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Into the (un)known

A Science Art journey of the Cosmos Data

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Abstract. Into the (un)known is a multi-sensory, immersive exploration of the Cosmos, where the most recent astrophysical data are heightened into real works of art, so to allow the public to access scenarios - until now reserved only to researchers - with emotional immediacy. The core of this multi-disciplinary project is the creation of immersive science art exhibitions easily tuneable for scientific outreach festivals, such as the INAF exhibition at the 2020 Science Festival in Genoa, and art installations, such as the 2021 Venice Cinema Biennale. In this work, we present the technical pipeline developed to transform scientific data into Cinematic Scientific Visualisations used for the project, and we present some highlights of the immersive exhibitions realised.

Key words. science art, Cinematic Scientific Visualizations, multidisciplinary, astrophysics outreach, public engagement

1. Introduction

Into the (un)known[1] is a multi-sensory, immersive exploration of the Cosmos, where the most recent Astrophysical data are heightened into real works of art, so to allow the public to access scenarios - until now reserved only to researchers - with emotional immediacy. Into the (un)known is the output of a Master thesis project named Fiber of the Universe For more details on the project, please visit the webpage: http://visitlab.cineca.it/index.php/portfolio/fiber-of-the-universe/ created in collaboration between the MAGCOW group of the University of Bologna and the CINECA Visual Information Technology Laboratory. In Fiber of the Universe, we develop a software pipeline to

[1] For more details on the project, please visit the webpage: https://www.giannandreainchingolo.com/ituk

transform the raw data of Astrophysics research into Cinematic Scientific Visualizations (CSV). The CSVs are used in Into the (un)known for images, videos, VR experiences and wall mapping exhibitions, in collaboration with Computer graphics artists, musicians and writers. Into the (un)known targets two audiences: the scientific community interested in the research contents; and both the Art community and the general public attracted by the appearance of the exhibitions. With carefulness for Artistic expression, Into the (un)known creates an emotive channel between Science, Technology, and Art to engage the public and facilitate the dissemination of the scientific works represented in the projects. We present in Sec. 2 the technical pipeline we developed in the project Fiber of the Universe for CSV creation. We analyze a case of study of this pipeline applied to galaxy evolution research data in Sec. 3. Sec. 4 and 5 describe some examples of how we use Into the (un)known artworks for respectively artistic exhibitions and scientific outreach events. We summarize the results and suggest future work in Sec. 6.

2. Fiber of the Universe and the CSV Pipeline

In this section, we present the CSV data processing pipeline, developed for Fiber of The Universe. CSVs are high-quality data representations produced in close collaboration with scientists. To Achieve high-quality visualizations, we use movie-making tools and techniques, such as good composition, camera direction and artistic aesthetics. In Fiber of the Universe, we realized CSVs suitable for immersive and interactive experiences and exhibitions for a general non-expert public and science specialists. Fig. 1 shows the data flow and the workflow of the pipeline we developed for Fiber of the Universe, along with the software used thereby. The pipeline is split into three steps: filtering, mapping and rendering. In the filtering, we apply processing algorithms to transform the scientific raw data into derived data suitable for CSVs. The main tools

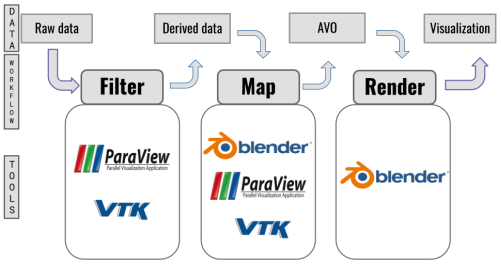

Fig. 1. The developed CSV pipeline with the tool used for the filtering stage, the mapping stage, and the rendering stage.

used for this step are VTK[2] and Paraview[3]. Examples of the algorithms we used are data format transformations, thresholding, contouring and gaussian smoothing. The mapping consists of turning the derived data into 3D graphical objects chosen to represent them, called Abstract Visualization Objects (AVO). AVO are graphic representations, characterized by attributes such as size, colour, transparency and textures. These attributes reflect the visualization idea and dissemination message the scientists and experts want to deliver. In addition to the tools used in the previous stage, we decided to use Blender[4], an open-source computer graphics toolkit. We chose this software because it implements a Python binding to easily ingest the data coming from the filtering step and build the geometry needed for the rendering stage. We continue to use Blender also in the final rendering stage, which consists of rendering the AVO into 2D images for the different CSV. Blender uses up-to-date cinematic techniques for the visualizations, for example, Volume Rendering, the path tracing engine[5], colourmaps and materials for the objects, cinematographic camera movements and more. With these tools, we can enhance the inherent beauty of the data and show their aesthetics in high-quality visualizations.

[2] https://vtk.org/
[3] https://www.paraview.org/
[4] https://www.blender.org/
[5] https://docs.blender.org/manual/en/latest/render/cycles/introduction.html

3. Galaxy cluster evolution: A case of study

In this section we see the application of the Fiber of the Universe pipeline for the CSV generated from the simulation data of a galaxy cluster evolution (Wittor et al. (2016)) (Wittor et al. (2017)), and radio observation data (Rajpurohit et al. (2018)) (Rajpurohit et al. (2020)) (Stuardi (2019)). The simulation investigates how weak shocks affect the production of electromagnetic radiations in the evolution of galaxy clusters, using test particles called Lagrangian tracers, and the data are a collection of regular 3D grids representing the electromagnetic radiations (emission volume) and the density of the baryonic matter (density volume) and a selection of scattered particles. To enhance the results of how the lagrangian tracers evolve and investigate the simulation data, we decided to represent them as spheres that change colours when crossing specific emission volume regions of the clusters; each sphere leaves an enlightened trail based on their trajectory, and we realize a camera motion along one of these trajectories. To realize this visualization, in the filtering step, we applied the vtkProbeFilter[6] of VTK to probe the emission volume at the positions of the particles. We associate the tracer's dataset with the volumetric emission dataset for changing the colour of the spheres exactly when the tracers cross the specified emission volume regions. In the mapping step, we created the AVO of the tracers as spheres with a trail. In particular, we built each trajectory starting from the tracer's position at each time step, later used to guide the AVO and the camera motion in Blender. In the final step, we render the CSV as a 360 stereoscopic animation, combining the Blender path tracing engine with its rasterization engine[7] . Fig. 2 reassumes all the techniques used in the pipeline for the Galaxy cluster evolution CSV. We used the CSV obtained in several contexts, both internal to the scientific community - awarding the 1st prize at the NRAO image contest for the VLA 40th anniversary[8] - and for public engagements. In particular, we realized for the general public a 360 VR video called "Relics of a cutting-out boarding", combining the aesthetics of the scientific visualization with evocative storytelling that describes the scientific phenomena through the analogy of a cutting-out boarding between ships in the ocean[9].

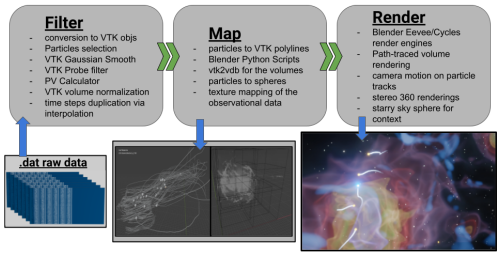

Fig. 2. Pipeline steps for the CSV realization of the galaxy clusters evolution case of study.

4. Application for artistic public engagement

One of the targets of Into the (un)known is the artistic community and the general public attracted by the aesthetics of the Science Artworks created. With this aim, we pay attention to the aesthetic aspects and the creation of evocative storytelling. Storytelling, in particular, is essential to recreate narrative analogies for the general public between known elements of one's daily life and the scientific elements represented in Into the (un)known. An example is a series of short VR videos[10] in which we describe complex and advanced Astrophysics concepts - such as Turbulence around massive black holes, the cosmic web, and the merging of galaxy clusters - with everyday life analo-

[6] https://vtk.org/doc/nightly/html/classvtkProbeFilter.html

[7] https://docs.blender.org/manual/en/latest/render/eevee/introduction.html

[8] https://public.nrao.edu/news/2020-image-contest-winners/

[9] https://www.youtube.com/watch?v=9R2PZ9gWbNU

[10] The videos are available on Youtube at the following link: https://www.youtube.com/playlist?list=PL1RbvscKZmDhH40L3l-8FJ7ueWk9cgUfb

Fig. 3. Into the (un)known exhibition at MEET digital Culture Center for the 2021 Venice Cinema Biennale.

Fig. 4. VR room at the Into the (un)known exhibition organized by INAF for the 2020 Genoa Science Festival.

gies. We put the videos on Youtube to make them easily accessible other than the exhibitions through a smartphone and cardboard. Into the (un)known has been selected for an artistic residence at the MEET Digital Culture Center in Milan, funded by the European project STARS. At the end of this artistic residency, we created an immersive video installation called "Light generators", presented during the 2021 Venice Cinema Biennale, as shown in Fig. 3 .

5. Application for Scientific Outreach

The artistic expressions of Into the (un)known help create emotional engagement with the public. However, public engagement is not sufficient for Scientific outreach and education purpose. With this aim, we rethink the Science Art installations using more suitable elements. An example is the exhibition we created in collaboration with the National Institute for Astrophysics at the 2020 Science Festival in Genoa. The subject for the exhibit was the Light and the Astrophysical scenarios in which Light is generated. For this exhibit, we designed a single itinerary combining the CSVs, in which we dedicated each room to a specific astrophysical process (see Fig. 4). This exhibition targeted the general public and primary school groups (6-10 years). For the general public, we run scientific guided tours and a conference to deepen the scientific concepts related to the exhibition with the researchers. For school groups, we created two hands-on workshops: the first was dedicated to turbulent phenomena, recreating a visual analogy with some of the installations; the second to realising a spectroscope that the children could take home at the end of the experience.

6. Conclusion

Into the (un)known is a Science Art project based on Cinematic Scientific Visualizations realized from astrophysical research data (see Fig. 5). We took care of the aesthetic and narrative aspects of CSVs collaborating with artists. Thanks to its aesthetics, Into the (un)known was exhibited in artistic environments, such as the 2021 Venice Cinema Biennale. Simultaneously, the emotional impact of Science Art works helps to make the scientific communication of the data represented more effective, as shown in the INAF exhibit at the 2020 Genoa Science Festival. Furthermore, CSVs allow the research community to look at the data differently, inspiring new ideas for further analysis and work. Proof of this is the study inspired by the case study "Galaxy evolution" (Sec. 3) (Inchingolo et al. (2022)) Finally, we remark that the processing algorithms, tools and data formats developed in Fiber of the Universe for the CSV pipeline can be easily adapted to other scientific and educational situations beyond their original application for astrophysical content. Using CSVs can aid the scientific community in presenting their results to citizens and the municipality, grow community awareness and support decision-making processes. For example, we

Fig. 5. Scanning the QR code, you can find the links to Into the (un)known and Fiber of the Universe projects, the photo gallery with the colored images of this paper, and the VR video produced on Youtube.

are currently working on a climate change issues project to adapt our pipeline for creating immersive, impactful scenarios generated from meteorological volumetric datasets.

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