Exploring Natural Language Processing on Enhancing Learning in Immersive Applications

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Background

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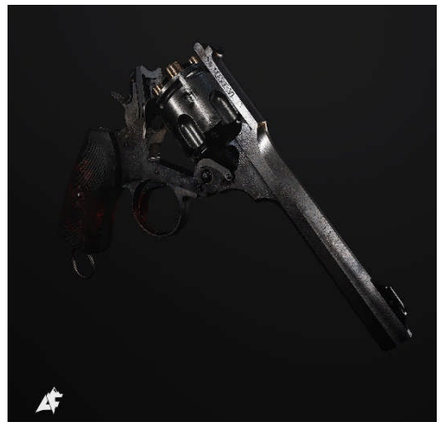
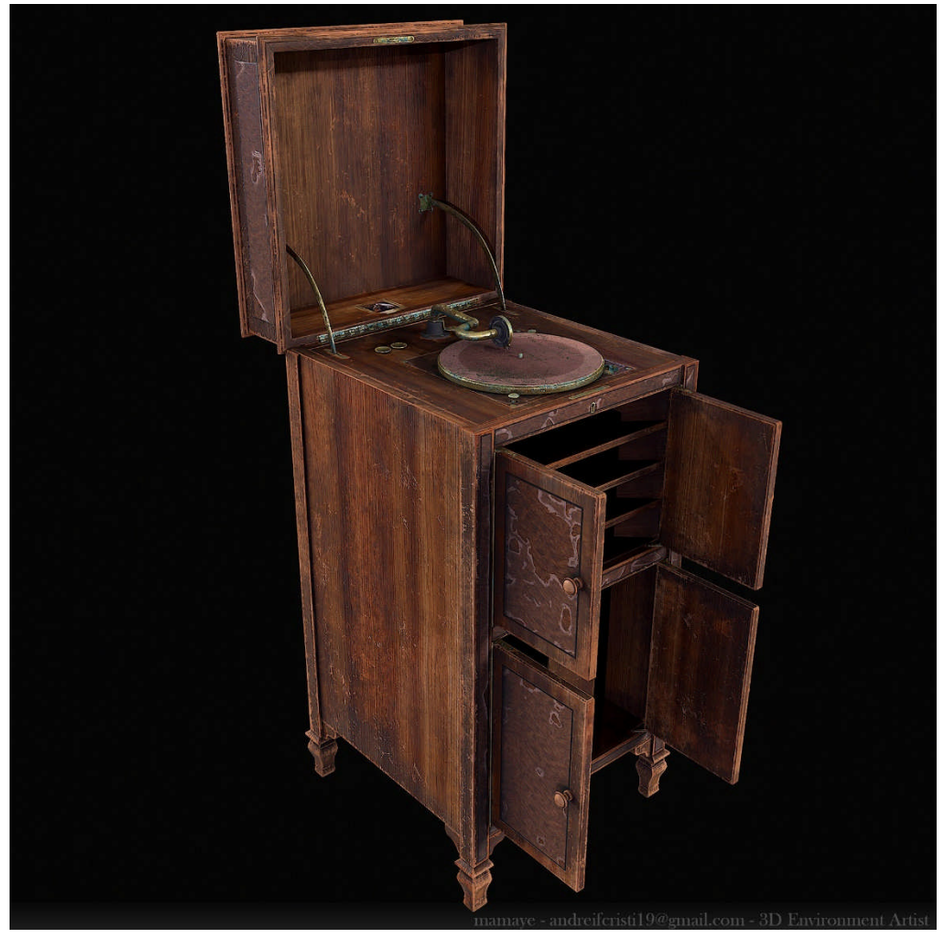




Introduction

- Integrating Natural Language Processing (NLP) with visualization systems and immersive technologies, such as Virtual Reality (VR), is a key area of research in simulation, training, and education.

- Through adaptive and dynamic visualization techniques, NLP can improve upon user presence and the realism of environments in simulations.

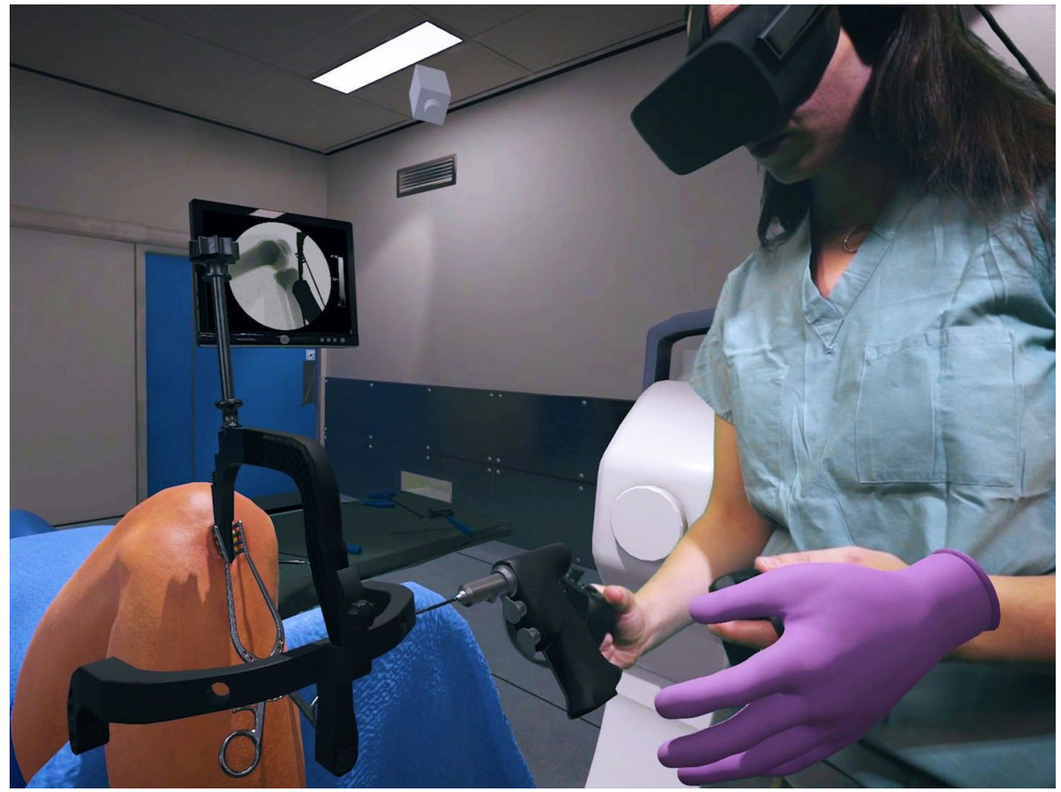
- This integration can create clarity and ease of interaction with complex visual data and thus can benefit skills acquisition and learning.

Why VR and NLP?

- **Virtual Reality, and other immersive simulation mediums, improve knowledge retention by creating a strong immersion and sense of presence.**

- Through adaptive and dynamic visualization techniques, NLP can improve upon user presence and the realism of environments in simulations.

- This integration is applicable in education, professional training, healthcare, and industry.



Source: https://www.wired.com/story/virtual-reality-surgical-training/

The Assumption

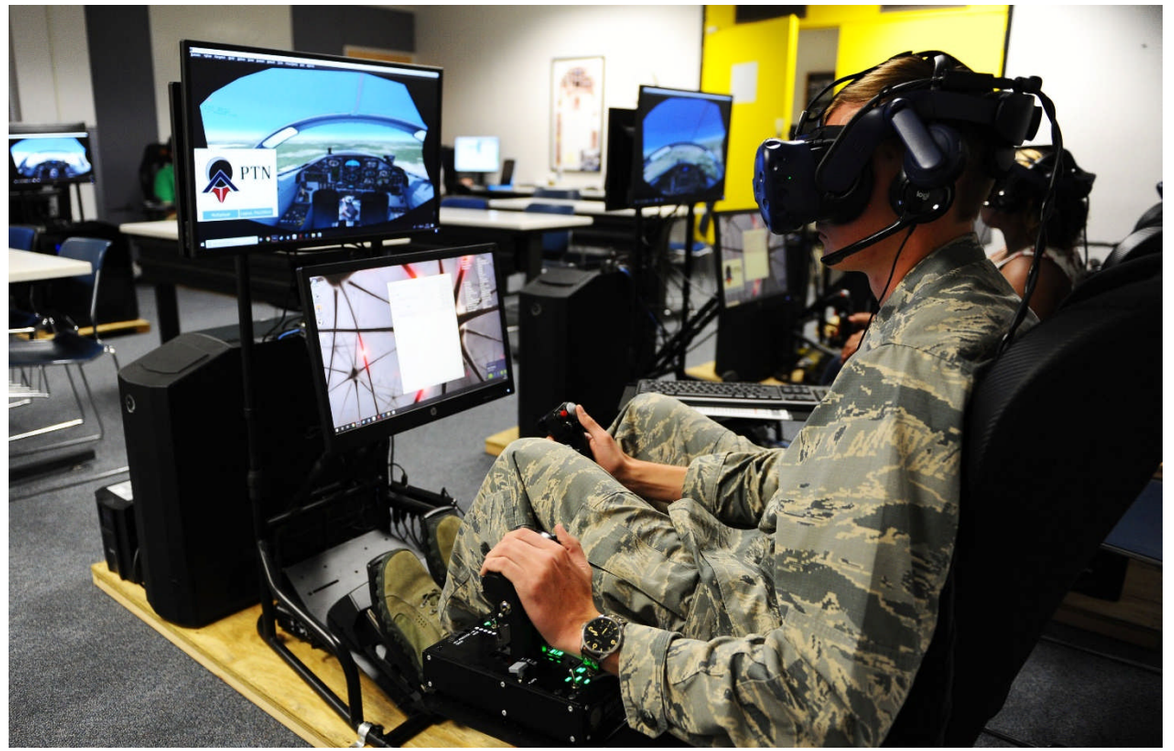
- Machine Learning (ML) algorithms have the potential to enhance immersive experiences and expand the capabilities of such VR environments. By continuously learning and adapting in real-time to user preferences and behaviors, ML-driven advancements allow more realistic, dynamic, and personalized simulations.

- Moreover, ML enhances VR by enabling the creation of complex interactions through the generation of realistic textures, environments, and dynamic elements. These improvements increase the adaptation of VR into various fields, from education to healthcare.

Natural Language Processing I

- NLP-powered dialogue systems in Virtual Reality applications are becoming increasingly integral in human-computer interaction and can be used both as task-based and non-task-based systems. In this case, a task-based system consists of Natural Language Understanding (NLU), Dialogue Manager (DM), and Natural Language Generation (NLG) components [1][7][24].

- Non-task-based systems refer to chatbots that simulate natural conversations and can fall into two categories: retrieval-based or generative models. Retrieval-based models can select responses from pre-defined options, and generative models create responses from scratch based on trained data.



Source: https://www.airforcetimes.com/news/your-air-force/2019/10/08/academy-brings-vr-pilot-training-to-cadets/

Natural Language Processing II

- These systems aid immersive learning scenarios by creating personalized experiences that can benefit from NLP real-time communication and enhanced task attribution based on the learning style of the students and their level of knowledge

- Evaluation systems can be implemented in VR simulations through the same NLP systems mentioned before, which can monitor the actions of the users and offer suggestions as well as warnings when mistakes are being made. In a similar technique, a final evaluation is made based on motion sensor data and the evaluation of actions and choices the user made during the exercise

NLP in Education

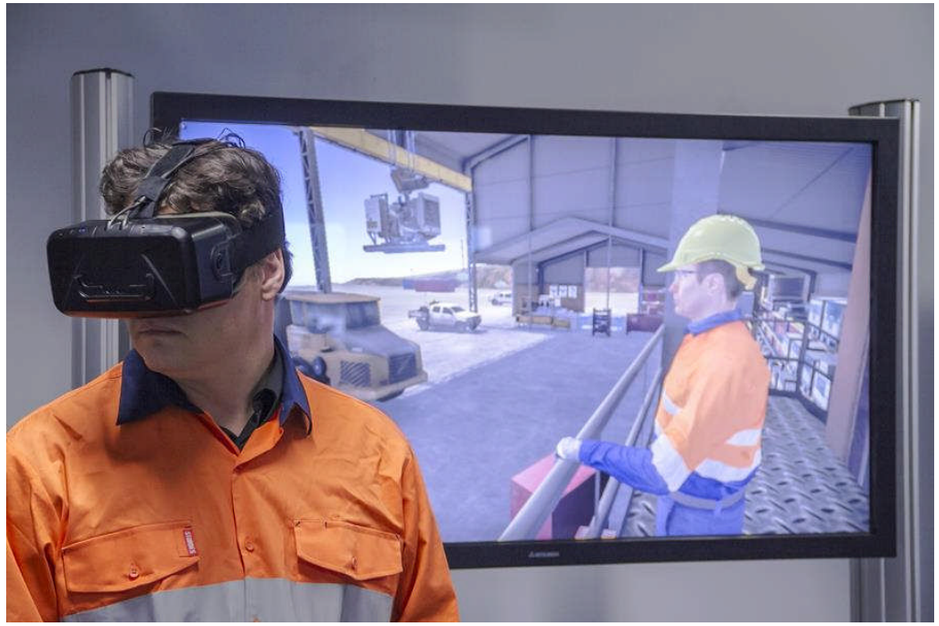
- For NLP-based educational VR, one of the commonly used subjects is Non-Native Language Learning and Teaching (NLLT). The main benefits include reflection on different learning styles, the autonomy of learners, higher motivation, and better achievement results. Information recall is an important aspect of training and education as it ensures better memory retention of a certain subject or activity. The level of agency in a virtual environment can be influenced by the level of cohesion a 3D scene can create between its elements with respect to its convention. Several applications in Virtual Reality benefit from a high level of photorealism such as medical training, diagnostic imaging and surgical simulation, architecture, engineering, industrial tasks, audiovisual production, flight simulation and others. When combining high immersion and agency with a high level of realism in a VR training experience, the results for competency-oriented education can be more than motivating.

NLP in Healthcare

- Medical training simulations for students.
- By providing verbal or text conversations with the chatbot, the systems give therapist-like responses to the users after analyzing the stress level of the student. In [27], the authors emphasize the sentiments of questions and the chatbot is capable of empathy-centric dialogues. Furthermore, as investigated in [7][9][14], authors present a conversational therapy VR game for patients with speech disorders like Autism or Aphasia. The sense of immediacy and control in a simulated environment engages the user by attaining their attention to the fullest resulting in better learning outcomes [20].

Source: https://www.mindbydesign.ca/vrtherapy

NLP in Engineering & Design



Source: https://www.viar360.com/virtual-reality-training-examples/

- **Guinn et al. demonstrated immersive worlds, which were successfully used in NASA's virtual space shuttle to train astronauts and flight controllers to repair the Hubble space telescope as well as by the Canadian Defence and Civil Institute for Environmental Medicine, which trained ship operators in sea manoeuvres and came to the result of an overall better performance [32]. Motorola also conducted a study of robotic manufacturing plant operations coming to similar results. These examples could be elevated using NLP communication possibilities thus improving learning time, and retention and reducing errors in performing complex tasks.**

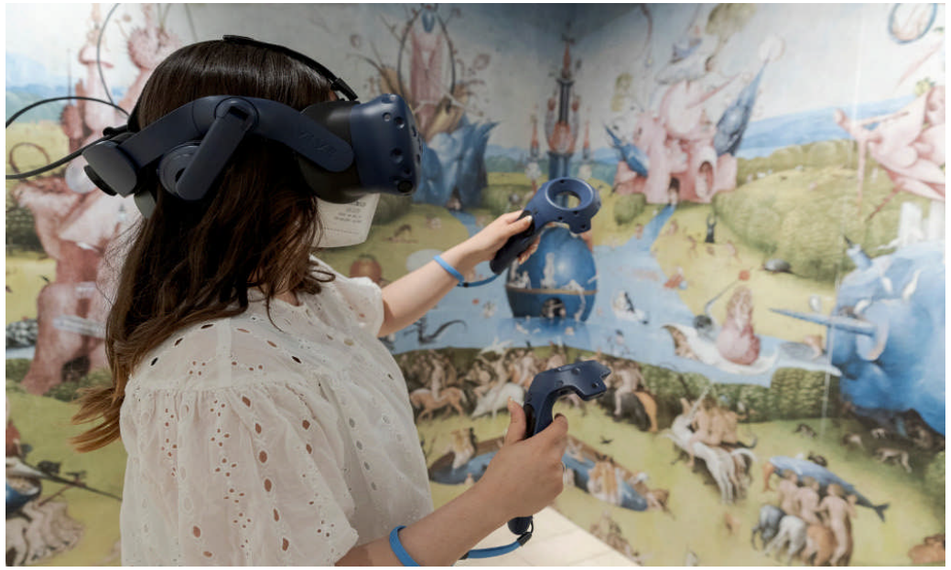
NLP in Digital Humanities

- **Interactive digital museums with AI-driven guides.**
- Virtual libraries with intelligent literary archives.
- Immersive experiences for historical understanding.

Source: https://powerhouse.com.au/program/victorian-reality

- The majority of the previously mentioned papers were developed through chatbot technologies. Users interact with the chatbot via speaking or typing. In the first case, speech is converted to text by Automated Speech Recognition (ASR) tools. For this purpose, state-of-the-art deep learning-based ASR models, like Google speech-to-text, are leveraged in some of the works. The acoustic model and language model are combined to create speech synthesis in such sophisticated ASR models.

VR Museum I



Source: https://www.mfk-frankfurt.de/delightful-garden-vr-en/

- **Future development of Virtual Reality experiences in conjunction with NLP, in digital heritage preservation, should aim to harness the possibilities of Artificial Intelligence (AI) by using AI agents who could offer guidance and information to the viewer. These agents utilize AI and NLP to provide personalized guidance, present relevant information, and respond to user inquiries in real-time. In a digital museum, an immersive library with meticulously created archives from the literature corpus and historical sources can benefit from AI technology. A musical instrument with an info screen can offer multiple choices to further one's research on a certain topic, which, by choosing to explore further, would enable the user to be transposed into a 3D environment created using AI, powered by a library of predefined 3D modular assets. Based on prior behavioral responses, the system can make a connection with visual or auditory material from the same period or genre.**

VR Museum II

- In a digital historical environment, for example, one can choose a book from a library and have the possibility of finding out how that book would “sound” by creating a book-based song with AI. This involves leveraging machine learning models trained on data cured for that period or genre. This process involves Text Analysis, NLP-based feature extraction, model training to map text to melody, defining musical parameters, iterative refinement with human intervention, and output evaluation [35]. The use of 3D assets can be a way of interacting with information in a digital museum. Each space can represent a different level of knowledge, gradually unlocked to the viewer. As the participant progresses through the experience, they uncover clues scattered across the spaces, gradually revealing more about the history and the lives of the people who lived there. This interactive application not only offers cultural and educational value but also provides an element of enjoyment, allowing users to learn through interaction. Of course, there can also be a disadvantage in AI-generated interpretations as it may inadvertently misrepresent or oversimplify complex cultural narratives, leading to ethical concerns and potential disrespect towards the heritage being presented. The paper [36] explores the ethical implications of AI in cultural heritage, highlighting the need for context-sensitive approaches to avoid negative impacts.

Challenges & Limitations

- NLP model accuracy in complex contexts.
- Ethical concerns and user data privacy risks.
- High development and implementation costs.
- Need for appropriate regulations in AI-driven education.

Future Developments

- Real-time translation in VR for global collaboration.
- Adaptive learning based on user behavior.
- Automated performance evaluation in VR training.
- Enhanced interactivity through advanced AI agents.

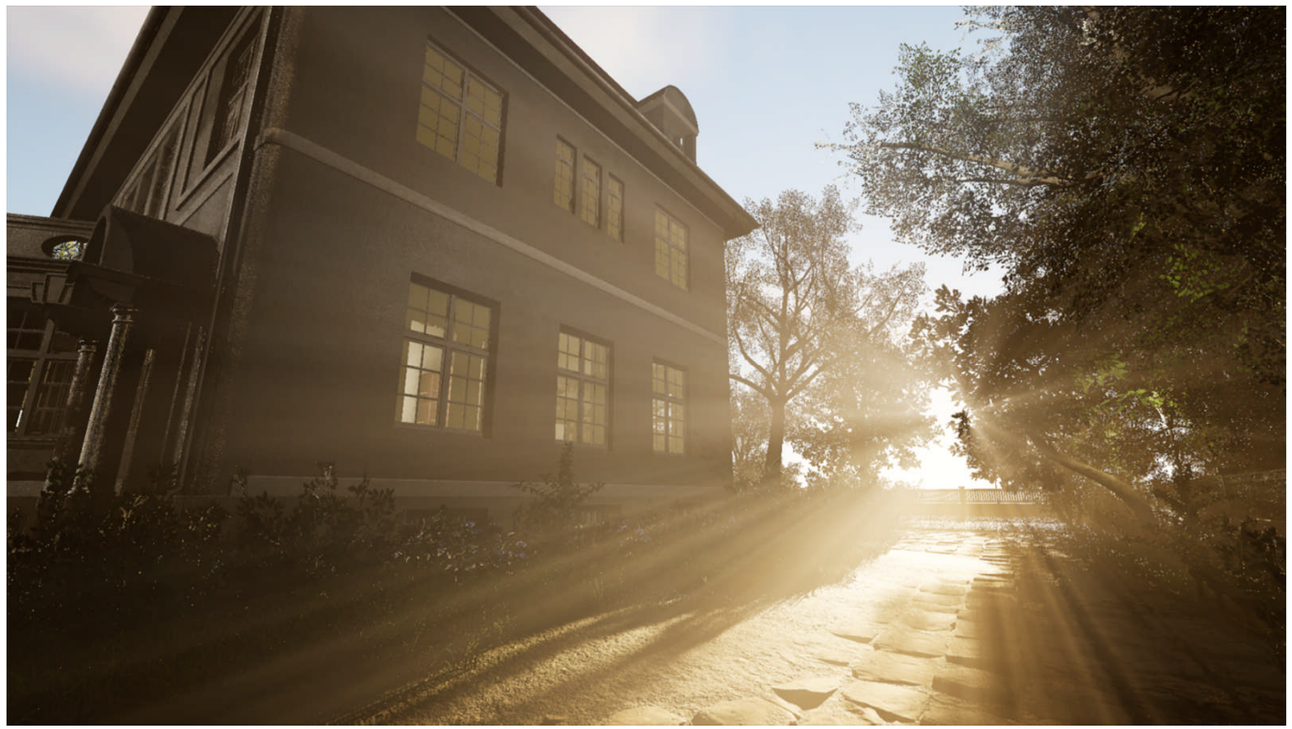
Conclusions

- NLP and VR can aid education, healthcare, and engineering.
- Natural interactions and personalization would enhance learning outcomes.
- The technology continues to evolve, opening new possibilities which must be considered.
- A responsible and ethical approach is needed for development.

Thank you

for your attention!

Questions ?



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