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Astro Arcade: the videogames in '80s style at the Time Machines exhibition

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Abstract. The *Time Machines* exhibition, held at the Palazzo Esposizioni Roma from November 2023 to March 2024, showcases the wonders of the cosmos through engaging images and interactive installations. As part of this event, the Italian National Institute for Astrophysics created three arcade-style videogames – Asteronoids, Planetris, and AstroPacman – using Scratch, a programming language developed by the Lifelong Kindergarten group at MIT Media Lab. Inspired by classic games such as Arkanoid, Tetris, and Pacman, these games incorporate astronomical themes to make learning fun. Visitors can play the games on mini PCs housed in original 1980s arcade consoles at the exhibition, and they are also available for free on the Play INAF website, where users can also view the underlying Scratch code. We describe the creative process behind the games, how astronomy and physics were integrated, and where the reader can find details about the algorithms created using Scratch, providing valuable insights for educators and science outreach events.

Key words. Coding – Scratch – Exhibition – Public Outreach

1. Introduction

In 2023, the Italian National Institute for Astrophysics (INAF) inaugurated the *Time Machines* exhibition at the renowned Palazzo Esposizioni in Rome, Italy. This innovative exhibition was designed to engage the public by showcasing the Universe's wonders through various interactive displays, simulations, and hands-on activities. Participants had the opportunity to explore various concepts related to astrophysics, including the nature of time and the vastness of space and cosmic phenomena, based on the assumption that looking far into space is equivalent to looking back in time. Indeed, light from distant objects takes time to travel to us, since the speed of light has a finite value. For instance, light from the Sun takes about 8 minutes to reach Earth, so we see the

Sun as it was 8 minutes ago. For faraway stars or galaxies, the light might take thousands, millions, or even billions of years to reach us. This means that, when we observe these distant objects, we are seeing them as they were in the past, not as they are today. In this sense, telescopes act like time machines, enabling us to study the history of the universe.

The exhibition aims to educate visitors of all ages about the complex mysteries of the Universe, fostering a deeper understanding and appreciation for astronomy and the scientific efforts that seek to make sense of the cosmos. For the exhibit, the INAF Play.Coding working group created three arcade-style videogames using Scratch (Resnick 2009), a programming language developed by MIT.

Game-based learning has emerged as an effective strategy in education, particularly in STEM fields such as astrophysics (Prensky 2001). By integrating playful elements, this approach encourages understanding of complex concepts while boosting student motivation and engagement. The three games developed for the exhibition – Asteronoids, Planetris, and AstroPacman – are an example of this approach, and they are available for free through the Play INAF website[1].

Fig. 1. The Astro Arcade at the *Time machines* exhibition, in Rome (Italy). Credits: Azienda Speciale Palaexpo / Claudia Gori (top); INAF / P. Soletta (bottom).

2. The three videogames

Inspired by classic titles such as Arkanoid, Tetris, and Pac-Man, the three videogames incorporate an astronomical twist that lets players learn about astronomy while having fun. Anyone can access and enjoy free gameplay on any computer by visiting the interactive website https://play.inaf.it/en/. This platform allows users to play the games but also provides an opportunity to delve into the underlying code blocks. These code blocks can be seamlessly integrated into classroom activities, making them a useful tool for enhancing students' computational skills and understanding of programming concepts.

In the three videogames, sprites (graphical objects in Scratch) representing various astronomical objects were custom designed to reflect the exhibition's visual identity. Furthermore, a unified framework has been established for all three games, which includes an introduction (with instructions, scientific explanations, and a countdown), gameplay until the game concludes, and a final sequence where players can enter their name next to their score and view the ranking list.

During the exhibition, we showcased an executable file created from the Scratch code on a compact mini-PC connected to a high-quality monitor. This setup was housed in a custom-built arcade cabinet that featured a joystick, creating an engaging gaming experience reminiscent of classic arcade games.

In the following, we detail how we thoughtfully integrated elements of astronomy and physics into the gameplay, ensuring that players have fun and gain insight into these sci-

[1] https://play.inaf.it/en/astro-arcade-time-machine/

entific fields. We think these products are beneficial for teachers and relevant for science festivals and outreach events where engaging the public in scientific topics is relevant.

2.1. Asteronoids

In this game, players are immersed in a space environment where they interact with asteroids, which are small celestial bodies found in the Solar System. These asteroids are remnants from the early stages of planetary formation and provide players with a unique opportunity to learn about their characteristics and classifications. Players learn that asteroids are categorized into three distinct types based on their composition:

- Type C (Carbonaceous Asteroids). These are the most abundant asteroids in the Solar System. They are primarily made up of clay and silicate rock, containing a high amount of carbon. A single shot is sufficient to destroy a Type C asteroid successfully, earning 1 point for their efforts.
- Type S (Stony Asteroids). Composed mainly of silicate minerals and metals, Type S asteroids are less common than their Type C counterparts. Players must use two shots to eliminate one of these stony bodies, rewarding them with 2 points upon destruction.
- Type M (Metallic Asteroids). The rarest of the three types, these asteroids consist primarily of metals such as iron and nickel. Their dense composition makes them more challenging to destroy; players will require three shots to eliminate a Type M asteroid. Successfully destroying one will grant players 3 points.

The game's primary objective is to destroy as many asteroids as possible with a bouncing yellow ball while being mindful of the number of shots needed for each type. Besides planetary science, the game also provides an opportunity to refresh concepts in classical physics such as elastic and inelastic collisions. For every asteroid successfully destroyed, players earn points contributing to their overall score. If a player manages to eliminate all asteroids

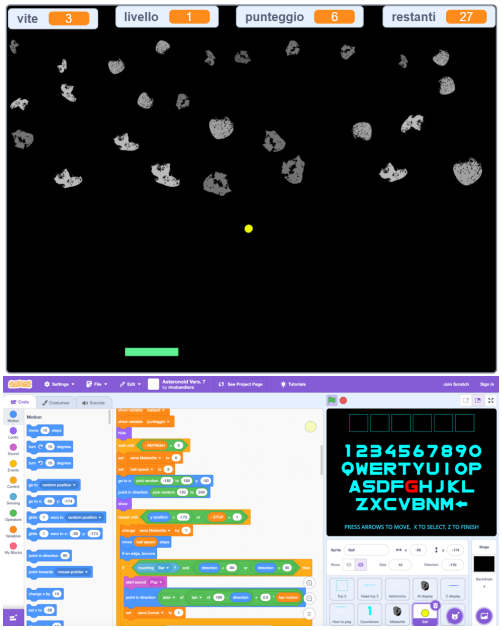

Fig. 2. Asteronoids: gameplay layout (top) and the underlying Scratch code (bottom). Credits: INAF.

within a level, they will be awarded an extra life, enhancing their chances of progressing further in the game. Moreover, players will occasionally encounter comets that appear randomly throughout the gameplay. Successfully hitting a comet awards players with a red bonus ball. The game continues until a player's lives are over, leading to a competitive atmosphere that motivates players as they strive to improve their scores and survive through the various levels.

2.2. AstroPacman

In this game, players have to guide the Pacman character through the galaxy, eating all the stars on its path. Moving between the stars, Pacman must watch out for asteroids, just as in the original version it had to watch out for ghosts. Asteroids drift through planetary systems, including our own: as such, in the game they represent obstacles for players. Players

must also avoid the black hole at the centre of the gameplay, which resembles the supermassive black hole at the centre of our galaxy. Black holes have intense gravitational fields that can trap matter and light: in the game, it represents a significant challenge for players navigating the galaxy. As they move through the galaxy, players may witness stellar explosions (supernovae) which have the same role as the fruit in the original Pacman game. At the beginning of the game, players learn that these dramatic events occur when certain massive stars reach the end of their life cycle and explode with incredible force: a star can release immense energy and radiation during a supernova, temporarily outshining an entire galaxy. In the game, these are represented by supernova remnants, what remains of a supernova explosion. These envelopes of gas and dust contain the building blocks of new generations of stars and planets: therefore, in the game, when Pacman reaches a supernova, it earns points. Through this game, players will enjoy an entertaining experience while gaining valuable insight into some of the most fascinating cosmic phenomena.

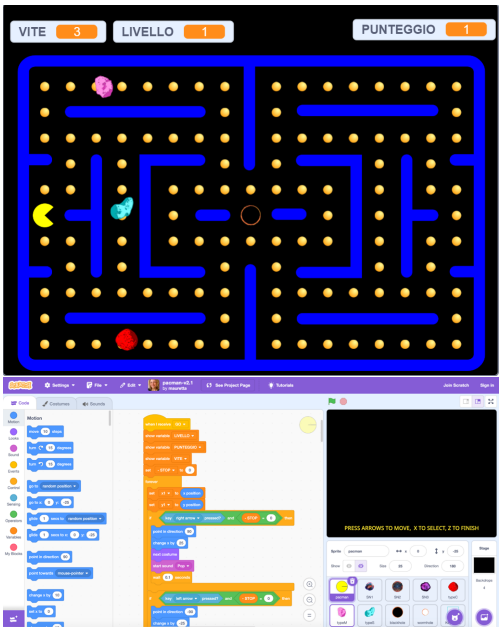

Fig. 3. AstroPacman: gameplay layout (top) and the underlying Scratch code (bottom). Credits: INAF.

2.3. Planetris

The primary objective of this game is to lead players on a journey to ”uncover” various celestial objects within our Solar System. Players are presented with tiles depicting different features of planets and other Solar System bodies. To successfully unveil these objects, players must arrange the tiles in the correct sequence and location, with the appropriate position indicated by a red outline. Players manipulate the tiles just like in the original Tetris, by rotation and translation: they must do so in a time-effective manner, as a countdown timer begins with each new arrangement, adding a sense of urgency to the gameplay. In addition to the time challenge, players must also navigate carefully to avoid passing asteroids that may come across their path and destroy the tile: this makes strategic planning an essential component of the game. Once a player completes a planet or other celestial body, the entire image is revealed, allowing the player to read a brief, informative note about that particular object in our Solar System.

This combination of fast-paced action and educational content provides an engaging experience for players as they explore the various bodies that make up the Solar System.

3. Conclusions

As part of the *Time Machines* exhibition, INAF developed three arcade-style videogames inspired by the ’80s using Scratch, a programming language created by the Lifelong Kindergarten group at MIT Media Lab. These games — Asteronoids, Planetris, and AstroPacman — draw on classic arcade titles such as Arkanoid, Tetris, and Pac-Man, but with an astronomical twist that allows players to learn scientific content (e.g., the asteroid classification for Asteronoids, the planetary arrangement for Planetris, and the variety of celestial objects that can be encountered in the galaxy for AstroPacman) while having fun.

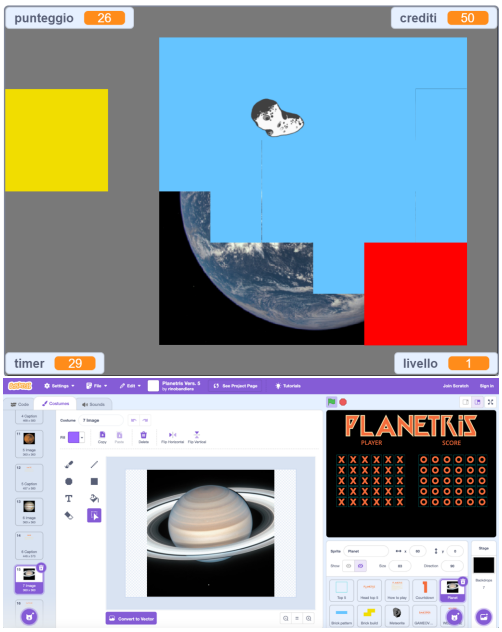

Fig. 4. Planetris: gameplay layout (top) and the underlying Scratch code (bottom). Credits: INAF.

The Time Machines exhibition, with its three astro-arcades, will be repeated at other venues, starting from OGR in Turin in 2025. Besides, the three games can be played online and downloaded for free by anyone, so that anyone can see how the code was written, and remix it to suit their needs.

Although no specific data were collected regarding the fruition of games (number of players, rankings, etc.), the number of people reached by the exhibition was almost 50,000, and the public's feedback on the three Astro-arcades was very positive. As an example, in figure 5 the comment of a visitor (Chiara L., a university engineering student) is reported.

The primary objective that guided us in developing these three games is to spark curiosity about astronomy and space exploration, motivating players to delve deeper into these subjects and to expand their understanding of the Universe. However, we also encourage teachers and students to explore the potential of Scratch to promote the development of computational thinking and problem-solving skills. Many more projects developed with Scratch by INAF researchers can be found on the Play INAF website, including the three Astro Arcade games.

Fig. 5. Final screenshot of the game Astro-Pacman. "An incredible experience. I spent maybe four hours inside [the exhibition]. I even broke the record for any visitor that day", commented the student. Credits: Chiara L.

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