



AID HCH IN GREENHER CoE DELAVNICA. **UI IN DEDIŠČINSKA ZNANOST: PRILOŽNOSTI,** **TVEGANJA, PRIHODNOST**

AID HCH AND GREENHER CoE WORKSHOP. **AI AND HERITAGE SCIENCE: OPPORTUNITIES,** **RISKS, THE FUTURE**

Ljubljana, 8. oktober / 8 October 2026

Knjiga povzetkov

Book of Abstracts

AID HCH in GREENHER CoE delavnica. UI in dediščinska znanost: priložnosti, tveganja, prihodnost / AID HCH and GREENHER CoE Workshop. AI and Heritage Science: Opportunities, Risks, the Future

Ljubljana, 8. oktober / 8 October 2026 | Knjiga povzetkov / Book of Abstracts

Programski odbor / Programme Committee

Gorazd Bajc (Univerza v Mariboru, Filozofska fakulteta / University of Maribor, Faculty of Arts)

Matija Strlič (Univerza v Ljubljani, Fakulteta za kemijo in kemijsko tehnologijo / University of Ljubljana, Faculty of Chemistry and Chemical Technology)

Domen Mongus (Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko / University of Maribor, Faculty of Electrical Engineering and Computer Science)

Polonca Ropret (Zavod za varstvo kulturne dediščine Slovenije / Institute for the Protection of Cultural Heritage of Slovenia)

Jana Kolar (Narodna in univerzitetna knjižnica / National and University Library)

Mojca Tancer Verboten (Univerza v Mariboru, Pravna fakulteta / University of Maribor, Faculty of Law)

Organizacijski odbor / Organising Committee

Gorazd Bajc (Univerza v Mariboru, Filozofska fakulteta / University of Maribor, Faculty of Arts)

Mateja Golež (Zavod za gradbeništvo Slovenije / Slovenian National Building and Civil Engineering Institute)

Nika Vrbek, Janez Osojnik, Tadeja Melanšek, Kaja Mujdrica, Ane Marie Herceg, Žana Plejić (Univerza v Mariboru, Filozofska fakulteta / University of Maribor, Faculty of Arts)

Uredniki / Edited by

Gorazd Bajc, Nika Vrbek, Janez Osojnik

Oblikovanje / Design and Layout

Gorazd Bajc, Nika Vrbek, Janez Osojnik

Lektoriranje (slovenščina) / Slovene language editing: Ane Marie Herceg

Lektoriranje (angleščina) / English language editing: Aja Barbič

Naslov projekta / Title of project: AID HCH – *Presežek pri razvoju humanistike in kulturne dediščine z umetno inteligenco* / *Break through in humanities and cultural heritage with artificial intelligence*, št. J7-60128.

Financer projekta / Funded by: Projekt AID HCH financira Javna agencija za znanstvenoraziskovalno in inovacijsko dejavnost Republike Slovenije (ARIS) / The AID HCH project is funded by the Slovenian Research and Innovation Agency (ARIS).

Nosilec projekta / Coordinating Institution:

Univerza v Mariboru, Filozofska fakulteta / University of Maribor, Faculty of Arts

Splet / Website: <https://aidhch.com>

E-pošta / E-mail: aid.hch@outlook.com

Vodja projekta / Principal investigator: red. prof. dr. Gorazd Bajc, Univerza v Mariboru, Filozofska fakulteta / full prof. dr. Gorazd Bajc, University of Maribor, Faculty of Arts

Vsebina je rezultat projekta AID HCH – *Presežek pri razvoju humanistike in kulturne dediščine z umetno inteligenco*, št. J7-60128, 2025–2027, in odraža izključno stališča in mnenja avtorjev, pri čemer GreenHer CoE in financer, ARIS, ne prevzemata odgovornosti. / The content is the result of the project AID HCH – *Break through in humanities and cultural heritage with artificial intelligence*, No. J7-60128, 2025–2027, and reflects solely the views and opinions of the author(s); neither GreenHer CoE nor the funder, ARIS, assumes any responsibility for it.



PROGRAM / PROGRAMME

10.00–10.30: Registracija / Registration

10.30–11.00: Pozdravni nagovori / Opening addresses

Gorazd Bajc (Univerza v Mariboru, Filozofska fakulteta / University of Maribor, Faculty of Arts, vodja projekta / principal investigator of AID HCH – *Presežek pri razvoju humanistike in kulturne dediščine z umetno inteligenco / Break through in humanities and cultural heritage with artificial intelligence*)

Matija Strlič (Univerza v Ljubljani, Fakulteta za kemijo in kemijsko tehnologijo / University of Ljubljana, Faculty of Chemistry and Chemical Technology, direktor / director of *GreenHer Center odličnosti / Centre of Excellence*)

Mateja Golež (Zavod za gradbeništvo Slovenije / Slovenian National Building and Civil Engineering Institute)

PRVI DEL / PART ONE

Moderator / Moderated by Gorazd Bajc

11.00–11.30: Predstavitev primerov petega delovnega sklopa (WP5) / Presentation of case studies from Work Package Five (WP5)

Janez Osojnik (Univerza v Mariboru, Filozofska fakulteta / University of Maribor, Faculty of Arts): *Umetna inteligenca in zgodovinske raziskave / Artificial Intelligence and Historical Research*

Jasna Vidinić (nekdanja sodelavka Univerze v Mariboru, Fakultete za elektrotehniko, računalništvo in informatiko / former colleague of University of Maribor, Faculty of Electrical Engineering and Computer Science) in / and **Karlo Crnek** (Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko / University of Maribor, Faculty of Electrical Engineering and Computer Science): *Vrednotenje modelov za analizo sentimenta za slovenščino na tematsko specifičnih zgodovinskih besedilih: primer revije Mladika (1980–1990) / Validating*

Sentiment Analysis Models for Slovenian on Historical Domain-Specific Texts: A Case Study of Mladika (1980–1990)

11.30–11.45: Diskusija / Discussion

11.45–12.00: Odmor za kavo / Coffee break

12.00–12.30: Predstavitev primerov šestega delovnega sklopa (WP6) / Presentation of case studies from Work Package Six (WP6)

Rok Vezočnik (Zavod za gradbeništvo Slovenije / Slovenian National Building and Civil Engineering Institute): *Digitalna vizualizacija dediščinskega jedra Zgornje Poljčane: pristopi, metode in orodja / Digital Visualization of the Heritage Settlement of Zgornje Poljčane: Approaches, Methods, and Tools*

Gregor Pobežin (Univerza na Primorskem, Fakulteta za humanistične študije / University of Primorska, Faculty of Humanities): *Od napisa do strukturiranih podatkov: z umetno inteligenco podprti postopki za EpiDoc in CIDOC CRM / From Inscriptions to Structured Data: AI-Assisted Workflows for EpiDoc and CIDOC CRM*

Lea Legan (Zavod za varstvo kulturne dediščine Slovenije / Institute for the Protection of Cultural Heritage of Slovenia): *Od karakterizacije materialov do vizualne predstavitve: pristop k rekonstrukciji zgodovinskih slik, ki temelji na umetni inteligenci / From Material Characterisation to Visual Representation: An AI-based Approach to Reconstruction of Historical Paintings*

12.30–12.45: Diskusija / Discussion

12.45–13.15: Predstavitev primerov sedmega delovnega sklopa (WP7) / Presentation of case studies from Work Package Seven (WP7)

Hend Mahgoub (Univerza v Ljubljani, Fakulteta za kemijo in kemijsko tehnologijo / University of Ljubljana, Faculty of Chemistry and Chemical Technology) in / and **Matej Brumen** (Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko / University of Maribor, Faculty of Electrical Engineering and Computer Science): *Napovedovanje mikroklim in*

*modeliranje akumulacije poškodb za preventivno konserviranje s pomočjo UI / AI-Driven
Prediction of Microclimates and Modelling of Damage Accumulation for Preventive Conservation*

13.15–13.30: Diskusija / Discussion

13.30–14.45: Odmor za kosilo / Lunch break

DRUGI DEL / PART TWO

14.45–16.00: Okrogla miza / Round table

Moderator / Moderated by **Domen Mongus** (Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko / University of Maribor, Faculty of Electrical Engineering and Computer Science), sodelujejo / participants:

Andreja Rudolf (Univerza v Mariboru, Fakulteta za strojništvo / University of Maribor, Faculty of Mechanical Engineering)

Mojca Tancer Verboten (Univerza v Mariboru, Pravna fakulteta / University of Maribor, Faculty of Law)

Dunja Legat (Univerza v Mariboru, Univerzitetna knjižnica Maribor / University of Maribor, University of Maribor Library)

Alenka Kavčič Čolić (Narodna in univerzitetna knjižnica / National and University Library)

Ernest Ženko (Univerza na Primorskem, Fakulteta za humanistične študije / University of Primorska, Faculty of Humanities)

16.00–16.30: Sklepna diskusija / Closing discussion

VSEBINA / CONTENT

Gorazd Bajc <i>Uvod / Introduction</i>	1
Janez Osojnik <i>Umetna inteligenca in zgodovinske raziskave / Artificial Intelligence and Historical Research</i>	4
Jasna Vidinič, Karlo Crnek <i>Vrednotenje modelov za analizo sentimenta za slovenščino na tematsko specifičnih zgodovinskih besedilih: primer revije Mladika (1980–1990) / Validating Sentiment Analysis Models for Slovenian on Historical Domain-Specific Texts: A Case Study of Mladika (1980–1990)</i>	5
Simon Kolmanič, Mateja Golež, Janko Rožič, Janez Poldaj, Polonca Vidmar, Rok Vežočnik <i>Digitalna vizualizacija dediščinskega jedra Zgornje Poljčane: pristopi, metode in orodja / Digital Visualization of the Heritage Settlement of Zgornje Poljčane: Approaches, Methods, and Tools</i>	7
Gregor Pobežin <i>Od napisa do strukturiranih podatkov: z umetno inteligenco podprti postopki za EpiDoc in CIDOC CRM / From Inscriptions to Structured Data: AI-Assisted Workflows for EpiDoc and CIDOC CRM</i>	9
Lea Legan, Klara Retko, Mitko Nikov, Hend Mahgoub, Domen Mongus, Polonca Ropret <i>Od karakterizacije materialov do vizualne predstavitve: pristop k rekonstrukciji zgodovinskih slik, ki temelji na umetni inteligenci / From Material Characterisation to Visual Representation: An AI-based Approach to Reconstruction of Historical Paintings</i>	12
Hend Mahgoub, Matej Brumen, Mitko Nikov, Domen Mongus, Matija Strlič <i>Napovedovanje mikroklim in modeliranje akumulacije poškodb za preventivno konserviranje s pomočjo UI / AI-Driven Prediction of Microclimates and Modelling of Damage Accumulation for Preventive Conservation</i>	14

Uvod / Introduction

Gorazd Bajc

Univerza v Mariboru, Filozofska fakulteta / University of Maribor, Faculty of Arts

Vodja projekta / principal investigator of AID HCH – *Presežek pri razvoju humanistike in kulturne dediščine z umetno inteligenco*
/ *Break through in humanities and cultural heritage with artificial intelligence*

Glavni cilj projekta AID HCH je ustrezno razumeti in izkoristiti potencial umetne inteligence v humanističnih raziskavah in pri ohranjanju kulturne dediščine. V ta namen razvijamo oziroma nadgrajujemo ustrezne metodološke in teoretične okvirje, da bi opredelili etične in pravne vidike za čim bolj učinkovito in ustrezno uporabo umetne inteligence v humanistiki in na splošno dediščinski znanosti. Ustrezna uporaba visokotehnoloških računalniških orodij namreč znatno prispeva k raziskovanju vedno večjega števila digitaliziranih virov in podatkov, kar ponuja izjemne priložnosti za nadgradnjo raziskav dediščinske znanosti ter učinkovitejše vrednotenje in ohranjanje kulturne dediščine. Ključnega pomena je, da se kulturna dediščina ohrani v svoji prvotni obliki, hkrati pa se ohrani in okrepi evropski in nacionalni družbeni kapital. Projekt predstavlja zahteven, a obenem nujen in za slovenske razmere povsem nov raziskovalni izziv tudi zaradi zaostajanja Slovenije pri raziskavah na tem področju. Zaradi tega smo moči združili raziskovalci posameznih humanističnih študij, dediščinske znanosti, prava in računalništva, kot tudi bibliotekarji in izvedenci za dediščinska vprašanja različnih slovenskih univerz oziroma osrednjih institucij.

Soorganizator delavnice je GreenHer Center odličnosti, interdisciplinarna skupina raziskovalcev, ki vključuje vse od arheologov do kemikov, od računalniških strokovnjakov do konservatorjev-restavratorjev, ki razvijajo nova znanja na področju razumevanja in upravljanja kulturne dediščine. Sodelovanje projekta AID HCH in GreenHer CoE tako predstavlja smiselno povezovanje humanističnih, naravoslovnih in računalniških pristopov pri iskanju novih rešitev za raziskovanje in ohranjanje kulturne dediščine.

Delavnica bo potekala v okviru Dnevov evropske kulturne dediščine 2026, ki se letos odvijajo pod geslom *Dediščina v vrtincu sprememb – priložnosti in izzivi*. Tako v ospredje postavljajo vprašanje, kako kulturno dediščino razumeti, raziskovati in ohranjati v času hitrih družbenih, tehnoloških, okoljskih in drugih sprememb, kar sovпада s tematiko našega srečanja. Z njim želimo predvsem spodbuditi razpravo o tem, kako lahko sodobne tehnologije in umetna inteligenca prispevajo k raziskovanju, razumevanju, varovanju in ohranjanju kulturne dediščine, ne da bi pri tem izgubili njeno avtentičnost, kontekst in pomen za prihodnje generacije.

Naše srečanje je namenjeno predstavitvi uporabe umetne inteligence pri doseganju raziskovalnih ciljev na različnih področjih – na izbranih študijah primerov. Referati bodo tako osredotočeni predvsem na proces in ne na končne rezultate, in sicer kako lahko umetna inteligenca prispeva k doseganju zelenih rezultatov, katere korake izvajamo, s katerimi izzivi se srečujemo, kakšna je dodana vrednost umetne inteligence pri raziskovalnem delu ipd. Drugi del bomo namenili razpravi v obliki okrogle mize, ki bo osredotočena na prihodnjo uporabo oziroma

prispevek umetne inteligence na področju humanistike, družboslovja in dediščinske znanosti, kot tudi na morebitne omejitve.

The main objective of the AID HCH project is to properly understand and harness the potential of artificial intelligence in humanities research and in the preservation of cultural heritage. To this end, we are developing and upgrading appropriate methodological and theoretical frameworks in order to define the ethical and legal aspects of the most effective and appropriate use of artificial intelligence in the humanities and in heritage science in general. The appropriate use of high-technology computational tools contributes significantly to the study of an ever-growing number of digitised sources and data, which offers exceptional opportunities for advancing heritage science research and for more effective evaluation and preservation of cultural heritage. It is crucial that cultural heritage be preserved in its original form, while European and national social capital is also maintained and strengthened. The project represents a demanding but also necessary research challenge, and one that is entirely new in the Slovenian context, partly because of Slovenia's lag in research in this field. For this reason, researchers from individual humanities disciplines, heritage science, law and computer science, as well as librarians and experts on heritage issues from various Slovenian universities and central institutions, have joined forces.

The workshop is co-organised by the GreenHer Centre of Excellence, an interdisciplinary group of researchers ranging from archaeologists to chemists, from computer experts to conservators-restorers, who are developing new knowledge in the field of understanding and managing cultural heritage. The collaboration between the AID HCH project and GreenHer CoE thus represents a meaningful linking of humanities, natural-science and computational approaches in the search for new solutions for researching and preserving cultural heritage.

The workshop will take place as part of the European Heritage Days 2026, which this year are held under the theme *Heritage in a Whirl of Change – Opportunities and Challenges*. The theme thus brings to the fore the question of how to understand, research and preserve cultural heritage in a time of rapid social, technological, environmental and other changes, which coincides with the topic of our meeting. Above all, we wish to encourage a discussion on how contemporary technologies and artificial intelligence can contribute to the research, understanding, protection and preservation of cultural heritage, without losing sight of its authenticity, context and significance for future generations.

Our workshop is devoted to presenting the use of artificial intelligence in achieving research objectives in various fields, through selected case studies. The presentations will therefore focus primarily on the process rather than on the final results, namely on how artificial intelligence can contribute to achieving the desired outcomes, which steps we are taking, which challenges we encounter, what the added value artificial intelligence brings to research work, among other questions. The second part will be devoted to a discussion in the form of a round table, focused on

the future use and contribution of artificial intelligence in the fields of the humanities, social sciences and heritage science, as well as on possible limitations.

Umetna inteligenca in zgodovinske raziskave / Artificial Intelligence and Historical Research

Janez Osojnik

Univerza v Mariboru, Filozofska fakulteta / University of Maribor, Faculty of Arts

Povzetek

Zgodovinarji se pri svojem znanstvenoraziskovalnem delu srečujemo s številnimi različnimi vrstami virov. Eni izmed teh so časopisni viri, ki so odraz aktualnega družbenega dogajanja, obenem pa so lahko tudi sredstva politične propagande. Zlasti zaradi nevarnosti pristranskosti v njihovem pisanju je potreba po primerjavi časopisnih virov z drugimi viri še kako dobrodošla. V referatu bo prikazano, kako lahko model, ki ga razvijamo v okviru projekta AID HCH, raziskovalcu pomaga pri spopadanju s časopisnimi viri zlasti v smislu hitrejšega in učinkovitejšega evidentiranja relevantnih števil in člankov. Predstavljen bo potek razvoja modela, ki je plod sodelovanja strokovnjakov s področja tehnike in humanistike – od idejne zasnove in posameznih razvojnih korakov ter njihovih testiranj do trenutnega stanja razvoja in načrtov za v prihodnje. To bo podkrepljeno s prikazom pomoči na raziskavah konkretnih študij primerov zgodovinopisnih raziskav. Poleg priložnosti, ki jih model kot nasploh umetna inteligenca predstavlja pri analizi časopisnih virov, bomo predstavili tudi, kateri izzivi se pri tem pojavljajo oziroma za kaj je raziskovalec lahko prikrajšan.

Abstract

In their scholarly research, historians encounter many different types of sources. Newspaper sources are among these, reflecting contemporary social developments while also potentially functioning as instruments of political propaganda. Given the potential for bias in newspaper reporting, comparing newspaper sources with other types of sources is particularly important. The presentation will demonstrate how the model being developed as part of the AID HCH project can support researchers in working with newspaper sources, particularly by enabling faster and more efficient identification and recording of relevant issues and articles. The development process of the model will be presented, which is the result of collaboration between experts in the fields of engineering and the humanities, covering its initial conceptual design, individual stages of development and testing, its current state of development, and plans for future development. This will be demonstrated through selected case studies showing how it can support historical research. Alongside the opportunities that the model, and artificial intelligence in general, offers for the analysis of newspaper sources, we will also present the challenges that arise in this process and the potential limitations it may impose on the researcher.

Vrednotenje modelov za analizo sentimenta za slovenščino na tematsko specifičnih zgodovinskih besedilih: primer revije *Mladika* (1980–1990) / Validating Sentiment Analysis Models for Slovenian on Historical Domain-Specific Texts: A Case Study of *Mladika* (1980–1990)

Jasna Vidinić (nekdanja sodelavka / former colleague), Karlo Crnek

Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko / University of Maribor, Faculty of Electrical Engineering and Computer Science

Povzetek

Prispevek obravnava vrednotenje modelov za avtomatsko analizo sentimenta v slovenščini na primeru revije *Mladika*, slovenskega zamejskega časopisa, ki izhaja v Trstu in predstavlja pomemben vir slovenskega javnega diskurza zunaj matične države. Analizirano je obdobje med letoma 1980 in 1990, za katero so značilne pomembne družbene in politične spremembe v Jugoslaviji ter vse izrazitejše razprave o slovenski samostojnosti. V raziskavo je bilo vključenih 82 besedil, ki so obravnavala teme, povezane s slovensko osamosvojitvijo, razpadom Jugoslavije, politično ureditvijo, gospodarstvom ter besedila, ki na splošno obravnavajo odnos do Slovenije oziroma Jugoslavije. Vse številke revije so bile ročno pregledane, ročno so bila izbrana relevantna besedila, nato pa analizirana na ravni povedi s tremi modeli za analizo sentimenta: ParlaSent, E5-Small Multilingual in Gemma 4. Namen raziskave je bil primerjati rezultate različnih modelov ter preveriti njihovo ujemanje z ročnimi oznakami. Za vrednotenje modelov je bil na reprezentativnem vzorcu 187 povedi izveden tudi ročni pregled. Dva neodvisna ocenjevalca sta povedi označila glede na tri kategorije sentimenta, rezultati pa so bili primerjani z oznakami posameznih modelov. Rezultati kažejo, da se modeli med seboj razlikujejo, in sicer najvišjo stopnjo ujemanja z ročnimi oznakami je dosegel model ParlaSent. Največ težav pri prepoznavanju sentimenta se pojavlja zaradi implicitno podanih informacij, pri katerih je potrebno poznavanje širšega konteksta, zlasti pri politično in ideološko zaznamovanih zapisih. Analiza hkrati kaže trend, da se skozi leta zmanjšuje delež negativnega in povečuje delež pozitivnega sentimenta. Rezultate je zaradi omejenega obsega ročno označenega vzorca in specifičnosti gradiva treba razumeti kot izhodišče za nadaljnje raziskave avtomatske analize sentimenta v zgodovinskih besedilih.

Abstract

This paper examines the evaluation of models for automatic sentiment analysis in Slovenian using the example of *Mladika*, a Slovenian minority journal published in Trieste, which represents an important source of Slovenian public discourse outside the country. The analysis covers the period from 1980 to 1990, which was marked by significant social and political changes in Yugoslavia and increasingly prominent discussions about Slovenian independence. The study included 82 texts addressing topics related to Slovenian (potential) independence, the dissolution of Yugoslavia, economy, the political system, as well as texts addressing attitudes towards Slovenia and/or Yugoslavia more generally. All issues of the journal were manually reviewed, and relevant

texts were selected manually. The texts were then analysed at the sentence level using three sentiment analysis models: ParlaSent, E5-Small Multilingual, and Gemma 4. The aim of the study was to compare the results produced by different models and assess their agreement with manual annotations. To evaluate the models, a manual review was also conducted on a representative sample of 187 sentences. Two independent annotators labelled the sentences according to three sentiment categories, and the results were compared with the labels assigned by each model. The results show considerable differences between the models, with ParlaSent achieving the highest level of agreement with the manual annotations. The greatest difficulties in sentiment recognition arise from implicitly conveyed information, which requires knowledge of the broader context, particularly in politically and ideologically marked texts. The analysis also indicates a trend towards a decrease in negative sentiment and an increase in positive sentiment over the years. Due to the limited size of the manually annotated sample and the specificity of the material, the results should be understood as a starting point for further research into automatic sentiment analysis of historical texts.

Digitalna vizualizacija dediščinskega jedra Zgornje Poljčane: pristopi, metode in orodja / Digital Visualization of the Heritage Settlement of Zgornje Poljčane: Approaches, Methods, and Tools

Simon Kolmanič¹, Mateja Golež², Janko Rožič (zunanji sodelavec / external colleague), Janez Poldas (zunanji sodelavec / external colleague), Polonca Vidmar³, Rok Vezočnik²

¹ Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko / University of Maribor, Faculty of Electrical Engineering and Computer Science

² Zavod za gradbeništvo Slovenije / Slovenian National Building and Civil Engineering Institute

³ Univerza v Mariboru, Filozofska fakulteta / University of Maribor, Faculty of Arts

Povzetek

Pri izbranem primeru Zgornjih Poljčan smo raziskovali, ali je mogoče z dovolj natančnim digitalnim modelom prikazati prostorske principe, s katerimi so stari mojstri skozi različna obdobja oblikovali in uglaševali zgodovinska jedra na ravni detajla in celote. Tak pristop je lahko pomembno orodje pri celoviti prenovi zgodovinskih jeder ter pri urbanističnem in arhitekturnem umeščanju objektov v prostor.

Izhodišče raziskave je fotogrametrični model območja Zgornjih Poljčan, zajet z brezpilotnim letalnikom, ki obsega približno 40 ha urbanega okolja. Za analizo širšega prostorskega in arhitekturnega konteksta je bilo območje dopolnjeno še z okoliškim hribovjem v velikosti 5,273 km², pridobljenim iz Digitalnega modela višin Slovenije.

Zaradi velike geometrijske kompleksnosti in značilnih pomanjkljivosti fotogrametričnega zajema izvorni model ni neposredno primeren za uporabo v realnem času. Zato so bili izvedeni ključni postopki optimizacije: odstranjevanje odvečne in napačno rekonstruirane geometrije, analiza topologije, odpravljanje nekonsistentne orientacije poligonov in normal ter poenostavitev geometrije ob ohranjanju prepoznavnih značilnosti objektov. Vizualne informacije iz visokoločljivostnega modela so bile na optimizirano geometrijo prenesene z uporabo UV-preslikav in projekcije površinskih lastnosti v teksturne preslikave.

Optimizirani modeli so bili vključeni v igralni pogon Unity, kjer je bilo vzpostavljeno virtualno okolje za prvoosebno raziskovanje kraja. Arhitekturno in kulturno pomembne lokacije so bile nadgrajene z interaktivnimi elementi, ki omogočajo izbiro objektov ter dostop do 3D-prikazov, slikovnega gradiva in umetnostnozgodovinskih opisov.

Predstavljeni pristop povezuje fotogrametrično dokumentiranje, optimizacijo 3D-podatkov in razvoj interaktivne aplikacije ter odpira možnosti za sodobno digitalno predstavitev, raziskovanje in interpretacijo kulturne dediščine.

Abstract

In the selected case study of Zgornje Poljčane, we investigated whether a sufficiently accurate digital model can be used to represent the spatial principles by which master builders of the past, across different periods, shaped and harmonized historic urban settlements at both the level of individual details and the overall spatial composition. Such an approach can be an important tool for the comprehensive renewal of historic urban sites, as well as for the urban planning and architectural integration of buildings into their surroundings.

The starting point of the research was a photogrammetric model of the Zgornje Poljčane area, captured using an unmanned aerial vehicle (UAV), covering approximately 40 ha of urban environment. To analyse the broader spatial and architectural context, the area was further extended to include the surrounding hilly terrain, covering 5.273 km², derived from the Digital Elevation Model of Slovenia.

Due to its high geometric complexity and the characteristic limitations of photogrammetric acquisition, the original model is not directly suitable for real-time applications. Key optimization procedures were therefore carried out, including the removal of redundant and incorrectly reconstructed geometry, topology analysis, correction of inconsistent polygon and normal orientations, and geometry simplification while preserving the recognizable characteristics of the buildings. Visual information from the high-resolution model was transferred to the optimized geometry using UV mapping and the projection of surface properties into texture maps.

The optimized models were integrated into the Unity game engine, where a virtual environment was established for first-person exploration of the settlement of Zgornje Poljčane. Architecturally and culturally significant locations were enhanced with interactive elements that enable users to select buildings and access 3D representations, visual materials (i.e. photographic images), and art history documentation.

The presented approach combines photogrammetric documentation, 3D data optimization, and the development of an interactive application, opening up opportunities for the contemporary digital presentation, exploration, and interpretation of cultural heritage.

Od napisa do strukturiranih podatkov: z umetno inteligenco podprti postopki za EpiDoc in CIDOC CRM / From Inscriptions to Structured Data: AI-Assisted Workflows for EpiDoc and CIDOC CRM

Gregor Pobežin

Univerza na Primorskem, Fakulteta za humanistične študije / University of Primorska, Faculty of Humanities

Povzetek

Srednjeveški in zgodnjenovoveški napisi predstavljajo bogat, a še vedno nezadostno raziskan zgodovinski vir, zlasti na slovenskem prostoru, kjer ohranjeno epigrafsko gradivo odraža specifične jezikovne, družbene, verske in kulturne okoliščine. Sistematična dostopnost tega gradiva za raziskave ne zahteva le njegove dokumentacije in strokovne interpretacije, temveč tudi strukturirane digitalne predstavitve, ki omogočajo povezljivost, iskanje in ponovno uporabo napisov kot raziskovalnih podatkov. Izdelava takšnih predstavitev je časovno zahtevna in zahteva tako epigrafsko znanje kot poznavanje specializiranih standardov, kakršen je EpiDoc/TEI XML.

Študija primera, razvita v okviru projekta AID HCH, raziskuje možnosti uporabe metod, podprtih z umetno inteligenco, pri pretvorbi epigrafskih besedil in njihovih strokovnih opisov v strukturirane podatke, skladne z uveljavljenimi standardi. Predstavljeni delovni proces se osredotoča na delno avtomatizirano kodiranje napisov v predlogi EpiDoc XML. Na podlagi epigrafskega prepisa in spremljajočih opisnih podatkov orodja umetne inteligence prepoznajo relevantne besedilne in semantične značilnosti ter predlagajo njihovo kodiranje v skladu z vnaprej določeno strukturo EpiDoc. Namen takšnega pristopa ni »izločiti človeško oko in roko« ali celo nadomestiti ročno strokovno označevanje, temveč umetno inteligenco uporabiti kot agenta-pomočnika, ki pomaga na vsaj dveh stopnjah procesa: med ročnim (terenskim) zbiranjem gradiva in formalnim podatkovnim modeliranjem ter nato pred znanstveno interpretacijo. Umetna inteligenca tako ni razumljena kot avtonomni epigrafski urednik, temveč kot del širšega raziskovalnega procesa, v katerem lahko kombinacija domenskega znanja, podatkovnih standardov in strojno podprte obdelave poveča tako raziskovalno dostopnost kot možnosti novih oblik uporabe doslej premalo izkoriščenega zgodovinskega vira. Samodejno ustvarjeno označevanje je omejeno z obstoječo predlogo in ostaja predmet strokovnega preverjanja.

Drugi vidik študije primera obravnava razmerje med dokumentno usmerjenim kodiranjem EpiDoc in semantičnim modeliranjem s CIDOC CRM. Podatke o osebah, krajih, predmetih, dogodkih in njihovih medsebojnih razmerjih je mogoče predstaviti tudi v obliki grafa znanja (knowledge graph) ter tako epigrafske vire povezovati z drugimi podatkovnimi zbirkami kulturne dediščine.

Strukturiranje gradiva pa odpira tudi nadaljnje možnosti njegove uporabe. Ena od njih je možnost poigritve (play potential) digitalizirane kulturne dediščine: možnost, da strukturirani in semantično povezani podatki postanejo osnova za raziskovalne, izobraževalne ali interpretativne oblike igrivega raziskovanja preteklosti. Igra pri tem ni razumljena zgolj kot način popularizacije, pač pa predvsem kot možen način interakcije s podatki.

Na konkretnih primerih bo predstavitev tako pokazala različne ravni preoblikovanja epigrafskega vira: od prepisa in delno avtomatiziranega kodiranja prek semantičnega povezovanja do možnosti njegove ponovne uporabe in (igrivega) raziskovanja. Posebna pozornost je namenjena vprašanju, katere postopke je mogoče avtomatizirati, pri katerih lahko umetna inteligenca ponudi uporabne predloge in kje ostaja strokovna interpretacija nepogrešljiva.

Abstract

Medieval and early modern inscriptions constitute a rich yet still insufficiently explored historical source, particularly in the Slovenian lands, where the surviving epigraphic material reflects specific linguistic, social, religious, and cultural contexts. Systematic accessibility of this material for research requires not only its documentation and scholarly interpretation, but also structured digital representations that enable the interoperability, searching, and reuse of inscriptions as research data. Producing such representations is time-consuming and requires both epigraphic expertise and knowledge of specialised standards such as EpiDoc/TEI XML.

This case study, developed within the AID HCH project, explores the potential of AI-assisted methods for transforming epigraphic texts and their scholarly descriptions into structured, standards-compliant data. The presented workflow focuses on the partially automated encoding of inscriptions in an EpiDoc XML template. Based on an epigraphic transcription and accompanying descriptive data, AI tools identify relevant textual and semantic features and propose their encoding according to a predefined EpiDoc structure. The aim of this approach is not to “remove the human eye and hand” from the process, let alone replace manual expert annotation, but rather to employ AI as an assistant agent that operates at no fewer than two stages of the process: between manual (field) data collection and formal data modelling, and subsequently as an intermediary prior to scholarly interpretation. AI is thus not understood as an autonomous epigraphic editor, but as part of a broader research process in which the combination of domain expertise, data standards, and machine-assisted processing can enhance both the accessibility of this underused historical source for research and the possibilities for new forms of its use. Automatically generated markup is constrained by the existing template and remains subject to expert validation.

A second aspect of the case study examines the relationship between document-oriented EpiDoc encoding and semantic modelling using CIDOC CRM. Data concerning persons, places, objects, events, and the relationships between them can also be represented in the form of a knowledge graph, allowing epigraphic sources to be linked to other cultural heritage datasets.

The structuring of the material also opens up further possibilities for its use. One of them is the play potential of digitised cultural heritage: the possibility of structured and semantically interconnected data becoming the basis for research, educational, or interpretative forms of playful exploration of the past. Here, play is understood not merely as a means of popularisation or public engagement, but above all as a possible mode of interaction with data.

Using concrete examples, the presentation will demonstrate different levels at which an epigraphic source can be transformed: from transcription and partially automated encoding, through semantic interlinking, to the possibilities for its reuse and (playful) exploration. Particular attention will be paid to distinguishing between processes that can be automated, those in which AI can provide useful suggestions, and those in which expert interpretation remains indispensable.

Od karakterizacije materialov do vizualne predstavitve: pristop k rekonstrukciji zgodovinskih slik, ki temelji na umetni inteligenci / From Material Characterisation to Visual Representation: An AI-based Approach to Reconstruction of Historical Paintings

Lea Legan^{1,2}, Klara Retko^{1,3}, Mitko Nikov⁴, Hend Mahgoub³, Domen Mongus⁴, Polonca Ropret^{1,5}

¹ Zavod za varstvo kulturne dediščine Slovenije / Institute for the Protection of Cultural Heritage of Slovenia

² Narodni muzej Slovenije / National Museum of Slovenia

³ Univerza v Ljubljani, Fakulteta za kemijo in kemijsko tehnologijo / University of Ljubljana, Faculty of Chemistry and Chemical Technology

⁴ Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko / University of Maribor, Faculty of Electrical Engineering and Computer Science

⁵ Univerza v Ljubljani, GreenHer Center odličnosti / University of Ljubljana. GreenHer Centre of Excellence

Povzetek

Rekonstrukcija verjetnega preteklega videza zgodovinskih slik je zahtevna, saj je njihov današnji videz posledica tako izvornih materialov in slikarskih tehnik kot tudi sprememb, ki so nastale zaradi staranja, degradacije in preteklih konservatorsko-restavratorskih posegov. V predstavljeni študiji primera je opisan pristop, ki temelji na umetni inteligenci in povezuje karakterizacijo materialov z vizualno rekonstrukcijo zgodovinskih slik.

Za razvoj nabora učnih podatkov sta bili izdelani dve modelni sliki. V ta namen smo uporabili tehnike, ki posnemajo baročne slikarske prakse in temeljijo na zgodovinskih recepturah. Modelni sliki vključujeta dve različni sestavi podloge, zgodovinsko relevantna veziva in različne anorganske pigmente, nato pa sta bila nanosena še dva zaščitna premaza – mastiks in jajčni beljak. S kontroliranim staranjem so bile simulirane spremembe, ki se pojavljajo skozi čas.

Končni nabor podatkov obsega več kot 500 posameznih primerov, ki predstavljajo različne kombinacije barvnih plasti, podlog in zaščitnih slojev. Vsak primer je dokumentiran z večmodalnim naborom podatkov, ki vključuje fotografije, UV-fotografije, refleksijske spektre, pridobljene z infrardečo spektroskopijo s Fourierjevo transformacijo (FTIR), ramanske spektre in kolorimetrične podatke, pri čemer so bili vsi podatki pridobljeni pred staranjem in po njem.

Naučeni model je zasnovan tako, da posnema vizualne spremembe različnih kombinacij materialov med staranjem, vključno s spremembami barve, nasičenosti in videza površine ter z različnimi procesi kemijske degradacije. Pri uporabi na resnični zgodovinski sliki se današnji videz slike poveže s podatki FTIR in ramanske spektroskopije, na podlagi česar model oceni njen verjetni pretekli videz. Rekonstrukcija lahko poda informacije o verjetnih izvornih barvnih tonih, stopnji bledenja, porumenelosti, potemnitvi ali posvetlitvi ter o morebitni degradaciji pigmentov in veziv. Pomemben vidik pristopa je, da poleg rekonstruiranega vizualnega videza omogoča tudi oceno negotovosti, ki odraža omejitve razpoložljivih materialnih in zgodovinskih podatkov.

Študija kaže potencial povezovanja vibracijske spektroskopije, fotografskih tehnik, kolorimetrije, eksperimentalnega modeliranja in umetne inteligence za prehod od materialnih

dokazov, ohranjenih v zgodovinskih slikah, k rekonstrukciji njihovega verjetnega preteklega videza.

Abstract

Reconstructing the probable past appearance of historical paintings is challenging, as their present-day appearance reflects both, the original materials and used techniques, as well as the changes caused by ageing, degradation, and past conservation treatments. This case study presents an artificial intelligence (AI) – based approach that aims to connect material characterisation with the visual reconstruction of historical paintings.

To develop the training dataset, two model paintings were prepared using techniques inspired by Baroque painting practices and historical recipes. The model paintings include two different ground layers, historically relevant binders, and a range of inorganic pigments, followed by the application of two protective coatings, mastic and egg white. Controlled ageing was used to simulate the changes occurring over time.

The resulting dataset comprises more than 500 individual samples, representing different combinations of paint layers, ground layers, and surface treatments. Each sample is documented through a multimodal dataset including photography, UV-induced photography, Fourier Transform Infrared (FTIR) reflection spectra, Raman spectra, and colorimetric data, collected before and after ageing.

The trained model was designed to learn how different material combinations behave visually as they age, including changes in colour, saturation, and surface appearance, as well as chemical degradation processes. When applied to a real historical painting, the present-day visual appearance was combined with FTIR and Raman data to infer its probable past appearance. The reconstruction may provide information on likely original colour tones, degree of fading, yellowing, darkening or lightening, and possible degradation of pigments and binders. Importantly, the approach is intended to provide not only a reconstructed visual appearance, but also an estimate of uncertainty, reflecting the limitations of the available material and historical evidence.

This study demonstrates the potential of combining vibrational spectroscopy, photographic techniques, colorimetry, experimental modelling, and AI to move from material evidence preserved in historical paintings towards an evidence-based reconstruction of their probable past appearance.

Napovedovanje mikroklim in modeliranje akumulacije poškodb za preventivno konserviranje s pomočjo umetne inteligence / AI-driven Prediction of Microclimates and Modelling of Damage Accumulation for Preventive Conservation

Hend Mahgoub¹, Matej Brumen³, Mitko Nikov³, Domen Mongus³, Matija Strlič^{1,2}

¹ Univerza v Ljubljani, Fakulteta za kemijo in kemijsko tehnologijo / University of Ljubljana, Faculty of Chemistry and Chemical Technology

² Univerza v Ljubljani, GreenHer Center odličnosti / University of Ljubljana, GreenHer Centre of Excellence

³ Univerza v Mariboru, Fakulteta za elektrotehniko, računalništvo in informatiko / University of Maribor, Faculty of Electrical Engineering and Computer Science

Povzetek

Ohranjanje kulturne dediščine zahteva stabilne notranje mikroklimatske razmere, saj visoke ali nihajoče vrednosti temperature (T) in relativne vlažnosti (RH) pospešujejo propadanje materialov, povzročajo mehanske napetosti ter spodbujajo rast plesni [ASHRAE, 2019]. Razumevanje povezave med zunanjim in notranjim podnebjem je ključno za dolgoročno ohranjanje dediščine [Leissner et al., 2015]. V okviru WP7 predstavljamo dve študiji primera, ki področe konserviranja premikata od retrospektivnega, reaktivnega spremljanja stanja k proaktivnemu, napovednemu upravljanju: (1) napovedno modeliranje notranje T/RH v objektih kulturne dediščine na podlagi zunanjega podnebja in metapodatkov, specifičnih za posamezno stavbo, ter (2) model akumulacije poškodb knjižničnega gradiva, ki temelji na pristopu občanske znanosti.

V študiji primera 1 približno eno leto podatkov zapisovalnikov T/RH s petih tipološko različnih slovenskih lokacij (Grad Brežice, Cerkev Javorca, Tehniški muzej Bistra, NUK Ljubljana in Pomorski muzej Izola) povezujemo z regionalnimi vremenskimi podatki, projekcijami IPCC ter metapodatki o stavbah (material sten, debelina sten, prostornina, kontrolne strategije). GEMMA FUSION SUITE (GFS), geokoljski SDK, združuje te heterogene prostorske in okoljske podatkovne sloje za potrebe mikroklimatskih modelov. V študiji primera 2 bodo uporabniki NUK-a posredovali fotografije poškodb knjig (npr. raztrganin in madežev), ki bodo povezane z okoljskimi podatki, pogostostjo izposoje ter letom nastanka gradiva.

Vloga umetne inteligence: modeli strojnega in globokega učenja (ML/DL) (XGBoost, naključni gozd, nevronske mreže) se učijo odziva ovoja stavbe na podnebne vplive, s čimer nadomeščajo potrebo po stalnih senzorjih na lokaciji ali fizikalnih simulacijah. Funkcionalnosti GFS skrbijo za predobdelavo in združevanje prostorskih podatkov. Analiza slik razvršča poškodbe na podlagi fotografij in tako zagotavlja vhodne podatke za model akumulacije poškodb. Orodje za podporo odločanju bo institucijam omogočalo nalaganje podatkov spremljanja in metapodatkov ter prejemanje lokacijsko prilagojenih napovedi T/RH.

Preizkušanje modelov ML/DL za napovedovanje notranjih vrednosti T/RH trenutno poteka; preliminarni rezultati kažejo, da vključitev metapodatkov izboljšuje sposobnost posploševanja med različnimi tipologijami objektov. Integracija GFS je zaključena, dodatne funkcionalnosti pa so še v razvoju. Orodje občanske znanosti je v fazi načrtovanja pred začetkom

pilotnega zbiranja podatkov. Med odprtimi vprašanji ostajajo prenosljivost modelov, kakovost množično zbranih podatkov ter validacija modelov.

Abstract

Preserving cultural heritage requires stable indoor microclimates, as high or fluctuating temperature (T) and relative humidity (RH) drive material decay, mechanical stress, and mould growth [ASHRAE, 2019]. Understanding the outdoor–indoor climates relationship is critical for the long-term preservation [Leissner et al., 2015]. Within WP7, we present two case studies shifting conservation from retrospective, reactive monitoring to proactive, predictive management: (1) predictive modelling of indoor T/RH in cultural heritage buildings based on outdoor climate and building-specific metadata, and (2) a citizen-science damage accumulation model for library books.

In case study 1, approximately one year of T/RH logger data from five typologically distinct Slovenian sites (Brežice Castle, Javorca Church, Bistra Technical Museum, the National and University Library (NUK) in Ljubljana, and Maritime Museum Izola) is linked with regional weather data, IPCC projections and building metadata (wall material, wall thickness, volume, control strategies). The GEMMA FUSION SUITE (GFS), a geoenvironmental SDK, fuses these heterogeneous spatial and environmental data layers for the microclimate models. In case study 2, NUK readers will submit photos of book damage (e.g. tears and stains), linked to environmental data, borrowing frequency, and production date.

Role of AI: machine learning and deep learning (ML/DL) models (XGBoost, Random Forest, neural networks) learn the response of the building envelope to climatic influences, replacing the need for permanent on-site sensors or physics-based simulation. GFS's functions handle spatial data preprocessing and fusion. Image analysis classifies photo-based damage, thus providing input data for the damage accumulation model. The decision-support tool will allow institutions to upload monitoring data and metadata and receive site-specific T/RH predictions.

Testing of ML/DL models for indoor T/RH prediction is underway; with preliminary results indicating that metadata improves generalisation across different building typologies. GFS integration is complete, with further functions in development. The citizen-science tool is in design phase, ahead of pilot data collection. Open questions include model transferability, crowd-sourced data quality, and model validation.

Reference / References

- ASHRAE. (2019). Museums, galleries, archives and libraries. In ASHRAE Handbook—HVAC Applications, American Society of Heating, Refrigerating and Air-Conditioning Engineers.
- Leissner, J., et al. (2015). Climate for Culture: assessing the impact of climate change on the future indoor climate in historic buildings using simulations. *Heritage Science*, 3(38). <https://doi.org/10.1186/s40494-015-0067-9>

