

3rd International Conference on Visual Pattern Extraction and Recognition for Cultural Heritage Understanding (VIPERC 2024)

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Abstract

This document presents the 3rd International Conference on Visual Pattern Extraction and Recognition for Cultural Heritage Understanding (VIPERC 2024), a premier forum for presenting academic and industry papers on big data, data mining and knowledge discovery, machine learning and deep learning, 3D modeling and simulation (structural, thermal, functional and acoustic analysis), software engineering, and, more generally, aspects related to digital transition for visual pattern extraction, analysis, and recognition to preserve cultural heritage.

Keywords

Cultural heritage, Artificial intelligence, Digital transition, Modeling and simulation.

1. Introduction

Cultural heritage encompasses all tangible and intangible elements of historical, archaeological, architectural, and artistic significance. Each piece of cultural heritage narrates the legends and traditions of people, families, communities, and nations around the globe. It serves as a valuable link to society's origins, helping to shape the future by drawing from the past. Cultural heritage is an integral part of daily life, evident everywhere from ancient ruins to contemporary natural landscapes and art. Tangible cultural heritage includes ancient buildings, archaeological sites, monuments, sculptures, paintings, coins, underwater ruins and cities, shipwrecks, manuscripts, photographs, films, and other items of artistic, archaeological, architectural, and historical importance. Intangible cultural heritage encompasses the acoustic heritage of ancient buildings, traditional crafts and festivals, oral traditions and expressions, dialects and sub-dialects, music, culinary traditions, and ways of life. The process of discovering and representing knowledge from cultural heritage primarily involves extracting, recognizing, and modeling visual patterns, which are crucial for analyzing and exploring hidden features, new hypotheses, relationships, trends, and modes within cultural heritage data. A visual pattern refers to any characteristic perceivable by the human senses. Today, the extraction, recognition, and modeling of visual

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patterns are increasingly achieved through digital transformation, utilizing modeling and automation techniques, intelligent systems, soft computing, and big data analytics in various real-world scenarios.

From all aforementioned, the 3rd International Conference on Visual Pattern Extraction and Recognition for Cultural Heritage Understanding (VIPERC 2024) aimed to be a satellite event of the IEEE 20th International Conference on Automation Science and Engineering (CASE 2024), presenting academic and industry papers on big data, data mining and knowledge discovery, machine learning and deep learning, 3D modeling and simulation (structural, thermal, functional and acoustic analysis), software engineering, and, more generally, aspects related to digital transition for visual pattern extraction, analysis, and recognition to preserve cultural heritage. VIPERC 2024 welcomed contributions from various research areas related to the digitization of cultural heritage, building recovery, conservation, and maintenance, leveraging current technologies and the support of robotics and automation. It also favored the participation of young research scholars who wanted to present their early-stage in-progress academic work.

VIPERC 2024 was part of the research activity of the Italian National Research Project: “MUD-MADE: MUlti-objective optimization of Digitally MAnufactured earth building components supported by neural networks”, PRIN PNRR 2022.

2. Topics

Topics of interest included, but were not limited to:

- Disruptive technologies
 - Machine learning and data science for cultural heritage multimedia data
 - Artificial intelligence in the recovery, analysis, and enhancement of cultural heritage
 - Augmented and virtual reality systems
 - 3D printing
 - Internet of things in cultural heritage
- Diagnostics
 - Intelligent sensor systems for building monitoring, recovery, conservation, maintenance and art restoration
 - Discrete geometry techniques for pattern recognition and pattern matching in cultural heritage images
 - Image processing, texture, shape analysis and natural language processing in historical data
- Acoustics and digital technology
 - Acoustics in cultural heritage
 - Soundscape planning and preservation
- Analysis
 - 3D reconstruction and model processing

- 3D modelling and simulation (e.g. structural, thermal, functional and acoustic analysis) for cultural heritage
- Remote sensing for cultural heritage preservation
- Surrogate models (computational models that approximate the behaviour of complex systems or processes)
- Manufacturing and intervention
 - Robotics and digital manufacturing for built heritage
 - Digitization of industrial products, projects, prototypes, and artefacts for cultural heritage preservation
 - Cutting-edge and sustainable digital-supported materials for built heritage
 - Metamaterials fabricated with specific patterns
 - Climate changes and intelligent mitigation strategies to preserve cultural heritage sites

3. Past VIPERC events

In the past, four VIPERC events were organized. Two of them were in the form of international workshop, and two of them were in the form of international conference:

- The 1st International Workshop on Visual Pattern Extraction and Recognition for Cultural Heritage Understanding, that was held on 30 January 2019 in the CNR Area of Pisa, Pisa, Italy (VIPERC 2019¹),
- The 2nd International Workshop on Visual Pattern Extraction and Recognition for Cultural Heritage Understanding, that was held on 29 January 2020 at the University of Bari Aldo Moro, Bari, Italy (VIPERC 2020²).
- The 1st International Virtual Conference on Visual Pattern Extraction and Recognition for Cultural Heritage Understanding, that was held on 12 September 2022 (VIPERC 2022³).
- The 2nd International Conference on Visual Pattern Extraction and Recognition for Cultural Heritage Understanding, that was held on 25-26 September 2023 in Zadar, Croatia (VIPERC 2023⁴).

Both VIPERC 2019 and VIPERC 2020 were in-site and co-located with the Italian Research Conference on Digital Libraries (IRCDL 2019 and 2020). The book of Proceedings of the two events is available in CEUR-WS (Volumes 2320 and 2602).

The attendance rate of VIPERC events in previous years made it possible to offer the next VIPERC events in the form of conference rather than workshop. In particular, VIPERC 2022 was in virtual form and co-located with the 19th International Conference on Artificial Intelligence: Methodology, Systems, Applications (AIMSA 2022). Also, VIPERC 2023 was organized as in-presence satellite conference of the 27th International Conference on Theory and Practice

¹https://ircdl2019.isti.cnr.it/?page_id=537

²<https://kdde.di.uniba.it/ircdl20/index.php/viperc-2020/>

³<https://sites.google.com/view/viperc-2022/>

⁴<https://sites.google.com/view/viperc2023/>

of Digital Libraries (TPDL 2023). The book of Proceedings of the two events is available in CEUR-WS (Volumes 3266 and 3600).

Finally, VIPERC 2024 was organized as in-presence satellite conference of the prestigious IEEE 20th International Conference on Automation Science and Engineering (IEEE CASE 2024), one of the three flagship conferences of the IEEE Robotics & Automation Society, and was held on 1 September 2024 in Bari, Italy.

4. Scientific Committee

The scientific relevance of the conference is assured by an international Organizing Committee which includes 8 researchers, six of them are from Italy and two of them are from Croatia, and an international Program Committee which includes 30 researchers from 12 different countries worldwide (Italy, France, Sweden, Greece, Bosnia and Herzegovina, Brazil, South Africa, Finland, Romania, Bulgaria, Serbia, Macedonia).

All members of the Scientific Committee are acknowledged as experts in cultural heritage, knowledge representation, information retrieval, algorithms, pattern recognition, artificial intelligence, and modeling and simulation techniques.

General Chairs:

- Alessia Amelio, Senior Researcher, InGeo University "G. d'Annunzio" Chieti-Pescara, Italy,
- Drahomira Cupar, Assistant Professor, DIS University of Zadar, Croatia,
- Valentino Sangiorgio, Senior Researcher, InGeo University "G. d'Annunzio" Chieti-Pescara, Italy.

Program Chairs:

- Marijana Tomić, Associate Professor, DIS University of Zadar, Croatia,
- David Ramírez Solana, Research Assistant, DIEI Polytechnic University of Bari, Italy,
- Sergio Montelpare, Full Professor, InGeo University "G. d'Annunzio" Chieti-Pescara, Italy,
- Luca Virgili, Tenure Track Researcher, DII Marche Polytechnic University, Italy,
- Alex Mircoli, Research Fellow, DII Marche Polytechnic University, Italy.

Program Committee:

- Adrian-Gabriel Chifu, Aix-Marseille University, France,
- Alessandro Ricciutelli, University "G. d'Annunzio" Chieti-Pescara, Italy,
- Anders Hast, Uppsala University, Sweden,
- Andreas Giannakouloupoulos, Ionian University, Greece,
- Belma Ramić -Brkić, Sarajevo School of Science and Technology, Bosnia and Herzegovina,
- Carlos Alexandre Barros de Mello, Federal University of Pernambuco, Brazil,
- Claudia Diamantini, Marche Polytechnic University, Italy,

- Cristina Cantagallo, University "G. d'Annunzio" Chieti-Pescara, Italy,
- Domenico Ursino, Marche Polytechnic University, Italy,
- Dustin van der Haar, University of Johannesburg, South Africa,
- Francesco Cauteruccio, University of Salerno, Italy,
- Gian Piero Zarri, Sorbonne University, France,
- Ionut Cosmin Duta, Huawei, Finland,
- Iuliana Georgescu, University of Bucharest, Romania,
- Ivo Rumenov Draganov, Technical University of Sofia, Bulgaria,
- Katerina Kabassi, Ionian University, Greece,
- Marco Ricci, University of Calabria, Italy,
- Maria Antonietta Pascali, ISTI-CNR, Italy,
- Marijana Ćosović, University of East Sarajevo, Bosnia and Herzegovina,
- Marius Popescu, University of Bucharest, Romania,
- Massimiliano Pepe, University "G. d'Annunzio" Chieti-Pescara, Italy
- Maura Mengoni, Marche Polytechnic University, Italy,
- Michail Panagopoulos, Ionian University, Greece,
- Michelangelo Ceci, University of Bari Aldo Moro, Italy,
- Naomi Di Marco, University "G. d'Annunzio" Chieti-Pescara, Italy,
- Radmila Janković Babić, Mathematical Institute of the Serbian Academy of Sciences and Arts, Serbia,
- Radu Tudor Ionescu, University of Bucharest, Romania,
- Samantha Di Loreto, University "G. d'Annunzio" Chieti-Pescara, Italy
- Tomislav Kartalov, "Ss. Cyril and Methodius" University in Skopje, Macedonia,
- Zoran Ivanovski, "Ss. Cyril and Methodius" University in Skopje, Macedonia.

5. Invited Speakers

The VIPERC 2024 Organizing Committee was honored to have invited Professor Stefano Ferilli from the University of Bari Aldo Moro, Italy, to deliver a brief lecture on the conference topics.

Prof. Stefano Ferilli's title of the talk was: "LPG-based Knowledge Graph Representation and Management for Cultural Heritage".

5.1. Biography

Eng. Stefano Ferilli, Ph.D., is a Full Professor at the Department of Computer Science of the University of Bari. From 2006 to 2018 he was the Director of the Inter-Departmental Center for Logic and Applications of the University of Bari. His research interests are centered on Logic and Algebraic Foundations of Machine Learning, Inductive Logic Programming, Theory Revision, Multi-Strategy Learning, Knowledge Representation, Expert Systems, Data Mining. Applications include Electronic Document Processing and Digital Libraries, Process Mining, Ambient Intelligence, Education. He currently leads the Automated Reasoning and Machine Learning (ARA) research group at the University of Bari. Since 2011 he is member of the Steering Committee, and since 2015 the Treasurer of the Italian Association for Artificial Intelligence.

5.2. Abstract

The traditional record-based approach used in Cultural Heritage (CH) has successfully served the need of users, scholars, researchers, and practitioners for many decades, but it has gone as far as it could. The enormous growth in production, types and availability of cultural items, the opening of their use to a wider public (with different background, goals, and perspectives), the advent of digital technologies, and the convergence of many different, traditionally separate disciplines call for new, advanced organization strategies and ways of exploitation, for both the items and the information they carry.

It is necessary to move from a set of predefined fields to a reticular approach, in which each of the different kinds of entities involved in a description has its own record and can be related to the others. In such a new setting the focus of the descriptions can also be broadened, from a fixed set of formal parameters about the items to a larger and more variable set also including information/metadata concerning their physical support, content, context, and even lifecycle. This ‘holistic’ approach allows us to support the needs and activities of different kinds of stakeholders.

In Artificial Intelligence (AI), the networking of data is the core of knowledge, and coupled with ontologies has been successfully used as a representation for Knowledge Bases (KBs), obtaining so-called Knowledge Graphs (KGs). KGs have been thoroughly studied in the Knowledge Representation (KR) branch of AI, interested in Ontologies and Automated Reasoning. Research in KR developed its own solutions for representing and storing knowledge, that have departed from the mainstream solutions for DBs. However, rooting KG data representation and storage in DB technology would ensure optimization and efficiency in data storage and handling. This requires advanced DB solutions, and some kind of cooperation with the solutions coming from KR, that may boost the effectiveness of data management to support the needs of different kind of users, providing them new possibilities for data exploitation and unprecedented opportunities to carry out their activities.

The GraphBRAIN framework was proposed for this setting, in which Formal Ontologies play the role of data schemas for LPG-based DBs. This enables the combined use of different kinds of AI algorithms to the available knowledge, from Graph Mining to Network Analysis, to Automated Reasoning (possibly combining multiple inference strategies). The proposed framework was implemented in a library and API that can be used by many different domain-specific application. A generic platform was developed for performing the general operations on the knowledge, including standard CRUD ones. The framework and technology were applied to several Cultural Heritage branches including history of computing, digital libraries and archives, linguistic analysis.

6. Best Paper and Best Presentation Awards

The VIPERC 2024 conference organized a ceremony to announce the best paper and best presentation awards.

The best paper was chosen by an Award Committee appointed by the General Chairs. This committee included various researchers from the Program Committee who were not affiliated with the authors of the papers. The Award Committee assessed the scientific quality and

innovation of the accepted papers, as well as their evaluations from the review process. Based on this assessment, they ranked the papers and selected the top-ranked paper as the best paper. The best presentation was selected by the General Chairs based on the clarity of exposition, quality of presentation, and the ability to effectively communicate the innovative aspects of the work.

The best paper award of VIPERC 2024 was assigned to Cristina Cantagallo, Giorgia Cianchino, Maria Giovanna Masciotta, Donato Palumbo, Massimiliano Pepe, Leonardo Cangelmi and Enrico Spacone, for their paper by title: "Documentation and rapid assessment of the health status of historic centers by the use of 360-degree videos and G.I.S.". The motivation for this choice by the Award Committee was the following: "The paper presents an outstanding contribution which successfully intersects different aspects, such as innovative application of low-cost technology, contribution to the cultural heritage preservation, and sustainability and resource efficiency. The aforementioned strengths made this paper a clear choice for the award. The approach is innovative, combined with a strong commitment to sustainability and cultural heritage, and constitutes a significant contribution to the field."

The best presentation award of VIPERC 2024 was assigned to Francesco Fieni, for presenting his paper by title: "Parametric Algorithm-Driven Robotic Fabrication of Minimal Surfaces using Terrazzo Slabs from Marble Waste".

7. Outcomes

The VIPERC 2024 conference ensured top-quality content by: (i) collecting high-level contributions from various research areas relevant to the digitization of cultural heritage, including image processing, data mining, artificial intelligence, software engineering, and 3D modeling and simulation; (ii) involving esteemed colleagues from different countries in the fields of cultural heritage, artificial intelligence, and pattern recognition in the Organizing and Program Committee, while also maintaining gender balance; (iii) inviting an internationally renowned speaker who is a leader in the event's topics; and (iv) conducting a fair peer review process based on clarity, topic relevance, and methodology.

VIPERC 2024 took place on September 1, 2024, from 9:00 AM to 1:30 PM (registration, welcome speech, invited talk, Session 1, and Session 2) and from 2:30 PM to 6:00 PM (Session 3, Session 4, Award ceremony, and closing) - Italian time - at the Nicolaus Hotel (room T2, floor -1), Via Cardinale Agostino Ciasca 27, 70124 Bari, Italy. The registration fee for each participant was set at 60 euros.

The event was attended by two General Chairs, Dr. Alessia Amelio and Dr. Valentino Sangiorgio, and three Program Committee members, Dr. Cristina Cantagallo, Dr. Alessandro Ricciutelli, and Dr. Samantha Di Loreto. On September 1, 2024, at 10:00 AM (Italian time), Dr. Alessia Amelio and Dr. Valentino Sangiorgio presented the welcome reception, followed by an invited talk by Prof. Stefano Ferilli from the University of Bari Aldo Moro. Dr. Valentino Sangiorgio chaired Session 1 on "3D Modeling and 3D Printing," Dr. Cristina Cantagallo chaired Session 2 on "Digitization of Diagnostics for Historic Constructions," Dr. Alessia Amelio chaired Session 3 on "Machine Learning and Pattern Recognition in Cultural Heritage," and Dr. Alessandro Ricciutelli and Dr. Samantha Di Loreto chaired Session 4 on "The Digital Transition

in Architectural Engineering."

The conference received 24 submissions, reviewed by 25 international research scholars from Italy, Pakistan, and Romania. Each submission was reviewed by at least two scholars from different institutions than the authors. Reviewers were not involved in co-authorship with the paper's authors.

The peer review process was conducted using the EasyChair system, evaluating each paper on clarity, topic relevance, and methodology. Only papers with at least two acceptance scores and no reject scores were accepted. The accepted papers were authored by 48 research scholars from Spain, India, Italy, and South Korea, resulting in 11 full papers included in the Proceedings.

Session 1 featured three presentations on the digital transition for 3D modeling and 3D printing in cultural heritage. Session 2 included four presentations on digital systems for diagnostics of historic constructions. Session 3 had four presentations on machine learning and pattern recognition approaches for cultural heritage understanding. Session 4 included three presentations on the digital transition in architectural engineering. The Organizing Committee authorized the online presentation of three papers via Microsoft Teams due to last-minute difficulties faced by the authors in reaching the conference location.

In total, VIPERC 2024 successfully hosted 40 participants.

8. Program

- **1 September 2024** (10 AM - 6 PM Italian time)
- (9 AM - 10 AM): Registration Desk
- (10 AM - 10.15 AM): Welcome presentation
 - Dr. Alessia Amelio, General Chair of VIPERC 2024
 - Dr. Valentino Sangiorgio, General Chair of VIPERC 2024
- (10.15 AM - 10.45 AM): Invited Speaker
 - Prof. Stefano Ferilli, University of Bari Aldo Moro, Italy. Talk: *LPG-based Knowledge Graph Representation and Management for Cultural Heritage*
- **Session 1. 3D modelling and 3D printing.** Chair: Dr. Valentino Sangiorgio
 - (10.45 AM - 11 AM) Alaa Ababneh. *Digital solutions for cultural heritage: preservation, interpretation, and engagement in line with the Venice charter principles* (online presentation).
 - (11 AM - 11.15 AM) Zahara Isania, Maria Pia Fanti and Giuseppe Casalino. *A Discrete event approach to the simulation of selective laser sintering 3D printing large scale production.*
 - (11.15 AM - 11.30 AM) Sreedharan Anuj, Wilson Suthakaran Santheep, John William Alfred Daniel, Rajendran Santhosh, Velusamy Parthasarathy. *Virtual resurrection leveraging 3D modeling for digital preservation of an ancient educational institution* (online presentation).
 - Discussion panel
- (11.30 AM - 12 PM) Coffee break

- **Session 2. Digitisation of diagnostics for historic constructions.** Chair: Dr. Cristina Cantagallo

- (12 PM - 12.15 PM) Vincenzo Mario Di Mucci, Angelo Cardellicchio, Sergio Ruggieri, Andrea Nettis, Vito Renò and Giuseppina Uva. *A new methodology to automatically detect cracks in existing RC bridges.*
- (12.15 PM - 12.30 PM) Luigi Salvatore Rainone, Vito Tateo, Siro Casolo, Giuseppina Uva. *Advanced non-linear 3D FEM modeling of masonry structures for the preservation of cultural heritage.*
- (12.30 PM - 12.45 PM) Sang-Yun Lee. *Measurement of displacement of petroglyphs of Bangudae Terrace in Daegok-ri, Ulju, using edge and region extraction.*
- (12.45 PM - 13 PM) Domenica Costantino, Vincenzo Saverio Alfio, Massimiliano Pepe. *TLS survey for material analysis and classification of marble pavement of the “Cappella di San Cataldo” in Taranto (Italy).*
- Discussion panel

- (1.30 PM - 2.30 PM) Lunch

- **Session 3. Machine learning and pattern recognition in cultural heritage.** Chair: Dr. Alessia Amelio

- (2.30 PM - 2.45 PM) Elisabetta Ferrara, Roberta Di Marco, Alex Zappacosta, Ilaria Filograsso, Valentina Gatta, Bruna Sinjari. *Integrating coastal cultural heritage, blue economy, and one health: a holistic framework for sustainable coastal management.*
- (2.45 PM - 3 PM) Samantha Di Loreto, Alessandro Ricciutelli, Valter Lori, Fabio Serpilli, Sergio Montelpare. *Pattern recognition and neural networks for acoustic monitoring and conservation of the historic port of Ancona.*
- (3 PM - 3.15 PM) Gino Iannace, Giovanni Amadasi, Franz Policardi, Amelia Trematerra. *Acoustic applications of metamaterials* (online presentation).
- (3.15 PM - 3.30 PM) Cristina Cantagallo, Giorgia Cianchino, Maria Giovanna Masciotta, Donato Palumbo, Massimiliano Pepe, Leonardo Cangelmi, Enrico Spacone. *Documentation and rapid assessment of the health status of historic centers by the use of 360-degree videos and G.I.S..*
- Discussion panel

- (4 PM - 4.30 PM) Coffee break

- **Session 4. The digital transition in architectural engineering.** Chairs: Dr. Alessandro Ricciutelli and Dr. Samantha Di Loreto

- (4.30 PM - 4.45 PM) Francesco Fieni, Fabio Parisi and Nicola Parisi. *Parametric algorithm-driven robotic fabrication of minimal surfaces using terrazzo slabs from marble waste.*
- (4.45 PM - 5 PM) Federica Fiorio and Nicola Parisi. *IoT for cultural heritage: valorisation in the digital age.*

- (5 PM - 5.15 PM) Mariangela Lops and Nicola Parisi. *Building with earth in construction 4.0 era: earth bee-hive, massive masonries using space-filling polyhedra.*
 - Discussion panel
- (5.30 PM - 5.50 PM) Award ceremony
 - Best Paper Award
 - Best Presentation Award
- (5.50 PM - 6 PM) Closing

9. Acknowledgments

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