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SORVEGLIATI SPAZIALI
LEVERAGING AR FOR PLANETARY DEFENSE AWARENESS

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Extended Abstract

Sorvegliati Spaziali is a communication initiative by the National Institute for Astrophysics and stands as one of the world's pioneering public awareness campaigns on Planetary Defense coordinated by a research institution. The project benefits from a close partnership with the external company *ASSA srl*, which aids in developing innovative digital communication experiences. As part of this collaboration, a brochure featuring augmented reality-enabled content and a dedicated app named Sorvegliati Spaziali were developed. The augmented reality app allows users to simulate Planetary Defense phenomena in their environment and provides in-depth content. Here, we briefly present the Sorvegliati Spaziali project and take a more detailed look at the AR app.

1. Introduction

Among the various threats we face on Earth, those originating from space present significant challenges, which are addressed within the field of Planetary Defense. This field encompasses all the capabilities required to achieve comprehensive Space Situational Awareness (SSA) around Earth, including the detection of asteroids and comets that could pose a threat, the study of space weather phenomena and the surveillance of space traffic , and the development of warnings and strategies to prevent or mitigate their potential impacts.

Despite the global importance and public interest in these topics—often seen as directly affecting our lives—public communication on Planetary Defense remains fragmented and underdeveloped. There are few outreach initiatives worldwide that cover all aspects of Planetary Defense comprehensively, and even fewer are coordinated by research institutions [1, 2, 3].

Conversely, the public is often exposed to sensationalized media reports about space threats, such as exaggerated claims of newly discovered asteroids being on a definite collision course with Earth. When an asteroid is discovered with a potential risk of collision, this risk is initially calculated based on available data. Many news outlets report on this threat, but as observations increase, the determination of the asteroid's orbital parameters becomes more precise, and the collision risk often drops to zero. Unfortunately, this part of the story is rarely covered because it lacks sensational appeal.

It is essential to communicate these developments to prevent misunderstandings and the spread of fake news, while also explaining the research process itself. Otherwise, the public might believe that scientists were initially wrong about the collision risk or lose trust in science communication due to repeated 'cry wolf' scenarios. This, in the long run, risks undermining public trust in science communication due to non-existent and clickbait alarms, and in scientific research due to the perception of scientists making incorrect predictions.
This underscores the importance of a well-organized and scientifically grounded public outreach campaign.

With this goal in mind, the initiative Sorvegliati Spaziali - looking up to Space to protect our Planet was created [4 , 5]. This public dissemination project by the Italian National Institute for Astrophysics (INAF) [6] is entirely dedicated to Planetary Defense and is endorsed by the Outreach Office [7] of the NASA Planetary Defense Coordination Office [8].
Sorvegliati Spaziali is the first public outreach initiative in Italy and one of the first in the world to be coordinated by a research institution on comprehensive Planetary Defense.

2. The project, its goals and team

The science communication project Sorvegliati Spaziali aims to communicate to the public on a wide range of topics related to Planetary Defense, including near-Earth asteroids and comets, space weather, meteors, meteorites, and space debris, as well as strategies for preventing and mitigating their potential effects on Earth's environment. The project seeks to promptly disseminate scientific and cultural knowledge through a variety of innovative multimedia products, leading the way with a transversal, multidisciplinary, and narrative science approach.
At the heart of the project is the fully graphic and multimedia Italian website, sorvegliatispaziali.inaf.it, developed in collaboration with the web design firm Assa srl [9] based in Bologna, available online since October 2021 (in Italian and partially in English), where all the other outreach products of the project are published.
The website presents Planetary Defense through a variety of original INAF information and in-depth products, while also relaunching news from other national and international research bodies.

The website serves as a hub for multiple communication products, including news articles, various types of video clips (educational, theatrical, interviews, in-depth), infographics, bulletins on near-Earth objects, solar activity, and meteor showers, a geo-localized map with live satellite and space debris tracking, augmented reality features, a glossary, and reviews of blogs, books, movies, public events, and more.

For the production of such a diverse range of communication products, we have assembled an equally diverse team. To do that, a coordinated INAF working group with personnel (communicators, scientists, and technologists) from multiple INAF sites across Italy was created. This cooperation is based on sharing know-how and skills and involves collaboration with external institutions active in the field, external firms, web designers, theatrical companies, the Italian national public broadcasting company RAI, comic book artists, and natural science museums.

3. Sorvegliati Spaziali in Augmented Reality

Augmented Reality (AR) is a technology that allows digital elements, such as images, sounds, or text, to be superimposed on the surrounding physical world in real time through devices like smartphones and tablets [10]. AR applications (AR apps) have great potential for communicating science in an engaging, accessible, and tangible way. This is especially true for younger generations, who have high expectations for digital communication and are attracted to technological innovation and interactivity.

To explore the potential of AR, we collaborated with *Vitruvio Virtual Reality,* a brand of the Italian company ASSA srl, which managed the development of the Sorvegliati Spaziali website. Together, we created a brochure for the project featuring AR content and the Sorvegliati Spaziali AR app to activate the AR experience. This partnership ensured stylistic consistency between the brochure and the website.

The brochure, designed in vertical A5 format, can also be opened in vertical mode. To ensure a consistent visual identity, the cover colors and font were chosen to reflect the main shade of blue and typography from the Sorvegliati Spaziali website, strengthening brand recognition across all communication material. This attention to detail helps create a uniform and professional visual experience, both online and in printed media.

The narrative comes to life right from the cover, which depicts Earth surrounded by a trail of visual elements open to multiple interpretations: the stars of the Milky Way, space debris in low Earth orbit, or the Main Asteroid Belt, a source of potentially hazardous asteroids.The conveyed message is that Earth is the protagonist of this cosmic scenario and must be protected (the illustration continues on the back cover as well). The first page offers a concise explanation of Planetary Defense and the Sorvegliati Spaziali project, including a QR code to download the relative AR app. Upon opening the brochure, readers find an overview of the four Planetary Defense themes covered by Sorvegliati Spaziali.

Further vertical unfolding reveals a version of the website's homepage. The colors used are those selected for the homepage, chosen based on the different themes, but with high-contrast adjustments specifically designed to optimize the activation of AR content via mobile device.

4. The Sorvegliati Spaziali AR app

The AR app developed to enhance the brochure with augmented reality content was named *Sorvegliati Spaziali*, the same as the project, as part of a strategy to strengthen the project's identity and ensure strong recognition.

The AR app allows users to simulate Planetary Defense phenomena directly in their environment, serving as an edutainment tool while also offering in-depth scientific and historical content. It can be used independently or in combination with the brochure and includes four main

AR experiences, plus an additional experience when used with the brochure.

The app utilizes 3D graphic content created through modeling software, which is then integrated into the Unity platform. By navigating the app, users can get a general overview of the Sorvegliati Spaziali project or dive directly into the interactive AR experiences.

The four AR experiences are as follows:

1. dynamic and colorful aurora with sounds generated from the sonification of emitted radio waves (space weather experience). The aurora is simulated with green drapes at the bottom and reddish hues at the top, faithfully reproducing the natural colors of the aurora borealis based on the atmospheric altitudes at which the phenomenon occurs. Users can observe the aurora from different angles and move beneath it.
2. Entry and explosion of an asteroid in the Earth's atmosphere, followed by the simulation of meteorite search on the ground (asteroid experience). Inspired by the 2013 Čeljabinsk event, the simulation begins with the entry of a dark object into the atmosphere, a common characteristic of most asteroids. The object progressively heats up, increasing its brightness until it explodes due to pressure forces. During the explosion, users can hear the boom, which arrives later than the luminous phenomenon, in full accordance with real physics. At the end of the experience, users can explore the ground to search for fragments of the asteroid, which appear as meteorites of various shapes. These meteorites have dark exteriors and lighter interiors, to reproduce their fusion crust, a real structure formed due to the high temperatures developed during their passage through the atmosphere. By approaching the ground, users have the opportunity to zoom in on them.
3. Space traffic orbiting Earth, consisting of active satellites and space debris at various orbital altitudes (space debris experience). It is possible to zoom in on Earth, zoom out, and rotate it to explore the orbits from different perspectives and angles, all via the touchscreen, using your fingers directly on the mobile device screen. The visual representation includes objects in geostationary orbit, which rotate at the same speed as Earth, and those in lower orbits, which move at progressively higher speeds and are more numerous than the geostationary satellites. These features are all accurately reproduced to reflect the reality of Earth's orbits.
4. meteor showers overlapping the starry sky appearing to emanate from their constellation’s radiant. Colors and brightness reflect statistical observations [12] (meteors experience).
   We have selected three meteor showers (Perseids, Leonids, and Eta Aquarids), each distinguished by intensity, color, and position in the celestial sphere. The angular distances between each shower and the surrounding constellations have been accurately reproduced to faithfully reflect reality, offering an authentic and accurate visual experience.

The Sorvegliati Spaziali AR app also allows users to take photos of AR experiences using the rear camera of their mobile device.
As anticipated, besides offering an engaging and interactive experience, the Sorvegliati Spaziali AR app provides scientific and historical content for each feature. For the asteroid experience (the first one in the enumerated list above), this includes information on the current number of Near-Earth Objects (NEOs), deflection strategies, and the stories of the Tunguska and Chelyabinsk events, making it a valuable tool in educational settings. Its goal is to facilitate learning in a dynamic way, stimulating curiosity and maintaining users' attention.

To give an immediate sense of the experiences offered by the app, with ASSA srl we created a video trailer showcasing one of the most captivating features: the visualization of an aurora in AR. In the background, alongside ambient music, you can hear distinct crackling sounds resulting from the transformation of radio waves emitted by the phenomenon into sound. The video is accessible on the Sorvegliati Spaziali website [13].

Finally, the app is completely free and available in Italian and English for iOS and Android mobile devices compatible with AR technology. It can also be downloaded from the Sorvegliati Spaziali website: the same page where the trailer is published provides links to correctly redirect to the Apple Store and Google Play [13].

5. Future perspectives

The Sorvegliati Spaziali app has been presented to the public and schools during various outreach and educational events.

The feedback has been largely positive, highlighting the intuitive interface, realistic graphics, and overall engaging experience. Some areas for improvement have also emerged, such as the app’s startup speed and the absence of a close button.

We are planning updates to address these aspects and further enrich the AR experience with new interactive and online content, aiming to deliver an even smoother and more captivating user experience.

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