

# Marco Polo's Travels Revisited: From Motion Event Detection to Optimal Path Computation in 3D Maps

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## Abstract

*In this work, we present a workflow for semi-automatic extraction of geo-references and motion events from the book "The Travels of Marco Polo". These are then used to create 3D renderings of the space and movement which allows readers to visually trace Marco Polo's route themselves to provide the experience of the entirety of the journey.*

## Introduction

Travel is a major motif in many literary works (Mewshaw, 2005). People's fascination with unknown regions and their exploration continues unabated (Brenner, 2011), and travel is a regular part of many people's lives. Travel literature appears in many forms, such as outdoor literature, guidebooks, nature writing, and travel memoirs (Cuddon & Birchwood, 2014). One of the earliest accounts of foreign travel and one of most popular works from the genre of travel literature certainly is the "Travels of Marco Polo", a medieval manuscript written down in Old French by Rustichello da Pisa in 1299, based on Marco Polo's stories. During Marco Polo's lifetime, the book was translated into many European languages. However, even then it was questioned whether Polo had really been to China or whether he had just reproduced stories that he had picked up from other travellers (Classen, 2013, p. 27).

In this work, we present a workflow for semi-automatic extraction of geo-references and motion events related to Marco Polo's travel from an English translation of the book. These are then used to create 3D renderings of the space and movement that will allow readers to visually trace Marco Polo's route themselves.

The workflow, see Fig. 1, comprises two processing stages. First, we use Natural Language Processing (NLP) methods to reconstruct Marco Polo's route from the actual written text. In the second stage, we present an innovative approach for route visualization using 3D-renderings of digital terrain models.

## Stage 1 – Natural Language Processing

We work with Henry Yule's English translations of Marco Polo's travelogues obtained from Project Gutenberg. For text processing, we used flairNLP (Halder et al., 2020), a state-of-the-art NLP framework based on Python NLTK (Bird et al., 2009) and the Stanford parser for constituency parsing (Manning et al., 2014). The lexical resources included VerbNet (Schuler et al., 2009) and FrameNet (Ruppenhofer et al., 2016), large verb-oriented resources based on which motion verbs and their arguments can be identified, as well as WordNet (WordNet, 1998), an English lexical database of lexical relations, and Semlink (Stowe et al., 2021) which provides cross-resource mapping.

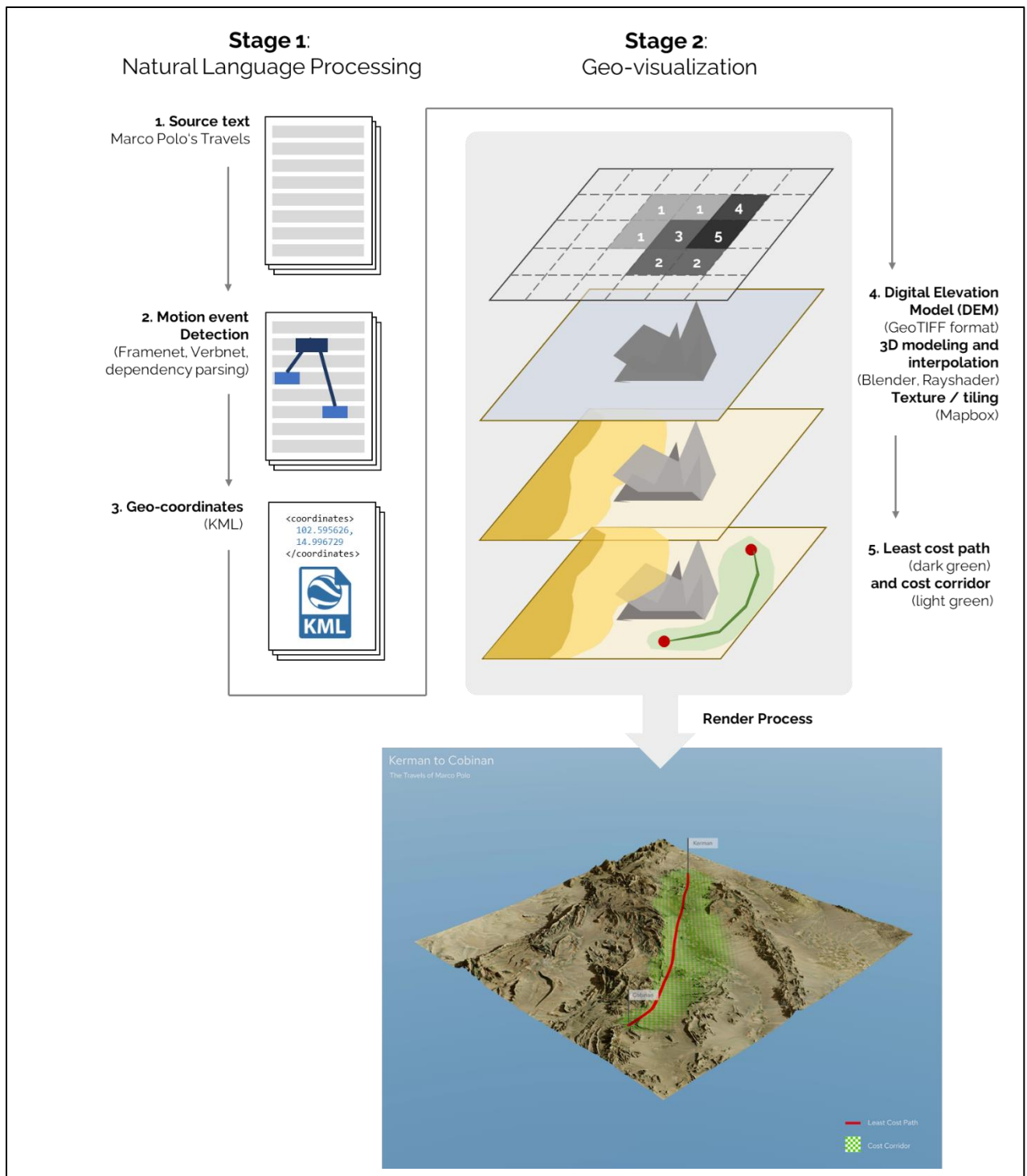


Figure 1: Schematic process description of our prototype. We divide our approach into two stages. One modularized NLP stage (Stage 1) and a modularized Geo-visualization stage (Stage 2).

**Step 1:** The text is first segmented into sentences and then analysed to extract movement-relevant entities: locations and motion events. To identify place names, we used a gazetteer and a flairNLP sequence tagger. The gazetteer was created semi-automatically from the index of Henry Yule's and Hugh Murray's translations of the books. We found that the gazetteer initially works with a higher recall, since the place name registers contain relevant places. flairNLP provides a high precision, but the recall is not optimal since many entities of interest are not identified.

**Step 2:** The extraction of motion events is based on the observation that places on the itinerary are connected to each other via travel verbs. Finding motion verbs and their arguments can be thus used as a way of identifying locations that are part of the travel route.

To identify motion verbs we use VerbNet, which groups verbs by their meaning (e.g. the 'Verbs of Motion' class; see, for instance, [run-51.3.2](#)) and FrameNet, which encodes verbs' predicate argument structures; WordNet is used to populate synonyms. The parser output is used to check whether the subject of a motion verb is Marco Polo, despite other characters in the book, and to classify whether the location argument of the motion verb is in Marco Polo's route. The ideal situation for extracting a route segment is to get a clear origin and destination. A problem that arises with travel accounts is that mentions of locations and motion can appear in a non-chronological order. As a first step to reconstructing the route we use heuristics to order the origin-destination sequences.

**Step 3:** The geo-coordinates were finally generated by resolving historical place names with historical Geographic Information Systems (GIS) and then acquiring the coordinates from the GISs and geonames.org, a geographical database which covers all countries. In particular we used the China Historical Geographic Information System (Bol, 2005), the Silk Road Historical GIS (<http://srhgis.com/dtcx>) and the Silk Road GIS (<http://silkroad.fudan.edu.cn>).

## Stage 2 – Geo-visualization

When analysing travel writing, regular point-based maps do not normally allow for analysing aspects of a more qualitative nature like the experiences that were made while traveling (Murieta-Flores et al., 2017). Vegetation, climate, obstacles, and vistas might be considered when thinking about traveling, especially by foot. Details about landscape, the travelled roads and days' worth of travel are often sparsely described in a text using just a few sentences. Therefore, we follow the claim of (Harris et al., 2016) "to create immersive geographies that link the experiential, the emotional and the symbolic elements of literary works to the nuanced, dimensional richness of places as inspired by authors and their works".

**Step 4:** With data based on the Digital Elevation Model Copernicus Global DEM (European Space Agency & Airbus, 2021) combined with Satellite Photos provided by Mapbox ([mapbox.com](http://mapbox.com)) we are not just showing points on a map but render 3D representations of the landscape. This integrates terrain, surface, and travel routes equally, which makes the travel experience tangible (Fig. 2). We create the rendering using Blender and Rayshader, a package to render 3D data to a raytraced representation in R.

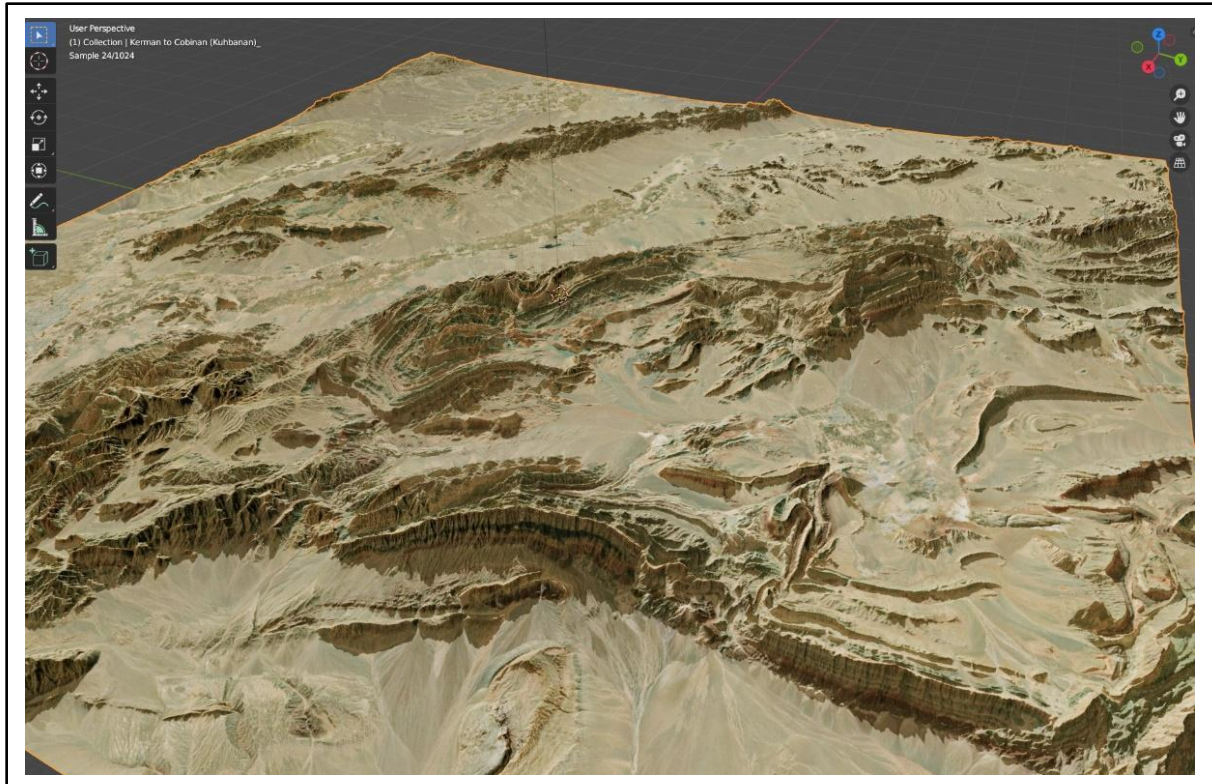


Figure 2: Example of a rendering of a DEM overlaid with satellite footage. The graphic was made in Blender.

**Step 5:** As suggested by (Murrieta-Flores et al., 2017), “Cost-Surface Analysis (CSA) and Least-Cost-Path Analysis (LCP) can be used to facilitate more nuanced interpretations of historical works of travel writing and topographical literature”. To back the readers’ intuition, the map can also be enhanced by highlighting the areas that are most easy to travel through. Therefore we also integrated a LCP and CSA to our visualization that includes a corridor of optimal movement between two points on the map.

## Final Remarks

With the demonstration of this prototypical workflow for the visualization of routes described in Marco Polo’s travels, many potentials but also challenges become apparent. The approach has a lot of potential, for example: fact checking using cost corridors can help to understand if the described travels and times are realistic and plausible. We can likewise experiment to see whether readers’ route imagery while reading is in line with the actual situation in the field. Ultimately, we can study if such maps help to mentally take in the entirety of the journey and thus generate a completely new experience.

## Bibliography

- Bird, S., Klein, E., & Loper, E. (2009). *Natural language processing with Python: Analyzing text with the natural language toolkit*. O'Reilly Media, Inc.
- Bol, P. K. (2005). China Historical GIS. *Historical Geography*, 150–152.
- Brenner, P. J. (2011). *El viaje y la percepción del otro: Viajeros por la Península Ibérica y sus descripciones (siglos XVIII y XIX)* (R. Musser, Hrsg.; Bd. 141, S. 11–22). Iberoamericana / Vervuert.
- Classen, A. (2013). *East Meets West in the Middle Ages and Early Modern Times: Transcultural Experiences in the Premodern World*. De Gruyter.  
<https://books.google.de/books?id=snPnBQAAQBAJ>
- Harris T. M., Lafone F. & Bonenberger D. (2016). From Mapping Text in Space to Experiencing Text in Place: Exploring Literary Virtual Geographies. In: Cooper, D., Donaldson, C., & Murrieta-Flores, P. (Eds.). *Literary Mapping in the Digital Age* (1st ed.). Routledge.  
<https://doi.org/10.4324/9781315592596>
- Cuddon, J. A., & Birchwood, M. (2014). *The Penguin dictionary of literary terms and literary theory* (R. Habib, Hrsg.; 5. ed., publ. in paperback). Penguin Books.
- European Space Agency & Airbus. (2021). *Copernicus DEM* [Data set]. European Space Agency. <https://doi.org/10.5270/ESA-c5d3d65>
- Halder, K., Akbik, A., Krapac, J., & Vollgraf, R. (2020). Task Aware Representation of Sentences for Generic Text Classification. *COLING 2020, 28th International Conference on Computational Linguistics*.
- Manning, C. D., Surdeanu, M., Bauer, J., Finkel, J., Bethard, S. J., & McClosky, D. (2014). The Stanford CoreNLP Natural Language Processing Toolkit. *Association for Computational Linguistics (ACL) System Demonstrations*, 55–60.
- Mewshaw, M. (2005). Travel, Travel Writing, and the Literature of Travel. *South Central Review*, 22(2), 2–10. <https://doi.org/10.1353/scr.2005.0042>
- Miller, G.A. (1998). *WordNet: An electronic lexical database*. MIT Press.
- Murrieta-Flores, P., Donaldson, C., & Gregory, I. (2017). GIS and Literary History: Advancing Digital Humanities Research through the Spatial Analysis of Historical Travel Writing and Topographical Literature. *Digital Humanities Quarterly*. <http://hdl.handle.net/10034/620256>
- Ruppenhofer, J., Ellsworth, M., Schwarzer-Petruck, M., Johnson, C. R., & Scheffczyk, J. (2016). *FrameNet II: Extended theory and practice*. International Computer Science Institute.
- Schuler, K. K., Korhonen, A., & Brown, S. (2009). VerbNet Overview, Extensions, Mappings and Applications. *Proceedings of Human Language Technologies: The 2009 Annual Conference of the North American Chapter of the Association for Computational Linguistics, Companion Volume: Tutorial Abstracts*, 13–14.
- Stowe, K., Preciado, J., Conger, Kathryn, Brown, S. W., Kazeminejad, G., & Palmer, M. (2021). SemLink 2.0: Chasing Lexical Resources. *30th Annual Meeting of the Association for Computational Linguistics*, 222–227.