variables of interest

Variables	Description
Close	Closing trade price

Open	Opening trade price
High	Highest trading price
Low	Lowest trading price
Adjusted Close	Closing price after adjustment
Volume	Total traded volume in a day
Date	Recorded day

The entire task involves processes like collection of data, processing, feature extraction, extended data wrangling, and then training the LSTM. Then, after the model is trained, it is finally used to predict and examine the prices of our list of cryptocurrency assets. The preprocessing comprised steps like data reduction, normalization, and cleaning to obtain the required dataset. The data is further split into test and train data. Feature extraction feeds the most important features to the network by combining correlated features and removing less important ones. In our case, it involves parameters like opening, high, low, and closing price and date. For accuracy in price prediction, random biases and weights are assigned.

The LSTM network contains a sequential input layer and a dense output layer where a linear activation function (RELU) has been applied. Using Adam Optimizer and setting the batch values in the LSTM functions will give us the best possible accuracy if applied correctly. The model predicts the value, and to check its efficiency, the statistic mean absolute error is considered.

	Date	Open	High	Low	Close	Adj Close	Volume
0	2014-09-17	465.864014	468.174011	452.421997	457.334015	457.334015	2.105680e+07
1	2014-09-18	456.859985	456.859985	413.104004	424.440002	424.440002	3.448320e+07
2	2014-09-19	424.102997	427.834991	384.532013	394.795990	394.795990	3.791970e+07
3	2014-09-20	394.673004	423.295990	389.882996	408.903992	408.903992	3.686360e+07
4	2014-09-21	408.084991	412.425995	393.181000	398.821014	398.821014	2.658010e+07
...	...	...	...	...	...	...	...
1927	2019-12-27	7238.141113	7363.529297	7189.934082	7290.088379	7290.088379	2.277736e+10
1928	2019-12-28	7289.031250	7399.041016	7286.905273	7317.990234	7317.990234	2.136567e+10
1929	2019-12-29	7317.647461	7513.948242	7279.865234	7422.652832	7422.652832	2.244526e+10
1930	2019-12-30	7420.272949	7454.824219	7276.308105	7292.995117	7292.995117	2.287413e+10
1931	2019-12-31	7294.438965	7335.290039	7169.777832	7193.599121	7193.599121	2.116795e+10

Figure 2. Sample Data

The sample data used is shown in Fig. 2. Based on Fig. 3, we get our data from yahoofinance.com. After reading the csv file, we apply feature extraction to it, and retrieve the important features. We split it into train and test datasets, apply LSTM layers, train the model, and post process it to show the prediction.

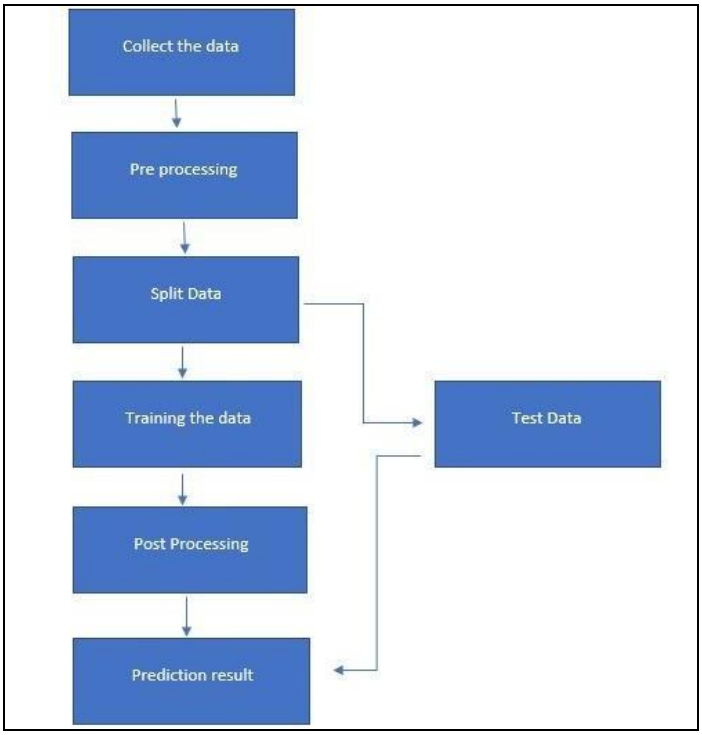

Figure 3. Flowchart of Process

Results

Fig. 4 shows the pre-processing stage when we load the dataset into the algorithm and show the opening and trading prices before we train and test the datasets.

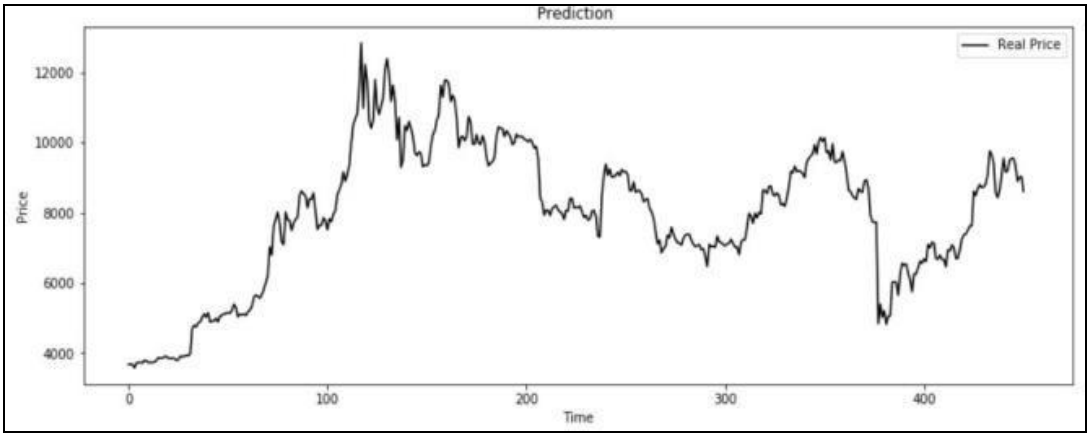

Figure 4. Price Action

Total data timestamps in our dataset are from May 2020 to August 2021, we have made the datasets split into two sets: for testing and training. Division has been done along March, and the data before March is used as training and after is used for testing our model. Before we finalize our results, we measure the loss as a mean

absolute error function, because it is more interpretable than using mean squared error. Four layers of LSTM has been applied in the network. The number of Trainable parameters were 1,79,561. By playing with the batch size and epochs for each dataset, we strive to optimize our algorithm to provide us the closest prediction.

As we have used the MinMaxScaler function for scaling, we have scaled down values which we revert to bring it to a scaler form. After visualizing the data, we get the graph in the form of a matplotlib function. Here we have shown how we optimized the dataset for Bitcoin, Ethereum and YFI in our model. The projections of predicted prices yielded different accuracy in each case and we had to play with our layers, epochs and batch size to find the most optimized prediction.

Fig. 5 and 6 show the calculated price predictions for Bitcoin, and YFI respectively. Final observations from these experiments imply that Bitcoin analysis yielded not such a bad outcome, but it isn't enough if you are riding your money on it. The Bitcoin (BTC) data was more predictable than Ethereum (ETH) as more loss protection is experienced.

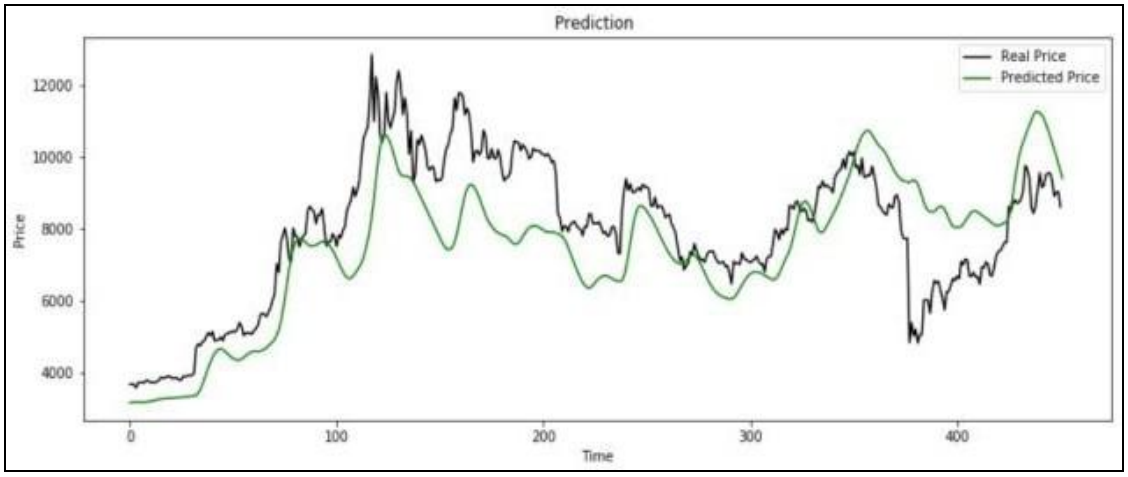

Figure 5. Predicted price of Bitcoin

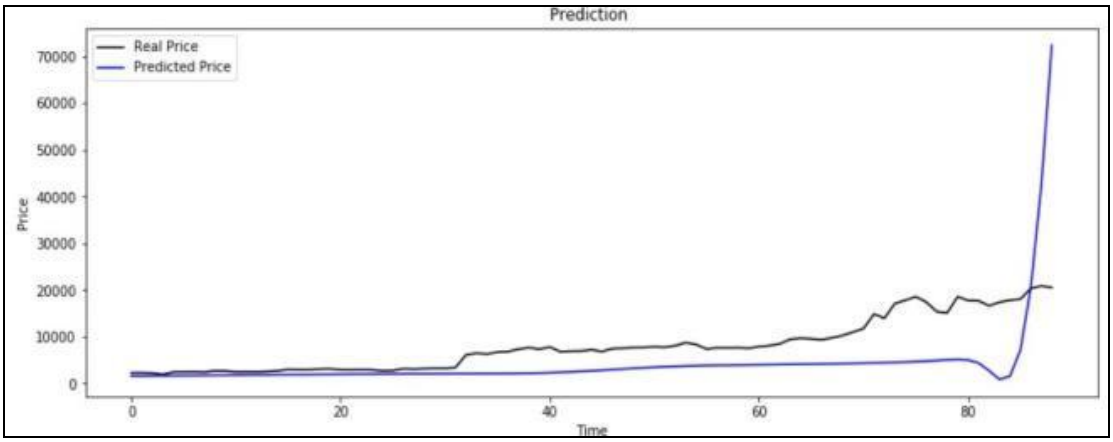

Figure 6. Predicted price of YFI

We saw a huge unaccounted spike in our predicted price in the case of Yearn.Finance (YFI), as depicted in Fig. 6, in the end dates of our model. This is due to the uncertainty that occurred in our feature extraction, while YFI also being highly volatile. The next price days according to our algorithm is around $15000.

Discussion

We have been successful in building a model capable of predicting crypto prices taking low, high, opening, and closing values, as well as volume of the currency traded as inputs. We explored different algorithms from past research work and experimented with the one that could best fit our requirements. Our model has shown decent results and accuracy. However, this paper should be treated as a study in interest in long-term short neural networks applied to cryptocurrency markets. It is wise not to rely solely on a deep learning model's prediction. Currencies like the ones examined in this study like Bitcoin, Ethereum, and YFI are extremely volatile. Price action of a crypto asset class depends on a variety of factors other than price action, such as the number of active users, revenue of the platform that the currency represents, and external events such as Fed rate hikes, regulations, etc.

Conclusion

There is scope for further exploration in this space. Cryptocurrency assets are a first step into the adoption of blockchain technology, which further has the potential to impact the way companies do business. There is potential for parabolic growth in crypto adoption and its market cap. It is expected that by 2030, the market cap will reach $10 trillion in asset worth. For this reason, it is prudent to explore which deep learning techniques can help an investor, regulator, or stakeholder accurately predict the prices of a cryptocurrency asset. This study was a start in this exploration. In the near future, I plan to continue this project to include other techniques such as ensemble learning, causal AI, and staking and blending. Additionally, I will include other assets, such as meme coins like Doge, Shiba, and analyze the relationship between crypto sub-cultures and their impact on the price actions. All of this while using deep learning and AI techniques to analyze social media behavior, price feeds, and engagement stats. This will be interesting because meme-coins are expected to go parabolic in the next cryptocurrency bull run in 2025.

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Ai and Its Application in Civil Engineering, a Vision of Trends

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Abstract: - Artificial intelligence (AI) transforms the construction industry by improving efficiency, reducing costs, and increasing safety. This study highlights the potential of tools such as predictive analytics and automation to optimize resources and minimize errors in project management. However, resistance to change is identified and exacerbated by a lack of training and education in using these technologies. High initial costs and the complexity of integrating existing systems represent significant challenges to their adoption, especially for small and medium-sized companies. The need for a comprehensive approach combining various technological tools, such as IoT and predictive analytics, is emphasized to maximize AI's positive impact. Current trends suggest continued growth in AI investments within the sector, presenting unique opportunities for companies to adopt these technologies. Finally, it is recommended that future research evaluate specific success stories and explore how regulations can be adapted to facilitate this transition. In conclusion, AI can contribute to a more efficient and sustainable future in construction, provided that the challenges associated with its implementation are addressed.

Keywords: AI, Civil Engineering, predictive analytics, automation

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Introduction

The construction industry has historically faced significant challenges, from inefficient resource management to workplace safety. In recent decades, the industry has begun to embrace emerging technologies, but the integration of artificial intelligence (AI) is still in its infancy. As the demand for sustainable and efficient infrastructure grows, it is imperative to explore how AI can address critical issues in this area.

The central problem lies in the resistance to change within the construction sector, which has traditionally been

reluctant to adopt new technologies. This contextual framework is further complicated by a lack of training and knowledge about available AI tools. Inefficiency in construction processes and high rates of workplace accidents are just some of the problems that require urgent attention. In this context, it becomes clear that the adoption of AI-based solutions can offer innovative responses to these challenges.

Studying this problem is crucial, as construction accounts for a significant share of global gross domestic product (GDP) and is responsible for a large proportion of carbon emissions. Effective implementation of AI-based technologies can not only improve operational efficiency and reduce costs but can also contribute to more sustainable and safer practices. Therefore, understanding how to integrate AI into this sector is critical to its future evolution.

Over the past few years, significant efforts have been made to investigate the impact of AI on construction. The State of the Art reveals a growing number of studies addressing specific applications, such as predictive analytics and process automation (Molina-Recalde & Molina-Granja, 2023). However, despite these advances, gaps in knowledge persist on how to implement these technologies effectively and sustainably.
The author's motivation for making this proposal stems from the recognition that, although promising tools exist, their adoption remains limited. It is essential to develop a framework that not only facilitates the implementation of AI in construction projects but also addresses concerns about costs and training. This research seeks to contribute to cultural change within the sector, promoting an open mind towards technological innovation.

The main objective of the article is to analyze how AI-based tools can be effectively integrated into the construction project life cycle. A methodological approach is proposed to assess the potential impact of these technologies in terms of efficiency, safety, and sustainability. The research is not only focused on identifying best practices but also on offering practical recommendations for their implementation.

Regarding the proposal presented in this article, a comprehensive model is suggested that combines predictive analytics with automation and constant monitoring through IoT. This approach seeks to optimize resources and improve occupational safety while promoting a more sustainable environment.

Finally, the article is organized into several key sections: first, a comprehensive review of the state of the art will be presented; then the methods used for the analysis will be addressed; later the findings and their relevance will be discussed; and finally, conclusions and recommendations for future research will be offered. Through this structure, it seeks to provide a clear and accessible vision of the transformative role that artificial intelligence can play in the construction sector.

Contextualization

Artificial intelligence (AI) has revolutionized the civil engineering and construction industry in recent years.

Through various applications, AI has improved the efficiency, safety, and sustainability of projects. This theoretical framework is based on the contributions of multiple authors and recent studies, analyzing the advantages, disadvantages, opportunities, and challenges presented by AI in this field. (Kineber, y otros, 2024)

Implementing AI enables the automation of repetitive tasks and the analysis of large volumes of data, resulting in greater operational efficiency. According to StackCT (2024), the use of artificial neural networks helps predict cost overruns and project delays, allowing managers to make informed decisions before significant problems arise. (Stack, 2024)

AI's ability to analyze data in real time facilitates more effective project management. Peiris (2024) highlights that, through predictive algorithms, AI can identify risks and optimize task scheduling, resulting in more informed decision-making. (Peiris, Hui, Duffield, & Ngo, 2023)

AI also contributes to improving workplace safety. Technologies such as computer vision image analysis can detect dangerous situations, such as workers without personal protective equipment (PPE), reducing the risk of workplace accidents. (Uma, 2023)

The adoption of AI-based technologies can require significant investment in software and hardware, which can be a hurdle for small businesses in the construction industry. As businesses become more reliant on these technologies, the risk of cyber vulnerabilities that can compromise data security arises. Automation can lead to a significant reduction in certain traditional jobs, raising concerns about the future of employment in the sector. (Kineber, y otros, 2023) (Pan & Zhang, 2021)

The integration of emerging technologies such as digital twins and drones offers new ways to optimize construction processes from planning to maintenance. These tools allow teams to anticipate potential delays and optimize resource allocation. (York, 2024)

AI can help manage energy consumption and other resources, thus reducing the environmental impact of construction projects. This is especially relevant given the growing focus on sustainable construction practices. (Masyhur, Alias, Haron, & Zulkafli, 2024)

AI-based tools can facilitate staff training, helping to close skills gaps needed to operate advanced technologies. (Fabio, Giuditta, Margherita, & Raffaeli, 2025)

Artificial intelligence (AI) has begun to transform the construction industry, offering innovative solutions to improve efficiency, safety, and sustainability. In recent years, various tools and applications have been developed that use AI to optimize different aspects of the life cycle of a construction project. (Regona, Yigitcanlar, Hon, & Teo, 2024)

AI Tools in Construction

- **OpenSpace.ai .-** OpenSpace.ai is notable for its visual documentation platform that captures 360-degree images of the construction site. This tool allows teams to document progress efficiently, facilitating real-time data analysis and improving communication between stakeholders. (Openspace, 2024)
- **ClickUp.-** It focuses on project management and productivity, making planning and execution easier through its customizable interface. (York, 2024)
- **Procore .-** Procore is an end-to-end solution that offers a comprehensive set of tools for project management. With more than 1.6 million users, its ability to integrate advanced analytics and automation into document management has been instrumental in optimizing construction processes and improving collaboration between teams. (Procore, 2024)
- **Fusion 360.-** Autodesk's Fusion 360 uses AI-based generative design capabilities to optimize architectural and structural designs. This tool allows designers to explore multiple alternatives before making final decisions, resulting in more efficient and sustainable solutions. (Autodesk, 2024)
- **Fieldwire .-**Fieldwire is a tool that allows you to track construction progress by analyzing data in real time. Its ability to aggregate information from a variety of sources helps teams visualize trends and anomalies, facilitating informed decision-making. (Fieldwire, s.f.)

Comparative Study of AI Tools Applied in Construction

Artificial intelligence (AI) has begun to play a crucial role in the construction industry, optimizing processes, improving safety, and facilitating decision-making. Below is a comparative study of four prominent AI tools in the construction sector, analyzing their characteristics, advantages, and disadvantages. See Table 1.

This comparative study highlights how each tool has its unique features, advantages, and disadvantages, allowing companies to choose the most suitable solution according to their specific needs within the construction sector.

Artificial intelligence is revolutionizing the way projects are managed and executed in the construction industry. Each tool presented has its strengths and weaknesses, which means that the right choice will depend on the specific type of project and the team's needs. The effective implementation of these technologies can result in a significant improvement in efficiency, safety, and sustainability within the sector.

Table 1.- Comparative study of outstanding AI tools in the construction sector.

Tool		Special Features	Advantages	Disadvantages
OpenSpace.ai	OpenSpace.ai is a pioneering tool in data analysis for pre-construction, specializing in visual documentation using	• Visual Documentation: Capture images of the site in virtual tours, making it easy to track progress.	• Improves transparency by allowing all stakeholders to visualize project	• It requires a significant upfront investment in hardware to capture

	360-degree images.	• Data Analysis: It uses AI to analyze captured images and provide detailed reports on the status of the project. • Integration with BIM: Integrates with BIM tools to improve project planning and execution.	progress. • Reduce time spent on manual inspections. • It helps identify problems before they become costly mistakes.	360-degree images. • The quality of the analysis depends on the quality of the images captured. • It requires investment in hardware to capture 360-degree images.
ClickUp	ClickUp is a comprehensive project management platform that incorporates AI tools to improve productivity and collaboration in the construction industry.	• Project Management: Allows you to track work on-site using more than 15 customizable views. • Automation: Offers automated features for repetitive tasks, saving time and reducing errors. • Collaboration: Facilitates communication between teams through real-time feedback and updates.	• Or an Intuitive interface that enhances the user experience. • Or Flexibility to adapt to different types of projects. • Or Integration with other popular tools, such as Google Drive and Slack.	• High learning curve. It can be overwhelming for new users due to its wide range of features. • Some advanced features require a premium subscription.
Procore	Procore is a complete construction management platform that offers a robust set of AI-based tools to manage projects from inception to completion.	• Document Management: Automated control of documents and workflows. • Advanced Reporting: Automatic report generation that helps managers make informed decisions. • Effective Collaboration: Allows teams to coordinate tasks and allocate resources efficiently.	• Wide global adoption with over 1.6 million users. • Integrated functionalities that facilitate the integral management of the project. • Good technical support and educational resources are available. • Wide global adoption, and integration with other BIM technologies and tools. technical support	• It can be expensive for small businesses or limited projects. • The learning curve can be steep due to its complexity. •
Fusion 360	Fusion 360 is a CAD tool that incorporates advanced AI-based capabilities, designed for engineers and architects looking to optimize their designs.	• Generative Design: Uses algorithms to generate multiple design options based on specific parameters. • Simulation and Analysis: Offers built-in tools to simulate performance and validate ideas before construction.	• Powerful ability to optimize complex designs using advanced simulations. • Seamless integration with other Autodesk products, making workflow easier. • Access to constant updates thanks to its	• It requires a monthly subscription which can be expensive for some users ($70/month). • Limitations in offline functionality, which can be inconvenient in remote sites without internet access.

		• Real-Time Collaboration: Allows teams to work together from different geographic locations.	cloud-based model.	
Fieldwire	It offers tools for progress tracking and task management, allowing teams to maintain control over project progress in real time.	• Real-time data analysis, and project progress tracking.	• It facilitates informed decision-making and improves operational efficiency.	• It may require additional training for effective use.

Specific AI Applications

AI is applied in various areas within the construction sector: (Raduis, 2024)

Design Optimization: Algorithms can analyze large volumes of data to generate optimized solutions in terms of energy efficiency and aesthetics.

Planning and Scheduling: AI improves planning by analyzing schedules and available resources, allowing real-time adjustments to avoid delays.

Cost Estimation: AI-based tools can make accurate estimates by analyzing historical data and patterns, reducing human errors in calculations.

Risk Prediction. - Through the analysis of historical data and predictive modeling, AI can identify and foresee possible risks in construction projects

Automated Quality Control. - AI is used to perform quality checks and perform automated inspections on Building Modeling Information (BIM) models.

Advanced Simulation and Visualization. - AI allows the creation of advanced simulations and visualizations of construction projects. The algorithms can generate simulation models that predict the building's performance in terms of lighting, ventilation, acoustics, and energy efficiency.

Smart Construction. - The integration of AI with building information modeling (BIM) forms a powerful duo. AI enables intelligent design proposals and better planning decisions.

Automatic BIM Model Generation. - Generative AI enables the automatic generation of BIM models from input data, such as architectural plans, laser scans, and photographs. Algorithms can interpret this information and create detailed and accurate BIM models in a matter of minutes, saving time and reducing manual workload.

Integration of Renewable Energies. - AI is applied in the integration of renewable energies in construction projects. Advanced algorithms can optimize the use of renewable energy resources, improving the sustainability of projects.

Analysis of Trends and Opportunities in the Application of Artificial Intelligence in Construction

The construction industry has historically been resistant to the adoption of new technologies, but in recent years, artificial intelligence (AI) has begun to transform this sector. This analysis focuses on emerging trends and the opportunities that AI presents to improve efficiency, safety, and sustainability in construction.

Emerging Trends in AI for Construction

Automation and Efficiency. - Automation is one of the most significant trends driven by AI. AI tools are making it possible to automate repetitive tasks such as data entry, project tracking, and resource management. According to Cedreo (2024), this automation not only saves time but also reduces human error and improves accuracy in projects. Example: Platforms like Procore use AI algorithms to optimize task scheduling, allowing teams to quickly adapt to unforeseen changes to the project. (Cedreo, 2024)

Risk Prediction.- The ability to analyze large volumes of data and spot patterns is critical to proactive risk management. AI makes it possible to foresee potential problems before they occur, facilitating more efficient planning. OpenSpace.ai, for example, uses predictive analytics to identify potential design delays and conflicts, allowing teams to take preventative action. This predictive capability not only improves time and cost management but also increases safety by allowing teams to identify hazards before they become incidents. (Baghalzadeh Shishehgarkhaneh, Moehler, Fang, Aboutorab, & Hijazi, 2024)

Integration with IoT and Drones.- The combination of AI with the Internet of Things (IoT) and drones is revolutionizing the way construction projects are managed. IoT sensors allow site conditions to be monitored in real time, while drones provide critical visual data for tracking progress. This integration improves decision-making by providing accurate and up-to-date information on project status, allowing for immediate adjustments. (Rashid & Kausik, 2024)

Opportunities Offered by AI in Construction

Sustainability.- Sustainability has become a key focus within the construction sector. AI can help optimize resource use and minimize waste through predictive analytics. Not only does this help reduce costs, but it also helps companies comply with increasingly stringent environmental regulations. For example, AI-based tools can analyze historical patterns of energy consumption and forecast future needs, thus facilitating more energy-efficient design. (Assets, 2024)

Improvement in Occupational Safety.- Safety is a primary concern in any construction project. AI can make a significant contribution to improving working conditions by constantly monitoring the site and automatically identifying potential risks. Systems such as those used by leading companies incorporate smart cameras that analyze video in real-time to detect dangerous behavior or unsafe situations. (Assets, 2024)

Optimization of Design and Planning.- AI enables advanced simulations and optimization of architectural design based on specific criteria such as cost, energy efficiency, and structural requirements. This helps designers explore multiple options before making final decisions. The ability to generate optimal designs not only saves time during the initial project phase but also minimizes costly errors during construction. (Kineber, y otros, 2024)

Challenges Associated with Implementing AI

Despite the numerous opportunities, there are significant challenges that must be addressed for effective implementation: (Assets, 2024) (Kineber, et.al., 2024)

High Upfront Costs: The upfront investment required to adopt AI-based technologies can be prohibitive, especially for small businesses in the sector. This may limit their ability to compete with larger companies that can afford these investments.

Resistance to Change.- The traditionally conservative culture of the construction sector can make it difficult to quickly adopt new technologies. Resistance to change is a common obstacle that must be overcome through education and continuous training.

Complex Technology Integration: Effectively integrating AI-based tools with existing systems can be tricky. The lack of interoperability between different technology platforms can limit their effectiveness.

As we move into 2024 and beyond, it is anticipated that the role of artificial intelligence will continue to expand within the construction sector, with a significant increase in investments in AI-based technologies expected within the construction sector. According to recent projections, these investments are expected to reach multimillion-dollar figures by 2031.

Technological innovations will continue to drive significant changes in how construction projects are planned, executed, and maintained. The combined use of digital twins and artificial intelligence will enable more efficient management based on accurate data.

The future also points towards smarter built environments thanks to the continuous integration of advanced technologies such as IoT, robotics, and artificial intelligence. This will not only improve operational efficiency but also contribute to creating more sustainable and climate-resilient infrastructures.

The analysis reveals that artificial intelligence is positioning itself as a key driver to transform the construction sector towards a more efficient, safe, and sustainable model. As companies begin to embrace these emerging technologies, significant opportunities present themselves to improve all aspects of the construction project lifecycle.

However, it is crucial to address the challenges associated with its implementation to maximize its potential benefits. Continuing education, strategic investment, and a proactive approach to change will be essential to navigating this changing technology landscape.

Ultimately, the future of the construction sector will depend not only on how these technologies are adopted but also on how they are integrated into an organizational culture willing to innovate and adapt to an increasingly

competitive and demanding environment.

Methodology

The analysis is based on a systematic review of recent literature on the application of artificial intelligence in construction. Qualitative and quantitative methods have been used, including:

Literature Review: A comprehensive review of relevant academic articles, industry reports, and case studies documenting current and emerging applications of AI in the sector was conducted.

Semi-Structured Interviews: Interviews were conducted with industry professionals to gain perspectives on the practical applications of AI and the challenges companies face when adopting these technologies.

Comparative Study: Projects that have integrated AI-based solutions will be compared with those that have not evaluated significant differences in efficiency, costs, and overall outcomes.

This approach will enable a comprehensive understanding of the impact that artificial intelligence has on the field of civil engineering and construction, providing a solid foundation for future research.

Discussion

The study's findings indicate that artificial intelligence has the potential to not only improve operational efficiency in construction but also to completely transform how projects are managed. The tools analyzed show that the implementation of AI can significantly reduce delivery times and costs associated with construction projects. OpenSpace.ai and Procore have proven to be particularly effective in enabling more streamlined and documented management of progress.

The use of technologies such as Fieldwire has allowed companies to monitor working conditions in real time, identifying potential risks before they become serious incidents. This not only protects workers but also reduces costs related to workplace accidents. AI's ability to optimize architectural designs contributes to more sustainable practices within the construction sector. Tools such as Fusion 360 allow energy performance to be assessed before physical construction begins, resulting in more energy-efficient buildings.

Despite the transformative potential, significant challenges such as high upfront costs and resistance to change within the sector remain. A lack of adequate training also limits the effective adoption of these technologies. Companies need to invest in continuous training for their staff. As investments in AI-based technologies continue to grow, their adoption is expected to expand further. Current trends suggest a future where the integration between AI, IoT, and other emerging technologies will redefine the construction landscape.

This analysis reveals that artificial intelligence not only offers innovative solutions to existing problems in the construction sector but also presents significant opportunities to improve all aspects of the construction project life cycle. The key will be to address the challenges associated with its implementation to maximize its potential benefits.

Conclusions

Research conducted on the influence of artificial intelligence (AI) on the construction sector has revealed several significant findings that underscore both the transformative potential of these technologies and the challenges that need to be addressed for their effective implementation. Key findings from the study are as follows:

AI has the potential to revolutionize the construction industry by improving efficiency, reducing costs, and increasing safety. Tools such as predictive analytics and process automation have proven their ability to optimize resources and minimize errors, resulting in more effective project management. The adoption of these technologies can not only speed up delivery times but also contribute to more sustainable practices.

One of the most relevant findings of the study is the critical need for training and education in the use of AI-based tools. Resistance to change within the sector is exacerbated by a lack of knowledge about how to implement and use these technologies. Companies must invest in continuous training for their staff, which will facilitate a smoother transition to a more digitized work environment.

Despite the excitement about the opportunities offered by AI, there are significant challenges that need to be overcome. The high upfront costs associated with adopting advanced technologies can be a barrier, especially for small and medium-sized businesses. In addition, integration with existing systems can be complex and require considerable effort to ensure interoperability.

The study highlights the importance of taking a comprehensive approach that combines different tools and technologies to maximize the positive impact of AI in construction. The combination of predictive analytics, automation, and IoT monitoring can offer robust solutions to today's industry problems. This approach not only improves operational efficiency but also promotes a safer work environment.

Current trends indicate that the use of AI in construction will continue to grow in the coming years, with projections suggesting multi-billion dollar investments in this field. This presents a unique opportunity for companies to take a proactive role in implementing advanced technologies, which could result in significant competitive advantages.

Future Work

Finally, the study suggests that future research should focus on evaluating specific success stories in the implementation of AI in construction projects. It would also be beneficial to explore how regulations and policies can be adapted to facilitate this technological transition. Collaboration between academic institutions, companies, and regulatory bodies will be crucial to create an ecosystem conducive to innovation.

This study concludes that artificial intelligence has the potential not only to transform how projects are managed in the construction sector but also to contribute to a more sustainable and secure future. However, it is essential to address the challenges associated with its implementation through appropriate education, strategic investment, and a collaborative approach among all actors involved.

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Ai in the Diagnosis of Low-Prevalence Diseases in Children

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Abstract:- The research focuses on the application of artificial intelligence (AI) in the diagnosis of low-prevalence diseases in children, a critical area due to the complexity and diversity of symptoms that these conditions present. Despite advances in medical technology, early diagnosis remains a challenge, which can lead to delays in treatment and affect the quality of life of patients. AI offers significant opportunities to improve diagnostic accuracy and facilitate early detection, as evidenced in successful cases such as PheNet and Face2Gene. However, it also raises important ethical considerations, including algorithmic biases, lack of transparency, data privacy, and inequality in access to advanced technologies. The research highlights the need for a clear ethical framework to guide the implementation of AI in pediatrics, ensuring that benefits are maximized while risks are mitigated. Ultimately, this research seeks to contribute to a more effective and equitable approach to the diagnosis of low-prevalence diseases in children through the responsible use of artificial intelligence.

Keywords: PheNet, Face2Gene, medicine, diagnosis

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Introduction

Artificial intelligence (AI) has emerged as a transformative tool in various fields, and medicine is no exception. In particular, medical diagnosis has undergone significant change thanks to AI's ability to analyze large volumes of data and detect patterns that can be difficult for healthcare professionals to identify. However, despite these advances, the diagnosis of low-prevalence diseases in children remains a considerable challenge, due to the complexity and diversity of symptoms presented by these conditions.

Diseases of low prevalence affect a small percentage of the population, but their impact can be devastating, especially in children. With more than 7,000 different types of low-prevalence diseases identified, many of them are genetic and present symptoms that can be mistaken for other, more common conditions. This confusion can lead to late or incorrect diagnoses, delaying proper treatment and affecting the quality of life for patients and

their families. In this context, AI is presented as a potential solution to improve the accuracy and speed of diagnosis.

Studying the use of AI in diagnosing low-prevalence diseases in children is crucial for several reasons. First, early diagnosis can be vital to initiating effective treatments that significantly improve the patient's quality of life. In addition, understanding how AI can optimize this process can contribute to reducing the emotional and financial burden faced by families affected by these diseases. Therefore, addressing this problem not only has medical implications but also social and economic ones.

Over the past few years, significant efforts have been made to integrate AI into medical diagnostics. Recent research has shown that advanced algorithms can identify phenotypic and genetic patterns associated with low-prevalence diseases with remarkable accuracy. Tools like PheNet and Face2Gene have shown promising results by facilitating faster and more accurate diagnoses. However, there are still limitations in terms of the quality of the data used to train these systems and their implementation in clinical settings.

The motivation behind this article lies in the urgent need to improve diagnostic methods for diseases of low prevalence in children through the effective use of AI. As these technologies continue to evolve, it is essential to explore how they can be applied to address current gaps in medical diagnostics. The proposal seeks not only to highlight the opportunities offered by AI but also to identify areas where more research and development is needed.

The main objective of this article is to analyze how AI can positively influence the diagnosis of low-prevalence diseases in children. Through a thorough review of the current state of the art and concrete examples of successful applications, it seeks to establish a framework that will facilitate future research and development in this critical area. The proposal presented in this article includes a detailed analysis of successful cases where AI has been implemented to improve the diagnosis of low-prevalence diseases. In addition, recommendations are suggested to optimize the use of these technologies in clinical settings, addressing challenges such as data quality and the ethical considerations involved.

The article is organized into several sections: first, a theoretical framework on AI in medicine will be presented; then specific cases where it has been successfully used to diagnose diseases of low prevalence will be addressed; Later, the ethical and social implications will be discussed; Finally, conclusions and recommendations for future research will be offered. This structure will allow the reader to understand both the context and the opportunities presented by AI in pediatric diagnosis.

Contextualization

Artificial intelligence (AI) has emerged as a transformative tool in the field of health, especially in the diagnosis of low-prevalence diseases in children. These conditions, which often present complex and uncommon

symptoms, can be difficult to diagnose, delaying proper treatment and affecting patients' quality of life. This theoretical framework examines how AI influences the diagnosis of low-prevalence diseases in children, analyzing success stories, statistics, and current trends. (Athar, 2024) (Rousta, y otros, 2024)

Diseases of low prevalence are those that affect a small percentage of the population. It is estimated that there are between 6,000 and 8,000 diseases of low prevalence, many of which are genetic and affect children. The difficulty in diagnosing these diseases lies in their low prevalence and the variability of their symptoms. (Herr, y otros, 2024)

Artificial Intelligence in Medicine refers to computer systems that can perform tasks that normally require human intelligence, such as learning, problem-solving, and decision-making. In medicine, AI is used to analyze large volumes of clinical data, medical images, and electronic records to support diagnosis and treatment. (Zelin, Chung, Jeanne, Zhang, & Weng, 2024) (Pandurangan, Meena, Karthick, & Moovendhan, 2024)

Applications of AI in the Diagnosis of Diseases of Low Prevalence. –
AI can help identify patterns in data that might go unnoticed by doctors. For example, deep learning algorithms have proven effective in the early detection of autism by analyzing magnetic resonance imaging. (Fatima, y otros, 2024)

Predictive models can assess the likelihood of a child developing a low-prevalence disease based on genetic and environmental factors. This allows for early and personalized interventions. (Jeddi, Gryech, Ghogho, Hammoumi, & Mahraoui, 2021)

AI-based tools can analyze symptoms reported by parents and doctors to suggest possible diagnoses. This has shown promising results in identifying conditions such as neonatal jaundice with an 85% success rate. (Mijwil, Abotaleb, & Dutta, 2024) (Hallowell, Badger, McKay, Kerasidou, & Nellåker, 2023)

Success Stories.-

- *Autism Screening.-* A study by Hazlett et al. used deep neural networks to analyze brain imaging and achieved 94% accuracy in predicting autism. This approach not only improves diagnostic accuracy but also speeds up the process. (Galdo, y otros, 2024)
- *Diagnosis of Neonatal Jaundice* An AI-based system was developed to detect neonatal jaundice using image processing techniques. This system compared its results with standard analysis and showed an effectiveness of 85%, which represents a significant advance in early diagnosis. (Kowshik, 2024)
- *Evaluation of Abnormal Movements.-* AI pose estimation has been used to classify abnormal movements in children with cerebral palsy. This method allows for a more accurate diagnosis and continuous monitoring of the patient's progress. (Maguiña & Vasquez-Roque, 2023)

Statistics on the Application of AI.- Since 2016, there has been an exponential increase in publications related

to the use of AI in pediatrics. This indicates a growing interest in and investment in technologies that improve the diagnosis and treatment of low-prevalence diseases. According to a McKinsey report, it is estimated that AI could generate significant value in healthcare, optimizing diagnoses and reducing costs. Artificial intelligence is revolutionizing the diagnosis of low-prevalence diseases in children by providing accurate and efficient tools that can speed up the diagnostic process and improve clinical outcomes. As we move towards more personalized, data-driven medicine, it is essential to continue researching and developing these technologies while addressing the ethical implications associated with their use.(Castillo, y otros, 2019) (Maguiña & Vasquez-Roque, 2023) (Vorecol, 2024) (Galdo, y otros, 2024)

This theoretical framework provides a solid basis for understanding how AI can positively influence the early and accurate diagnosis of low-prevalence diseases in children, opening up new possibilities to improve their medical care.

Methodology

To establish a research methodology on the influence of artificial intelligence (AI) in the diagnosis of diseases of low prevalence in children, the approach proposed by Hernández Sampieri can be followed, adapting it to the specific needs of the study. Each component of the methodology is detailed below:

Definition of the Problem.- The central problem is to determine how AI can improve the diagnosis of diseases of low prevalence in children, considering the current limitations in traditional diagnostic methods.

Research Question.- How does AI influence the diagnosis of low-prevalence diseases in children?

Research Objectives

- **General:** To evaluate the effectiveness of AI in diagnosing low-prevalence diseases in children.
- **Specific:**
  - Analyze success stories in the application of AI for diagnosis.
  - Collect statistics on the effectiveness of these tools.
  - Identify current trends in the use of AI in pediatrics.

Literature Review.- An exhaustive review of previous studies on AI applications in medicine, especially in pediatrics, documented cases where AI has been used to diagnose low-prevalence diseases, challenges, and limitations associated with the use of AI in this field is carried out.

The type of study is bibliographic and systematic. This methodology provides a structured framework for investigating how artificial intelligence can positively influence the diagnosis of low-prevalence diseases in children.

Analysis of ai in pediatric diagnosis

Success stories in the application of AI for diagnosis.

Artificial intelligence (AI) has transformed the medical diagnostics landscape, offering innovative and efficient

solutions that have improved accuracy and speed in disease identification. This essay explores success stories in the application of AI for diagnosis in general, with a particular focus on its use to diagnose low-prevalence diseases in children.

Success Stories in General Diagnosis

One of the most prominent examples of the use of AI in diagnosis is its application in cancer detection. A study published in The Lancet Digital Health showed that an AI system developed by the German company Vara, in collaboration with radiologists, achieved a 2.6% higher success rate in detecting breast cancer compared to radiologists working alone. This system analyzed more than 367,000 mammograms and helped significantly reduce false positives and negatives, which not only improves diagnostic accuracy but also eases the workload of specialists. (Leibig, y otros, 2022) (Marinero, 2022)

AI has also shown promising results in diagnosing neurological diseases. For example, algorithms that analyze magnetic resonance imaging (MRI) scans have improved diagnostic accuracy in patients with multiple sclerosis by 44%, reducing the time needed to interpret the images. This is crucial in a field where time is of the essence to initiate effective treatments. (Philips, 2022)

In oncology, AI has made it possible to reduce the time needed to analyze genomic data from weeks to hours. This has optimized the selection of specific therapies for cancer patients, increasing treatment response rates by 30%. Integrating clinical data using AI facilitates more informed and timely decisions by medical teams. (Vorecol, 2024)
AI-based tools have proven effective in automatically monitoring vital signs, helping to identify early signs of deterioration in hospitalized patients. This has led to a 35% reduction in serious adverse events and an 86% reduction in cardiac arrests. This preventive approach is essential to improve clinical outcomes and save lives. (itTrends, 2022) (Philips, 2022)

Application of AI in the Diagnosis of Diseases of Low Prevalence in Children

Diseases of low prevalence are often difficult to diagnose due to their low prevalence and variability in symptoms. This situation is exacerbated when it comes to children, as the symptoms can easily be confused with other, more common conditions. Lack of an accurate diagnosis can result in significant delays that complicate treatment and affect the patient's quality of life. (Roche, 2024)

A notable case is the development of the PheNet algorithm by researchers at the University of Los Angeles (UCLA), specifically designed to identify low-prevalence diseases such as common variable immunodeficiency (CVID). This algorithm uses electronic records to compare phenotypic patterns between diagnosed and undiagnosed patients, managing to detect more than 64% of patients with CVID one or more years earlier than traditional methods. Not only does this reduce the time to diagnosis, but it also decreases the complications

associated with late diagnoses. (Roche, 2024)

Effective AI implementation can radically transform the approach to low-prevalence diseases. By allowing for faster and more accurate diagnoses, unnecessary hospitalizations and inadequate treatments can be avoided, thus improving the quality of life for many affected children.

Artificial intelligence is proving to be an invaluable tool in the field of medical diagnostics, for both common and low-prevalence diseases. The successful cases illustrate how collaboration between humans and machines can lead to better clinical outcomes, optimizing processes and reducing diagnostic errors. In particular, its application in the early diagnosis of low-prevalence diseases offers new hope for many children facing complex and challenging conditions. As these technologies continue to evolve, it is critical to continue researching their potential and applying them ethically to maximize their benefits in healthcare.

Effectiveness of AI in diagnosing diseases.

Artificial intelligence (AI) has emerged as a revolutionary tool in the field of medical diagnostics, offering solutions that not only improve accuracy but also optimize patient care processes. This essay examines the efficacy of AI in diagnosing diseases, supported by relevant statistics and success stories, with a special focus on its application to diagnose low-prevalence diseases in children. (Molina-Recalde, Marakala, Bhattacharya, & Mukherjee, 2022)

Efficacy of AI in Medical Diagnosis.-The implementation of AI in medical diagnostics has proven to be effective in various areas. According to a report, diagnostic errors are responsible for 10% of deaths and 17% of complications in patients, underscoring the urgent need to improve diagnostic accuracy through new technologies. AI is presented as a viable solution, as it can analyze large volumes of clinical data and detect patterns that could go unnoticed by humans. (Innowise, 2022) (Bahadori, y otros, 2023)

Success Stories in General Diagnosis .-Cancer Screening: A collaborative study between radiologists at Essen University Hospital and Memorial Sloan Kettering Cancer Center showed that when physicians worked alongside an AI system, the success rate in detecting breast cancer increased by 2.6% compared to radiologists working alone. In addition, this system managed to significantly reduce the rate of false positives. This is crucial, as early detection can significantly increase survival rates. (Marinero, 2022)

Neurological Diseases: AI has shown promising results in the early diagnosis of neurological diseases. Algorithms that analyze MRI images have improved diagnostic accuracy by 44%, allowing treatments to be started more quickly and improving long-term outcomes. (Kale, y otros, 2024)
Continuous Monitoring: AI-based tools have been implemented to monitor vital signs in hospitalized patients, reducing serious adverse events by 35% and cardiac arrests by 86%. This demonstrates how AI not only improves diagnosis but also contributes to prevention. (Shaik, y otros, 2023) (Innowise, 2022)

Efficacy of AI in the Diagnosis of Diseases of Low Prevalence in Children

Diseases of low prevalence present a significant challenge due to their low prevalence and variability in symptoms. It is estimated that there are more than 7,000 different types of low-prevalence diseases, many of which are genetic and affect children. Difficulty in diagnosing these conditions can lead to significant delays in treatment.

PheNet Algorithm A prominent case is the PheNet algorithm developed by UCLA researchers, designed to identify low-prevalence diseases such as common variable immunodeficiency (CVID). This algorithm uses electronic records to compare phenotypic patterns between diagnosed and undiagnosed patients. In one study, it was shown that PheNet could have diagnosed 64% of patients with CVID one or more years before definitive diagnosis. This anticipation not only reduces costs associated with late treatments but also significantly improves the patient's quality of life. (Roche, 2024)

Face2Gene.- Another innovative tool is Face2Gene, which uses facial recognition algorithms to identify conditions related to low-prevalence diseases from photographs. This app has demonstrated 91% accuracy in providing differential diagnoses between the ten most likely conditions based on facial features. Although it is not a substitute for definitive genetic testing, it acts as a valuable tool to alert doctors to potential diagnoses before performing more expensive and time-consuming tests. (itTrends, 2022)

The global AI market in the healthcare sector is projected to reach a value of $7.3 billion by 2028, with a compound annual growth rate (CAGR) of 39.6%. (Innowise, 2022)

In the case of breast cancer, survival rates have improved thanks to more accurate diagnoses; however, it is still responsible for 7% of global cancer deaths. (Marinero, 2022)

Artificial intelligence is proving to be an effective and transformative tool in medical diagnosis. Its ability to analyze large volumes of data and detect complex patterns has led to significant improvements in diagnostic accuracy and reductions in time to diagnosis, especially for diseases of low prevalence in children.

As these technologies continue to evolve and integrate into clinical practice, it is critical to continue researching their potential and applying them ethically to maximize their benefits in healthcare. The collaboration between doctors and artificial intelligence promises to open new frontiers in personalized medicine, thus improving outcomes for all patients.

Current trends in the use of AI in pediatrics

Artificial intelligence (AI) has begun to transform the field of pediatrics, offering innovative tools to improve the diagnosis and treatment of diseases, especially in the context of diseases of low prevalence in children. This

essay explores current trends in the use of AI in pediatrics, highlighting its applications, benefits, and challenges.

One of the most promising applications of AI in pediatrics is its ability to facilitate the early detection of diseases. Recent studies have shown that deep learning algorithms can analyze medical images with greater accuracy than radiologists. For example, a study published in Pediatric Radiology found that an AI system could detect pneumonia in pediatric patients with 90% accuracy, surpassing the 80% achieved by human radiologists. This ability to identify critical conditions quickly can be crucial to improving clinical outcomes. (Fernández, 2023)

Diagnosing low-prevalence diseases in children represents a significant challenge due to the diversity and complexity of symptoms. AI has been used to identify unique patterns that could indicate these uncommon conditions. For example, the PheNet algorithm has proven to be effective in diagnosing common variable immunodeficiency (CVID), identifying up to 64% of cases a year or more earlier than traditional methods. This ability to predict diagnoses can significantly reduce the complications associated with late diagnoses. (Galdo, y otros, 2024)

AI is also driving personalized medicine in pediatrics. By analyzing large volumes of clinical and genomic data, algorithms can help personalize treatments based on individual patient characteristics. This is especially relevant in the treatment of childhood cancer, where predictive models are being used to anticipate chemotherapy-related complications. (Galdo, y otros, 2024)

With the increased use of digital technologies, AI has made it easier to continuously monitor patients through connected devices. This allows clinicians to be alerted to changes in the patient's condition in real time, which is vital for quick interventions. In addition, telemedicine has gained popularity, allowing virtual consultations that are essential for the follow-up of pediatric patients with chronic or low-prevalence diseases. (Otero, 2023)

Benefits of AI in Pediatrics

The integration of AI in pediatrics offers multiple benefits: a)Efficiency: Automating diagnostic processes reduces the workload on medical professionals, allowing them to focus more on patient care. b)Accuracy: AI-based systems can deliver more accurate diagnoses by analyzing complex data that is difficult to interpret manually. c)Enhanced Access: Digital tools allow for more accessible care, especially for remote or underserved communities.

Artificial intelligence is redefining the landscape of diagnosis and treatment in pediatrics, offering valuable tools to address both common and low-prevalence conditions. As these technologies continue to evolve, it is critical to continue researching their effective and ethical application.

Collaboration between clinicians and computer engineers will be essential to maximize the potential benefits while addressing the challenges inherent in its implementation. Ultimately, AI has the potential not only to improve clinical outcomes but also to radically transform how healthcare is delivered to children.

Discussion

Artificial intelligence (AI) has revolutionized the field of medical diagnosis, offering tools that promise to improve accuracy and efficiency in disease identification, especially in the context of diseases of low prevalence in children. However, its implementation also entails challenges and ethical considerations that must be analyzed. This discussion focuses on the advantages and disadvantages of applying AI in this area, providing a balanced analysis of the pros and cons.

Table 1.- Advantages and disadvantages of the application of AI in diagnosis

Advantages of the Application of AI	**Disadvantages and Challenges**
Improved diagnostic accuracy: AI algorithms can analyze large volumes of data and detect complex patterns that can be difficult for doctors to identify. This is especially useful in diagnosing low-prevalence diseases, where symptoms can be subtle and varied. Studies have shown that systems like PheNet can identify low-prevalence conditions with remarkable accuracy, reducing the time to diagnosis.	Data Quality and Bias: The effectiveness of AI algorithms is highly dependent on the quality and quantity of data used to train them. Incomplete or biased data can lead to misdiagnosis, which is particularly concerning in the context of low-prevalence diseases where less data is available.
Early Detection: AI's ability to process data quickly allows for earlier detection of diseases. Early diagnosis is crucial to initiating effective treatments that can significantly improve the patient's quality of life. For example, tools such as Face2Gene have shown promising results in facilitating differential diagnoses based on phenotypic characteristics.	Lack of Transparency: Many AI models function as "black boxes," meaning that their internal processes are not easily understood by humans. This lack of transparency can lead to mistrust among doctors and patients, who might be hesitant to fully trust an AI-based diagnosis.
Clinical Process Optimization: AI can automate repetitive tasks, freeing up time for doctors to focus on patient care. This can lead to greater efficiency in clinical settings, reducing	Ethical Considerations: The collection and use of sensitive data about children raises important ethical questions related to informed consent and privacy. It is

the burden on healthcare professionals and enabling more patient-centric care.	essential to ensure that the patient's rights are respected and confidentiality is maintained.
Access to Medical Resources: AI-based technologies can facilitate access to specialized diagnostics and treatments, especially in rural or underserved areas where medical resources are limited. AI-powered telemedicine can connect patients with specialists without the need for travel.	Inequality in Access: There is a risk that advanced technologies will not be equitably available to all patients, which could increase existing health disparities. Disadvantaged communities may not have access to AI-based tools, perpetuating inequalities in diagnosis and treatment.

General Analysis

The application of artificial intelligence in the diagnosis of low-prevalence diseases in children presents a mixed picture. On the one hand, the advantages are significant; Improved accuracy, early detection, and optimization of the clinical process are aspects that can radically transform how these complex conditions are diagnosed and treated. On the other hand, disadvantages related to data quality, lack of transparency, and ethical considerations should not be underestimated.

It is critical to address these challenges through ongoing research and appropriate ethical development. Rigorous standards must be established to ensure that the data used is representative and free of bias. In addition, it is essential to foster greater collaboration between technology developers, medical professionals, and policymakers to ensure that AI-based solutions are accessible and equitable.

Although artificial intelligence offers exciting opportunities to improve the diagnosis of low-prevalence diseases in children, its implementation needs to be carefully considered. A balanced approach that recognizes both advantages and disadvantages will maximize potential benefits while mitigating associated risks. As we move towards a future where AI will play an increasingly important role in healthcare, it is crucial to maintain a patient-centric approach that prioritizes both efficacy and ethics in its application.

Ethical Aspects

The implementation of artificial intelligence (AI) in medical diagnosis, especially in the context of diseases of low prevalence in children, raises a series of ethical considerations that are fundamental for its acceptance and effectiveness. While AI offers significant opportunities to improve diagnoses and treatments, it also carries risks that need to be carefully evaluated. This discussion addresses the ethical aspects associated with the use of AI in pediatrics, analyzing its advantages and disadvantages.

Table 2.- Ethical advantages and disadvantages of the application of AI in diagnosis

Ethical Advantages of the Application of AI	**Ethical Disadvantages and Challenges**
Improved Diagnostic Accuracy: AI can analyze large volumes of clinical data and detect patterns that may not be apparent to clinicians. This is crucial in the diagnosis of low-prevalence diseases, where symptoms can be subtle and varied. Improved diagnostic accuracy can lead to more timely and effective treatments, which directly benefit patients.	Algorithmic bias: AI systems can learn and reproduce existing biases in the data with which they are trained. This is especially concerning in the context of medical diagnosis, where bias could lead to incorrect or discriminatory diagnoses. For example, if an algorithm doesn't include enough data from diverse ethnicities, it might fail to recognize specific symptoms in certain racial groups.
Access to specialized diagnostics: AI can facilitate access to specialized diagnostics, especially in rural or underserved areas. This contributes to more equitable care and can reduce health disparities, allowing more children to receive appropriate care regardless of their geographic location.	Lack of Transparency: Many AI models operate as "black boxes," meaning that their decisions are difficult for humans to interpret. This lack of transparency can lead to mistrust among doctors and patients. The ability to understand how decisions are made is essential to maintaining trust in the healthcare system.
Clinical Process Optimization: By automating repetitive tasks, AI frees up time for clinicians to focus on patient care. Not only does this improve the efficiency of the healthcare system, but it can also increase patient satisfaction by receiving more personalized care.	Privacy and Informed Consent: The collection and use of sensitive data about children raises important ethical questions related to privacy and informed consent. It is critical to ensure that parents understand how clinical data will be used and that patient rights are respected. A lack of clarity about the use of this data can erode public trust in AI-based technologies.
	Inequality in Access: There is a risk that advanced technologies will not be equitably available to all patients, which could increase existing health disparities. Disadvantaged communities may not have access to AI-based tools, perpetuating inequities in diagnosis and treatment.

Artificial intelligence has the potential to transform medical diagnosis, especially in low-prevalence diseases in children, offering significant improvements in accuracy and access to specialized care. However, its implementation must be accompanied by a deep ethical reflection that addresses the risks associated with algorithmic biases, lack of transparency, privacy, and inequality in access. By establishing a strong ethical framework and fostering ongoing collaboration between technology developers, medical professionals, and

policymakers, the societal benefit of these technologies can be maximized while mitigating their inherent risks.

Conclusions

Research on the influence of artificial intelligence (AI) on the diagnosis of low-prevalence diseases in children has revealed significant results that answer the question posed: how does AI influence the diagnosis of low-prevalence diseases in children? Through the analysis of successful cases and the review of the state of the art, the following conclusions have been reached:

AI has proven to be a valuable tool for improving accuracy in diagnosing low-prevalence diseases. Algorithms such as PheNet and Face2Gene have shown promising results in identifying phenotypic and genetic patterns, allowing for faster and more accurate diagnoses. This is critical, as early diagnosis can be crucial to initiating effective treatments. The implementation of AI facilitates the early detection of low-prevalence conditions, which can significantly reduce the time to diagnosis and improve clinical outcomes. This aspect is especially relevant in pediatrics, where symptoms can be difficult to identify and can be confused with other more common diseases.

Despite its benefits, the application of AI also raises important ethical considerations, such as algorithmic bias, lack of transparency, and issues related to privacy and informed consent. It is essential to address these challenges to ensure responsible and equitable use of these technologies. The research underscores the importance of establishing a clear ethical framework to guide the implementation of AI in pediatric diagnostics. This includes ensuring the quality and diversity of the data used to train algorithms, as well as fostering transparency and explainability in decision-making processes.

Future work

The continuous integration of AI into medical diagnostics has the potential to radically transform pediatric care, especially for low-prevalence diseases. However, future research must focus on optimizing these applications while addressing ethical concerns and promoting equitable access to these technologies.

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Examining the Digitalization Process of the Social Studies Curriculum in Line with Teacher Opinions

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Abstract: Technology integration in education is defined as the effective incorporation of information and communication technologies (ICT) into teaching processes. This integration plays a critical role in facilitating both teachers' and students' access to information, improving their ability to collect and analyze data from different sources, as well as providing students with digital literacy. In Turkey, the Social Studies course is an interdisciplinary curriculum designed to enable students to understand social, historical and geographical events, develop citizenship awareness, and acquire basic values related to society. This study aims to examine the digitalization of the social studies curriculum in line with teachers' views. The study was conducted with a semi-structured interview form from qualitative research methods. The study group of the research consists of 6 social studies teachers. According to the data obtained, the reflection of technology integration in the Social Studies curriculum in Turkey is an important step towards the goals of digital transformation in education. The Social Studies course offers a multifaceted opportunity for this integration. However, the success of this process will only be possible by increasing teacher competencies, eliminating infrastructure deficiencies, and harmonizing course content with technology. Digitalization in education offers a great opportunity to develop students' 21st century skills and make them active members of the information society. The integration of technology into education offers important opportunities to enrich the teaching process of this course and make the course content more interesting. However, both strengths and challenges arise in this process.

Keywords: Digitalization, Technology, Education.

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Introduction

Today, the rapid development of technology has led to radical changes in many areas from education systems to individual learning methods (Alkan, 1984; Cakir et al., 2019; Ozturk, 2023; Yeşilorman & Koç, 2014). Digitalization in education enriches teaching and learning processes by contributing to making information more accessible and interactive; in this context, curricula are also affected by digital transformation (Ünlü & Yangın, 2020; Selanik-Ay, 2020; Ozturk. & Ozturk, 2022, 2024). Social studies curriculum is one of the basic courses that aims to raise conscious individuals in a democratic society by providing students with history, geography,

culture and citizenship knowledge (Eskici & Altun, 2023; Van Eck & Waltman, 2010).

Digitalization of this course can make the curriculum more dynamic, accessible, and engaging (Kilic & Yesiltas, 2021; Yalçın, 2022). The digitalization process of the social studies curriculum brings about significant changes in both the professional roles and pedagogical approaches of teachers, and understanding the problems and opportunities that teachers face while adapting to this transformation is critical to the success of the process. While moving educational materials to digital environments, teachers aim to attract students' attention and make learning more participatory by integrating new teaching strategies and tools provided by technology into their practices (Koca & Daşdemir, 2018; Ünal & Sarı, 2012).

This study examines the digitalization process of the social studies curriculum in Turkey, how teachers experience this process, what challenges they face, and their views on the process. In particular, it focuses on how teachers integrate digital tools and materials into their lessons, the infrastructural and educational barriers they face in this process, and the impact of digitalization on teaching quality.

The aim of the study is to develop recommendations on how to make the digitalization process of the social studies course more efficient by understanding teachers' perceptions of digitalization in depth. Thus, it is aimed to provide data to guide educational policies and practices. In addition, the findings of this study may enable valuable comparisons to be made for other countries and education systems undergoing similar transformations in the field of digitalized education on a global scale.

This study aims to understand the role and experiences of social studies teachers in the digitalization process and to identify the conditions necessary for the successful management of this process. In order to benefit more effectively from the opportunities offered by digitalization in education, the challenges and needs faced by teachers need to be clearly identified (Uygun & Uzun, 2019; Sarıgöl, 2022).

Method

In this study, qualitative research method was adopted to examine the digitalization process of the social studies curriculum in line with teachers' views. Qualitative research methods were deemed appropriate for the purpose of this study as they allow in-depth understanding of participants' experiences, perceptions and emotions.

Research Design:

Phenomenology design was used in the study. Phenomenology is an approach that aims to reveal individuals' personal experiences about a particular phenomenon or phenomenon and its meanings. Within the scope of this study, teachers' experiences and views on the digitalization process of the social studies curriculum were examined.

Participants

The participants of the study consisted of 6 social studies teachers working in public schools in different regions of Turkey. Purposive sampling method was used to determine the participants. this method aimed to provide rich information about the process from teachers with different experiences. The selection of the participants was based on the fact that the teachers came from various geographical regions and had different experiences.

Data Collection Tools:

Semi-structured interview technique was used to collect the data. The interview form was developed by reviewing the literature and taking expert opinions. The interview questions were designed to understand teachers' general attitudes towards digitalization, the challenges they face in this process, and to what extent and how they use digital tools.

Data Collection Process:

Interviews were conducted via online platforms depending on the preference of the participants. Each interview lasted approximately 30-45 minutes and participants participated voluntarily. During the interview process, the purpose of the research was explained to the participants and they were informed about the confidentiality of the data.

Data Analysis:

The collected data were analyzed using content analysis method. Content analysis provides a systematic examination of the data through thematic coding and categories. At this stage, the data were first coded, and themes were created by combining similar codes. The themes were used to explain teachers' views and experiences on the digitalization of the social studies curriculum.

Reliability and Validity:

The reliability of the study was ensured by the participation of more than one researcher in the coding process. Reliability was increased by calculating the agreement between the coders. For validity, participant feedback was received and the accuracy of the findings was confirmed by the participants. In addition, external expert opinions were obtained to ensure objectivity in the interpretation of the findings. Within the framework of this method, the study aimed to provide teachers with rich and meaningful information about the digitalization process of the social studies curriculum.

Results

In this section, the findings obtained from teachers' views on the digitalization process of the social studies curriculum are presented in themes. The data obtained were evaluated within the framework of teachers' general attitudes towards the digitalization process, the difficulties they faced and their expectations for the future.

General attitudes towards digitalization:

The majority of teachers view the digitalization of the social studies curriculum positively. Participants stated that digital materials make lessons more effective and interesting. Students were observed to be more enthusiastic and engaged in learning with digital content. Some teachers noted that digital tools offer significant advantages in terms of concretizing knowledge and appealing to different learning styles.

Challenges encountered:

Teachers reported facing various challenges in the digitalization process. Among these challenges, lack of digital infrastructure in the classroom, schools lacking adequate technological equipment, and internet access problems stand out. In addition, teachers' lack of adequate training in digital tools and materials was also mentioned as an important barrier. in particular, some teachers stated that they were unable to effectively integrate digital materials into their lessons due to their inability to use technological tools.

Digital content development and use:

Most of the teachers indicated that the existing digital content is not fully suitable for social studies lessons and that they have to create their own materials. the lack of well-structured digital resources makes teachers' lesson preparation processes more time-consuming. In addition, teachers emphasized the importance of creating quality and reliable content and expressed the need for more support and resources for developing educational materials.

Need for professional development and support:

Participants expressed the need for continuous professional development opportunities to adapt to the digitalization process. In particular, it was stated that training programs in the field of technological pedagogical content knowledge (TPCK) should be increased. Teachers emphasized that professional development programs should be up-to-date and applicable and requested more in-service training in this area.

Expectations for the future:

Teachers have certain expectations for the digitalization process to become more effective and efficient. In addition to infrastructure improvements, teachers should be more involved in decision-making processes. They also emphasized the importance of teachers taking a more active role in the development of digital materials. Teachers anticipate that at the end of these processes, both their professional satisfaction will increase and students' learning experiences will be enriched.

Conclusion and Recommendations

The findings show that teachers should be supported more in the process of digitalization of the social studies curriculum (R Core Team 2016). While digitalization makes the lesson more effective and impressive, problems such as lack of infrastructure and training appear as the biggest obstacle to the process (Sarıtepeci, 2016). This situation indicates that education policies should increase investments in digital infrastructure and offer more in-service training programs for teachers (Aslan, 2016).

It is clear that teachers need more resources and training support in the digital content development process (Aslan, 2021). Educational institutions and policymakers should provide digital content development training for teachers and encourage their active participation in the development of quality materials (Ayas, Kaya, Taştan & Özder, 2015; Beydoğan, 2022).

In order for digitalization to be successful in disciplines such as social studies courses, it is of great importance to take into account the experiences, needs and suggestions of teachers (Keskin, 2018; Balçın & Çalışkan, 2021). The effective implementation of digitalization will be possible by effectively integrating teachers into the process and providing the necessary resources. Making the most of the opportunities offered by digitalization in education requires a comprehensive and holistic approach to overcome the challenges in this process (Aydemir, 2019).

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