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virtual journeys to discover *in*accessible heritages

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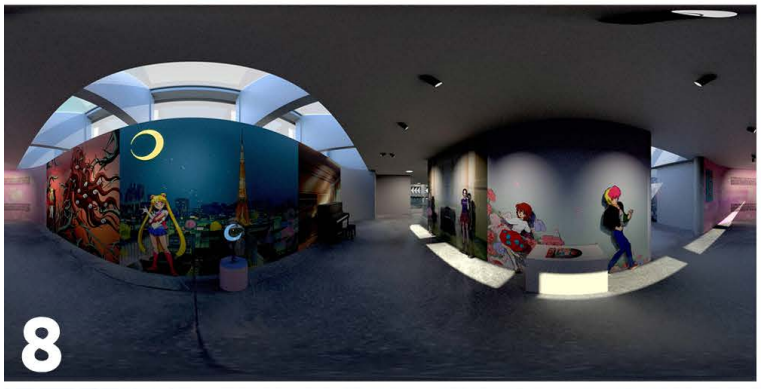
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Rediscovering and re-functionalizing a forgotten heritage through digital representation techniques. Enzo Venturelli's aquarium-retilarium for a *Museum of Japanese Comics and Animation* in Turin.

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Keywords: Virtual museum, Virtual tour, Enzo Venturelli, Museum ecosystem, Digital ecosystem / *Museo virtuale, Tour virtuale, Enzo Venturelli, Ecosistema museale, Ecosistema digitale*

Abstract

The paper aims to explore the use of digital technologies to make the spaces of a currently disused building – the Enzo Venturelli aquarium-retilarium in Turin – accessible and navigable.
The study also analyses the interdisciplinarity between drawing and representation, exhibition design, and museography. Thanks to digital technologies, these disciplines, which are constantly evolving, now explore design and visual communication through complementary dynamics.
Digital models enable designers to model, communicate, document, analyze, and share their ideas on platforms accessible from desktops and smartphones. Thanks to virtual environments, this digital revolution involves greater functional and representational complexity than in the past. The design strategy can follow two main approaches: focus exclusively on the exhibition content, neglecting the host building, or consider the space as an integral part of the exhibition experience. Considering the space, the exhibition layout and visitors together means shifting to a comprehensive museum vision, intended as an ecosystem where these three elements are interconnected and occur together to enhance and communicate cultural heritage.
This paper considers the museum ecosystem as a unicum, aiming to reuse the volumetric and spatial complexity of an already scenic building by rethinking its paths and functions. The proposed virtual environment constitutes the digital ecosystem of a museum where the environment (container) and exhibition design layout (content) give rise to a three-dimensional space that can be navigated according to virtual and immersive reality principles, engaging the public.
Thanks to digital technologies, the design proposal can offer new insights into rehabilitating and enhancing a currently inaccessible place, reintroducing it to the community as a *Museum of Japanese Comics and Animation* and its digital replica made accessible through a virtual tour. The building intended to house this proposal is the aquarium-retilarium in Turin's Michelotti Park. Currently, the building shows obvious signs of degradation due to abandonment. Although the City of Turin has planned restoration and maintenance work to create an indoor theatre, the debate about its future use remains open. In this context, digital technologies can help to imagine possible new uses for this forgotten and, to date, inaccessible heritage.

Fig. 1 - Panoramic images of the virtual tour of the *Museum of Japanese Comics and Animation* (Graphic processing by Elisabetta Caterina Giovannini and 3D model by Vittorio Bottari).

Il contributo mira a esplorare l'uso delle tecnologie digitali per rendere accessibili e navigabili gli spazi di un edificio attualmente in disuso: l'acquario-rettilario di Enzo Venturelli a Torino.
Lo studio analizza anche l'interdisciplinarità tra disegno e rappresentazione, allestimento e museografia. Queste discipline, in continua evoluzione grazie alle tecnologie digitali, oggi esplorano la progettazione e la comunicazione visiva attraverso dinamiche complementari.
L'uso di modelli digitali consente ai progettisti di modellare, comunicare, documentare, analizzare e condividere le proprie idee su piattaforme accessibili sia da desktop che da smartphone. Questa rivoluzione digitale, grazie agli ambienti virtuali, comporta una maggiore complessità funzionale e rappresentativa rispetto al passato. La strategia progettuale può seguire due approcci principali: concentrarsi esclusivamente sul contenuto espositivo, trascurando l'edificio ospitante, oppure considerare lo spazio come parte integrante dell'esperienza espositiva.
Questo lavoro adotta il secondo approccio, con l'obiettivo di riutilizzare la complessità volumetrica e spaziale di un edificio già scenografico, ripensandone percorsi e funzioni. L'ambiente virtuale proposto costituisce un ecosistema digitale dove ambiente (contenitore) e allestimento (contenuto) danno luogo ad uno spazio tridimensionale navigabile secondo i principi della realtà virtuale e immersiva.
La proposta progettuale, grazie alle tecnologie digitali, può offrire nuovi spunti per il recupero e la valorizzazione di un luogo attualmente inaccessibile, riproponendolo alla comunità come Museo del fumetto e dell'animazione giapponese*. Una proposta di riqualificazione digitale resa accessibile mediante un* virtual tour*. L'edificio destinato a ospitare questa proposta è l'acquario-rettilario situato nel Parco Michelotti di Torino. Attualmente, l'edificio mostra evidenti segni di degrado dovuti all'abbandono. Sebbene il Comune di Torino abbia previsto interventi di recupero e manutenzione per la creazione di un teatro interno, il dibattito sul suo futuro utilizzo rimane aperto. In questo contesto, le tecnologie digitali possono aiutarci a immaginare possibili nuovi usi per questo patrimonio dimenticato e ad oggi inaccessibile.*

Museum ecosystem, digital ecosystems, and digital assets

A museum ecosystem is a complex cultural organism that integrates physical and digital elements to provide enriching and interactive experiences for visitors. The relationship between a museum and its digital ecosystem is critical to broadening accessibility, improving the enjoyment of collections, and fostering interaction between diverse audiences and museum objects. People often consider the museum ecosystem a link between institution and audience, neglecting the building that houses the museum, a cornerstone of the visitor experience. Considering the museum ecosystem as a set of relationships between exhibition spaces, exhibits, and visitors allows us to understand the complexity and representations of the phenomenon, which today are increasingly becoming more and more digital.

A museum's digital ecosystem comprises various tools and platforms that extend and enhance the museum experience. For example, a website or mobile app can provide guided tours, detailed information about the works, additional multimedia content, and interactive features such as Augmented Reality (AR). Virtual reality (VR) allows collections and exhibitions to be explored immersively, even from a distance. Online databases and archives enable researchers and enthusiasts to access detailed and in-depth information about collections.

These tools for enjoyment and management would not be accessible without digital assets, the key elements of a museum's digital ecosystem. These assets include images, video, audio, 3D models, metadata, and specific software for creating user interfaces that facilitate the user experience.

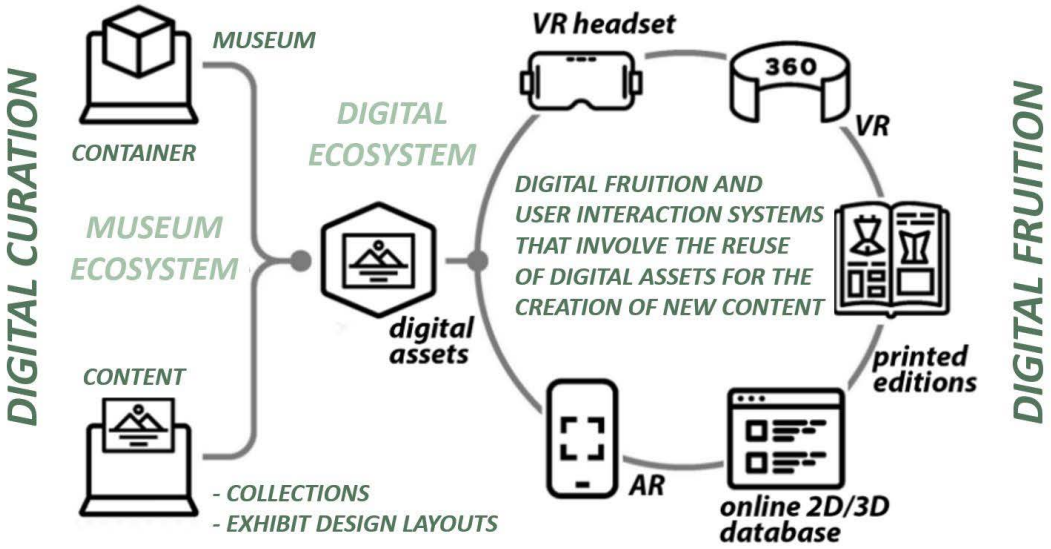

Fig. 2 - The museum ecosystem, its digital ecosystem, and possible reuses of digital assets for communication and enhancement of cultural heritage (Author: E. C. Giovannini).

Integrating the museum and digital ecosystem creates a synergy that enriches the overall experience. A visitor can begin their exploration online, viewing images and videos of the works, and then have a more in-depth and immersive experience during a physical visit to the museum. Mobile apps and augmented reality platforms can guide visitors through exhibitions, offering additional interactive content that enhances understanding and appreciation of museum objects and collections. In addition, digital transition enables collections to be preserved and shared with a global audience, overcoming geographic and temporal barriers. Online archives and digital databases become valuable resources for research and education, enabling scholars and diverse audiences to deepen their knowledge (fig. 2).

In conclusion, a well-integrated museum ecosystem with its digital ecosystem not only broadens the accessibility and attractiveness of collections but also creates new opportunities for interaction, education, preservation, and understanding of cultural heritage (Giovannini, 2023).

Digital ecosystems can also serve as digital replicas of inaccessible spaces, providing novel opportunities for lost and disused heritage to remain alive in the community's collective memory. The *Museum of Japanese Comics and Animation* project follows this direction by configuring a virtual tour from a wholly digital environment developed using archival resources and architectural drawings. The museum ecosystem and the relationship between the building (container) and museum layout (content) are developed consecutively to propose a digital and immersive visit to an inaccessible heritage.

Virtual digital ecosystems for museums and cultural institutions

The digital transition in cultural and architectural heritage affects many disciplines involved in its enhancement. These domains are the ones involved in the modern museum's ecosystems. Among the challenges of digital technology is creating new strategies to preserve, promote, and make our society's heritage, including lost heritage, accessible. Digital representation tools, therefore, offer different prefigurative possibilities for heritage enhancement through innovative and engaging methods. They facilitate communication and collaboration between cultural institutions, scholars, artists, and the public and create online communities dedicated to sharing and discussing cultural heritage.

Within this landscape, virtual and immersive reality is increasingly revolutionizing project communication, whether architectural or exhibition. As early as the 1990s, Apple introduced QuickTime VR (Virtual Reality), which allowed panoramic images to be created and displayed through the PC. At its origins, the technological development of digital cameras allowed panoramic photos to be captured.

In later years, partly due to the advent of high-speed Internet, platforms such as Google Maps have since 2007 introduced the Street View feature, allowing users to explore places around the world through 360° panoramic images (Frau & De Luca, 2021; Paris, 2022). Since 2011, Google Arts & Culture has promoted cultural heritage through the massive digitization of works of art worldwide, creating digital galleries of high-resolution images. In the 'Museum Views' section (fig. 3), on the other hand, it is possible to access as many as 4966 360° virtual tours that include a wide range of cultural places, including monuments and museums (Kennicott, 2011; Wani et al., 2019; Verde & Valero, 2021).

Moreover, the use of 360° virtual tours, also as a result of the pandemic event due to COVID-19, has revolutionized several other sectors, among which museum and real estate sectors emerge (Sulaiman et al., 2020). In the museum sector, examples in the literature are numerous. There was a need, in that precise historical period, to make environments generally frequented by the public accessible, but at the same time, the use of digital and social media gave greater visibility to smaller realities and smaller heritages as well (Nemo, 2021; Resta et al., 2021).

Among the most used platforms in the museum field, in addition to Google Arts & Culture, there is also Google Street View's Museum View, which has partnered with numerous museums to create virtual tours that allow users to explore their interiors, observe artworks and artifacts up close, and obtain detailed information about each object in the collection. Sketchfab, despite being a platform primarily known for hosting 3D models, also allows users to view spherical panoramas and navigate within them, giving visibility not only to digital artists and designers but also to numerous cultural institutions. Many museums use Sketchfab to share digital models of their collections, allowing users to explore artworks at medium resolution. Finally, ArtSteps enables users to create virtual tours from a 3D model directly on the web and is mainly

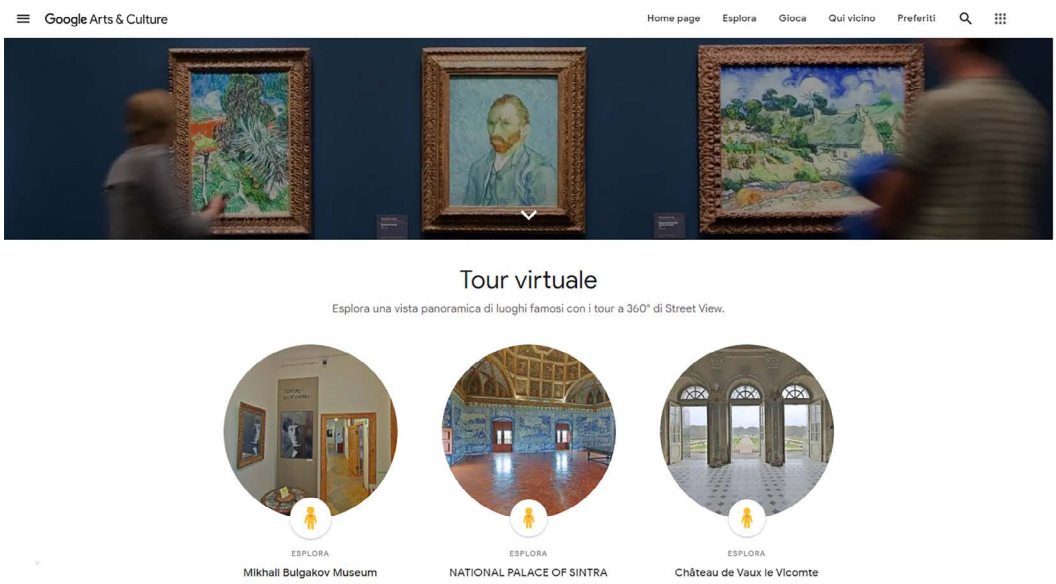

Fig. 3 - Google Arts & Culture platform interface dedicated to virtual tours (https://artsandculture.google.com/).

used to make virtual exhibitions. Similarly, Mozilla Hubs allows users to upload 3D scenes online through the Spoke configurator and make them accessible online through a web address (Rahaman, 2023; Giovannini, 2024).

There remains no doubt that virtual tours are also particularly suitable for commercial purposes, mainly for promoting real estate and tourism (Bogicevic et al., 2019). Indeed, we have also witnessed their recent use in visualizing design proposals and interior design. Again, the choice of platform depends on both the digital capture tools available to individual companies and the specific needs of real estate agents, as well as the availability of features and integration with other tools and services used (Yan et al., 2023). Among the most widely used tools is Matterport, which provides advanced tools for creating 3D virtual tours, including high-definition tours, that allow users to explore real estate spaces interactively. Zillow 3D Home allows virtual tours of homes to be indexed in the better-known U.S. real estate web platform Zillow. iStaging integrates augmented reality (AR) and virtual reality (VR) tools by providing the ability to enjoy the environment through the latest generation of VR viewers. The same is true for the platform used in this project, WeboBook, which allows for virtual real estate tours with a web-based system.

While the virtual tour proposed, for example, by Street Map View, consists of spherical photographs taken at close range that allow the user to explore and view streets with a full 360° view, at the same time, it is possible to obtain panoramic images of fully digital environments based on 3D modeling techniques. A virtual tour consists of a sequence of spherical images whose base-to-height ratio is 2:1 and are therefore called equirectangular. These images, reproduced through graphic restitution obtained by

rendering engines, reproduce the interior environments according to the proposed layout of the exhibition. The images obtained were ordered in such a way that their sequence, in the virtual tour, simulates the succession of spaces as well as in the simulated virtual environment. Finally, the images can be enriched with additional infographic content and linked to each other using unique icons (arrows), thanks to which the user can move from one camera viewpoint to another with personal freedom of movement and fruition (fig. 1).

The *Museum of Japanese Comics and Animation* design proposal

The study of Japanese comic book culture, in its many facets, demonstrates the enormous exhibition potential that manga titles can offer to a museum. The selection of manga and the definition of the exhibition's narrative modes constituted the first museum approach to this topic outside Japan.
The realm of comic books, increasingly expanding into various domains, particularly art, has long thrived on Italian soil, shaping the formative years of countless individuals. However, when examining exhibitions dedicated to "manga" and "anime", the animated counterparts, in Italy, a notable absence of permanent installations is evident, with only occasional temporary exhibits. Upon broadening the scope internationally, this lack of museums focused on Japanese comic books becomes even more apparent across Europe and globally, except in Japan itself. Such museums are prevalent nationwide and serve as integral cultural institutions that deepen one's understanding of the Land of the Rising Sun.
An analysis of previous themed exhibitions showed that the international public's interest is not limited to comic books of Japanese origin but also extends to Western comic books, digital aspects, and virtual installations offered by museums, which are rapidly growing sectors (Bottari, 2023).
The *Museum of Japanese Comics and Animation* project here presented a proposal to integrate the possibility of having a novel and specific Museum in Turin, a city characterized by a diverse cultural offering, facilitating urban redevelopment and the re-functionalization of an inaccessible heritage. Aquarium-retilarium by Enzo Venturelli, because of its crocodile-shaped visual appearance, lends itself to hosting a museum of comics and manga because it embodies some characteristics of the manga. Osamu Tezuka said in the 2018 Annie Awards that "Manga is virtual. Manga is feeling. Manga is endurance. Manga is whimsy. Manga is pathos. Manga is destruction. Manga is arrogance. Manga is love. Manga is kitsch. Manga is a sense of wonder. Manga is... there is no conclusion yet".

The container: the aquarium-retilarium of Enzo Venturelli

The acquarium-retilarium, built in 1959 in the Michelotti Park of Turin, was designed in 1957 by Enzo Venturelli, an architect of great expressive potential and author of

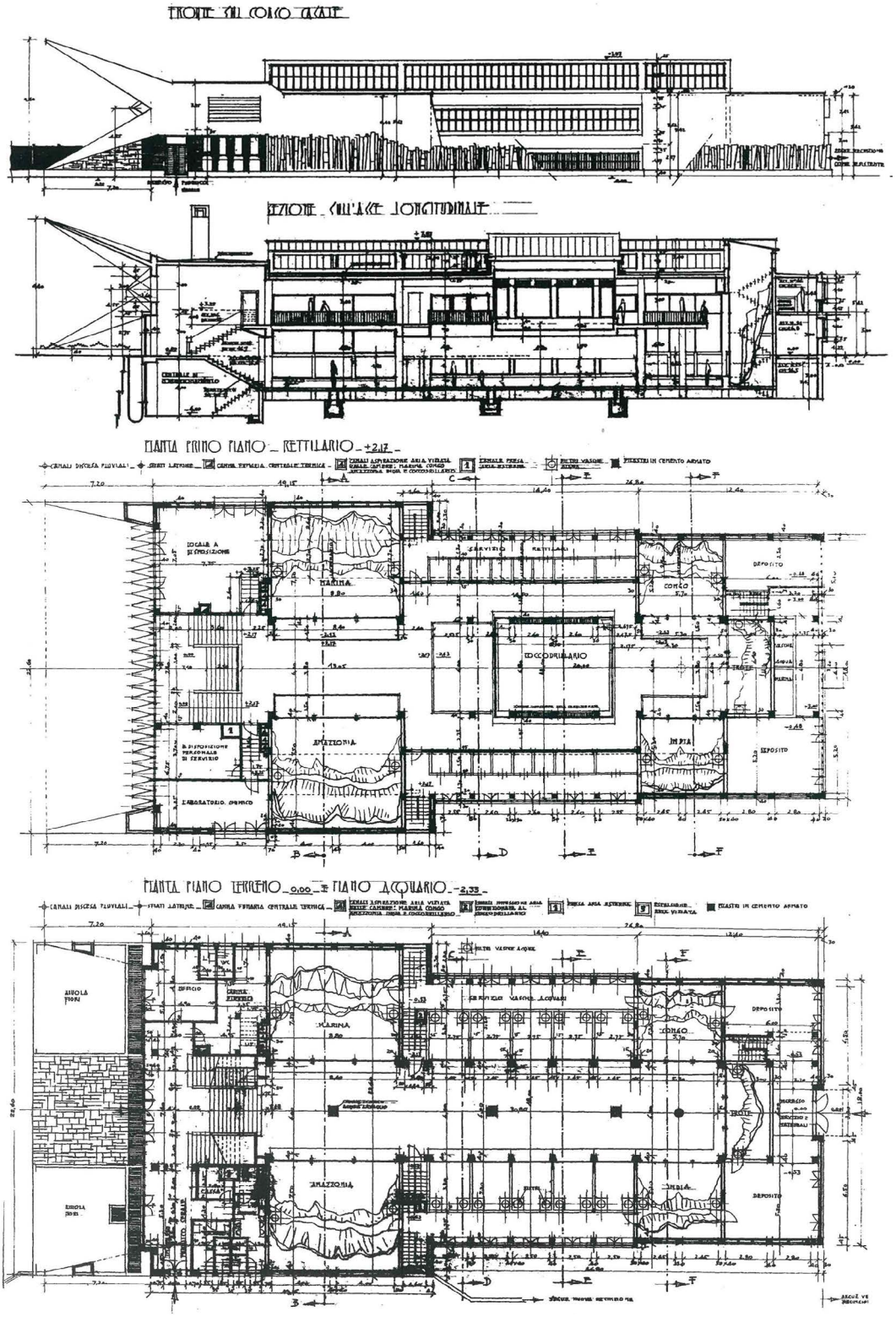

Fig. 4 - Enzo Venturelli, *Prospetto sul Corso Casale, Sezione longitudinale e Piante del primo e del secondo piano dell'acquario-rettilario dello Zoo di Torino*, 1958, State Archive of Turin, AEV, c.3/c.1.

the *Manifesto dell'architettura nucleare* and the work *Urbanistica spaziale,* from which emerges a utopian vision of urban planning (Venturelli, 1960).
The Reptile House, standing two stories above ground, featured a main facade designed to resemble a crocodile's teeth and a whale's gaping jaws. This distinctive structure was the main attraction of the Turin Zoo.
It addressed the postwar demand for recreational spaces. Its unique expressionistic style and meticulously planned interior layout characterized it, ensuring visitors a memorable experience as they explored its spaces. (Venturelli et al., 1999).
The elevation features expansive continuous glazing framed by structures coated with rough gravel. Above the glazing, a series of indentations serve as sunshades, forming the dominant architectural elements along with the canopy and the seamless access glazing (Venturelli, 1965).
The building is in disrepair, with the central openings bricked up and the elevations barricaded. Approximately 40 percent of the total volume has been demolished, and the entire structure has been made inaccessible by blocking the main entrances. The proposed digital restoration and functionalization project relies on Venturelli's original technical drawings and historical building photographs. Plan, section, and elevation drawings have been created by digitizing the original paper versions found in the collection at the State Archives of Turin (fig. 4).
A three-dimensional digital reproduction of the actual state was made to understand better the exterior appearance, the internal distribution, and the different levels of space in the tanks for the natural biomes. Venturelli's real innovation in the aquarium-retilarium design is the interior areas designed to give visitors a better view of the animals' environments. Enzo Venturelli creates a three-level decomposition of the walking floors: a "zero" floor for the public entrance, services, and ticket area; a lowered floor with large tanks, some double-height, whose water level is higher than the visitors to observe the animals in their natural habitat better; and finally the floor for reptiles, located two meters higher than the outside ground, with environments divided by species and ecosystems. A large section, the "crocodile house", is arranged in the center of the floor, the floor of which rests on the lintels that support the aquariums below. The total area of the aquarium-retilarium system is about 980 square meters, developed in a T-shaped plan on two primary levels. The rooms and tanks are divided by the geographical origin of the animals in the display cases.
The modeling phase made it possible to obtain a virtual and digital replica of the state of the building, as designed by the architect, allowing moving inside it and exploring its different digital spaces (fig. 5). The texturing of the building and its components was carried out using 3Ds Max software. Using its integrated render engine, Arnold, it was possible to create architectural views and views of the interior spaces using 360° spherical images as render outputs for the final virtual tour. The 3D model digitally represents a detailed picture of Enzo Venturelli's original design, creating a starting point for the novel design proposal to refunctionalize and recover the architectural

Fig. 5 - Perspective views of the aquarium-retilarium. From the top, the main entrance and a side view (Author: V. Bottari).

artifact for creating a museum building. Finally, the digital ecosystem of the proposed museum was made accessible via virtual tour.

The content: a permanent exhibition for the Museum of Japanese Comics and Animation

The proposed design project for the *Museum of Japanese Comics and Animation* intends to continue the exhibition life of Enzo Venturelli's project, modifying its exterior and interior appearance as little as possible. Proposals for site reuse have been made in previous years, but without contemplating the possibility of repurposing the building as an exhibition environment (Baldi & Bertero, 2005; Manzone & Menato, 2012; Alladio, 2013). Taking advantage of the full-height spaces of the original design, the layout of this proposal includes large display areas at the entrance centered on the characters and settings that have characterized Japanese comic book productions over the past seventy years and strongly influenced many generations around the world. The research has led to the creation of an exhibition and narrative itinerary that addresses

the themes of Japanese culture, history, and entertainment as represented through comic books and their storytelling.
Enzo Venturelli's reptile house, originally conceived as an exhibition of living animals, has thus been repurposed as a new museum, preserving the original architecture's peculiar and attractive appearance. The building, with its structure that Bruno Zevi called "schizophrenic" in his time and its geometric magnetism, becomes a point of attraction for passersby on Corso Casale and frequent visitors to the area (Astengo, 2019). The recovery intervention was guided by preserving the original spatial hierarchies and adapting to the norms of accessibility and inclusion of the interior spaces. A more functional study of the visitor routes required some slight modification of the facades: a new entrance was opened on the northwest side to allow an autonomous use of the cafeteria for the museum.
Regarding distribution, the ground floor is developed in two areas: the entrance area and the back of the building. The different elevation levels, organized according to misalignments that generate a highly varied spatial experience and scenic views, required the insertion of elevators to replace the original stairs partially. The ticketing and service areas were placed at the entrance of the museum and adapted to accessibility standards since, of course, the original design did not yet contemplate this aspect. Finally, the museum bookshop is located near the entrance stairs, becoming a focal point for those entering the building and those ending their tour.
The internal distribution respects the original layout as much as possible (fig. 6), enhancing the display potential inherent in the large tanks (the first two whole heights) and the views between the different levels. The visitor experience was conceived in its temporal unfolding as a succession of surprising exhibits, characters, and eras. Controlling the virtual museum experience through the three-dimensional model was a strategic support.
Different aspects of the contemporary museum world were addressed at the design level, including studying the exhibition systems used to organize the spaces and using new digital technologies related to the virtual world.
The permanent layout of the comics museum focuses on three macro-themes that explore critical aspects of the museum (fig. 7). The first section examines the history of Japanese comics and animation, focusing on significant works divided by decades since the 1960s. The second section analyzes the impact of manga and anime on fashion, showcasing examples of collaborations with big names. The third section examines the different genres of manga to understand the target audiences divided by gender and age. The characters on display are set in settings that recall their context and meaning.
The ground floor houses the leading exhibition, with the first two large tanks devoted to the origins of contemporary Japanese comics (fig. 8). The interior display system, consisting of display cases that are also very small in size, has been adapted to the needs of the new exhibition, which requires more prominent showcases, but without disrupting the layout. The stairwells and service corridors were kept for the exclusive use

Fig. 5 - Demolition and construction for the *Museum of Japanese Comics and Animation* design project inside Enzo Venturelli's aquarium-retilarium. From the bottom ground floor, first floor, and longitudinal section view (Author: V. Bottari).

of the staff. The three end pools toward the rear of the building are redesigned without unevenness, with a second distributive system of stairs and elevator providing access to the cafeteria and the second floor. The cafeteria has been placed at an intermediate level between the basement and ground floor, with physical and visual connections through large, glazed openings. These visuals seek to engage visitors by anticipating the museum experience.

Fig. 7 - Themes/Narratives sections present in the proposed exhibition layout. From the left, ground floor and first floor (Author: V. Bottari).

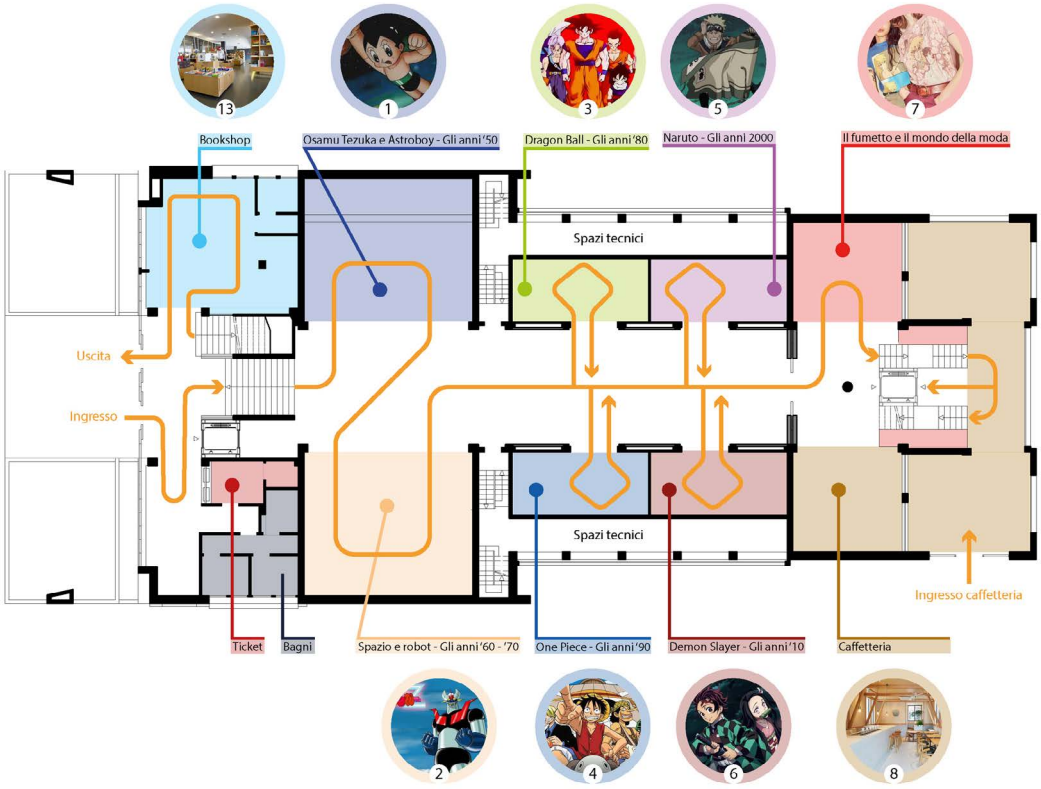

Fig. 8 - Thematic/narrative layout of the ground floor (Author: V. Bottari).

The exhibition begins with Astroboy, representative of Osamu Tezuka's modern manga, symbolizing post-World War II Japan and the fascination with science. The setting recalls the futuristic settings of comic books, contrasted with the room opposite, devoted to the great robots of the 1970s, such as Gundam or Mazinga Z, represented with scale replicas. The following section covers famous manga from the 1980s to the present, divided into four thematic rooms dedicated to Dragon Ball (with a setting inspired by martial arts tournaments), One Piece (conceived by Eiichiro Oda, the best-selling manga in history), Naruto (with references to the Hokage and an interactive presentation of

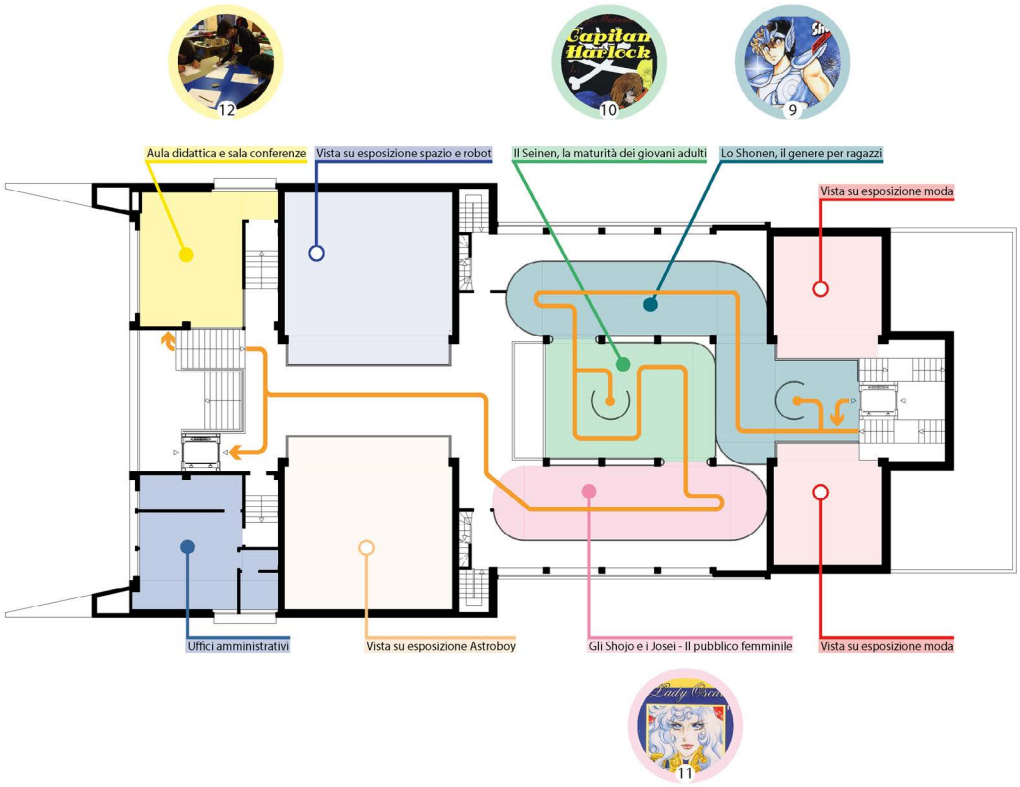

Fig. 9 - Thematic/narrative layout of the first floor (Author: V. Bottari).

ninja techniques), and finally Demon Slayer (with a purple wisteria flower portal and a battle scenario between demons and swordsmen defending humanity). Next, the environment deals with the meeting between the fashion world and manga: clothing from collaborations with brands such as Dolce & Gabbana, Gucci, and Jimmy Choo are displayed in the tanks. Finally, the museum's cafeteria offers an experience similar to Japanese "manga cafes", where visitors can read manga and enjoy foods typical of Japanese culture, often mentioned within the manga themselves.

Modifications to the second floor include removing small terrariums to adapt the museum spaces. The "crocodile house" was connected to the floor level by removing the glass windows that divided the space to make the path more fluid. Finally, curvilinear plasterboard walls characterize the exhibition language of this level (fig. 9).

The rooms above the entrance have been converted into teaching rooms and offices for museum staff. The overall intervention aims to preserve the Venturelli building's original features while targeting adaptation to museum needs.

The exhibition continues, passing near the cafeteria area and up to the second floor with the so-called "shonen", a genre of comics mainly dedicated to a young male audience, ages 6 to 18, characterized by themes of friendship, adventure, and victory. Famous titles such as Osamu Tezuka's "Kimba, the White Lion" and "Saint Seiya", better known as The Knights of the Zodiac in Italy, as well as titles from "Hunter x Hunter",

written by Yoshihiro Togashi, "Bleach" by Tite Kubo and "My Hero Academia" by Kohei Horikoshi, are on display.
The next area explores "seinen" comics, which are aimed at a more adult target audience and thus touch on more complex issues. Works such as "Captain Harlock" and his ship, "Akira", "Neon Genesis Evangelion", and "Vinland Saga" are mentioned in the exhibit.
The final part of the museum focuses on "shojo" and "josei", which are particularly popular with female audiences. Titles such as "Roses of Versailles" or Lady Oscar for Italian audiences, "Kiss Me Licia", "Sailor Moon," "Nana", and "Nodame Cantabile" are presented. The thematic diversity of these comics, from Shojo to Josei, is highlighted by their narratives focusing on different characters' emotions and feelings, relationships, and personal stories.
At specific points related to certain comic books, the museum offers interactive activities designed based on the narrative subjects on display, as well as reconstructions of iconic objects from the different titles, such as the motorcycle from the film Akira or the Lunar Scepter from Sailor Moon. The tour ends with a broad view of the initial tanks, which can be seen at the beginning of the visit via a final elevated corridor.
Finally, the museum also has an educational room designed for possible workshops and a bookstore with books, merchandise, and comics related to the characters on display.
Overall, the idea of the proposed museum layouts offers a comprehensive journey through the most significant genres and works in Japanese comics, offering an immersive, interactive, and educational experience.

The Museum's digital fruition and immersive environments

As previously mentioned, new digital technologies related to the virtual world were used as means of communication and information through the use and reuse of metadata and as tools for recovering and witnessing an architectural asset through its virtual and digital representation.
In fact, along with the study for the re-functionalization of the building, the project included a hypothesis of a new layout whose curatorship sought to integrate real and virtual, reconstructing both the actual layouts and in virtual environments some fantastic worlds from comic books. It is precisely this latter perspective that can, in the authors' opinion, open the door to transdisciplinary experiments of great interest, in which the physical layout becomes a bridge to virtual worlds connected to the collection and the themes on display.
The project site and its new layout have been recreated digitally and made usable and navigable by developing a 360° virtual tour based on nine spherical panoramas (fig. 10).
This last project phase demonstrates how, through augmented reality (AR) and virtual reality (VR), gamification and edutainment enrich the proposed and developed museum tour. Possible further development of this project could refine the idea of a museum

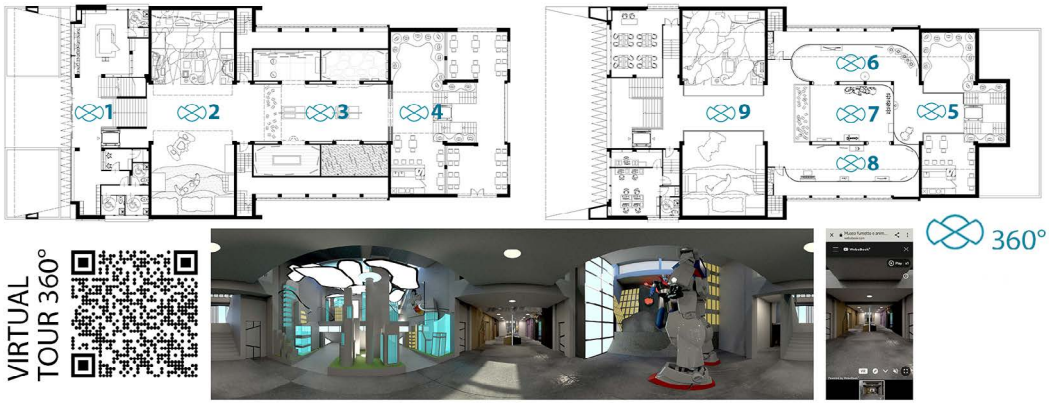

Fig. 10 - Position of picture capture of panoramic images for creating the virtual tour (Author: V. Bottari)

Fig. 11 - Namecc planet views. On the left, 3D views of the virtual environment prototype and on the right image from an episode of Dragon Ball (Author: V. Bottari).

that, once designed and potentially implemented, could, for all intents and purposes, already be enjoyed through an interactive and emotional experience with important cultural content and food for thought. For example, AR stations could be implemented within the virtual museum to interact with the exhibits, providing information and 3D models. Viewer participation could then be further enhanced through sensory and communicative systems such as specific background soundtracks and audio and video explanations, adapting to the learning of modern audiences. Finally, gamification and

video game elements could be developed further, taking inspiration from the rooms dedicated to Dragon Ball or One-Piece titles mentioned in the context of the evolution of comics over the different decades (fig. 11).

Conclusions

The path of the design proposal and its fruition in the digital environment reflects the structure of a real museum ecosystem, the components of which, once digitized and three-dimensionally modeled, constitute the digital copy of the ecosystem itself. This new digital museum ecosystem has greater representation flexibility; both the container (building) and the content (collection and display) are digital objects, modifiable and decomposable into multiple forms and interpretations. The ability to easily change both the architectural aspects, the arrangement of the works, and their arrangement and settings allows for a variety of approaches and strategies that would not be possible in the physical world, making, in fact, the virtual museum an utterly dynamic environment that can be adapted to multiple design needs. The use of virtual environments and Web-based systems such as catalogs of exhibits with additional information and hyperlinks, Web sites, animations, and spherical images could also, in the future, be helpful in the creation of thematic paths for different types of users. The combination of these digital assets is also aligned to create resources that are findable, accessible, interoperable, and reusable for future uses by diverse audiences and professionals of the creative sector.

Attributions

Although the contribution was conceived jointly, E. C. Giovannini is author of paragraphs 'Museum ecosystem, digital ecosystems, and digital assets'and 'Virtual digital ecosystems for museums and cultural institutions'. V. Minucciani and V. Bottari wrote jointly paragraphs 'The Museum of Japanese Comics and Animation design proposal' and 'The content: a permanent exhibition for the Museum of Japanese Comics and Animation'. V. Bottari is author of paragraphs 'The container: the aquarium-retilarium of Enzo Venturelli' and 'The Museum's digital fruition and immersive environments'. The authors wrote jointly the paragraph of 'Conclusions'.

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