SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2025
ORGANIZATION AND MANAGEMENT SERIES NO. 221

PROTECTING AND PROMOTING POLISH TECHNOLOGICAL HERITAGE WITH THE TOURIST TRAIL OF DIGITAL CULTURAL HERITAGE: CONCEPT, CRITERIA, AND GROWTH POTENTIAL

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Purpose: Digital technology has significantly affected Poland's socioeconomic and cultural development. Regrettably, information about the early days of Polish software, computers, factories, and research centres is yet to be aggregated. The study aims to develop the concept of the Tourist Trail of Digital Cultural Heritage in Poland (the Trail) and refine its theoretical foundations. It focuses on expanding the list of places relevant to the history of the Polish computer and electronics industry and specifying inclusion criteria.
Design/methodology/approach: The primary method, desk research, included reviewing the literature, reports, and online sources. The authors identified critical locations that could be included in the Trail. The study also investigates existing thematic routes in Poland to identify and employ the best practices.
Findings: The desk research yielded several dozen places linked to the history of Polish technology. These are museums, former production sites, and heritage landmarks, like monuments, squares, and plaques. The authors also proposed potential trail signage and ways to promote the Trail. Integrating historical, educational, and technological domains can improve the awareness of Poland's contribution to preserving digital cultural heritage and promote thematic tourism.
Research limitations/implications: This exploratory research requires verification in the field. The challenges include unstable museum premises and the lack of specific regulations on establishing and maintaining tourist trails.
Practical implications: The Tourist Trail of Digital Cultural Heritage in Poland has the potential to improve public awareness of Poland's contribution to the history of the global computer and electronics industry. It can also animate technology heritage tourism. Increased tourist traffic can stimulate local economies.
Originality/value: It is the first attempt to devise a concept of the Tourist Trail of Digital Cultural Heritage in Poland. The study offers new insights into the protection of technological

heritage and suggests how it can be effectively incorporated into tourist and educational portfolios.
Keywords: digital heritage, tourist trails, computer science history, technology museums, electronics industry.
Category of the paper: Research paper.

1. Introduction

With technology inherently fused with our daily lives, cultural heritage is a natural object of interest. It includes unique human knowledge and forms of expression that convey cultural, educational, scientific, and administrative values. Less obvious digital heritage items are technical, legal, medical, and other content that was born digital or digitised from analogue renditions (UNESCO, 2003). It is critical to protect it so posterity can access these resources (Król, Zdonek, 2022).

Today, digital heritage faces a severe risk of oblivion. The history of electronics, computers, and video games has become an important domain worthy of preservation and promotion (Kowert, Quandt, 2015). The main threats are rapid ageing of equipment, lack of stable funding mechanisms, blurred responsibility for maintaining digital heritage assets, and inadequate regulations (Thwaites, 2013). These challenges call for effective strategies and administrative and legal tools to support heritage protection. They should align with local conditions, available resources, the urgency of the problem, and long-term forecasts on the future of technology and archiving methods (UNESCO, 2003). In light of the above, computer and gaming museums not only record the course of technological development but also play an important educational, cultural, and socioeconomic role (Naskali et al., 2013). When included in thematic routes, they can aid in disseminating knowledge of the history of technology, furthering digital education, integrating communities, and stimulating the local economy by attracting tourists interested in digital culture. However, many challenges lie on the path of those who intend to establish, maintain, and expand the operations of such places. The concept of the Tourist Trail of Digital Cultural Heritage in Poland is an attempt to support them.

Poland has many thematic routes through which people can discover a plethora of cultural heritage dimensions: historical, culinary, and architectural, to name a few. Why not offer a Tourist Trail of Digital Cultural Heritage in the digital era? Research shows that digital heritage includes hardware (Król, 2021a) and software (Król, 2021b), shaping today's culture just as much as paintings, sculptures, sacral masterpieces, and architectural monuments (Portalés et al., 2018). The digital Trail could comprise technology museums, innovation centres, and places linked to the history of the Polish computer industry to provide education, inspire young generations, and support thematic tourism (Król, 2024).

Digital technology has significantly affected the socioeconomic and cultural development of Poland. Regrettably, information about the early days of Polish software, computers, factories, and research centres is yet to be aggregated (Król, Zdonek, 2022). There is no single, unified method for celebrating history in the tourist context. The present study addresses this gap by identifying specific places and objects that could become part of the thematic route. The present study is intended to elaborate on the existing concept of the Tourist Trail of Digital Cultural Heritage in Poland (Król, 2024) and evaluate its potential role in promoting the history of the Polish computer and electronics industry. The Trail would include technology museums and locations central to the development of the Polish computer and electronics industry, such as former production facilities, research centres, and other landmarks. Additionally, the study aims to define the criteria for including locations in the Trail and analyse its potential impact on cultural tourism and technology education in Poland.

This is the second article in a series on the concept of a thematic route in Poland focused on digital cultural heritage (Król, 2024). The authors put forward a hypothesis that, just like tourists are offered wooden architecture routes, trails of wooden churches, or culinary trails, they should be able to follow a digital cultural heritage tourist trail. It assumes that a coherent and well-marked tourist trail of digital cultural heritage could contribute to: (1) improving public awareness of the Polish contribution to the history of the computer and electronics industry; (2) stimulating interest in technology heritage tourism in Poland; (3) integrating existing museum and historical initiatives; and (4) stimulating local economies through larger numbers of visitors to places linked to the history of technology. The hypothesis further posits that digital heritage can be effectively promoted as a tourism product, just like architectural or culinary heritage, as long as the concept for promoting it and information dissemination tools – signage and digital channels – are prepared appropriately.

Research to date focuses on digital cultural heritage museums (Król, 2024). The present article is the next step and fills in a research gap by covering museums of old equipment and software as well as places celebrating the history of Polish technology efforts, such as monuments, squares, factory buildings, and industrial facilities. Therefore, the tangible outcome of the study is an expanded list of sites commemorating the history of technology in Poland. The study is part of a mini research project, ‘Mapping Digital Cultural Heritage Museums in Poland (DigiMap)’. DigiMap is part of ‘Regional Excellence Initiative’ (RID/SP/0039/2024/01).

2. Background

2.1. Thematic routes as part of tourist infrastructure in Poland

Thematic routes are an important component of the Polish tourism infrastructure. They support tourism in its many varieties: sightseeing, cultural, and ecotourism. Their impact goes beyond recreation and covers economic, social, and cultural aspects as well (Niedziółka, Krasnodębski, 2023).

Polish tourism has a long history of tourist trails. They also come in diverse types: walking, cycling, horseback riding, kayaking, and special trails (Niedziółka, 2011). The modern approach to trail blazing takes into account their role in creating tourism products, shaping the tourism environment, and attracting tourists (Stasiak, 2006). Still, the legal framework for blazing and operating trails in Poland is inconsistent (Stasiak et al., 2014). Two acts of law are relevant to tourist safety: (1) the Act of 18 August 2011 on safety and rescue operations in mountain areas and organised skiing sites (Polish Journal of Laws of 2023, item 1154) and (2) the Act of 18 August 2011 on safety of people in water areas (Polish Journal of Laws of 2023, item 714). Nevertheless, comprehensive regulations for planning and blazing tourist trails are yet to be enacted, so further conceptual and legislative effort is called for.

Trails focused on eminent figures and important historical events are an outstanding category of thematic routes in Poland (Table 1). Some examples include the Nicolaus Copernicus Memorial Road Tourist Trail, Fryderyk Chopin Trail, John Paul II Papal Trail, or the Grunwald Trail, marking the largest medieval battle in Europe near Grunwald. Another remarkable collection is architectural heritage trails, such as the Trail of the Eagles' Nests, among castles and castle ruins in Silesia and Lesser Poland.

Table 1.
Selected tourist trails in Lesser Poland

No.	Name	Place, location, range	Primary theme
1.	Lesser Poland Trail of Wooden Architecture	Małopolskie Voivodeship	A total of 255 secular and sacral objects
2.	Lesser Poland Oscypek Trail	Suski, Nowosądecki, Nowotarski, and Tatrzański Districts in Małopolskie Voivodeship	Traditional Podhale products (primarily Oscypek, a traditional cheese from the region) promoted in 26 shepherds' huts
3.	Trail of the Eagles' Nests	Śląskie and Małopolskie Voivodeships	Castles and castle ruins in the Kraków-Częstochowa Upland
4.	Lesser Poland Gothic Art Trail	Małopolskie Voivodeship	Gothic architecture heritage
5.	Lesser Poland John Paul II Papal Trail	Małopolskie Voivodeship	Places where Karol Wojtyła (Pope John Paul II) hiked
6.	Lesser Poland Wine Trail	Małopolskie Voivodeship	Meetings with owners of 65 vineyards and their products
7.	Lesser Poland Garden Trail	23 municipalities in Małopolskie Voivodeship	Regional garden science, history, culture, and architecture

Cont. table 1.

8.	Lesser Poland Kościuszko Uprising Trail	Małopolskie Voivodeship: Krakó, Krakowski, Proszowicki, and Miechowski Districts	Places linked to the Kościuszko Uprising
9.	Kraków Fortress Trail	Kraków	Forts, defence walls, fortifications, and similar objects
10.	Lesser Poland Way of St James	Małopolskie Voivodeship	St James, patron saint of pilgrims

Source: own study.

Cultural trails often focus on tangible heritage, including architecture. However, some cover intangible heritage as well, such as culinary traditions and local foods. The most important thematic routes in Lesser Poland are the Oscypek Trail, with shepherds' huts where traditional regional cheeses are made, and the Wine Trail, which promotes wine tourism (Kruczek, 2018). Other prominent thematic routes are military trails and pilgrimage ways. The Kraków Fortress Trail invites tourists to defensive structures from various historical periods. The most outstanding pilgrimage trail is the Lesser Poland Way of St James, part of the European network of ways leading to Santiago de Compostela (Mróz, Mróz, 2013).

The popularity of tourist trails reflects the growing demand for such products in regions' promotional strategies to enhance their tourism value. Research indicated that the routes have to employ new technologies and embrace evolving tourist expectations (Stasiak, 2014). The central challenge for the immediate future is to introduce coherent regulations for establishing, managing, and promoting tourist trails so that their potential for the tourism sector can be fully used.

2.2. Museums of digital cultural heritage. Establishing, potential and limitations of growth

The Polish legal framework sets principles for establishing, organising, and operating public and private museums. To establish a museum, one has to satisfy specific formal criteria that guarantee proper operation and attainment of educational, cultural, and scientific goals. It is relevant here that 'Under the current legal framework, private and public museums are created in two steps…' (Golat, 2008, p. 12). Additionally, there are two procedural paths: (1) the 'official' one provided in such regulations as the Act of 21 November 1996 on museums (Polish Journal of Laws of 2022, item 385) and (2) the 'private' one, which is more flexible. The official method involves listing the museum with the Ministry of Culture and National Heritage of Poland. In this case, the museum needs a policy with the name, registered office, scope, and funding. Such an organisation also has to keep a register of all items in its collection. Experts noted that '…operators of such places face numerous financial problems. These give rise to issues with personnel and factual value when they cannot employ competent staff. It leads to troubles with ensuring conditions for proper storage and exhibition. Another challenge is to inventory, document, analyse, and catalogue the artefacts (Studnicki, 2018, p. 171). It makes it a little easier to establish a museum if it is given the status of 'pending

organisation'. This way, the institution can be created in stages with a temporary policy and organisation of the exhibition area, depending on the resources. Experts noted that 'The "pending organisation" status gives more freedom to select and arrange exhibits. A predefined, and inalterable permanent exhibition is not required then' (Pstrocka-Rak, Rak, 2021, p. 163). Despite more freedom, the museum institution still remains a museum according to the Act. In this context, private museums seem to enjoy greater organisational flexibility. This way, individuals can create expositions in line with their vision and the local community's needs. Private museums are often the fruit of the passion of their founders, which makes them particularly unique. Experts noted that 'Communing with old objects, experiencing their purpose during workshops, for example, and living the narrative around them can provide a journey different from everyday life, which makes them a source of ludic quality' (Studnicki, 2018, p. 171). Private initiatives can be more personal and individualised, which is an added potential for addressing market niches. On the other hand, public museums operated by central or local public authorities under the Act on museums have an official statute. They are obliged to pursue the mission of protecting national heritage, such as the National Museum in Warsaw or the Museum of the History of Poland. In addition, museums under the aegis of state or international organisations usually enjoy more funds and access to professional staff at the cost of a more rigid structure and less flexibility in responding to the audience. The bottom-up approach helps stimulate local communities and aficionados to protect and promote digital heritage. However, it comes with funding and professionalisation challenges.

Museums of computers and games have great potential. They provide technology education, preserve digital cultural heritage, and support thematic tourism and innovation. As education venues, they allow visitors to learn the history of technology and its impact on the world today. Unlike traditional exhibitions, these institutions are often interactive so that visitors can commune with the exhibits. Operational 1980s or 1990s consoles allow them to see and experience the technology of the era long gone. It is particularly attractive for younger generations who find retro gaming and retrocomputing increasingly fascinating, and allows older people to remember their youth. Digital cultural heritage museums can also play a central role in tourist trails. When included in thematic routes, they can promote regions and enhance their cultural product portfolio. A well-designed trail combining various technological heritage aspects can become an international tourist attraction.

Still, cultural heritage museums face numerous constraints, challenges, and problems, especially private museums. The primary challenge is operational funding. Most private technology museums worldwide do not receive steady support from the state. They need to look for alternative income sources. Workshops, space rentals, sponsors and patrons (crowdfunding), or special events are the most common funding methods. Alas, they often fail to cover all operational costs. Experts noted that 'Most IT museums in the world lack patronage and central or local government funding' (Pstrocka-Rak, Rak, 2021, p. 168). Another challenge is to keep digital exhibits operational. Maintenance of decades-old electronics requires specific

storage conditions and expert knowledge. Then, the next complication, expected to worsen with time, is the dwindling number of experts familiar with archaic technologies, combined with limited access to original spare parts. Experts noted that '…hardware and games (software) are more at risk of digital decay, worsening poor accessibility of digital media even more' (Swalwell, 2009, pp. 265-266). This is not only due to the limited durability of plastics but also the condition of microchips and data carriers (Garda, 2014). In addition, it takes significant time to repair and restore hardware and software, and the conservation effort is not made easier when documentation is unavailable. The problems will intensify with time, bringing new digital heritage protection challenges for museums (Setniewski, 2006).

2.3. Exhibitions in digital cultural heritage museums

How exhibits are displayed at museums of digital cultural heritage is relevant here. Should consoles, arcade video games, and computers be merely 'silent machines' in display cases with emulated software? Experts noted that 'Retro gamers do not prefer emulation as such because the reconstruction of the actual experience requires original equipment from the period' (Garda, 2014, p. 123). Emulation fails to offer the complete journey, starting with booting, controls, smell, and original sounds, down to image clarity and pace of operation. Therefore, the original devices are critical for retaining the 'original experience'. The hardware includes monitors, joysticks, and keyboards that contribute to the authentic experience from the past. This exhibit display approach necessitates substantial effort and funds to preserve and keep the devices operational. Private museums can allow visitors to see and interact with exhibits thanks to greater freedom and fewer formal restrictions. Experts noted that 'Exhibiting institutions face a daunting task today. On the one hand, they have to respond to visitors' needs. On the other hand, they have to ensure appropriate safe conditions for exhibits in line with regulatory requirements to protect and preserve them for posterity (Makiłła-Polak, 2019).

2.4. Digital cultural heritage museums and the co-exhibition of arcade video games, pinball machines, computers, and consoles

Museums of digital cultural heritage play a central role in preserving the history of video games. They often offer arcade video games, pinball machines, computers, and consoles. Furthermore, their collections can include household appliances like radio receivers, TV sets, or mobile devices, as well. Their co-occurrence in the museum space is an opportunity to present the evolution of technology, interactive entertainment, and its impact on culture and socioeconomic development. The functional analysis enforced with such a display design reveals the complexity of relationships among household appliances and arcade video games: differences as well as similarities.

Arcade video games used to be an impactful part of the entertainment landscape for decades. Their build and usage set them apart from computers and consoles at home. As new technology opportunities occur and retro gaming grows more popular, a question arises as to whether

arcade video games could be integrated into household gaming equipment. The problem is especially relevant considering the changes in practices related to collections, historical reconstructions, and exhibitions on video gaming.

Personal computers and game consoles have been designed for private entertainment at home. In contrast, arcade video games were intended to be used in public spaces as commercial coin-op machines. Through placement in arcades, pubs, train stations, hotels, or tourist accommodations, they were readily available. Such machines were seldom kept for private use (Dziatkiewicz, 2017). During socialism in Poland and in the 1990s, arcade video games provided the only access to video games for many Poles, especially those who could not afford a computer or console. Today, arcade video games are a rare occurrence. Original devices are mostly found in museums, entertainment venues, and private collections (Dziatkiewicz, 2024).

The main obstacles limiting private ownership of arcade video games are their price and spatial requirements. Original devices are expensive and hard to fit in a typical residential unit. In addition, the original arcade video game experience is relatively hard to replicate at home, which is much easier for consoles and computers. Although emulators like MAME and arcade video game box replicas are available, the experience of communing with original systems cannot be simulated (Dziatkiewicz, 2024).

The technology behind the original arcade video games is substantially different from the inner workings of household gaming hardware. Their dedicated hardware architecture makes most models compatible with specific titles (games) only. In some, the data carriers, such as motherboards or cartridges, could be changed, but it was more complicated than in the case of personal computers or consoles. The appearance and functions of arcade video games were often modified in Poland. For example, the original controls of ‘Defender’ with a single joystick and five buttons were expanded to accommodate two players (Dziatkiewicz, 2019a).

Arcade video games offered much better technology than devices at home in the 1980s and 1990s. The graphics quality, animation smoothness, and controls responsiveness were much better, which made arcade video games more attractive. Ported versions of arcade video games for personal computers and consoles were usually less perfected in visuals and mechanics due to hardware limitations (Dziatkiewicz, 2019b). Moreover, arcade video games were easier to use. All the player had to do was insert a coin. They were structurally built to be more robust than household devices, allowing them to withstand intensive use in public spaces. The virtually uninterrupted use in readily available locations required special components. Unlike computers and consoles, which could require some technical knowledge to maintain, arcade video games were intuitive and thus accessible to a broad audience (Dziatkiewicz, 2019a).

Arcade video games are exhibited in various museum institutions and thematic areas today. There are several types of such places, like video game museums, computer museums, and other entertainment venues. Poland’s most prominent arcade museums are the Kraków Arcade Museum and the Warsaw Arcade Museum, with both vintage machines and more

contemporary models. Another important place of digital heritage in Poland is the Museum of Electronics in Kraków with the Chorzów branch (Figure 1).

(a) (b)

Figure 1. Part of the exhibition at the Museum of Electronics in Kraków. Left to right: computer and audio equipment (a). TVs and telephones (b).

Source: Król (December 2023).

All the exhibits at the Museum of Electronics in Kraków are operational. It is mostly thanks to the knowledge and skills of the curators and access to spare parts. All this is because the museum used to be an electronics store and service centre. Hence the substantial spare parts resources.

Some places are devoted solely to computers and consoles, like the Museum of Consoles, Video Games in Karpacz, Museum Games & Computers of the Past Era in Wrocław, or the Museum of Computers and Games in Warsaw, which offers VR experiences as well as retro hardware. In some locations, arcade video games are displayed together with other electronics, as is the case in Land of Retro Gaming Pixel-Mania in Władysławowo or the Museum of the History of Computers and IT in Katowice. There are also thematic institutions like Terra Technica – Jukebox & Pinball Time Travel Museum (Chvalovice-Hatě, Znojmo, Czechia), which displays arcade video games, jukeboxes, pinball machines, and vintage vehicles (Table 2).

Table 2.
Selected (described) centres / meeting venues / exhibitions / pinball machine and arcade museums in Poland and abroad

No.	Name	Place	Primary focus	Comments
1.	Kraków Arcade Museum	Kraków (Poland)	Arcade video games, simulators, and pinball machines	The largest arcade museum in Poland
2.	Warsaw Arcade Museum	Warsaw (Poland)	Arcade video games, simulators, and pinball machines	A branch of Kraków Arcade Museum
3.	Museum of Consoles, Video Games in Karpacz	Karpacz (Poland)	A private museum of consoles and video games	The first video games museum in Poland

Cont. table 2.

4.	Land of Retro Gaming Pixel-Mania in Władysławowo	Władysławowo (Poland)	Arcade video games and household appliances	A very extensive and diversified collection
5.	FunHouse Katowice	Katowice (Poland)	Pinball machines and arcade video games	An interactive museum of pinball machines and arcade video games
6.	Museum of the History of Computers and IT	Katowice (Poland)	Polish and foreign computers, including ODRA	A private museum (pending organisation) of the history of computers and computer science
7.	Terra Technica – Jukebox & Pinball Time Travel Museum	Chvalovice-Hatě, Znojmo (Czechia)	A collection of arcade video games and jukeboxes	The largest global museum of jukeboxes and pinball machines
8.	ArcadeHry	Červený Újezd (Prague-West, Czechia)	Nearly only arcade video games	A retro gaming house and museum

Source: own study.

User experience is critical for investigating differences between using an arcade video game and an emulator. Although modern technology can emulate original games, it is no match for interaction with a physical machine. Relevant aspects include visuals, how the image is displayed, control modes, and the arcade atmosphere. Arcades played a social role; people met, competed, cooperated, and enjoyed spontaneous interactions there. Memories of people who spent time in arcades often involve a combination of sharing emotions, cheering, and watching players compete (Dziatkiewicz, 2024). Culturally and socially, arcade video games stay relevant as part of video gaming heritage. Their presence in museums and collections confirms their unique impact on the history of electronic entertainment.

3. Materials and methods

The research was conducted under the ‘Mapping Digital Cultural Heritage Museums in Poland’ (DigiMap) project, REI project No. K/658/2024/WRE. It has been funded through regranting under ‘Improved potential of management and quality sciences through better use of Polish rural capital’ co-founded by the Republic of Poland under a Minister of Science scheme ‘Regional Excellence Initiative’ (contract No RID/SP/0039/2024/01). A popular science description of the research results, a raster map, and an interactive map of the museums of digital cultural heritage in Poland, together with preliminary conclusions and results of a pilot study, were published on a thematic website http://digitalheritage.pl and in a research article (Król, 2024). The present effort is a continuation of work on the concept of a tourist trail of digital cultural heritage. It focuses on reviewing historical analyses and media reports and identifying critical elements that can be integrated into the digital cultural heritage trail in Poland.

The desk research reported here involves analysis of available sources on digital cultural heritage, including popular science literature, media reports, and information on cultural trails (Bednarowska, 2015). It is founded on scientific and popular science references as well as reports of institutions involved in cultural heritage protection and promotion. The authors analysed input from experts, retro fans, and museum curators in conjunction with academic publications, strategic documents, and online resources, including content on websites of organisations engaged in cultural heritage digitisation. Exploration of secondary sources revealed new places that could be valuable additions to the Tourist Trail of Digital Cultural Heritage in Poland.

4. Results

An analysis of the existing tourist trails confirmed that the Tourist Trail of Cultural Heritage can seek inspiration from thematic routes. Architectural trails, such as the Trail of the Eagles' Nests and the Wooden Architecture Route, offer well-blazed paths and detailed guides. These can be presented as a mobile application or interactive maps. Historical trails, such as the Grunwald Trail, focus on commemorating historic events and figures, which can be transposed into the story about milestones in the history of the Polish computer and electronics industry, told through plaques in places linked to former production sites (Table 3).

Table 3.
Comparison of existing tourist trails and the planned Tourist Trail

Trail category	Characteristics	Primary advantages	Potential aspects to adopt
Architectural trails (Wooden Architecture Route, etc.)	Architectural heritage: sacral and secular. Focused on aesthetic and historical values	Preservation and promotion of heritage buildings, stimulation of regional tourism	Marked routes, guides, and mobile applications with descriptions
Historical trails (the January Uprising Trail, Grunwald Trail, etc.)	Commemoration of historic events and figures. Monuments, battlefields, graves, burial sites, and commemoration sites often included	Building a historical identity and historical education	Information plaques at locations critical for the history of the computer industry
Thematic routes (the John Paul II Papal Trail, etc.)	Focused on historic figures and their heritage (routes along places linked to famous scientists, artists, or politicians)	Promotion of historic figures and cultural education	Interactive narratives on people and events relevant to the history of computers and microelectronics in Poland
Industrial trails (Industrial Heritage Trail, Old Mines Trail, etc.)	Former industrial plants, mines, and factories. History of regional technology and industry.	Preservation of industrial heritage and promotion of post-industrial regions.	Organisation of routes connecting former production plants, museums, and research centres.

Cont. table 3.

Planned: Tourist Trail of Digital Cultural Heritage	Route of museums of computers and games, places linked to the history of the computer industry, former production plants, and technology heritage sites.	Popularisation of the history of the Polish computer and electronics industry and growth of technology heritage tourism.	Marking, online guides, interactive applications, routes between museums, factories and technology heritage sites.

Source: own study.

Thematic routes, like the John Paul II Papal Trail or Nicolaus Copernicus Memorial Road Tourist Trail, demonstrate how historic figures can be effectively promoted. In the context of the Tourist Trail of Digital Cultural Heritage, this could mean narration on the pioneers of Polish computer design and the places where they worked, which could be displayed in public spaces or available in an interactive guide. Industrial trails, such as the Industrial Heritage Trail, provide models for organising routes connecting former factories and research centres. The tourist Trail of digital heritage must integrate museums and historic sites to build a cohesive tourism product.

4.1. List of points of interest on the Tourist Trail of Digital Cultural Heritage

The public space explored so far revealed locations that collect and exhibit digital cultural heritage artefacts. Over thirty institutions in Poland have ‘museum’ in their name. The list of museums operating under a statute or rules approved by the minister for culture and national heritage (not to be confused with the State Register of Museums) contains several facilities partially or entirely devoted to computers, consoles, and games. These are (List MCNH, 2025): (1) Museum of Engineering and Technology in Kraków (item 77), (2) National Museum of Technology in Warsaw (item 355), (3) Museum of the History of Computers and IT (pending organisation) (item 463), (4) Museum of Computers and Gaming Consoles in Osielsk (item 794), (5) Museum of Computers and Games in Warsaw (pending organisation) (item 800); and an interesting proposal: (6) Museum of Radio-frequency Engineering in Bydgoszcz (pending organisation) (item 582). Their number changes quite dynamically. Two such museums were closed down in 2024: (1) Museum of Toys and Computer Games RetroManiak in Zakopane and (2) Club Museum of Retrocomputers, Games, and Demoscene in Opole – Dragon Museum Project 1.0. Two new ones were opened at the same time: (1) Good Old Retro, an interactive museum of old computers and consoles in Gniezno and (2) Museum of Games and Technology in Białystok by the Podlachia Retromaniacs Foundation. Places celebrating the history of technology in Poland, mostly museums of digital cultural heritage, are presented in Figure 2. This fact poses a certain difficulty with keeping the Tourist Trail of Digital Cultural Heritage up to date.

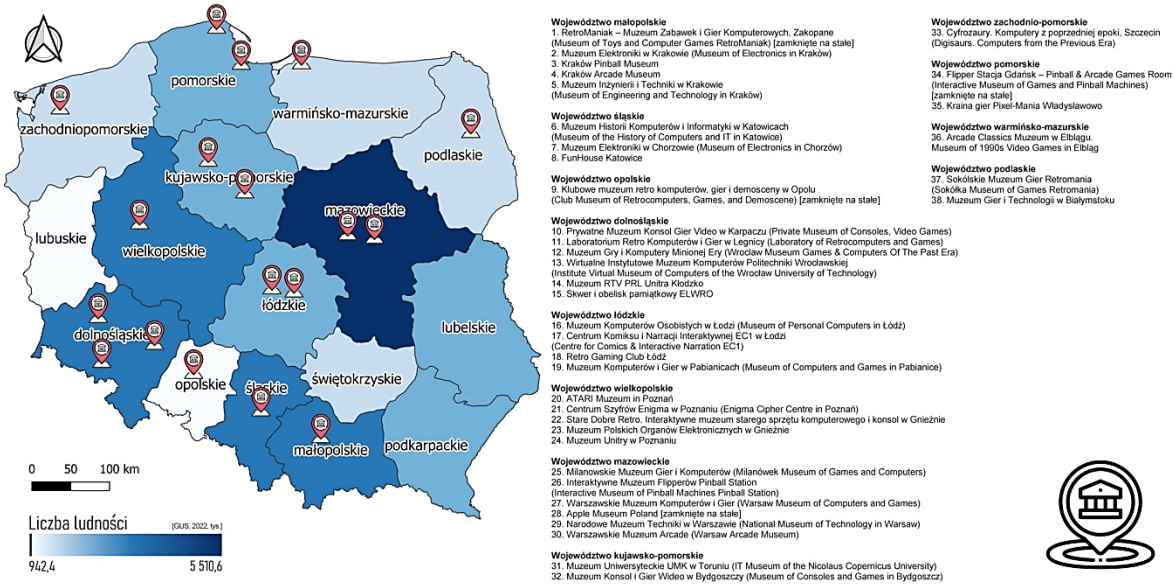

Figure 2. Map of places celebrating the history of technology in Poland, mostly museums of digital cultural heritage (Population, Statistics Poland, 2022, thousand).

Source: original work by Król, K. *A high-resolution map file can be downloaded from one of the authors'* website: https://digitalheritage.pl/2024/04/18/szlak-dziedzictwa-cyfrowego/, 3.04.2025.

Objects that form the core of thematic routes, such as architectural trails, are often permanently attached to their locations. It is not true for museums of digital cultural heritage. They often struggle to rent premises for a long term and are forced to relocate, like the Apple Museum Poland (moved in 2024), or have no permanent seat, like the Museum of Personal Computers in Łódź (as on 28.02.2025). Other museums/exhibitions are mobile or virtual, like the Museum of the History of CPUs and Computer Science (CPU Museum, 2025). Interviews with museologists and retro fans demonstrated that premises and rent, followed by utilities, are among the most severe problems when establishing and maintaining a museum of digital hardware (Król, 2024).

Research to date (Król, 2024) yielded a list of locations – especially museums – that could potentially make up the Tourist Trail of Digital Cultural Heritage. In-depth studies enlarged the list with other types of places. Although not museums, they celebrate the history of Polish computer design, so they fit the profile of the Trail. The Polish computer design was not limited to research or university environments. Production plants and R&D centres played just as important a role. One can still find their traces in cities in Poland. Many of them have ceased to exist, but there are monuments, squares, or new buildings in their places, still marking Poland's contribution to the history of the electronics and computer industry (Table 4).

Table 4.
Selected locations marking the history of Polish engineering

No.	Name	Address	Description	Current status
1.	Krakowskie Zakłady Teleelektroniczne (Kraków Communications-electronics Facility) TELKOM-TELOS	14–18 Lubelska Street, Kraków	A factory of radio equipment and telephones, including specialist telephones	A residential estate has been built in place of the factory floor
2.	Ośrodek Badawczo-Rozwojowy Mikroelektroniki Hybrydowej i Rezystorów (R&D Centre for Hybrid Microelectronics and Resistors)	39 Zabłocie Street, Kraków	A research and development facility of TELPOD	A building from the late 1970s still exists. It is currently Zakład Mikroelektroniki (Microelectronics Facility) in Kraków. In 2002, it was incorporated into the state Institute of Electron Technology
3.	Centrum Naukowo-Produkcyjne Mikroelektroniki Hybrydowej i Rezystorów (Science and Production Centre for Hybrid Microelectronics and Resistors) Telpod in Kraków UNITRA-TELPOD	4 Lipowa Street, Kraków	Zakłady Wytwórcze Podzespołów Telekomunikacyjnych (Communications Sub-assembly Production Facility)	The building still exists. The business has moved to Skawina near Kraków. The building now hosts the MOCAK Museum of Contemporary Art.
4.	Krakowska Fabryka Aparatów Pomiarowych (Kraków Factory of Measuring Apparati) MERA-KFAP	G. Zapolskiej Street, Kraków	A manufacturer of measuring equipment and computers	The office and factory buildings have been demolished and replaced with blocks of flats
5.	Krakowska Fabryka Kabli i Maszyn Kablowych, Zakład Maszyn Kablowych w Krakowie (Kraków Factory of Cables and Cable Machines, Cable Machine Facility in Kraków)	114 Wielicka Street, Kraków	A cable manufacturer	The factory building still exists and currently houses Tele-Fonika Kable SA
6.	A granite obelisk commemorating 23 workers of Kraków Cable Factory who died tragically during the German occupation	114 Wielicka Street, Kraków	A granite obelisk with a plaque	Still at the original location
7.	ELBUD	12 Wielicka Street, Kraków	The most popular electronics market in Kraków	The building has been demolished and replaced with an office building
8.	RADMOR S.A.	3 Hutnicza Street, Gdynia	A manufacturer of communications and household audio equipment	The building and company still exist. It now manufactures high-tech communications equipment

				for the military.
9.	DIORA S.A.	38 Świdnicka Street, Dzierżoniów	The first Polish factory of radios	The factory building has been demolished. Currently, a hypermarket is located at the site.
10.	Monument to Zakłady Radiowe im. Marcina Kasprzaka (Marcin Kasprzak Radio Facility) in Warsaw	18 Kasprzaka Street, Warsaw	The monument by Edmund Matuszek was revealed in 1975	Still at the original location
11.	Zakłady Wyrobów Elektrotechnicznych (Electrical Engineering Product Facility) Eltra in Bydgoszcz; Elda-Eltra Elektrotechnika S.A.; the Eltra brand (1956)	2a Narcyzowa Street, 86-005 Lipniki near Bydgoszcz	A manufacturer of electrical sub-assemblies and radio equipment	Today, the company offers about 50 audio products and focuses on DAB+ models. It celebrated a centenary in 2023
12.	Monument to Wrocławskie Zakłady Elektroniczne (Wrocław Electronics Facility) 'Elwro' and Elwro Square	Situated on the intersection of Ostrowskiego, Grabiszyńska, and Klecińska Streets in Wrocław	The monument and the square commemorate Wrocławskie Zakłady Elektroniczne ELWRO from 1959–1993	The surroundings of the monument are well-kept. The monument still at the original location
13.	Stereo Style s.c. Adam & Marek Ziemianin	3 Poturalskiego Street, Kraków	The company has been manufacturing compact cassettes for over 30 years.	One of a few companies in the world today to offer cassette recording and production.

Source: own study.

Wrocławskie Zakłady Elektroniczne ELWRO, in existence from 1959 to 1993, is among the most prominent places related to the history of Polish electronics. It manufactured the ODRA computers, which were a milestone of Polish computer science and industry. Today, the factory is commemorated by Elwro Square in Wrocław, which marks its impact on Polish technology.

Kraków had plenty of enterprises focused on electronics and microelectronics. Science and Production Centre for Hybrid Microelectronics and Resistors Telpod, at 4 Lipowa Street, manufactured telecommunications sub-assemblies. The building has been converted into the MOCAK Museum of Contemporary Art but remains an important part of the city's technology heritage. There was the R&D Centre for Hybrid Microelectronics and Resistors at 39 Zabłocie Street nearby. The building still exists and is home to the state-controlled Institute of Electron Technology.

Warsaw has a monument to the Marcin Kasprzak Radio Facility, an electronics and telecommunications equipment factory. It marks the institution's contribution to the history of technology in Poland. Another interesting example is RADMOR SA in Gdynia. It has been manufacturing communications equipment since the 1950s. Unlike many other enterprises, RADMOR still supplies high-tech communications equipment to the military and secret service, keeping its position in the Polish high-tech industry.

Stereo Style s.c. Adam & Marek Ziemianin boasts years of traditions in the production and reproduction of magnetic and optical data carriers. It has been promoting compact cassettes for years, driving the renaissance of the technology among fans of analogue music all over the world. Thanks to its commitment and experience, Stereo Style is respected for its high-quality cassettes and professional recording services. It combines a passion for classical formats with new technologies while ensuring precise craftsmanship and high fidelity. It is one of a few places in Poland where tradition meets high-tech craftsmanship.

The landmarks mentioned above, existing buildings, monuments, or squares, are important locations on the map of Polish digital heritage. They bear witness to the history of the Polish computer, electronics, and telecommunications industry. Their protection and promotion should play a critical role in how Poland's technology identity is shaped. The identity includes unique characteristics, development directions, and technology sectors determined by historical achievements, available resources, and state economic and scientific policies.

5. Discussion

The points of interest included in the Tourist Trail of Digital Cultural Heritage were selected with the following criteria: (1) a link to the history of the Polish computer and electronics industry. The point of interest has to be highly relevant to the development of digital technology in Poland. These are former production facilities, R&D centres, technical universities, and computer history museums; (2) status of a museum or exhibition. The Trail should contain institutions that collect and display artefacts linked to the history of computers, games, and electronics; (3) tangible remains of former facilities and institutions. This criterion covers buildings of former factories or technology institutions; (4) memorials in public space. This category includes monuments, commemorative plaques, or squares related to the history of technology. The Tourist Trail of Digital Cultural Heritage will be expanded into more places that meet the inclusion criteria. The focus will be on identifying lesser-known places that are highly relevant to the history of the Polish computer and electronics industry. Furthermore, promotional efforts are planned: educational events, interactive exhibitions, and collaborations with cultural institutions and technical universities. Trail use and access to the history of technology in Poland will be streamlined with digital tools, such as a mobile application or virtual guides.

5.1. Inclusion of institutions no longer operating in the original location

The inclusion of locations of former production facilities, research institutes, and other places linked to the history of the Polish computer industry can be of great historical and educational value (Gross, Huber, 2020). Although they may be gone now, such places can be

marked with plaques, monuments, digital reconstructions, or even virtual tours (Löwenborg et al., 2021). They can be significant for historical narrative by standing as testimony to the dynamic changes in the socioeconomic environment in Poland. It is a common practice to put up a commemorative plaque on an elevation or a different symbol in public space. One example is the plaque marking the location of Spółdzielnia Spożywców 'Oszczędność' (Frugality Food Producer Association) in Radom (Figure 3) or the Elwro obelisk and square in Wrocław (Figure 4).

(a) (b)

Figure 3. Tenement elevation today (a). Radom (Poland). Plaque reads (b): A store of the Frugality Food Producer Association was opened in this house in 1869. The Board of the Branch of the Voivodeship Food Producer Association in Radom installed the plaque in 1969 to mark the centenary. Source: Król (October 2024).

Figure 4. Elwro obelisk and square in Wrocław. Source: Król (June 2024).

It is worth illustrating legal barriers to placing commemorative plaques in public space with case studies. The monument to Wrocław Electronics Facility ELWRO was erected thanks to the collaboration of the local government with community organisations. Although no transparent regulatory framework was available, the idea was included in the local heritage strategy thanks to the support from the City Council. In contrast, the housing cooperative in charge of the building constructed in the place of a demolished MERA-KFAP facility in Kraków refused to approve a commemorative plaque. It resorted to the lack of legal basis for modifying the building wall and the undetermined legal status of the parcel. These examples

show that successful signage installation hinges on regulations, goodwill, and grassroots initiatives. Simplifying administrative procedures could streamline the effort significantly.

Plaques, obelisks, monuments, squares, and street names are essential to ensuring a historical continuum and a full view of socioeconomic and cultural development. These markers commemorate important places and events, even if the original buildings have been demolished or converted to preserve heritage in public space. Plaques and memorials linked to digital cultural heritage celebrate lost cultural heritage (Maćkowiak et al., 2018). Some points of interest can be an important testimony to the history of the computer and microelectronics industry in Poland, even if they are gone. Marking them in urban spaces with monuments, plaques, or interactive methods such as QR codes could restore the memory of the places (Figure 5).

(a) (b)

Figure 5. Statue of Prince Pribina in Nitra (Slovakia) (a) a QR code used to label a heritage point of interest (b).

Source: Karol Król (March 2025).

Figure 5 shows how QR codes can be used in the context of heritage. The Statue of Prince Pribina in Nitra (Slovakia) has a QR code as a new method of conveying information. After scanning the code with a mobile device, the user is redirected to a website with details of the place, its history, cultural significance, and local trivia. This way, knowledge is easily accessible in an attractive and interactive form without needing large signs or plaques on the monument. The content of the QR code can be updated without any physical intervention. These practical tools are particularly useful to tourists who wish to find out more about local history in a user-friendly way. This makes the statue a place of interactive historical interpretation in addition to a component of public space.

Placement of information signs and other markers of the past on the Trail entails particular challenges and can fail to meet tourists' expectations. They could be disappointed when they arrive at a location with no visible remains of the commemorated place. This issue could be prevented by providing a detailed description of the landmarks (Mansouri, Ujang, 2016). Moreover, legal, administrative, and bureaucratic obstacles must be tackled before plaques and other signage can be installed (Hjemdahl, 2022). It may be challenging to mark some locations

without approval from the local government or site owners. In light of the above, the best approach seems to be to divide the points of interest into two categories: (1) existing places that can be visited, such as museums, education centres, and former production facilities that are still operating or allow visitors and (2) historical places and objects that do not exist physically but have been commemorated differently, for example, with plaques, signs, or digital reconstructions. Notably, the priority seems to be to compile a complete documentation of the history of the Polish computer and electronics industry. Therefore, the Trail has to include marked locations of places that no longer exist. The combination of the two categories could yield the best outcome and make the Trail attractive for tourists as well as valuable in terms of education, heritage recording, and history.

5.2. Criteria for including points of interest in the Tourist Trail of Digital Cultural Heritage

Today, the Tourist Trail of Digital Cultural Heritage in Poland covers several dozen Polish technological development landmarks. The list of Trail landmarks can be expanded based on the inclusion criteria (Table 5). The role of the specific place in the development of Polish technology design is central here. The Trail can include places of science and education, such as research institutes, technical universities, or university laboratories that created the first Polish digital devices, computers, and IT solutions. This could make it more than just a historical record, perhaps an educational platform for posterity.

Table 5.
Selected inclusion criteria for the Tourist Trail of Digital Cultural Heritage

Criterion	Description
Links to the history of the Polish computer and electronics industry	The point of interest is highly relevant to the development of digital technologies in Poland, such as former production facilities, universities, and research centres
Status of a museum or exposition	Institutions that collect and display exhibits linked to the history of computers, games, and electronics
Material remains of former facilities and institutions	Places with former factory or technology institution buildings
Memorials in public space	Presence of monuments, commemorative plaques, squares or other markers related to the history of technology
Tourism potential and accessibility	Places that are easy to reach for tourists. They need to have tourism infrastructure and allow marking
Role in education and dissemination of knowledge	Places linked to technology education, such as university laboratories and research institutes
Social significance	Places linked to important historic events, conferences, demoscene meetings, or computer clubs
Degree of preservation and potential for interactive exhibition	Places with interactive exhibitions, operational retro hardware, and direct interaction with artefacts
Digital signage and online availability	Virtual presentation of the Trail, interactive online exhibitions, and historical reconstructions

Source: own study.

Another important criterion is the socioeconomic and cultural significance. The Trail should encompass places linked to historic events relevant to the Polish electronic culture, such as the first scientific conferences, microcomputer clubs, or spaces where the demoscene thrived. This highlights the social aspects of the history of the digital cultural heritage in Poland, in addition to the technological side.

The degree of preservation and the potential for interactive presentation are also important. Tourists naturally find places with operational exhibits where they can commune with technology more attractive. This criterion helps select those locations that allow visitors to run old computers, games, or other devices from the past.

Digital marking and online availability of reconstructions or models can be a factor in the future. The inclusion of virtual spaces, like interactive exhibitions or historical reconstructions in augmented reality, could substantially improve its reach and availability on a global scale. Integration with local initiatives and support from local communities are important as well. Collaboration with local governments, retro gaming festivals, or industrial museums can further the Trail's expansion, promote it, and help adjust it to the evolving needs of the audience. This way, it could contribute to the popularisation of knowledge by engaging enthusiasts and technical and computer amateurs in addition to merely recording the past.

The concept of the Tourist Trail of Digital Cultural Heritage is best put in a broader context by calling on similar international initiatives. One example is the Computer History Museum in Mountain View (California, USA), the centrepiece of the Silicon Valley Tech Trail, which offers a narrative on the history of computers using the latest exhibition techniques. Terra Technica in Czechia is a European leader. The largest museum of jukeboxes and pinball machines in the world combines museum, entertainment, and education. Retro Computer Museum in Leicester (United Kingdom) has interactive stations with original vintage hardware, inspiring practical solutions for exhibit management and visitor engagement. These institutions integrate education with user experience and a pronounced online presence (such as virtual tours and online databases of exhibits). These insights can help design a better Trail in Poland by transferring good practices for protecting and promoting digital cultural heritage.

6. Conclusion

The analyses reported in the article have led to several new decisions regarding the concept of the Tourist Trail of Digital Cultural Heritage. First, the list of places that make up the trail now includes new locations, like former factories and R&D centres. It was also noted that museums of technology often have problems with maintaining a constant address, which poses a challenge to the Trail's stability. The authors also defined inclusion criteria that take into account the historical significance, educational value, tourist accessibility, and knowledge

dissemination potential of the places. The analysis further revealed that Trail signage should involve public space (plaques, monuments) and digital solutions, such as mobile applications and interactive maps. Still, the research is far from exhausting the topic. It is a mere foothold for future work on the most extensive possible list of landmarks that should be part of the Tourist Trail of Digital Cultural Heritage in Poland.

These should be both museums and places marking the history of Polish computer design. Some types of points of interest include squares, monuments, and former businesses and factories that played a vital role in Poland's technological growth. Their inclusion affects the educational and cultural strength of the Trail. The places could be marked with signs with interactive QR codes giving access to old photographs, documents, and witness stories. Such an extended Trail could help build the public awareness of Poland's contribution to the history of technology, while putting digital heritage in the urban context. It could also 'invigorate' history so it is easier to learn and integrate with today's urbanscape.

Museums of computers and games are important institutions that record the history of technology and significantly affect education and culture. When included in thematic routes, they can substantially enhance the tourism opportunities offered by the region, attracting history and retro gaming enthusiasts. Despite the numerous challenges the institutions face, their role in education and culture is highly relevant. Their contribution to protecting and promoting digital heritage is pivotal, empowering future generations to delve deeply into the fascinating history of computers and games.

Research limitations and prospects

The primary limitation is the single research method, desk research. Secondary source analysis is valuable, but it cannot replace empirical studies. The research should be expanded to include interviews with experts, consultations with institutions involved in digital heritage, as well as public opinion research. Moreover, field visits to the prospective points of interest will be necessary to verify their status and availability. All this should be complemented with a survey among potential visitors and a legal and financial analysis to evaluate the feasibility and long-term survivability of the Trail.

The challenges and limitations of the Tourist Trail of Digital Cultural Heritage call for further in-depth analysis. Legal and administrative barriers that could affect the marking and formal establishment of the Trail require special attention. Analysis of financial models and potential support from public funds, public-private partnerships, or crowdfunding is just as critical. The final key component should be to analyse the Trail's impact on tourism and education, especially the public interest in the initiative.

Funding

Co-financed by the Minister of Science under the 'Regional Initiative of Excellence' programme. Agreement No. RID/SP/0039/2024/01. Subsidised amount: PLN 6,187,000.00. Project period: 2024-2027.

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