Context-Aware Explanations: Leveraging Knowledge Graphs for Adaptive Explainability in Dynamic Environments

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Abstract

We argue that integrating Knowledge Graphs (KGs) with Generative AI (GenAI) models provides context-aware, adaptive explanations in dynamic environments. By leveraging structured knowledge from KGs, GenAI systems can offer explanations that adjust to user needs and real-time contexts, enhancing transparency and user trust.

1. Introduction

Generative AI (GenAI) models have achieved impressive results across various domains, from natural language processing to image generation [1]. However, one of their critical shortcomings is the lack of transparency in their decision-making processes [2]. The 'black-box' nature of GenAI systems becomes particularly critical in dynamic environments where context is vital, such as autonomous systems, personalized recommendation engines, and adaptive decision-making tools [3].

Several lines of evidence suggest that Knowledge Graphs (KGs), as structured representations of information, offer a promising solution to the explainability issue [4, 5]. By integrating KGs with GenAI, we can enable models to generate explanations that are not only understandable but also dynamically adjusted based on the user's context and the specific task at hand [6]. This paper discusses the role and challenges of utilising KGs to produce context-aware, adaptive explanations in dynamic real-world environments.

2. Context-Aware Explainability in GenAI

Explainability is crucial for building trust in GenAI systems [7]. Traditional static explanations, while helpful, often fail to account for the varying needs of different users or the dynamic nature of real-world environments [4]. For example, an explanation suitable for a novice user may not be detailed enough for an expert, and a static system might miss critical changes in context, such as real-time traffic updates for an autonomous vehicle.

Context-aware explainability can broadly be defined as the ability of an AI system to tailor its explanations based on factors such as user expertise, task complexity, or environmental variables [8]. This dynamic approach ensures that explanations remain relevant and valuable, regardless of the ever-changing circumstances.

3. Leveraging Knowledge Graphs for Adaptive Explanations

KGs are structured repositories of interconnected facts and relationships, which researchers and practitioners can leverage to provide explanations grounded in factual knowledge [6]. For example, a KG in the healthcare domain might contain relationships between diseases, symptoms, and treatments, enabling an AI model to generate detailed explanations for a medical diagnosis [9].

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GenAI models can produce multi-layered explanations by integrating KGs into their architecture [6]. Consider a recommendation system in an e-commerce setting. The system might first explain why a customer received a product recommendation, such as 'based on browsing history'. With the help of a KG, the user could then explore deeper layers of the system's reasoning, such as specific item similarities or product ratings, thus adjusting the depth of the explanation to the user's needs [10].

4. Applications in Dynamic Environments

Personalised recommendation engines, like the ones being utilised in retail, e-commerce and streaming services, KGs can enhance explainability by drawing on user preferences, historical data, and item relationships [11]. For instance, if a movie recommendation is generated, the system could explain it by showing connections in the KG, such as genre preferences, actors or similar movies the user has watched, creating a tailored, context-sensitive explanation.

Autonomous vehicles are an example of a dynamic environment where context-aware explanations are critical. When making decisions, such as selecting a route or dealing with sudden obstacles, the system must explain its choices in real time [12]. A KG-based system could provide high-level explanations like 'avoiding traffic congestion' while offering deeper insights such as weather conditions, real-time traffic data, and road safety statistics, all drawn from the KG.

5. Challenges and Future Research

Despite the potential benefits, several challenges must be addressed before deploying KGs in real-world applications. First, constructing and maintaining KGs for specific domains is resource-intensive, which might hinder their development in SMEs. Second, the computational overhead of querying large-scale KGs in real-time environments remains a constraint for most public and private organisations. Consequently, future studies should focus on developing automated or semi-automated methods for KG creation and maintenance as well as optimising the scalability of KG-query processes.

Future work needs to be done to refine the mechanisms of adaptative explanation. For instance, understanding the best ways to balance explanation depth and usability to maximise the impact of KG-based applications, or exploring how to handle conflicting explanations in large and multi-source KGs solutions.

6. Conclusion

We argue that Knowledge Graphs are necessary to enhance explainability in Generative AI models. By providing context-aware, dynamic explanations, we can significantly improve the transparency and user trust in AI systems, particularly in dynamic environments like autonomous systems and personalised recommendations. While challenges remain, integrating KGs into explainable AI is a promising direction for future research with substantial real-world applications.

7. Declaration on Generative AI

During the preparation of this work, the author(s) used GPT-4 and Grammarly for Grammar and spelling checks. After using these tool(s)/service(s), the author(s) reviewed and edited the content as needed and take(s) full responsibility for the publication's content.

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