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EFFECTIVENESS OF ARTIFICIAL INTELLIGENCE IN CIVIL ENGINEERING

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Abstract: A branch of computer science called Artificial intelligence (AI) deals with the study, creation, and use of intelligent machines. A very large amount of processing power is required to solve difficult problems, but AI-based technologies provide an easier alternative. This includes the description of recently developed ideas and methods for the development and implementation of AI in civil engineering and also gives an overview of the field's advancement. With the tremendous development and advancement in big data, deep learning, and machine learning technologies, it has been used effectively and successfully in various sectors of civil engineering. The important areas of artificial intelligence research in civil engineering include structural management and maintenance, as well as design optimization. Data collection, sustainability assessment, and productivity are just a few advantages and prospects that the use of AI in civil engineering offers to civil engineers. With the use of digital technology, the construction trend has now been transformed into one that emphasizes sustainability. Using of computers in civil engineering is primarily focused on numerical, algorithmic calculations, which is inappropriate for solving the empirical and poorly structured problems that arise in actual practice and are instead handled by expert systems and artificial intelligence.

Keywords: Artificial Intelligence, Civil Engineering, Artificial Neural Networks, Big Data, Deep Learning, Genetic Algorithms.

I. INTRODUCTION

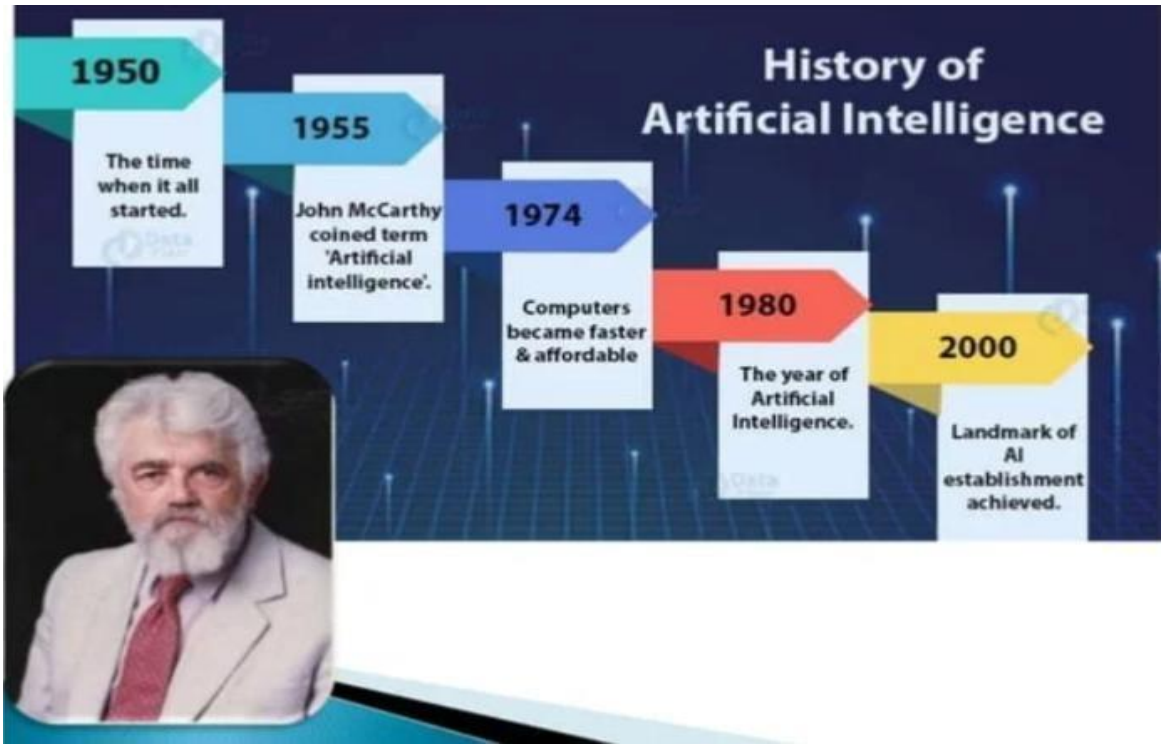

FIG – HISTORY OF ARTIFICIAL INTELLIGENCE

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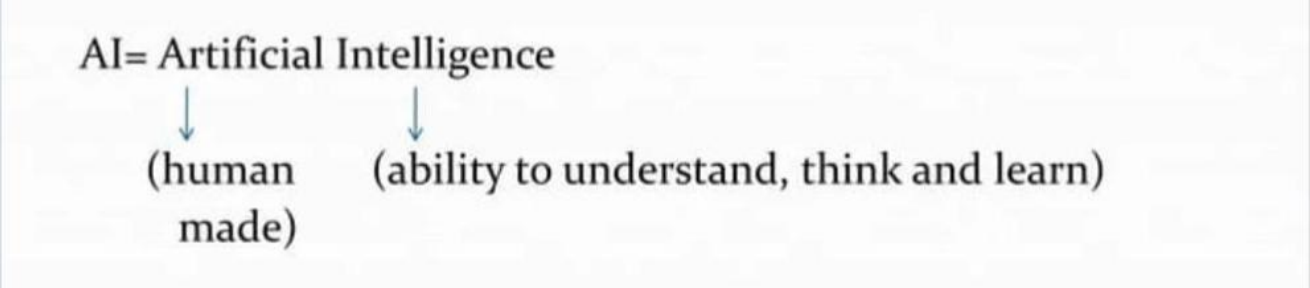
1.1. ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) is the simulation of human intelligence processes by machines, especially computer systems. These processes include learning (the acquisition of information and rules for using the information), reasoning (using rules to reach approximate or definite conclusions) and self-correction. Al can be categorized as either weak or strong. Weak Al, also known as narrow Al, is an Al system that is designed and trained for a task. Virtual personal assistants. Strong Al also known as artificial general intelligence, is an Al system with generalized human cognitive abilities. When presented with an unfamiliar task, a strong Al system can find a solution without human intervention Artificial Intelligence is becoming increasingly prevalent in our daily, social, and professional life. The construction industry is also welcoming a new technology of artificial intelligence. In the construction industries, artificial intelligence is playing a larger role in terms of improving productivity, quality, and safety on the johnte. As the years go by, more and more advanced forms of technology are making their way into our workplaces, offering a wealth of efficiency and information instantly. There is no doubt Artificial Intelligence and autonomous vehicles could herald the transformation that the construction industry has been looking for, potentially leading to safer, more productive, more environmentally friendly projects. In the field of Construction, it covers a vast area for human benefits especially in engineering design, construction management and program decision- making and can solve complex problems to the level of experts by imitating the experts. The traditional methods for design, modeling, optimizing complex structure systems and manual observation of activities are difficult time-consuming and prone to error, so, Al helps in automated data collection and data analysis techniques to improve several aspects of construction engineering and management for productivity assessment, safety management idle time reduction, prediction, risk analysis, decision-making and optimizing construction costs.



1.2. METHODS OF ARTIFICIAL INTELLIGENCE

1. Machine Learning

It is one of the applications of AI where machines are not explicitly programmed to perform certain tasks; rather, they learn and improve from experience automatically. Deep Learning is a subset of machine learning based on artificial neural networks for predictive analysis. There are various machine learning algorithms, such as Unsupervised Learning, Supervised Learning, and Reinforcement Learning. In Unsupervised Learning, the algorithm does not use classified information to act on it without any guidance. In Supervised Learning, it deduces a function from the training data, which consists of a set of an input object and the desired output. Reinforcement learning is used by machines to take suitable actions to increase the reward to find the best possibility which should be taken in to account.

2. Natural Language Processing(NLP)

It is the interactions between computers and human language where the computers are programmed to process natural languages. Machine Learning is a reliable technology for Natural Language Processing to obtain meaning from human languages. In NLP, the audio of a human talk is captured by the machine. Then the audio to text conversation occurs, and then the text is processed where the data is converted into audio. Then the machine uses the audio to respond to humans. Applications of Natural Language Processing can be found in IVR (Interactive Voice Response) applications used in call centers, language translation applications like Google Translate and word processors such as Microsoft Word to check the accuracy of grammar in text. However, the nature of human languages makes the Natural Language Processing difficult because of the rules which are involved in the passing of information using natural language, and they are not easy for the computers to understand. So NLP uses algorithms to recognize and abstract the rules of the natural languages where the unstructured data from the human languages can be converted to a format that is understood by the computer.

3. Machine Vision

Machines can capture visual information and then analyze it. Here cameras are used to capture the visual information, the analogue to digital conversion is used to convert the image to digital data, and digital signal processing is employed to process the data. Then the resulting data is fed to a computer. In machine vision, two vital aspects are sensitivity, which is the ability of the machine to perceive impulses that are weak and resolution, the range to which the machine can distinguish the objects.

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The usage of machine vision can be found in signature identification, pattern recognition, and medical image analysis, etc.

4. Knowledge-Based Systems(KBS):

A KBS can be defined as a computer system capable of giving advice in a particular domain, utilizing knowledge provided by a human expert. A distinguishing feature of KBS lies in the separation behind the knowledge, which can be represented in a number of ways such as rules, frames, or cases, and the inference engine or algorithm which uses the knowledge base to arrive at a conclusion

5. Neural Networks:

NNs are biologically inspired systems consisting of a massively connected network of computational "neurons," organized in layers. By adjusting the weights of the network, NNs can be "trained" to approximate virtually any nonlinear function to a required degree of accuracy. NNs typically are provided with a set of input and output exemplars. A learning algorithm (such as back propagation) would then be used to adjust the weights in the network so that the network would give the desired output, in a type of learning commonly called supervised learning.

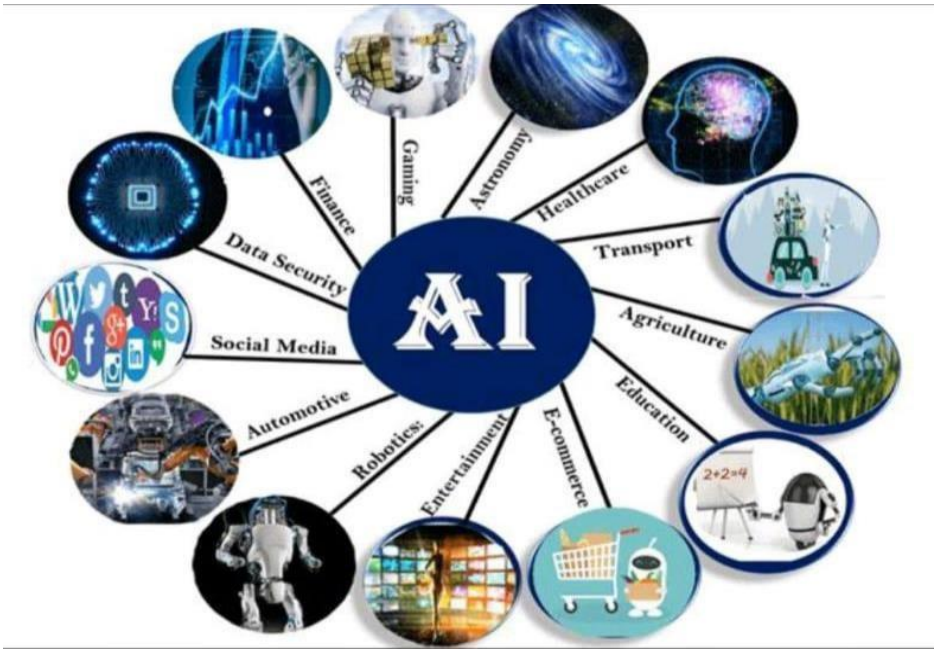
1.3 MERITS OF ARTIFICIAL INTELLIGENCE-

1) Increases productivity and reduces labor costs.
2) Consistently produces results.
3) Improves client satisfaction by personalizing the experience.
4) Cost Reduction - AI can work around the clock, creating more value in the same day as a human worker.
5) 24/7 availability – AI programs are available at all times, where as humans work 8 hour a day.
6) Reduction in Human Error
7) Faster decision making.

1.4 DEMERITS OF ARTIFICIAL INTELLIGENCE

1) Strong technical competence is necessary.
2) Reduces employment and raises unemployment rates.
3) Limited availability of skilled personnel to create AI technologies.
4) More expensive
5) Security Risks: As AI becomes more sophisticated, there is an increased risk of cybersecurity threats.
6) Job Displacement: Automation and AI can lead to job losses in certain industries, as machines may replace human roles in routine tasks.

1.5 APPLICATIONS OF ARTIFICIAL INTELLIGENCE



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- AI in Astronomy –

AI can be very useful to solve complex universe problems
AT Technology can be helpful for understanding the universe such as How it works, origin etc..

- AI in Healthcare –

In the last 5 to 10 years AI becoming more helpful for the healthcare industry. Healthcare industries are applying AI to make better and faster diagnosis than humans, AI can help doctor with diagnosis

- AI in Gaming –

AI can be used for gaming purpose .The AI machine can play strategic games like chess where machine needs to think of a large number of possible places

- AI in data security –

The security of data is crucial for every company. Cyber attacks are growing very rapidly in the digital world. AI can he used to make your data more safe and secure.

- AI in travel and transport –

AI is becoming Highly demanding for travel industries. AI is capable of doing various Travel related works such as suggesting the hotels Flights & test routs to the customers.

- AI in automotive industry –

Some automotive industries are using At to provide virtual Assistant to their user. For better performance various industries are currently working for developing self driving. cars which can make your journey more safe and secure

- AI in Education-

AI in the future can be work as personal Virtual tutor for students, which will be accessible easily at any time, any place.

- AI in E – Commerce

AI is becoming more demanding in the E- commerce business. AI is helping shoppers to discard associated products with recommended size.

- AI in Construction -

Smart building operation and health. Construction management progress and safety. Architectural design and visualization.
Sustainability life cycle analysis and circularity. Off site manufacturing and automation.
Material Design and optimization. Structural design and analysis.

1.6 WORKING OF ARTIFICIAL INTELLIGENCE

The working of Artificial Intelligence (AI) involves several key components and processes. Here's a simplified overview:

1) Data Collection: AI systems start by gathering large sets of relevant data. This data could include text, images, videos, or any other type of information depending on the task.

2) Data Pre-processing: Raw data is often noisy or unstructured. In this step, the data is cleaned, organized, and prepared for analysis. This may involve tasks like normalization, data scaling, and handling missing values.

3) Training Data for Machine Learning: In supervised machine learning, the AI model is trained on labelled data, where the algorithm learns to map input data to corresponding output labels. During training, the model adjusts its parameters to minimize the difference between predicted and actual outcomes.

4) Feature Extraction: Features are the characteristics or attributes of the data that the AI model uses to make predictions or decisions. Feature extraction involves selecting relevant features from the data.

5) Algorithm Selection: Different AI tasks require different algorithms. For example, image recognition might use convolutional neural networks (CNNs), while natural language processing tasks might use recurrent neural networks (RNNs) or transformers.

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6) Model Training: The selected algorithm is fed with the pre-processed data to train the AI model. During training, the model learns to recognize patterns and relationships in the data.

7) Testing and Evaluation: The trained model is tested on a separate set of data that it has never seen before (testing data). The model's performance is evaluated based on its ability to generalize and make accurate predictions.

8) Model Deployment: Once the model has demonstrated satisfactory performance, it can be deployed for real-world applications. Deployment involves integrating the AI model into the system or application where it will be used.

9) Feedback and Iteration: AI systems can improve over time by receiving feedback on their predictions or decisions. This feedback is used to update and refine the model through iterative processes.

10) Inference: In the operational phase, the trained model processes new, unseen data to make predictions or decisions. This is called inference, where the AI model applies what it has learned during training.

1.7 ARTIFICIAL INTELLIGENCE IN VARIOUS CIVIL ENGINEERING BRANCHES

- **Geotechnical Engineering**

Geotechnical engineering involves study and use of earth materials such as soil, rock and intermediate geo- materials (e.g., coal). It plays a crucial role in a wide range of engineering domains such as road pavements, foundations, dams, landfills, seismicity, surface and subsurface mineral exploration and mine slop stability . Soil has one of the most complicated physical, mechanical, and chemical behaviors among all engineering materials. Unlike other engineering materials used in construction and manufacturing, soil structure is a three- phased system and responds to changes in water content and environmental conditions in a highly non-linear manner. Soil and rock are anisotropic and heterogeneous by nature due to differences in their origin and formation process. This high level of diversity makes it difficult to study and predict their behavior thus imposing a limit to develop analytical and numerical solutions to some problems. In geotechnical engineering, two main methods are traditionally used to study the behavior of materials: (i) laboratory and field tests, and (ii) numerical and analytical methods. Laboratory and field tests are usually descriptive, costly, and time consuming. Moreover, studies in specific areas such as rock fracturing requires large-scale tests with sophisticated equipment which is generally not cost-effective (Wallace and Ng, 2016). Another constraint with experiments is the inability to study a large number of parameters involved in the same experiment. On the other hand, numerical methods such as finite elements or discrete analyses can virtually assess the behavior of geotechnical materials cost-effectively, However, the modelling of these complex material systems is challenging and hence traditional computational methods, are kept simple leading to restrictive predictive capabilities (Wallace and Ng, 2016).

Application of AI methods in geotechnical engineering

This section describes how AI has been used in geotechnical engineering applications as reported in published literature. Nine key areas of interest, including (i) frozen soils and soils thermal properties, (ii) rock mechanics, (iii) subgrade soil and pavement, (iv) landslide and liquefaction, (v) slope stability, (vi) shallow and piles foundations, (vii) tunneling and tunnel boring machine (TBM), (viii) dams, and (ix) unsaturated soil.

- **Estimate** –

AI is employed in various ways during the preparation of construction estimates:

Data Analysis: AI algorithms analyze historical project data, including materials costs, labor expenses, equipment usage, and project durations, to identify patterns and trends. This analysis helps in predicting the costs associated with similar future projects more accurately.

Cost Prediction: AI models can predict the costs of materials and labor based on factors such as market trends, location, project size, and complexity. This enables estimators to generate more precise estimates by considering various cost variables.

Risk Assessment: AI tools assess the risks associated with construction projects by analyzing factors like project scope, site conditions, regulatory requirements, and supplier reliability. By identifying potential risks early on, estimators can adjust their estimates to account for contingencies and uncertainties.

Optimization: AI algorithms optimize resource allocation by determining the most cost-effective mix of materials, labor, and equipment for a given project. This optimization helps in minimizing costs while maximizing efficiency and productivity.

Automation: AI-powered software automates repetitive tasks involved in estimate preparation, such as quantity takeoffs, cost calculations, and document generation. This streamlines the estimation process, savestime, and reduces the likelihood of errors.

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Overall, AI enhances the accuracy, efficiency, and reliability of construction estimates by leveraging data analytics, predictive modeling, risk assessment, optimization techniques, and automation capabilities

- **Structural Engineering**

AI in structural engineering involves the application of advanced algorithms and machine learning techniques to streamline and enhance various aspects of the design and analysis process. It empowers engineers with tools that can quickly and accurately analyze complex structural systems, optimize designs, and assess the structural integrity of infrastructure. I-driven structural analysis tools can simulate and evaluate complex structural behavior, helping engineers identify potential vulnerabilities, predict failure modes, and optimize structural performance.

Predictive Maintenance and structural Health Monitoring

AI algorithms can analyze real-time sensor data from smart structural monitoring systems to detect anomalies, predict potential failures, and assess the health of a structure. By continuously monitoring structural behavior through embedded sensors and IOT devices, AI can provide early warnings for maintenance and repair, ensuring the safety and longevity of buildings and infrastructure. In the future, AI will play a vital role in developing Smart Structures that can self-monitor and self-adapt, optimizing maintenance schedules and improving overall resilience. This integration of AI into smart infrastructure offers a powerful combination for the efficient and proactive management of structural health.

- **Traffic Engineering**

Artificial Intelligence (AI) has brought about numerous benefits to the transportation industry, revolutionizing the way we move people and goods. Some key benefits of AI in transportation include:

Efficient Traffic Management - AI-powered traffic management systems can analyze real-time data from various sources such as sensors, cameras, and GPS devices to optimize traffic flow, reduce congestion, and minimize travel times. This leads to improved fuel efficiency and reduced emissions.

Predictive Maintenance - AI can help predict maintenance needs in vehicles and infrastructure by analyzing data from sensors and historical maintenance records. This proactive approach reduces downtime and enhances the safety of transportation systems.

Autonomous Vehicles - AI plays a critical role in enabling autonomous vehicles to navigate and make decisions in complex environments. Self-driving cars, trucks, and even drones can enhance road safety, reduce accidents caused by human error, and provide mobility solutions for people with disabilities.

Public Transportation Optimization - AI can optimize public transportation routes, schedules, and capacity allocation based on passenger demand patterns. This leads to more efficient services, reduced waiting times, and improved rider experiences.

Ride-Sharing and Mobility-as-a-Service (MaaS) - AI-powered platforms like ride-sharing apps utilize algorithms to match riders with drivers, optimize routes, and determine pricing dynamically. Mobility-as-a- Service concepts integrate various transportation modes into a seamless experience, enhancing convenience and reducing the need for private vehicle ownership.

Supply Chain and Logistics - AI aids in optimizing supply chain and logistics operations, from inventory management to route planning. This leads to reduced transportation costs, faster deliveries, and better resource utilization.

Enhanced Safety - AI can detect potential hazards, such as pedestrians, cyclists, and other vehicles, in real- time and alert drivers or autonomous systems to take appropriate actions to prevent accidents.

Environmental Benefits - By optimizing routes, reducing idling times, and enhancing fuel efficiency, AI contributes to reducing carbon emissions and promoting more sustainable transportation practices.

Infrastructure Planning - AI can assist in designing and planning transportation infrastructure by analyzing data on traffic patterns, population growth, and urban development. This helps cities make informed decisions for future transportation needs.

Data-Driven Decision Making - AI enables transportation agencies to make data-driven decisions by analyzing vast amounts of information collected from sensors, cameras, and other sources. This leads to improved resource allocation and better policy formulation.

Emergency Response - AI can help emergency response teams by providing real-time traffic updates and suggesting optimal routes for first responders to reach accident scenes or critical locations faster.

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In summary, AI in transportation holds the potential to improve efficiency, safety, and sustainability across various modes of transportation. As technology continues to advance, we can expect even more innovative applications of AI that will further transform the way we move and interact with our transportation systems.

- **Irrigation Engineering**

Artificial intelligence (AI) is increasingly being utilized in irrigation engineering to optimize water usage and improve crop yield. Some applications include:

Precision Irrigation: AI algorithms analyze data from various sources such as soil moisture sensors, weather forecasts, and crop characteristics to determine the exact amount of water needed by plants at different stages of growth. This helps in delivering water precisely where and when it's needed, reducing water wastage and optimizing irrigation efficiency.

Predictive Analytics: AI models can predict soil moisture levels, water requirements, and crop health based on historical data and real-time inputs. This helps farmers anticipate irrigation needs and plan their irrigation schedules accordingly, leading to better resource management and improved crop outcomes.

Smart Irrigation Systems: AI-powered irrigation systems can automatically adjust watering schedules and irrigation levels based on real-time environmental conditions and plant needs. These systems can be remotely monitored and controlled, allowing farmers to manage irrigation operations more efficiently and effectively.

Data-driven Decision Making: AI algorithms analyze large datasets related to soil, weather, crop types, and water availability to provide insights and recommendations for optimizing irrigation practices. This enables farmers to make informed decisions about irrigation management, leading to more sustainable and productive agricultural practices.

Overall, AI plays a crucial role in modernizing irrigation engineering by enabling data-driven decision- making, improving water efficiency, and enhancing agricultural productivity.

II. SCOPE

Comparison between Artificial Intelligence and Traditional method.

III. CONCLUSION

The use of artificial intelligence will undoubtedly make life easier for humans in the future and may even encourage humans to expand their skill sets. The work for the constructors and architects is getting much simpler due to AI techniques.

Artificial intelligence has been effectively applied to a variety of civil engineering applications, including prediction and risk management. Artificial intelligence used in Civil engineering is important in the construction, maintenance, and management of several components of civil infrastructure.

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