Cloud-Based Visual Discovery in Astronomy: Big Data Exploration using Game Engines and VR on EOSC

Game engines are continuously evolving toolkits that assist in communicating with underlying frameworks and APIs for rendering, audio and interfacing. A game engine core functionality is its collection of libraries and user interface used to assist a developer in creating an artifact that can render and play sounds seamlessly, while handling collisions, updating physics, and processing AI and player inputs in a live and continuous looping mechanism. Game engines support scripting functionality through, e.g. C# in Unity [1] and Blueprints in Unreal, making them accessible to wide audiences of non-specialists. Some game companies modify engines for a game until they become bespoke, e.g. the creation of star citizen [3] which was being created using Amazon's Lumebryard [4] until the game engine was modified enough for them to claim it as the bespoke "Star Engine". On the opposite side of the spectrum, a game engine such as Frostbite [5] which specialised in dynamic destruction, bipedal first person animation and online multiplayer, was refactored into a versatile engine used for many different types of games [6]. Currently, there are over 100 game engines (see examples in Figure 1a).

Game engines can be classified in a variety of ways, e.g. [7] outlines criteria based on requirements for knowledge of programming, reliance on popular web technologies, accessibility in terms of open source software and user customisation and deployment in professional settings. The latter are also referred to as serious games, i.e. especially designed games that can be used in academia, industry or public organisations for research, training and outreach. A comparison of engines for developing serious games is presented in [8]. Game engines are increasingly exploiting Virtual and Augmented Reality (VR/AR) technologies. VR uses algorithms and behavioural interfaces to simulate entities residing in a virtual world that interact with each other and with one (or more) users in real-time, in a mode of pseudo-natural immersion via sensorimotor channels [9]. AR adds to VR by combining with the real world [10], so that users can see everything in front of them as if they are wearing a weak pair of sunglasses [11]. Head mounted displays (HMDs) are essential instruments for VR/AR experiences and can be used in a mobile, tethered or standalone setting (Figure 1b).

(a) (b)

Fig.1: Popular technologies for (a) game engines and (b) head mounted displays

Mobile HMDs are shells with lenses with allocation to insert a smartphone. The lenses separate the screen into two images for the eyes for stereoscopy, e.g. the Samsung Gear VR [12] and the Google Daydream View [13]. Low cost mobile solutions typically exhibit narrow fields of view and low pixel and polygon count which is not enough to provide fully engaged experiences. Tethered HMDs include the Oculus Rift S [14], the HTC Vive Cosmos [15], and PlayStation VR [16] and require a physical connection to computing resources. Standalone headsets were at first a useful novelty that offered a taste of VR without investment into a gaming PC or a flagship phone. Earlier released headsets such as Oculus Go and Lenovo Mirage Solo were both capable headsets that worked well on their own, but they had the same limited controls and motion tracking as mobile headsets. The recently released Oculus Quest [17], has been suitably used as standalone VR. Currently, in the VR game industry, there are two main competitors, namely Oculus Rift and HTC Vive, although new exciting HMDs are being released such as the 8K resolution XTAL [18] which is supporting a wide field of view, automatic eye detection, integrated leap motion, voice control, and also works with a range of tracking systems (such as ART, SteamVR and OptiTrack) for deep user immersion experiences (Figure 2).

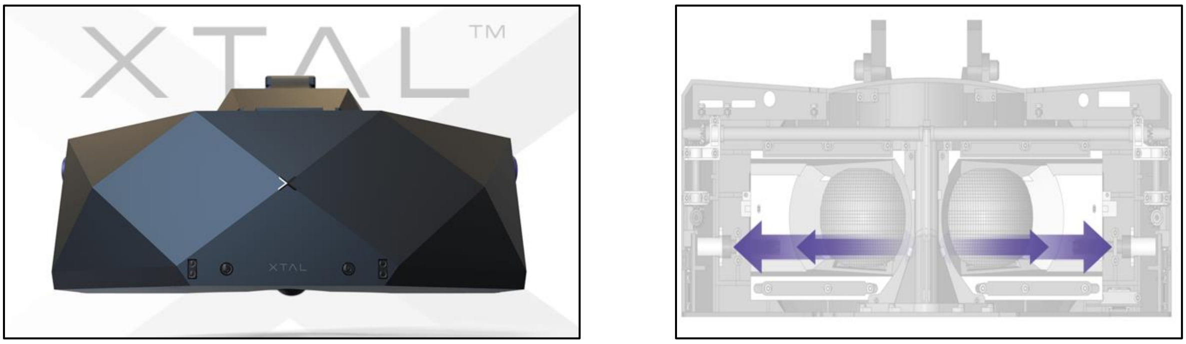
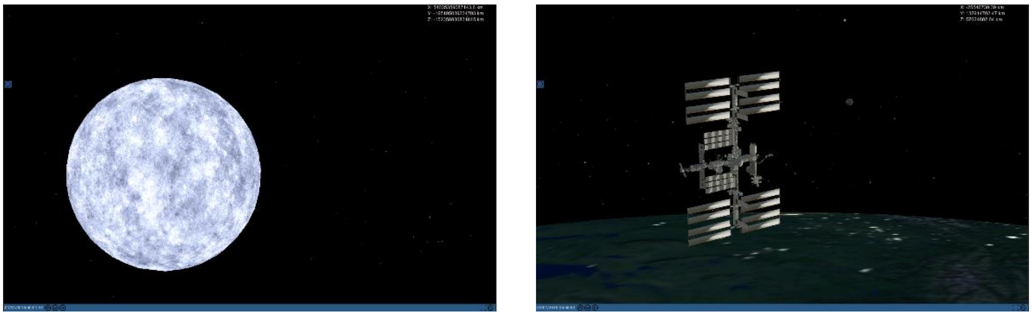


Fig.2: The XTAL HMD

Astronomers are facing an emerging flurry of enormously large, incredibly rich and highly complex data volumes expected to be delivered by a new generation of technologically advanced telescopes, in particular in the radio bandwidth, such as the SKA [19]. Such enormous data volumes impose extremely challenging demands on traditional approaches, e.g. analysis and imaging software tools will have to be adapted at various levels, if not completely re-designed, to run efficiently at scale with satisfactory performances. NEANIAS is addressing such challenges by prototyping new innovative services to develop agile, fit-for-purpose and sustainable offerings accessible through the European Open Science Cloud (EOSC). An earlier NEANIAS blog posting discusses the challenges in radioastronomy in the SKA era [20].

The data visualization services (NEANIAS S1) will deliver a set of functionalities to enable efficient cloud-based visual discovery in large datasets from multiwavelength surveys, ensuring scalability and exploiting innovative approaches through VR/AR. We are building upon the Astra Data Navigator (ADN), which is a 3D visualization environment developed with the Unity3D game engine for large stellar catalogues supporting interactive data exploration and navigation mechanisms e.g. for advanced comparisons in multidimensional and multifrequency datasets (Figure 3 and Figure 4). Our focus is on enhanced realism, precision and usability along a number of aspects relating to enriched user experiences covering e.g. novel navigation mechanisms and advanced real-time tracking. The core components consist of a tracking system interface integrated with motion tracking, a specialised data connector for retrieving data coming from different sources and a positioning manager for retrieving specific data about position/rotation of particular objects relating to specific temporal instants.



(a) (b)

Fig.3: The Astra Data Navigator (a) Blue Giant Star and (b) ISS, Earth and Moon

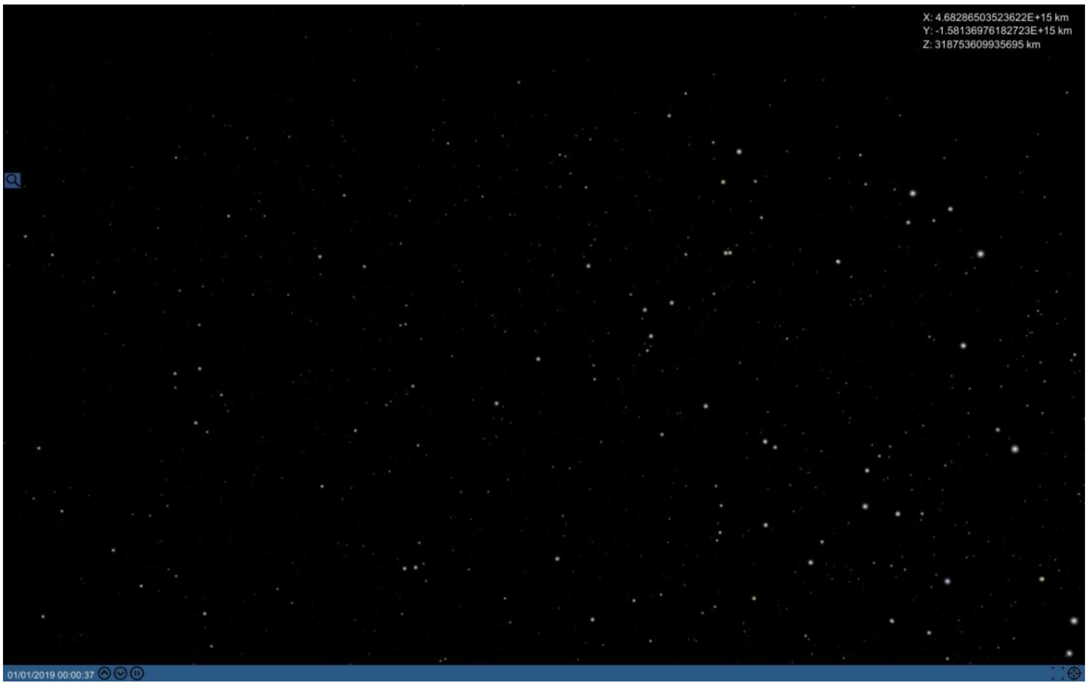


Fig.4: The Astra Data Navigator: visualising Hipparcos

ADN is being enabled to extend navigation mechanisms within the Hipparcos catalogue [21] which contains 110K celestial objects with ultimate goal to fully integrate the GAIA catalogue [22] which contains over 1.8 billion objects. Given the amount of data to be loaded, the existing internal logic is being re-designed to be independent from the amount of objects in the catalogue. Other existing tools, such as CosmoScout [23] and SpaceEngine [24] are developed completely from scratch, making their maintenance and therefore scalability over time complex. ADN in contrast is developed using the

Unity3D game engine, to allow for continuous maintenance of the physics and graphics underpinnings automatically. Additionally, it is possible to manifest ADN versions targeting different hardware platforms with minimal developments, as typically only small-scale code modifications have to be performed.

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[1] https://unity.com

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[3] https://robertsspaceindustries.com/star-citizen

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