Deductive Support for Automated Argument Maintenance

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Abstract

Automated theorem provers (= ATPs) employ truth maintenance systems (= TMS) to maintain deductive consistency in the face of changing knowledge. However, with broadening the scope from normative branches of knowledge like mathematics into the digital humanities, where abductive and inductive inferences are necessary for knowledge discovery and gap filling, TM strategies have to be broadened beyond the deductive cases as well. Using the example of contemporary art interpretation of Albrecht Altdorfer's *Alexanderschlacht* of 1529, we enumerate some key forms of argumentation found in digital art history; their relationship to C.S. Peirce's three modes of inference; the way changing evidence refutes arguments; and the contribution that deductive theories of argument maintenance can make to alert digital art historians to problems automatically.

1 Introduction

This research is part of an ongoing effort to check the argumentation needs of the humanities against the representational capabilities of common-sense reasoning using ATP.¹ By identifying and filling as far as possibly any gaps, we aspire to advance the state of the digital humanities. As such, this paper has some of the characteristics of a progress report.

2 The logical Needs of Digital Humanities

John Sowa gives the following description of truth maintenance systems and their benefits for nonmonotonic systems of reasoning:

In effect, a TMS [i.e. a truth maintenance system] is a bookkeeping system for metaleval reasoning about logical dependencies among propositions. For nonmonotonic systems, it can improve efficiency by replacing global consistency checks with local tests in a limited region of the network. [16, 381]

Nonmonotonicity describes the digital humanities to a tee: the predominant mode of historical reasoning in academia is *underdetermined historiography* [17], meaning that discovering new information can prune proposed interpretations, without however bringing the number of interpretations commensurate with the existing evidene to one. Sciences such as art history therefore interpret their works in a context of competing proposals supported by evidence.

At the same time, such an "inference to the best explanation" [11] is not only deductive, but an argument that involves both abductive and inductive steps, to use the terminology of Peirce [16, 389-392]. Thus, other than in Sowa's description, it is not the dependency between propositions, but the dependency between arguments that keeps the overall claims of an interpretation in line with the best evidence.

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¹At AITP 2019, we presented how to use coordinated scripts [15] to model the narratives explaining symbolic actions, using the World War I centennial commemorations as our exemplar.

3 Arguing about Altdorfer's Alexanderschlacht

Some of the arguments given in analyses of Albrecht Altdorfer's famous painting *Die Alexanderschlacht* (the Battle of Alexander; see p.5) from 1529 [13, 68, Item 290] illustrates how argumentation and argument revision figure in the practice of art history.

Koselleck [9, 19] interprets the concurrent visibility of sun and moon as an indication of the cosmic importance of the battle. Oberstadler [12] views it as an accurate depiction of the sky on that day at that time, courtesy of Altdorfer's astrologer friend Joseph Grünpeck. Goldberge [6, 14] takes it to sympobilze the duration of the battle as lasting a day. Goldberger's case is strengthened by another Altdorfer painting from 1518, the *Battle of Regensburg*, uses that same symbolism, a concurrent sun and moon, to indicate a duration of three days of Charlemagne fighting the Avars. Thus, a single (!) example induces a pattern in Altdorfer's style repertoire for the interpretation of the (later) Alexander-painting.

The group of women in festive clothes fleeing the battle field² also needs explanation. One historical source that Altdorfer used, Quintus Curtius Rufus, describes (3.9.6b) [14, 40] how in accordance with Persian customs, the womenfolk of Darios III are placed onto the battlefield at the start but later captured during the Macedonian sacking of the Persian camp (3.11.24-26) [14, 44]. The depicted flight from the battle field, however, is implied by the account but not actually narrated and has to be abduced for an argument.

The problem of the women is compounded by their rendering. Though Altdorfer paints the Persians as Renaissance Turks and the Macedonians as German landsknechts [9, 19], the Persian women wear German fashion. The abduced scene and the unclear depiction has led some art historians to argue that the women cannot represent Darius III's womenfolk [8, 234].

Alternatively, Altdorfer may have lacked sources for depicting Turkish women. The military garb of Turkish soldiers were known from fly-leafs of the First Siege of Vienna in 1528. The earliest known illustrations of Turkish women's attire first appeared in Western Europe in the 1580s.³ Of course, this argument is—like many *terminus post quem* arguments—nonmonotonic and overturned by the discovery of an appropriate new source.

The interpretation is complicated by the painting's history: it was trimmed and the originally German inscription overpainted with a Latin one. There is a bill for restoration work done in 1658 by Johann de Pey on the *Alexanderschlacht* in the Bavarian duchy's archives (*Hofzahlamt*) [2, 14], but only an abductive leap can connect Pey's restoration to these specific modifications.

4 Modeling Argumentation: A Progress Report

In forensic situations, Aristotle observed (*Rhetoric* 1.2.8; 13f; et al. [5]), people will not give syllogistic proofs, but rather enthymemes: proof fragments that elide shared assumptions and skip "obvious" steps in the proof sequence. Art historic argumentation is similarly succinct. In addition, as the suspicion of de Pey overpainting the German inscription as part of his "restoration" indicates, the understood parts are often not directly supported by historical evidence, but require abducing new entities—events, visual references or similar—to bridge the inferential gaps.

Though the art historical claims need to discharge eventually as FOL sentences for ATP to find deductive footing, this is not the appropriate level of modeling. Rather, one has to

²The scene takes place to the left and below Darius III's scythe chariot.

 $^{^{3}}$ Cf. the Italian codex I Turchi (Codex Vindobonensis 8626, 1585-1591), the drawings by Johannes Lewen-klaw (Codex Vindobonensis 8615, 1585) or the Turkish Book of Manners (1595), now in Kassel.

Deductive Support of AAM

model the claims which then expand into the appropriate sentences, together with any needed scaffolding entities as well.

Furthermore, we model arguments like the ones above in ResearchCyc [10] [3] using microtheories as contexts [7]. Contexts allow to resuse the shared assumptions as well as isolate the actual interpretation differences. Modeled claims can be analyzed in their description context and discharged as FOL sentences in a dependent context, akin to conversational implicature. Though such a separation of context allows some deductive TMS at the projected level, this separation is no substitute for maintence of the argument claims.

That separation comes at a price, however: At the level of FOL TMS, the clash between contradictory information can be detected syntactically: If p is already asserted, then $\neg p$ cannot be added (and vice versa). The connection is far less direct at the level of claims in argumentation. As noted above, perhaps Altdorfer drew Persian women in German dress because he lacked references. One way in which such references could be lacking—and weaker conditions may also suffice—is that no information about Turkish female clothing was available in Western Europe before 1529 at all.

The problem is not reasoning about the absence of illustrations depicting items of certain types from before the 1580s,⁴ but recognizing the need to trigger reconsideration cheaply. Lacking the syntactic similarity between p and $\neg p$ as a simple tip-off, such an AMS has to validate the assumptions under its management by running queries, in the limit after every new fact added—an expensive solution that is a stop-gap measure at best. At least, due to the separation between the claims and the representation, it is possible to notate which queries need to be run.

The situation is very similar for inductive knowledge, such as distributions of various features over a population. In [18], we used WEKA's J45 [4] as an external decision tree inducer to generate the *modus operandi* probabilities, which Cyc accessed via removal-module at inference time. Efficiently detecting that such information has gone stale and needs to be re-exported and re-generated remains a desideratum.

5 Outlook

In a deductive truth-maintenance system, the repair strategy of the bookkeeping system is either not to accept the new information or to retract the conflicting propositions as new information arrives. In a argumentation maintenance system, it is not clear that retraction is the correct behavior. However, there remains a significant body of problems that can be flagged deductively, a form of conceptual spell-checking for digital humanities researchers that would already be a significant improvement over the current state of the art, the *Zettelkasten*, whether implemented in paper or document files.

 $^{{}^{4}}$ ResearchCyc supports reasoning about unavailable information via the relation unknownSentence in queries; cf. [1].

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Deductive Support of AAM

Kahlert, Berendt and Rode



Figure 1: Albrecht Altdorfer, Die Alexanderschlacht (1529), now in the Pinakothek in Munich.