Ontology of Time for the Digital Humanities: A Foundational View

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Abstract. Time merits careful treatment in the digital humanities because it is one of the most fundamental constituents of the world. In this paper we bring up for discussion foundational ontology of time with an emphasis on its application to this discipline. An interesting finding from our study is that a traditionally unpopular theory of time might be of practical significance for the modeling in the domain.

Keywords. time; formal ontology; digital humanities; realism; past, present and future

1. Introduction

The Digital Humanities (DH) [1,2] are roughly an area of inquiry that lies at the intersection between the humanities and modern digital technology. The DH are multifaceted: they are not only a methodological movement within the humanities but also an interdisciplinary field that would prompt our society to (re)consider the relationship between humankind and rapid development of science and technology [3]. We focus in this paper upon (ontology of) time in the DH. The concept of time is central to the DH because it serves as a point of reference for comparing and integrating multiple approaches (whether theoretical or practical) in the DH: e.g., the usage of time intervals for the annotation of cultural objects in cultural heritage applications [4].

The utility of ontology of time for the DH nonetheless remains fairly unexplored. For instance, the Network for Digital Methods in Arts and Humanities (NeDiMAH) was a research networking program that was funded mainly by the European Science Foundation (ECF) (see [5] for a general description of the NeDiMAH) and one working group thereof researched into the visualization of space and time [6], but with no much attention to the ontological aspect of time. The NeDiMAH also convened a working group who devoted themselves to the NeDiMAH Methods Ontology (NeMO) [7] project to build a comprehensive ontological model of scholarly practice in the arts and humanities, while the NeMO leaves room for foundational treatment of time. This may be not unnatural, however, granted that many fundamental issues with the nature of time are yet to be addressed directly even in existing prominent upper ontologies [8].

In this paper we present an overview of ontology of time (Section 2) and discuss some relevant implications of each theory of time for the modeling in the DH (Section 3). It is not our aim in this short paper to tailor a new specific theory of time for the DH,

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nor to conduct an exhaustive study of time in the DH; but rather to provide some preliminary indications as to how foundational exploration of time will be able to support data integration and knowledge management in the DH over the long run. We conclude the paper with some brief remarks on future work (Section 4).

2. Ontology of Time: An Overview

2.1. 'NOW' and Temporal Ontology

Broadly speaking, ontology of time revolves around two issues (see e.g., [9]). One is the dispute over what we may call 'NOW' between the A-theory (aka the tensed theory) and B-theory (aka the tenseless theory).[2] Our experience of time teaches us that there is something special about NOW. We (directly) experience only the present time, but not any past or future time. Additionally, NOW seems to move in one direction and the irreversible movement of NOW appears to be the single most important factor of our experience of the 'passage' or 'flow' of time. The question is whether NOW, the flow of time, and the distinction between the past ('before NOW'), the present ('contemporaneous with NOW'), and the future ('after NOW') are the objective (mind- and language-independent) characteristics of the real world or not. The A-theory says yes: the movement of NOW creates the passage of time from the past through the present towards the future [11]. The B-theory says no: NOW, the flow of time, and the purported past-present-future distinction are nothing more than the features of our experience of time, but not those of fundamental reality of time [12].

The other is the controversy over temporal ontology between presentism, eternalism, the growing block theory.[3] Presentism says that only the present exists [13]. Eternalism says that the past, the present, and the future exist [14]. The growing block theory says that the past and the present exist, but the future does not [15,16]. More precisely, the presentist contends that that only the present times, objects, and, events exist.[4] The eternalist counters that past and future times, objects, and events are as real as the present times, objects, and events. The growing blocker takes a middle course: the universe becomes ever 'greater' as time passes, and the present remains at the 'edge' of this growing 'block'. Imagine that one asks: "Does Socrates exist?" The eternalist and the growing blocker say yes; and the presentist says no. Suppose further that one asks: "Does the 5-billion-year-old earth exist?" The eternalist says yes; and the presentist and the growing block say no. Those three temporal ontologies are summarized in Table 1.

Table 1. Comparison in Temporal Ontology between Presentism, Eternalism, and the Growing Block Theory

	Does the Past Exist?	Does the Present Exist?	Does the Future Exist?
Presentism		X	
Eternalism	X	X	X
Growing Block Theory	X	X	

[2] The terms 'A-theory' and 'B-theory' are attributed to McTaggart's [10] terms 'A-series' and 'B-series' of time in his argument for the unreality of time, respectively.

[3] In this paper we employ the terms 'ontology of time' and 'temporal ontology' differently in such a way that the former refers to a general, foundational topic or theory of time that comprises the latter.

[4] By the term 'object' we here mean so-called 'concrete particulars' or 'ordinary (material) objects' (e.g., molecules, people, and galaxies), leaving aside abstract objects (e.g., numbers and sets).

2.2. Varieties of Time

Ontology of time can be generally characterized by a combination of a theory of NOW with a stand on temporal ontology. First of all, the presentist and the growing blocker argue invariably for the A-theory since they both acknowledge the ontological specialty of the present; so we will henceforth use the terms 'presentism' and 'the growing block theory' to refer to a pair of the A-theory with the presentist and the growing blocker accounts of temporal ontology, respectively, unless otherwise specified. In addition, the B-theorist unexceptionally espouses eternalism, so that their couple is usually called the 'block universe theory', according to which the 'block spacetime' is a four-dimensional manifold of points that in no way changes or grows. While most eternalists are block universe theorists, a few eternalists adopt the A-theory and endorse the moving spotlight theory [17]: the view that all the times, objects, and events exist but the presentness is still privileged. A variety of ontologies of time are summarized in Table 2.

Table 2. Summary of Ontologies of Time

	Presentism (narrow)	Eternalism	Growing Block Theory (narrow)
A-theory	Presentism (wide)	Moving Spotlight Theory	Growing Block Theory (wide)
B-theory	? (untenable)	Block Universe Theory	? (untenable)

3. Discussion

3.1. 'Moderate Realism' for Ontology of the Humanities

Let us scrutinize ontology of time *vis-à-vis* the DH. The first thing to note is that, as Galton [8] alludes to, an inquiry into the nature of time in ontology is closely intertwined with the heated debate over (formal) ontology between realism and conceptualism (see e.g., the exchange of views in [18-20]). The realist/conceptualist issue of ontology is too global to be handled within the scope of our investigation. We may be nonetheless justified in accepting a kind of realist approach to ontology for all our practical purposes. In providing foundations for an ontology of philosophy, Grenon and Smith [21] suggest that realism be a guiding principle for ontology building in the sense that: "Ontology (…) is concerned with providing an account of the entities existing within a given domain of reality, where 'reality' is here understood in the broadest possible sense" [21, p. 189]. For instance, ontologies represent "not only molecules and planets but also works of literature, laws, and historical epochs" [ibid.]; and it is even the case that: "Concepts and terms may (…) perfectly well form the subject matter of ontologies addressing psychological or linguistic domains" [ibid.]. Presumably this moderate version of realism would be useful enough to enable us to explore time in a number of different humanities, ranging from literature and language to history and philosophy.

3.2. Ontology of Time for the Digital Humanities

We begin by considering the subject of NOW in the context of the DH. It is generally acknowledged that the B-theory (and *mutatis mutandis* the block universe theory) tends to be less susceptible to criticism than the A-theory. For instance, the A-theory is

traditionally vulnerable to 'McTaggartian arguments' (e.g., [22]) against the A-theory.[5] For another example, the B-theory is allegedly concordant with modern physics because it treats time merely as another dimension than space in compliance with contemporary physicists' standard practice.[6] We think however that the A-theory would be preferable with respect to time in the DH. Besides what we may call 'moderate realism', Grenon and Smith [21] justify the revisability of the representation as another requisite for ontology construction on the grounds that not only our knowledge of reality changes, but also the world as such does.[7] Taken seriously, this statement would compel us to exploit the A-theoretic worldview because it consists in giving the dynamic view of time by emphasizing the ontological (but not epistemic) movement of NOW.

The next issue to be tackled is which temporal ontology would be suitable for the A-theory with respect to the DH. Let us look first at presentism. The presentist's primary motivation is the intuition that the only (concrete) objects that exist are presently existing ones. Although we speak of Socrates and the 5-billion-year-old earth, we believe normally that neither exists, for instance. Furthermore, the A-theory would seem to be naturally paired with the presentist's temporal ontology because the A-theorist endows time with NOW just as the presentist confers existence only on present existents.[8] Presentism nevertheless faces a not inconsiderable number of challenges, the most formidable of which is arguably the truthmaker objection (see [25] for an overview of this problem). A truthmaker [26,27] is something that 'makes true' (i.e., bears the 'truthmaking relation' towards) a proposition.[9] Consider the true proposition (say *P*) that Socrates is wise. As the denier says, the presentist fails to make *P* true because the truthmaker for *P* (e.g., a state of affairs of Socrates being wise) would require the existence of Socrates but the presentist is not ontologically committed to him.[10] This could be problematic for the ontological modeling in the DH because digital humanists frequently engage in the representation of past objects and events such as old landscapes that are currently 'lost' in time [29] (e.g., pre-earthquake Lisbon [30]).

One may be then tempted to choose the moving spotlight theory because its ontology comprises entities that existed in the past. There is however a strong epistemic objection [31] to the moving spotlight theory. We believe that we exist in the present and we do know it; but given the spotlight theory, there are many other people who think that they are in the present but who believe wrongly so because the times at which they are located

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[5] See e.g., Deasy [23] for the A-theorist's reply.

[6] See Curtis and Robson [9, Chapter 10] for a brief guide on the relationship between physics and ontology of time.

[7] "The reasons to allow for ontology change turn not only on the fact that our knowledge is growing and being constantly subjected to correction, but also on the fact that *the world is changing*. The changes affect not only the world of information artifacts, which some ontology terms will be used to describe, but also *the world that is represented in these artifacts*. Ontologies rest on accounts of reality which are based on expert knowledge, but not only can knowledge of reality (in particular that of experts) evolve, so also can *reality itself*. This is true, too, in a domain such as philosophy." [21, p. 192, our italicization added].

[8] The passage of time may be problematic for presentism, though. See e.g., Gołosz [24].

[9] By the term 'proposition' we mean something abstract that plays three major roles. (i) The semantic content of a (declarative) sentence. E.g., two sentences "Snow is white" and "La neige est blanche" express the same proposition that snow is white. (ii) The object of various linguistic and cognitive attitudes ('propositional attitudes') including belief, assertion, and denial. E.g., when she sincerely utters "Snow is white," Mary bears the believing attitude towards the proposition that snow is white. (iii) The truthbearer: the bearer of truth-values (truth and falsehood). E.g., the proposition that snow is white is true.

[10] A state of affairs is, roughly, a concrete portion of reality with a 'propositional structure'. See Armstrong [28] for details.

do not enjoy the privileged presentness. We have nevertheless no better evidence to support our knowledge of our time being the present than e.g., Socrates and those living on the 5-billion-year-old earth have to vindicate their knowledge of their times being the present. The spotlight theory would thus lead to skepticism about whether we are in the present (but see [17] for the moving spotlighter's responses). In this respect, the spotlight view may be too pricy to be exploited in the practice of the DH.

All those observations would lead us to arrive finally at the growing block theory, which is actually the least popular account concerning temporal ontology. In fact, the growing blocker could encounter the same epistemic difficulty as the moving spotlighter does (but see [16, Chapter 6] for her reply). We may be able to offer some considerations in favor of the growing block theory with regard to its application to the DH, however. The main impetus for this view pivots around the intuition that the past is 'fixed', but the future is 'open'. For instance, propositions about the past will never change in truth value, whereas propositions about the future may change in truth value. This idea may be attuned to the essential practice of the humanities: to learn new things from the unchangeable past and to maximize them to ameliorate the changeable future. It could be further said that an ontological commitment to future entities is redundant for ontology of time in the DH, which represent basically the past and the present rather than the future.

3.3. Possible Application Examples

We finally discuss some possible implications of our study on the foundational aspects of time for the modeling in the DH, although we leave detailed applications for future owing to spatial limitations. One possible application example may be about historic or artistic epochs (see e.g., [32]). The difference between calendrical systems would be also well worth investigating. For instance, the October Revolution in the digital system based on the Julian calendar would not be seen as correctly identical with the November Revolution in the digital system based on the Gregorian calendar unless one ensures the interoperability between those two informational structures. The growing block theory is expected to serve as a common semantic framework for this integration.

4. Concluding Remarks

To recapitulate briefly, we examined (foundational) ontology of time in relation with the DH. One interesting consequence of our study is that, despite its theoretical unpopularity, the growing block theory might be congenial to a solid basis for the representation of time in the domain of the DH. Our investigation is restricted in scope for space reasons, however. For instance, careful consideration should be given to the so-called 'shrinking block' view of temporal ontology [33-35] according to which the past is unreal, while the present and the future are real. One promising line of future research would be nevertheless to apply the growing block theory to knowledge representation in the DH ontologies, e.g., by leveraging Correia and Rosenkranz's [16] temporal logical system for the growing block of time. More generally, close investigation is clearly warranted into a formal system for each ontological theory of time so that we will be able to strengthen the symbiosis between ontology of time and the DH: e.g., the enhancement of the formalization of diachronic identity of localities [36] with ontology of time.[11]

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