AI-Aided-XR: AI aided Augmented/Virtual Reality applications and VR aided Machine Learning

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The domains of Artificial Intelligence (AI) and Extended Reality (XR) are growing rapidly, with many sectors making meaningful contributions at blistering pace and providing an opportunity for applications in the space domain to make use of recent state-of-the-art innovations. A notable example of this is game engines and their novel use in creating realistic simulations for capturing data [1], or bleeding edge Convolutional Neural Networks (CNN) such a DeepLabV3+ for computer vision on Mars imagery [2], [3]. The European Space Agency (ESA) have acknowledged this by integrating AI into their Mission Operations Data Systems through the preparation of the Artificial Intelligence for Automation (A2I) Roadmap [4]. As well as the A2I Roadmap, ESA have also dedicated a prominent place for AI and XR in their 2025 Agenda [5]. While the benefit of AI and XR technologies being applied to astronaut training, teleoperations and maintenance tasks [6] have been explored and are well understood - even up to being deployed on the International Space Station (ISS) [6], [7] - there remains a significant scope in the context of space exploration, and other areas, for AI and XR technologies to demonstrate significant impact.

Both AI and XR have huge potential to change the way the international community interacts with space. This can range from educational devices using AR to interact with satellite imagery for commercial tourism [8] or the ability for mission operators to view automatically labelled and classified images of terrain taken by planetary rovers [3]. AI is also playing a key role in the abundant research opportunities arising from the Mars Sample Return Mission [9], where computer vision techniques for object pose estimation plays a foundational part of the mission. Object pose estimation, like many other space domain AI applications, is severely limited in the availability of data for sufficient training, and as such projects like [1] offer to fuse VR and AI to synthetically create datasets in a simulator. The Mars Sample Return Mission and corresponding Orviz[1] project highlight a real need for well-labelled, high-fidelity and varied datasets to unlock the potential of AI technology in the space sector through the use of XR. Efforts to tackle this were made in the CISRU [10] activity, in which a real dataset was captured at the ESA Planetary Robotics Lab (PRL) to address the lack of data for In-Situ Resource Utilization (ISRU).

As such, the AI-Aided-XR activity, funded by ESA, proposes to build upon these concepts, in which XR and AI can be used in a harmonious loop to mutually benefit one other. With AI and XR existing in a cyclical function, the proposed use is that the AI will enhance the XR and the XR will thus enhance the AI. We propose a symbiotic relationship which directly addresses the lack of data in space AI applications: a simulated environment which is procedurally generated using fractal algorithms and an AI platform built upon ESA's AI4OPs [11] technology which trains on the generated scenery for planetary terrain classification, building upon the success of the recent ESA ViBEKO [3] activity, using Google's DeepLabV3+ [12] model. This symbiotic relationship has potential applications in areas which require rich and bespoke datasets, with operators able to configure the details of the environment simulator as required.

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