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DEVELOPMENT OF A MULTI-AGENT SYSTEM FOR ENHANCED INTERACTIVE STORYTELLING

Master's project

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REZUMAT

Această cercetare explorează sistemele multi-agent cu scopul dezvoltării unui sistem de narațiune interactivă îmbunătățită.

Partea de explorare include agenți autonomi și sisteme multi-agent în sistemele interactive de povestire. În plus, se investighează fundațiile tehnice ale MAS, incluzând arhitecturi, framework-uri, mecanisme de comunicare, modelare de comportament și mecanisme de luare a deciziilor. Ca exemple ale sistemelor similare existente, se descriu două jocuri interactive, „Façade” și „Versu”. Apoi, se indică direcțiile pentru viitorul dezvoltării a MAS în contextul dezvoltării sistemelor de narațiune.

Etapa de concepere include alegerea și argumentarea tehnologiilor și design-ul sistemului conceput. Tehnologiile alese includ Unity, ChatGPT API, LLM și MAS. Designul sistemului este ilustrat prin utilizarea mitului antic grec „Perseu și Meduza”. Sunt descrise toate etapele principale prin care trebuie să treacă utilizatorul în interiorul acestei narări și interacțiunile posibile în interiorul mitului.

Faza descrierii sistemului realizat conține integrarea ChatGPT API în Unity, crearea și fine-tune a modelelor, demonstrarea simulării comunicării MAS a modelelor făcute și interacțiunea utilizatorului cu sistemul dezvoltat.

În esență, acest studiu oferă o perspectivă asupra fuzionării tehnologiilor MAS și LLM pentru crearea unui sistem de narațiune interactivă îmbunătățită care să fie robuste din punct de vedere tehnic, ușor de utilizat și capabile să ofere experiențe imersive. Framework-ul, narațiunea și tehnologiile alese stabilesc o bază solidă pentru progresele viitoare în domeniul sistemelor interactive de povestire.

ABSTRACT

This research explores multi-agent systems with the aim of the development of a multi-agent system for enhanced interactive storytelling.

The exploration part includes autonomous agents and multi-agent systems in interactive storytelling systems. Additionally, it investigates the technical foundations of MAS, including architectures, frameworks, communication mechanisms, behavior modeling, and decision-making mechanisms. Two interactive games, "Façade" and "Versu," are described as examples of existing similar systems. Then, future directions for the development of MAS in the context of narrative system development are outlined.

The design phase involves choosing and justifying the technologies and designing the conceived system. The chosen technologies include Unity, ChatGPT API, LLM, and MAS. The system design is illustrated by using the ancient Greek myth "Perseus and Medusa." All the main stages that the user must go through within this narrative and the possible interactions within the myth are described.

The system description phase contains the integration of ChatGPT API into Unity, the creation and fine-tuning of models, demonstrating the MAS model communication simulation, and the user interaction with the developed system.

Essentially, this study provides an insight into merging MAS and LLM technologies to create an enhanced interactive storytelling system that is technically robust, user-friendly, and capable of providing immersive experiences. The chosen framework, narrative, and technologies establish a solid foundation for future advancements in the field of interactive storytelling systems.

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LIST OF ABBREVIATIONS

- **MAS** – Multi-Agent Systems;
- **AI** – Artificial Intelligence;
- **AUML** – Agent Unified Modelling Language;
- **JADE** – Java Agent DEvelopment Framework;
- **SPADE** – Smart Python Agent Development Environment;p=
- **PyMAS** – Python Multi-Agent Simulation;
- **ACL** – Agent Communication Languages;
- **FSM** – Finite state machine;
- **RL** – Reinforcement Learning;
- **AR** – Augmented Reality;
- **VR** – Virtual Reality;
- **API** – Application Programming Interface;
- **LLM** – Large Language Models;
- **OS** – Operational System;
- **GPT** – Generative Pre-trained Transformer (refers to the ChatGPT models);
- **JSONL** – JSON Lines (a format for storing newline-delimited JSON data).

INTRODUCTION

Within the digital narrative domain, the fusion of technology with the age-old art of storytelling has presented fresh and transformative possibilities. Key to this evolution is the incorporation of Multi-Agent Systems (MAS) and autonomous agents. When incorporated into interactive storytelling, these elements add more depth, thereby changing the way users interact with and shape stories.

Interactive narratives invite users to actively navigate and influence the storyline, distinguishing it from conventional storytelling where engagement is more passive. The addition of MAS and autonomous agents further boosts this interactive dimension.

Here, agents step into roles resembling characters or narrative influencers, each operating under a set of predefined conditions. Their ability to promptly adjust to user interventions ensures a lively and fluid narrative experience.

MAS ensures that multiple agents coalesce in harmony. These agents, based on the narrative's design, can either collaborate or be in contention. Their shared interactions, shaped by user decisions and inter-agent dynamics, can result in a large number of story trajectories. Such dynamics can produce what is often termed "emergent narratives", a phenomenon where story developments spontaneously arise from agent interactions, delivering a distinct experience for every user.

Notably, these agent-driven characters in narratives go beyond basic scripted roles. They showcase a variety of emotions and behaviours, enriching the narrative's depth and appeal. Their innate capacity to adapt based on unfolding events augments the narrative's immersive quality.

Moreover, the collaboration of MAS with storytelling promises the crafting of custom-made narrative experiences. When systems recall and adapt to past user engagements, they pave the way for stories that strike a more intimate emotional connection with the audience.

In essence, by integrating MAS and autonomous agents, interactive storytelling is poised for an era of richer dynamism and personalisation, marking an exciting chapter in the evolution of digital narratives.

BIBLIOGRAPHY

- [1] S. V. Albrecht and P. Stone, ‘Autonomous agents modelling other agents: a comprehensive survey and open problems’, Accessed: Sep. 27, 2023. [Online]. Available: <https://arxiv.org/pdf/1709.08071.pdf>
- [2] ‘Multi-agent system’, Autoblocks. Accessed: Sep. 27, 2023. [Online]. Available: <https://www.autoblocks.ai/glossary/multi-agent-system>
- [3] ‘Belief desire intention software model’. Accessed: Sep. 28, 2023. [Online]. Available: <https://academic-accelerator.com/encyclopedia/belief-desire-intention-software-model>
- [4] ‘Jade’. Tilab. Accessed: Sep. 28, 2023. [Online]. Available: <https://jade.tilab.com/>
- [5] J. Parker Henderson, ‘Spade decision framework’. Accessed: Sep. 29, 2023. [Online]. Available: <https://github.com/joelparkerhenderson/spade-decision-framework>
- [6] ‘PyMAS’. PyMAS. Accessed: Sep. 29, 2023. [Online]. Available: <https://pypi.org/project/PyMAS/>
- [7] ‘PADE’. Grei-ufc. Accessed: Sep. 29, 2023. [Online]. Available: <https://github.com/grei-ufc/pade>
- [8] G. K. Soon, C. K. On, and A. R. Hamdan, ‘Finite-state machine’, *Springer*, Aug. 2018, Accessed: Oct. 01, 2023. [Online]. Available: https://link.springer.com/chapter/10.1007/978-981-13-2622-6_47
- [9] ‘Finite-state machine’, Techtargt. Accessed: Oct. 01, 2023. [Online]. Available: <https://www.techtargt.com/whatis/definition/finite-state-machine>
- [10] J. M. Pittman, ‘The secret world of utility-based agents’, *Medium*, Accessed: Oct. 02, 2023. [Online]. Available: <https://betterprogramming.pub/the-secret-world-of-utility-based-agents-fa2da2fba839>
- [11] S. Parsons, ‘Journal of autonomous agents and multi-agent systems’, Sep. 2000. Accessed: Oct. 01, 2023. [Online]. Available: <https://www.sci.brooklyn.cuny.edu/~parsons/publications/editorials/jaamas.pdf>
- [12] ‘Façade’, *Facade Wiki*. Accessed: Oct. 03, 2023. [Online]. Available: <https://facade.fandom.com/wiki/Fa%C3%A7ade>
- [13] ‘Versu’. Versu. Accessed: Oct. 03, 2023. [Online]. Available: <https://versu.com/>
- [14] *Building systems with the ChatGPT API*. Accessed: Oct. 18, 2023. [Online course]. Available: <https://learn.deeplearning.ai/chatgpt-building-system/lesson/1/introduction>
- [15] K. Fagerlie, ‘How to fine-tune a ChatGPT 3.5 turbo model - Step by Step Guide’. Accessed: Oct. 19, 2023. [Online]. Available: <https://www.allabtai.com/chatgpt-3-5-turbo-fine-tuning-guide/>

- [16] *Perseus and Medusa*. Pressbooks. Accessed: Oct. 19, 2023. [Online]. Available: <https://pressbooks.pub/iagtm/chapter/story-perseus-and-medusa/>
- [17] ‘OpenAI-API-dotnet’. OkGoDoIt. Accessed: Oct. 18, 2023. [Online]. Available: <https://github.com/OkGoDoIt/OpenAI-API-dotnet>
- [18] A. Kelly, ‘How to use ChatGPT in Unity’, Immersive limit. Accessed: Oct. 18, 2023. [Online]. Available: <https://www.immersivelimit.com/tutorials/how-to-use-chatgpt-in-unity>
- [19] *ChatGPT prompt engineering for developers*. Accessed: Oct. 18, 2023. [Online course]. Available: <https://learn.deeplearning.ai/chatgpt-building-system/lesson/1/introduction>