Article:
McDonough, K. and Vitale, V. (2024) Introduction. Imago Mundi, 76 (2). pp. 279-284.
ISSN: 0308-5694

https://doi.org/10.1080/03085694.2025.2453329

Routledge
Taylor & Francis Group

Imago Mundi

The International Journal for the History of Cartography

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rimu20

Introduction

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To cite this article: Katherine McDonough & Valeria Vitale (2024) Introduction, Imago Mundi, 76:2, 279-284, DOI: 10.1080/03085694.2025.2453329

To link to this article: https://doi.org/10.1080/03085694.2025.2453329

Published online: 28 Mar 2025.

Forum:

Maps and Machines: Recent Perspectives on Humanities Research Using AI and Maps

Introduction

This Forum showcases work from a cluster of related projects using computational methods to analyse large collections of digitised maps. Essays here demonstrate how to link the humanistic tradition of close reading of historical maps with emerging computational approaches for distant reading and viewing of scanned versions of those maps.[1] Reading the content of maps does not have to be at odds with an understanding of maps as subjective documents reflecting the priorities of many actors, the technical possibilities of different techniques and tools, and the vicissitudes of preservation.

'What if historians could change the way we interact with maps?'– this is the question one of us (McDonough) asked in a recent chapter introducing the concept of 'maps as data' within the computational humanities.[2] Thanks to intensive methodological developments during the Living with Machines (LwM), Machines Reading Maps (MRM), and Data/Culture projects, it is no longer a 'what if' question.

A window into ongoing research, these Forum essays represent novel engagements with digitised maps in the humanities, including historical, pedagogical, and curatorial perspectives. Each contribution is an invitation to consider what you might do with 'maps as data.'[3] They are examples of, or reflections on, collaborative and digital workflows with map collections: by showcasing these here we hope to provide evidence for the importance of open, interdisciplinary research practices centered around digitised maps. In particular, the MapReader software features in this Forum alongside other tools and methods, such as mapKurator, to demonstrate the promise of open and reproducible software co-designed by historians and data scientists. MapReader is an open, end-to-end computer vision pipeline for analysing visual and text content on maps.[4] It lowers barriers to creating data from map scans and does so in a way that infuses key elements of cartographic source criticism and mapping processes in its design.

What sets MapReader apart from other digital approaches to working with map images is our intention to find creative, source-appropriate methods for asking and answering questions about the content of maps. MapReader does this by providing scholars with tools for finding two main types of signs on maps: visual patterns and text. It does so in ways that reject a) the reduction of a map to its discrete features as independent parts isolated from the whole object and b) the reification of content elements as 'real' objects located precisely on the ground in the past. The first position explains, for example, why MapReader proposes image classification at the level of a 'patch' (a square region of a map image) rather than applying object detection. The second is what sets MapReader apart from another popular computer vision task, semantic segmentation, where each pixel in an image is assigned to a particular semantic type (e.g. road, water, building).

Imago Mundi Vol. 76, Part 2: 279–313

That MapReader is not always chasing after the latest state-of-the-art trends in AI is due to these commitments.

In its first few years, MapReader has transformed from a tool that was developed within a specific research project into infrastructure that new research is depending on to ask questions of maps. From Pelagios and its well-known Recogito annotation software to the movement to embrace open and reproducible research across the disciplines, there are many building blocks that made MapReader not only *imaginable*, but also *buildable*. Before introducing the essays in this Forum, we turn first to briefly outline the contributions of these fellow travelers and predecessors in what has recently been called an emerging ecosystem of 'open maps' infrastructure.[5] This origin story contextualises the essays and is an opportunity for us to lay out MapReader's intellectual, methodological, and curatorial lineage.

Open, Reproducible Digital Humanities (DH) Research

LwM was a large, multidisciplinary project funded in the UK to use digitised collections from the long-nineteenth century to write histories about the experience of industrialisation in Britain. On LwM, maps were only one of the types of primary sources we worked with. But, uniquely among these sources–including, microcensus data and newspapers–maps were accessible to us thanks to the National Library of Scotland's massive digitisation and georeferencing efforts over more than twenty years. We might speak of these maps as 'research ready' because of this preliminary work (in particular the georeferencing), but also because of the way they can be made available to scholars: via tile servers or as IIIF resources. We were therefore in a position to experiment with ideas for translating the content of maps into historical research data much more quickly than would have been possible with a non-georeferenced collection not already available online. What we now know as MapReader began life in the 'Space & Time Lab' in LwM as a piece of work called 'Vision with Machines.' In time, this work developed into a pipeline that enabled us to ask questions, for example, about the footprint of railway infrastructure across Britain ca. 1900. Our overall approach to MapReader was heavily influenced by the culture of open and reproducible science at The Alan Turing Institute, our institutional home. 'The Turing Way' project is an important piece of the puzzle in understanding why we now support a well-documented, easy-to-use software library that goes beyond the remit of most code written to support research for a single publication.[6] Through the work of the Computer Vision for Digital Heritage Interest Group at The Alan Turing Institute, we have also worked to encourage others to develop projects in the open with an eye towards reuse.[7]

Digitisation and Collections as Data

Libraries and archives around the world have been scanning, and continue to scan, historical map collections. While the initial motivations can vary, institutions usually make these images available online. This investment in digital collections has been accompanied by careful assessments of how to preserve, document, and share them.[8] The emerging infrastructure, in particular around how to share images and their metadata, is central to the future of working with map collections as data.

As with considerations for other digitised historical sources (books, newspapers, paintings, recordings, etc.), requests to not just browse, but search inside the contents of these collections has added new use cases for library and archival infrastructure developers to consider. The ways that images and metadata are shared are key parts of the research process and require close collaboration with library colleagues to understand a) the relationship between a physical and a digital collection and b) how the formats of the digital collection and the ways in which it is stored will impact research workflows. MapReader both to researchers and to map curators about possible solutions for accessing map images and metadata.[9]

In turn, the data that tools like MapReader create – inferences from machine learning models about what is on maps, whether this is visual or textual content – should be shared in such a way that it is clear what physical and digital artefacts the data derives from. Derived data and associated models should likewise be available for reuse – in order to reproduce the experiments and to reuse models and data it in new contexts. For example, the results of the MRM collaboration with the David Rumsey Historical Map Collection have been deposited in the Stanford Digital Repository (along with the metadata of the maps that were processed) and one of the models that created the data has been documented and shared on

Huggingface (a platform for openly sharing machine learning models and training data).[10] Similarly, our MRM results for text on Sanborn fire insurance maps from the Library of Congress collections will be available through LC Labs.[11] We hope that publishing these documented datasets as citable objects in their own right will highlight opportunities for working with map collections as data, enable data comparison and combination, and, where possible, prevent unnecessary duplication of the same data.

Annotation, Gazetteers, and Linked Open Data

Another important part of the MapReader family tree is the Pelagios project.[12] Its initial aim, in 2011, was to promote an approach to spatial information at scale that leveraged the power of semantic connections between resources from different collections, and explored what new kinds of queries, and research questions, this enabled. But perhaps the Pelagios component most instrumental to working with maps as data was the semantic annotation platform Recogito.[13] The tool, developed by Rainer Simon, enabled users to easily annotate text and images, connecting them to an internal library of historical gazetteers. A bespoke version of Recogito was developed as part of MRM to create manual annotations to evaluate the performance of text spotting models. This soon revealed a much wider potential as a thinking tool to define and test semantic categories for the analysis of maps.[14]

Pelagios, and the community that grew around it, also fostered discussion about and methodological thinking around historical gazetteers, and, in particular, the idea that digital representations of our knowledge of historical places are better served by relational graphs, i.e. by an interconnected network of knowledge bases, rather than a single authority list. This framework has been expanded and further nuanced by the World Historical Gazetteer, now a successful independent project. This flexible thinking about how we represent knowledge about historical places, and how it is formally structured in digital settings, is one of the reasons we see text on maps as a rich, but complicated source of information about the politics of place and naming. Being able to examine text across thousands of different maps opens doors to the kinds of metageographic considerations that Kären Wigen and Martin Lewis have long suggested are key to understanding how geographic ideas take shape, change, and impact culture and society.[15]

Computer Vision and Visual DH

Finally, MapReader emerged at a specific moment when computer vision methods were becoming easy to implement for a range of applications. The 'visual turn' in the digital humanities DH was in large part a response to this increased accessibility and reliability of computer vision for tasks such as object detection, optical character recognition, semantic segmentation, and more. Coining the phrase 'distant viewing' in 2019, Arnold and Tilton intentionally contrasted text and visual data, honing in on the challenge of the semantic gap when trying to assign 'codes' to elements of images.[16] The semantic gap proved an extremely useful concept for MapReader, one that prompted our interest in creating a computer vision pipeline that reminded users of this gap between the image and data derived from the image. A few months later, Wevers and Smits focused on the opportunities presented by convolutional neural networks for historical research and flagged the potential consequences of isolating textual and visual approaches: what is needed, they argued, are methods 'to process and examine multiple forms of discourse in conjunction.'[17]

It was from considerations like this that MRM was born. Working alongside the LwM team where MapReader was initially designed to classify the *visual* content of maps, the MRM project focused on *text* on maps. The tools and datasets that emerged from MRM and were later implemented in MapReader were made possible by earlier work from Knoblock, Chiang, Leyk, Uhl, and others on the Linked Maps project, including, in particular, their early approach for detecting and recognising text on maps.[18] Together, MRM and LwM created an environment in which to cultivate a new approach to working with maps as data, one that works against the tides of the extractive motivations driven by military and industrial concerns (such as critical mineral mining). The emergence of Visual DH as a pendant to text-based DH has been a timely opportunity to develop new computer vision tools that reflect concerns about just what we are trying to capture, classify, describe, label, or structure on images, and to consider how such methods have a different shape when humanities researchers are involved in their design.

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The Forum opens with Nelson's use of the text-spotting capabilities in MapReader to detect, at scale, labels on digitised Sanborn fire insurance maps in new public health-driven research emerging from the Mapping Inequality project.[19] Focusing on labels describing the functions of buildings and industrial sites, Nelson is creating a composite dataset of industrial and other environmentally burdensome sites in mid-twentieth-century US cities. This case study points to ways in which maps can be used to create new historical data and to associate it with intellectual frameworks such as the concept of 'environmental burdensome' sites. Nelson's case study also implicitly highlights the crucial role that MapReader's detailed documentation plays in making this tool reusable in the wider research community.

After seeing the use of MapReader to enrich our understanding of redlining and racial inequality in US cities, we move to the essay by Larsen, Thornberry, and Vitale who explore the pedagogical potential of AI-powered approaches to maps. The authors illustrate how data created with machine learning and computer vision plays a role in attracting new audiences to historical map collections and, more specifically, in shaping how maps can be used in curricula. This piece looks at how the introduction of the Text on Maps search functionality has changed the ways in which the online collection of the David Rumsey Map Center is used in teaching programmes and collaborations with schools and universities. The authors initially highlight how the expectations around search in digital interfaces have changed for younger audiences, and why other collections may want to consider such findings when designing paths through digital collections. They proceed to discuss how affordances in the digitised Rumsey collection open the door not only to more rewarding engagement, but to a completely new relationship with maps as teaching and learning tools.

Third, McDonough, Beelen, Wilson, and Wood demonstrate, for the first time, how to distantly view and read maps by combining visual and textual information to search for patterns across expansive landscapes. This is made possible by bringing together data from both MapReader tasks: patch classification and text spotting. Building on previous work completed during LwM, the authors demonstrate linking patch and text data as a means to characterize types of areas impacted by railway infrastructure in nineteenth-century London.[20] Just as it is possible to analyse sentences, paragraphs, and pages of text, groups of text that intersect with visual concepts on map (such as 'rail-space') are useful units of analysis for understanding the grammar and syntax of historical landscapes. In other words, this analysis moves from keyword searching to collection-level analysis, organising text on maps in multiple, flexible ways in order to enhance our understanding of the British industrial landscape.[21]

Lastly, Coleman takes the reader on a reflective journey across the complex and evocative relationships between cartography, arts, and machines, inviting us to rethink the role of digital and analogue technologies in the production and study of maps. Contrasting the mechanisation of human labour in digital environments with the re-appropriation of AI methods by emerging artists, Coleman suggests that humanities-driven and ethically-developed computational technologies can become powerful tools for knowledge creation and curation rather than deterministic constraints to our own thinking and interpretation.

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The essays in this Forum are part of an ongoing dialogue around the future of computational map studies using MapReader and other emerging tools and infrastructures. They illustrate the potential of interdisciplinary research where maps are increasingly being used as sources for all kinds of research questions.

The resources that made these contributions possible together are transparent and accessible code, data, and documentation. Only by investing in creating and maintaining documentation for specific disciplinary communities can we build robust and comparable datasets and workflows that are truly open. With MapReader, the dedication to documentation and training made it possible for a much larger community of researchers to try out new methods. By lowering the threshold to access to such technologies we wish to encourage a diversity of applications, in research, teaching and curation, and we aspire to an increased dialogue between them, facilitated by more shared and interoperable technologies and data.

We invite *Imago Mundi* readers to get involved with these new ways to search, interpret, and teach maps. With output from MapReader and

similar tools, researchers can use the full array of structured, textual, and spatial data analysis methods. For text in particular, there are rich opportunities that await scholars who have struggled to geolocate place names in text documents, wish to understand the role of maps in place name histories, and seek to analyse map text data across maps as a new kind of text corpus. As more map content becomes searchable, pedagogical opportunities await colleagues interested in map education and new collaborative research initiatives connecting historians, geographers, and data scientists may emerge. In these early days of computational map studies, this Forum showcases careful work using maps as data. We hope they will serve as jumping off points for research that combines the history of maps and mapping with new computational methods for analysing map content.

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https://doi.org/10.1080/03085694.2025.2453329

Acknowledgements: This work was supported by Data/Culture (AHRC grant AH/Y00745X/1), Living with Machines (AHRC grant AH/S01179X/1), a generous gift from David Rumsey, Machines Reading Maps (AHRC grant AH/V009400/1 and NEH grant HC-278125-21) and The Alan Turing Institute (EPSRC grant EP/N510129/1).

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Mapping Environmental Inequalities: Using MapReader to Uncover Mid-Century Industrial Burdens

In the past few years, dozens of studies have revealed spatial correlations between the redlining maps produced by the Home Owners' Loan Corporation (HOLC) from 1935 to 1940 and the landscape of contemporary inequalities in more than 200 US cities. They show that maps of twenty-first-century disparities in asthma rates and urban heat islands, preterm births and bird biodiversity, food apartheid and gun violence are strikingly—and statistically—similar to 85- to 90-year-old 'security maps' that graded perceived risk for mortgage lenders on a scale from A, 'best,' to D, 'hazardous.' On those security maps, African American neighbourhoods were all but universally deemed 'hazardous.' The field agents and real estate professionals who made them explicitly claimed that the presence of African Americans, and to a lesser extent immigrants, increased risk to such an extent that lenders should avoid areas where those populations lived. With some exceptions, the authors of these studies are careful not to argue that these maps or even redlining practices directly caused the specific contemporary disparities being studied. Instead, as HOLC was a New Deal agency, they suggest that the maps can serve as proxies for US government-endorsed structural racism. They argue that structural racism, not redlining in isolation, is what helped produce a legacy of ubiquitous spatial inequality that lasts to today.[1]

Still, several critics have found this formulation —moving from redlining maps to structural racism to contemporary inequalities—profoundly wanting. They charge that it oversimplifies complex historical processes and lacks the necessary depth to fully capture the causes of contemporary racial inequalities. Robert Gioelli, for example, suggests that 'to focus on the maps and to use them as the primary data set in our analysis of why a particular neighborhood is too hot, too poor, and too crime ridden, is … a scholarly miscalculation that fails to get us close to an accurate picture of the causes of contemporary racial inequalities.'[2] Alan Mallach has similarly criticised the reliance on 'statistical associations' without deeper historical context, contending that it replaces 'complexity and nuance with a flattened and arguably misleading narrative.'[3] These are important criticisms which beg the question: given the significant causal distance between inequalities in access to mortgage capital in the 1930s and 1940s and contemporary inequities in areas like the environment and health, why exactly have the HOLC maps become, and remain, such a go-to resource for so many studies exploring the historical roots of today's inequalities? There are several ways to answer that question, but the simplest explanation might also be the best one: there are not any better options for broad and detailed spatial datasets of historical inequalities in US cities during the first half of the twentieth century, particularly as they relate to the environment and health.[4]

MapReader can help. As part of a National Institutes of Health-funded research project, 'The Impact of Redlining and Place-Based Systemic Racism on Health Inequalities at Mid-Life,' my