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COMPARATIVE ANALYSIS OF THE APPLICATION OF LARGE AND DIFFUSION LANGUAGE MODELS OF ARTIFICIAL INTELLIGENCE IN THE FIELD OF CONSTRUCTION PROJECT MANAGEMENT

Abstract. *The article provides a comparative analysis of the application of Large Language Models (LLM) and Diffusion Language Models (DLM) in the context of construction project management. The theoretical foundations of both approaches, their architectural differences, training principles, and potential areas of application in the construction industry are considered. It has been established that large language models are effective in analyzing, predicting, and generating textual information, which allows for the automation of technical documentation, tender applications, reports, and communications between project participants. Diffusion language models, on the other hand, demonstrate higher controllability and accuracy in editing, reconstruction, and scenario modeling processes, which is useful for refining work schedules, optimizing resources, and verifying the consistency of project data. The paper presents a comparative table of LLM and DLM characteristics in terms of their suitability for construction process management. It is concluded that the most promising direction for further research is the integration of LLM and DLM into unified hybrid systems that combine the analytical capabilities of large language models with the controlled generation of diffusion models. Such systems can improve the efficiency of planning, monitoring, and decision-making in the construction industry.*

Keywords: large language models; diffusion models; artificial intelligence; construction project management; BIM; automation; data analysis

Introduction

In the current era of digital transformation, artificial intelligence (AI) plays a key role in the development of information technology, business, education, and science. In particular, language models have become the basis for innovation in the field of natural language processing (NLP), providing qualitatively new opportunities for automating communication, text generation, translation, data analysis, and content creation. Among the most notable achievements in this field are Large Language Models (LLMs) such as GPT, BERT, and LLaMA, which are capable of processing enormous amounts of data and demonstrate a high level of semantic understanding of text.

At the same time, *Diffusion Models*, which were initially used mainly for image generation, are rapidly gaining popularity in the scientific community and have recently been actively integrated into language tasks. Their key feature is gradual learning through noise and denoising processes, which allows for high-quality data synthesis and increased resistance to distortion.

The relevance of the research is determined by the need for a comprehensive comparison of the effectiveness, architectural approaches, application possibilities, and limitations of large and diffusion language models in the context of modern artificial intelligence tasks. Such a comparison enables the identification of trends in the development of language systems, optimal areas of their application, as well as potential directions for integrating both approaches to enhance the productivity and creativity of AI.

The study aims to analyze the architectural features, learning principles, effectiveness, and application potential of large and diffusion language models of artificial intelligence, as well as to identify prospects for their further development.

Literature review

1. Theoretical Foundations of Large Language Models (LLMs) [1].

Current research [1] focuses on the scalability and Transformer-based foundations of LLMs.

2. Representative LLMs and their capabilities.

GPT-4: Declared as a multimodal system with competitive performance on professional and academic tests; the technical report describes architectural principles, security methods, and benchmark results;

PaLM 2: Demonstrates improved reasoning and multilingualism thanks to a higher-quality corpus and training objectives;

Llama 3: Meta's open line of dense models up to 405B parameters with a context window of up to 128k tokens.

3. LLM evaluation. Benchmarks and metrics.

– GLUE/SuperGLUE: Used for general language understanding;

– MMLU: Used for broad multi-task testing;

– TruthfulQA: Used for truthfulness verification;

– BIG-bench: Used for complex and non-standard tasks. Collectively, these sets highlight both the advantages of scaling and vulnerabilities, such as hallucinations and biases.

4. Diffusion models in language tasks.

Although diffusion models initially dominated visual synthesis, a number of works have transferred the idea of denoising to discrete sequences. The D3PM paper (Austin et al., NeurIPS 2021) formalised diffusion for discrete states, paving the way for language modelling through stochastic corruption/denoising of tokens.

Diffusion-LM proposed non-aggressive text generation through sequential denoising of word vectors with the possibility of fine-grained control (syntax, style) without complete retraining; subsequent publications confirmed significant advantages in controllability.

Recent work is moving towards continuous time/flow-oriented formulations (diffusion/flow for language), which simplify log-likelihoods and improve training stability; in particular, rectified-flow Transformers and masked diffusion approaches for sequences are emerging.

Additionally, there is a trend towards Discrete Diffusion LMs for long texts and conditional generation, with a focus on the efficiency and quality of local edits.

5. Comparative features. LLM vs. diffusion language models.

Architecture and inference. Autoregressive LLMs (Transformer) generate tokens sequentially, which scales well on GPUs/TPUs and supports long context, while diffusion approaches implement parallel updates/edits of sequences but require many denoising steps for high quality.

Controllability/control. Diffusion-LM naturally supports global and complex constraints (rhythm/syntax/style) through optimisation in latent sequence spaces; LLMs typically rely on instructional fine-tuning, RLHF, and prompt-level "controllers".

Evaluation. On benchmarks such as MMLU, SuperGLUE, and BIG-bench, the current SOTA is demonstrated by large Transformer-LLMs; diffusion language models are more common in controlled generation and editing tasks.

Reliability and truthfulness. Work with TruthfulQA and related research points to hallucinations and "imitation errors" even in large LLMs; diffusion approaches potentially reduce local artefacts but do not eliminate the need for fact-checking and safety filters.

6. Applications and integration trends.

In practical scenarios, LLMs dominate in knowledge generalisation, reasoning, and instrumental function invocation, while diffusion language models show strength in controlled stylistic rephrasing, local editing, and structured constraints. At the method level, there is a noticeable movement towards hybrids (e.g., the use of flow/diffusion decoders on top of transformer LMs) as well as computationally optimal training according to the "Chinchilla rule."

Current research shows that large language models (LLMs) and diffusion language models open up new opportunities for automation, increased efficiency, and improved quality in construction project management. However, their application has its own characteristics, advantages, and limitations.

Basic approaches and effectiveness of LLMs

Large language models based on the Transformer architecture are already widely used for contract analysis, planning, risk management, routine task automation, and decision support in construction. They effectively process unstructured data, automate document analysis, improve the accuracy of delay cause classification, and enable quick retrieval of relevant information for decision-making [1; 2; 5; 10].

For example, GPT-4 in zero-shot mode showed high accuracy in classifying causes of delays without the need for retraining 5. Domain-oriented retraining and integration with knowledge bases further improve the quality of results [2; 7].

Diffusion language models. Potential and challenges

Diffusion language models, such as LLaDA, offer an alternative to autoregressive LLMs. They demonstrate competitiveness in in-context learning, multi-turn dialogue, and code generation tasks, and address some of the limitations of autoregressive models, such as the "reversal curse".

Diffusion models have the potential for more flexible probabilistic modelling, but their application in construction is only beginning to be explored. Issues of energy consumption, ethical risks, and integration with industry tools remain important [6].

Comparison of LLMs and diffusion models based on key criteria in construction is presented in the Table.

*Table – **Comparison of LLMs and diffusion models based on key criteria in construction***

Criterion	Large language models (LLMs)	Diffusion language models
Application in construction	Widely implemented, proven	Initial research, promising
Accuracy	High (up to 93% in QA, 88% in NER)	Competitive, depends on the task
Flexibility	High, especially with retraining	Potentially higher, but requires research
Resource requirements	High, but optimisable	Similar or higher, depending on implementation
Ethical/social risks	Present, require regulation	Similar, additional energy consumption issues

LLMs have already proven their effectiveness in construction project management, especially in text analysis, planning, and risk management tasks.

Diffusion language models have the potential for further development but require additional research for widespread implementation in the industry.

Comparative analysis of large and diffusion language models in the context of construction project management

1. Architectural Features of LLM and DLM

- *Large Language Models (LLMs):*

– Based on Transformer architecture;

– Use self-attention mechanism for parallel processing;

– Generate text autoregressively, token by token;

– Efficient for long-context understanding, summarization, and reasoning;

– Require large datasets and computational resources.

- *Diffusion Language Models (DLMs):*

– Based on iterative denoising processes;

– Gradually transform noisy sequences into meaningful text;

– Offer higher controllability in editing and reconstruction;

– Support structured text generation with precise constraints;

– Computationally intensive due to multi-step denoising.

The field of construction project management is characterized by high complexity, multi-level coordination of participants, and a significant amount of technical, economic, and regulatory information. Intelligent data analysis and management support systems are increasingly being used for effective planning, monitoring, and decision-making. In this context, artificial intelligence language models are becoming a promising tool for automating document flow, risk management, reporting, and optimizing communication between customers, contractors, and project teams.

2. The Potential of Large Language Models (LLMs) in Construction

- *Large language models (GPT-4, PaLM 2, Claude, LLaMA, etc.) are capable of:*

– Automating the creation of documentation: formation of technical tasks, contracts, tender applications, and reports on the completion of work;

– Analyzing project risks based on text descriptions, previous reports, and estimates;

– Supporting communication between teams through integration with project management systems (BIM platforms, ERP modules);

– Optimizing resource planning through analytical processing of text reports, construction logs, and correspondence;

– Training staff through management scenario simulation or training case generation.

The main advantage of LLMs is their ability to understand the context of large text arrays, integrate different types of information (technical descriptions, standards, norms, instructions), and formulate consistent recommendations. However, LLMs have limitations – they often generate generalized or probabilistic responses, which can be risky in precise technical construction scenarios where accuracy and compliance with standards are critical.

3. The Potential of Diffusion Language Models (DLMs)

- *Diffusion language models (DLMs), based on the principles of denoising and stochastic sequence recovery, and are a promising alternative for controlled text generation in construction processes. In project management, they can:*

– Generate various work planning scenarios (e.g., optimization of the sequence of construction stages);

– Restore incomplete or damaged records (construction logs, financial data, reports);

– Adjust technical documentation taking into account the context (changes in materials, weather conditions, suppliers);

– Perform quality control of reports through diffusion "denoising" – eliminating errors and inconsistencies in texts;

– Model alternative solutions when changes occur in the schedule, budget, or resources.

The advantage of DLMs is the high level of controllability of results – the system can create text that strictly corresponds to the specified parameters (format, style, structure), which is especially useful in the creation of technical documentation. At the same time, DLMs require significant computing resources for each denoising cycle, which complicates their application in large corporate management systems.

Thus, LLM is an effective tool for intellectual support of management decisions in construction projects, particularly when working with large amounts of text data, documents, and reports. On the other hand, DLM demonstrates potential in the controlled generation and reconstruction of information that can be used in tasks such as plan optimization, verification of project documentation consistency, and creation of work execution scenario options.

In the future, it may be possible to combine approaches: using LLM for analyzing and summarizing information, and DLM for accurately forming structured results and scenario modeling in construction management systems.

4. Analysis of the Risks of Using Large and Diffusion Language Models in Construction Projects

The introduction of artificial intelligence systems into the construction industry opens up significant opportunities for improving management efficiency, but at the same time creates new technological, organizational, informational, and ethical risks.

Main Risk Groups

Information and Security Risks:

– *Data confidentiality:* When using cloud-based LLMs, there is a risk of leakage or unauthorized access to project documentation, estimates, and contracts;

– *Algorithm opacity:* LLMs are "black boxes" – it is difficult to trace why a particular decision was made. This complicates auditing in construction companies, where complete traceability of actions is required;

– *Manipulation of information:* In the event of an error or malicious use, key parameters in estimates or project data may be tampered with;

– *Use of third-party datasets:* DLMs can be trained on uncertified or irrelevant texts, creating a risk of incompatibility with local construction standards (DIN, ISO, DBN).

Organizational Risks:

– *Untrained personnel:* Using LLM and DLM requires special skills in formulating queries, interpreting results, and verifying data;

– *Dependence on AI suppliers:* If the model belongs to a third-party company (e.g., OpenAI, Anthropic, or Google), there is a risk of service interruption or changes in access policy;

– *Lack of regulatory oversight:* In most countries, the legal status of AI-generated decisions is undefined, especially in the areas of technical design and facility security.

Ethical and Legal Risks:

– *Liability for errors:* In the event of an accident or damage, it is difficult to determine who is responsible for a decision made using AI;

– *Copyright:* Texts created by models may contain fragments that are protected by copyright;

– *Ethical bias:* LLMs can reproduce cultural or social biases that influence management decisions (e.g., the selection of contractors or quality control methods).

Ways to Minimize Risks:

1. Use of on-premise models or special corporate versions of LLM/DLM with internal security controls;
2. Implementation of dual control – verification of AI results by a human (engineer, estimator, architect);
3. Development of internal AI policies in construction companies, including data auditing, decision logs, and change logs;
4. Training staff on the principles of LLM/DLM and the rules for formulating queries;
5. Use of explainable AI (XAI) – models that allow the logic of decisions made to be interpreted;
6. Regulatory harmonization – inclusion of AI modules in BIM, ISO 19650, DIN SPEC 91391, and other standards.

Conclusions

The study conducted a comparative analysis of the capabilities of Large Language Models (LLM) and Diffusion Language Models (DLM) in terms of their application in construction project management.

Large Language Models (LLMs) have proven their effectiveness in:

– Automating the creation and processing of technical and reporting documentation;

– Optimizing risk and resource management;

– Maintaining real-time communication between project participants;

– Generating recommendations based on past projects and standards.

Diffusion Language Models (DLMs) have demonstrated high potential in:

– Accurate formation of construction schedules and scenarios;

– Correction of technical documentation in accordance with changes in resources or conditions;

– Generation of specifications and technical tasks with clear parameters.

The most promising direction for development is the integration of LLM and DLM into unified hybrid project management systems, where LLMs provide the analytical part and DLMs provide accurate formation of documents and scenario modeling.

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References

1. Wang, M., Lu, S., Li, C., Hu, Y., & Tian, Z. (2025). Application and practice of construction project planning based on large language model (LLM). *Proceedings of SPIE*, 13575, 135750J. https://doi.org/10.1117/12.3061653

2. Niv, S. (2025). Leveraging the performance of Large Language Models in Systems Engineering applications. *Journal of Information Systems Engineering and Management*, 10 (29). https://doi.org/10.52783/jisem.v10i29s.4483

3. Francis, M., Perera, S., Zhou, W., & Nanayakkara, S. (2025). Artificial intelligence applications for proactive dispute management in the construction industry: A systematic literature review. *Journal of Information Technology in Construction (ITcon)*, 30, 560–584. https://doi.org/10.36680/j.itcon.2025.029

4. Zhang, J., Song, X., Tian, B., Tian, M., Zhang, Z., Wang, J., & Fan, T. (2025). Large language models in the management of chronic ocular diseases: a scoping review. *Frontiers in Cell and Developmental Biology*, 13. https://doi.org/10.3389/fcell.2025.1608988

5. Bushuyev, S., Chumachenko, I., Galkin, A., Bushuiev, D., & Dotsenko, N. (2025). Sustainable Development Projects Implementing in BANI Environment Based on AI Tools. *Sustainability*, 17 (6), 2607. https://doi.org/10.3390/su17062607

6. Bushuyev, S., Piliuhina, K., & Elams, C. (2023) Transformation of values of the high technology projects from a VUCA to a BANI environment model. *Innovative Technologies and Scientific Solutions for Industries*, 2 (24), 25–44. https://doi.org/10.30837/ITSSI.2023.24.025

7. Pan, N., & Zhang, L. (2024). Unleashing the Potential of Large Language Models in Construction Management: A Critical Review and Future Directions. *Journal of Management in Engineering*, 40 (4). https://doi.org/10.1061/JMENEA.MEENG-5743

8. Austin, J., Johnson, D. D., Ho, J., Tarlow, D., & van den Berg, R. (2021). Structured Denoising Diffusion Models in Discrete State-Spaces. *Advances in Neural Information Processing Systems (NeurIPS)*, 34, 17981–17993.

9. Li, X., Thickstun, J., Gulrajani, I., Liang, P., & Hashimoto, T. B. (2022). Diffusion-LM Improves Controllable Text Generation. *Proceedings of the 36th Conference on Neural Information Processing Systems (NeurIPS 2022).* https://arxiv.org/abs/2205.14217

10. Badini, S., Regondi, S., Pagliari, M., & Pavan, A. L. C. (2023). NLP and Chatbots in Construction and Building Management: A Systematic Review. *Buildings*, 13 (9), 2337. https://doi.org/10.3390/buildings13092337

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ПОРІВНЯЛЬНИЙ АНАЛІЗ ЗАСТОСУВАННЯ ВЕЛИКИХ ТА ДИФУЗІЙНИХ МОВНИХ МОДЕЛЕЙ ШТУЧНОГО ІНТЕЛЕКТУ В СФЕРІ УПРАВЛІННЯ БУДІВЕЛЬНИМИ ПРОЄКТАМИ

Анотація. *Представлено комплексний порівняльний аналіз застосування великих мовних моделей (LLM) та дифузійних мовних моделей (DLM) у специфічному контексті управління будівельними проєктами. Актуальність дослідження зумовлена необхідністю цифрової трансформації галузі та пошуком ефективних інструментів штучного інтелекту для обробки великих обсягів технічної, економічної та нормативної інформації. Розглянуто теоретичні засади обох підходів, їхні фундаментальні архітектурні відмінності, принципи навчання та стратегічні сфери впровадження в будівельній індустрії. У результаті дослідження встановлено, що великі мовні моделі (такі як GPT-4, LLaMA) демонструють виняткову ефективність в аналізі неструктурованих даних, прогнозуванні та генерації текстового контенту. Це дозволяє суттєво автоматизувати підготовку технічної документації, формування тендерних заявок, звітів та оптимізувати комунікаційні процеси між усіма учасниками інвестиційно-будівельного циклу. З іншого боку, дифузійні мовні моделі виявляють значний потенціал у задачах, що потребують високого рівня керованості та точності. Вони є незамінними для детального редагування, реконструкції пошкоджених даних, уточнення графіків робіт та перевірки внутрішньої узгодженості проєктної документації на відповідність галузевим стандартам. Особливу увагу приділено аналізу технологічних, організаційних та етичних ризиків, пов'язаних із впровадженням інтелектуальних систем, зокрема питанням конфіденційності даних, «непрозорості» алгоритмів та відповідальності за помилки. Авторами запропоновано дієві механізми мінімізації цих ризиків через використання корпоративних версій моделей та впровадження систем подвійного контролю. На основі проведеного порівняння характеристик зроблено стратегічний висновок: найбільш перспективним вектором розвитку інтелектуальних систем у будівництві є створення гібридних архітектур. Такі системи дозволяють поєднати аналітичну потужність та когнітивні можливості LLM із контрольованою і структурованою генерацією дифузійних моделей. Інтеграція подібних гібридних модулів у середовище BIM та ERP-системи здатна кардинально підвищити точність планування, моніторингу та підтримки прийняття управлінських рішень, забезпечуючи сталий розвиток будівельних організацій у складному сучасному середовищі.*

Ключові слова: великі мовні моделі; дифузійні моделі; штучний інтелект; управління будівельними проєктами; BIM; автоматизація; аналіз даних

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