Editing and Analysing Historical Astronomical Diagrams with Artificial Intelligence

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Abstract. The EIDA project explores the historical use of astronomical diagrams across Asia, Africa, and Europe. We aim to develop automatic image analysis tools to analyze and edit these diagrams without human annotation, gaining a refined understanding of their role in shaping and transmitting astronomy. In this paper, we present a baseline method to detects lines and circles in historical diagrams, based on text removal, edge detection and RANSAC. We compare this strong baseline to a deep learning approach based on LETR. This work contributes to historical diagram vectorization, enabling novel methods of comparison and clustering, and offering fresh insights into the vast corpus of astronomical diagrams.

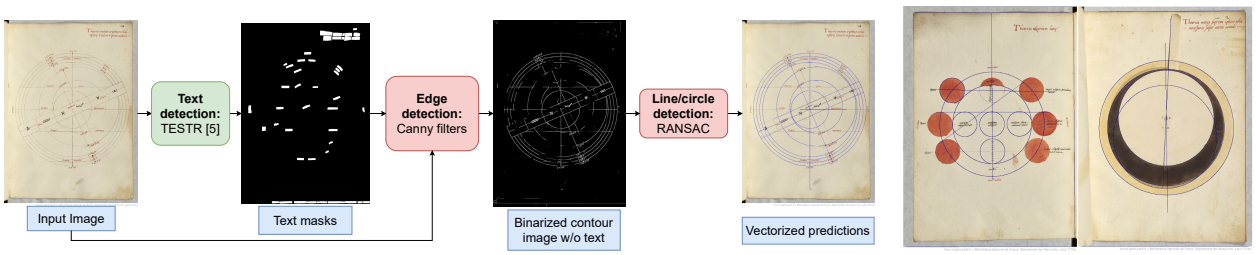
Keywords. Astronomy; Diagrams; Line/Circle detection; Manuscripts; Vectorization.

Context

Astronomy flourished across premodern Eurasia as a means to understand the natural world and fulfill religious, ritualistic, and political needs. This knowledge primarily circulated in handwritten documents, which contained a rich diversity of diagrams and numerical tables alongside the texts. Building on the visual turn in the history of astronomy, we explore astronomical diagrams as visual heritage and as representations of, and support for, historical scientific reasoning. We aim to develop new image analysis tools that do not require previous human annotation to enhance the study and edition of diagrams [3]. We present a computer vision approach to examine diagrams on a large scale independent of linguistic or cultural origin, enabling a deeper understanding of their roles in shaping and transmitting astronomy.

Methodology

Line segment detection is a fundamental task in computer vision, commonly tackled using traditional methods such as Hough transform and more recently deep learning approaches. We propose a baseline vectorization method that leverages RANSAC [2] for line and circle detection after initial edge detection and text removal steps. RANSAC fits models to subsets of data iteratively, selecting the most consistent ones as the final result. Our edge detection is based on Canny [1] and we use TESTR [5], a text-spotting transformer network, to effectively detect text, we validate the benefits of this step in Tab. 1. Additionally, we introduce a deep learning approach based on LETR [4] , trained on synthetic data and extended to perform line and circle detection simultaneously. Our evaluation demonstrates the superior performance of the learning approach over the baseline method across a dataset of 15 annotated diagrams, which we distribute.



(a) Detection pipeline (b) Detection examples

Fig. 1: **Fully automatic diagram vectorization pipeline.** We perform text and edge detection on a raster image, then apply RANSAC on the edge pixels to obtain the line and circle proposals.

Discussion and perspective

While our baseline yields satisfactory results, it has limited generalization capabilities and several failure cases. The LETR extension resolves this, enabling faster inference, but faces challenges in diagrams with curves. We believe this network can be extended to perform arc and curve detection as well. Addressing these challenges will open new methods of comparison and clustering for diagrams, and prepare the stage for a fresh view of the huge corpus of astronomical diagrams.

Method	Fscore Lines ↑	Fscore Circles ↑
RANSAC baseline	0.33	0.52
RANSAC baseline w/o text removal	0.24	0.35
LETR extension	0.38	0.70

Tab. 1: **Quantitative results.** We compare our RANSAC method with the LETR-based learning approach over our annotated set of 15 diagrams. Detected shapes are considered true positives when they are within a marginal distance of ground-truth annotations and false positives otherwise.

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