Digital palaeography: What is digital about it?

Arianna Ciula[1]
King's Digital Lab, King's College London, UK

Abstract

Compared to the epistemic traditions digital palaeography builds on, how is it transformative? In this article I will outline the emergent meanings and possible research directions of digital palaeography by reflecting on the past 15 years of approaches and conceptualizations in the field. By departing from a contextualized take of the term digital coupled with humanities and palaeography, I will show how digital approaches relate to the scholarly tradition of the study of handwriting and writing systems as a whole and how recent approaches of digital palaeography can be defined as critical, self-reflective, multidisciplinary and interdisciplinary. Moving between a formal and a historically situated analysis, I will relate practices of modelling of handwriting in digital palaeography to modelling in digital humanities more generally. Digital palaeography will emerge well positioned to represent the complexity of handwritten objects from the unfamiliar perspective of the substance of the expression of handwriting (text as shape).

Correspondence:
Arianna Ciula,
King's Digital Lab,
King's College London,
Room VWB 2.50,
Virginia Woolf Building,
22 Kingsway, London
WC2B 6LE, UK.
E-mail:
arianna.ciula@kcl.ac.uk

The aim of this article is to contribute to a theoretical underpinning of digital palaeography from multiple perspectives, ideally to inspire further research and practical applications. The first perspective is mainly terminological; the second is historical; the third one methodological; and the fourth one formal. The terminological and historical aspects are treated briefly despite being crucial to contextualize the argument.[2] The main argument of the article is developed in the last two sections. In Section 3 the significance of modelling practices in digital humanities—hence also in digital palaeography—is discussed briefly to make emerge the value of shifting iteratively from rule-based abstraction and the constraints of computing to the specificity of the objects under study and of the epistemic traditions via which they are studied. In Section 4 the argument moves back to (digital) palaeography seen this time from a formal angle. In particular, its role in connecting structures of form and meaning in the study of textual artefacts is brought forward as an original and potentially transformative approach in modelling textuality.

What emerges from these reflections are both a practice-based yet theoretical overview of what doing digital palaeography means in methodological terms and a glimpse of what research in the field could entail if the practice of modelling, analysing, and understanding texts as shape was exploited to its limit (provided the technologies are there to experiment with or developed accordingly).

1. Words in Context

It seems self-evident that to understand what digital palaeography means, one must look at words and how they are used. In parallel to how terminology to describe digital scholarship in the humanities has evolved in the past 70 years at least, a shifting and

doi:10.1093/llc/fqx042 Advance Access published on 27 September 2017

Table 1 Terminology in context and emergent meaning of digital palaeography as subsuming computational palaeography

Terms	Semantic facets	Overall emergent meaning
Digital e.g. Digital versus analogue	Representational form of data	Digital Palaeography ⊃ Computational Palaeography
Computational e.g. Computational palaeography	Formal manipulation of symbols Processability of data	
Digital + e.g. Digital humanities; digital palaeography	Research methodology Augmenting, extending humanistic methods with science, technology, engineering, mathematics and *vice versa*	

often ambiguous use of the adjectives computational and digital applies also to palaeography. Generally, the distinction between the terms computational and digital[3] emphasizes the processability of data—being images, texts, or other media in combination—over their representational form, as for example in the use of digital versus analogue. However, the convergence towards the use of digital coupled with humanities—digital humanities[4]—and therefore palaeography—digital palaeography—denotes the methodology of research being enabled rather than the symbolic form and manipulation of its objects of analysis and of its outcomes.

As amply theorized by others (McCarty, 2014a), the cultural understanding of digital calls for a wider semantic spectrum that transcends the opposition with analogue. In particular, in digital humanities research, it is not the value of discrete (binary) operations that matters *per se* but the opportunities they open up for scholars to paying attention to choices being operationalized. When interpreting, structuring, or, we could say, dividing up artefacts or phenomena of study, what matters to scholars in the humanities are not as much the partitions, but how they come to be and how such analytical processes impinge on the understanding of those artefacts and phenomena. In this sense, the term digital palaeography is not more restrictive or less concerned with implementation than computational palaeography is, as it subsumes it while at the same time problematizing operational choices in a critical perspective. This is not to say that there exists something digital that cannot be computed but rather that there are some applications in digital palaeography[5] that are less focused on the development of automatic or semi-automatic tools processing images of texts and that lean instead towards the exploitation of the representational rather than the computable power of digital models (e.g. to annotate manually minute variations in strokes, to superimpose and compare hands at human glance). As shown in Table 1, by taking into account a variety of uses of the term digital palaeography, the overall emergent meaning for the field encompasses both initiatives that are mainly engaged at the level of the representational form of digital data as well as those mainly involved in the manipulation of the data in computational terms. Often these uses are not clear-cut, but they can be pinned down in relation to the porous border between digital humanities and digital media studies. The third semantic facet (digital +), however, constrains digital palaeography to the pragmatics of its methodology as outlined above and implies that a use of the digital that is not transformative falls out of the picture of what digital palaeography should encompass. The plus sign in Table 1 is a deliberate borrowing of Cecire's reflections on the 'problem of the plus' being additive rather than transformative (McCarty, 2014b, p. 292): 'it should not be possible to have the "plus" without the two terms—"digital" and "humanities"—themselves changing' (Cecire, 2011).

To sum up, within the term digital palaeography—where palaeography means at once the history and the science of handwriting encompassing formal analysis as well as social and cultural ones at least until the widespread of print—different understandings and corresponding exploitations of the digital are subsumed.

Image processing as well as image annotation and conceptual models of handwriting can be categorized as digital palaeography when applied critically to handwritten artefacts of the past; all of these approaches imply the operationalization of a certain understanding of handwriting in software of different kinds. Those operationalizations are the processes where transformative understanding of what doing palaeography in the digital age means might occur.

It should be premised, however, that attempts at formalizing ancient handwriting—e.g. with respect to script morphologies, and typologies of literacy and terminology used to describe them—is not novel; it relates to a systematic approach to handwriting that predates computers all together. For instance, the understanding of handwriting in terms of its compositional and measurable elements is nothing new; it dates back at least to the 15th-century treaties on scriptural typologies. While commenting on Sigismondo Fanti's *Theorica et Pratica de modo scribendi fabricandique omnes litterarum species*, Montecchi writes:

> Thanks to the revelation and the mastering of the procedures and the relationships that animate it, handwriting loses that halo of mystery that has always surrounded it; it exits once and for all from the gloom of history and becomes an art completely slaved to human kind. In other words, it is led by the rigid and reassuring domain of the laws of mathematics and geometry, where nothing is left to the uncontrolled influences of chance. [...] In the handwriting produced *more geometrico* there is nothing hidden or mysterious. [...] it reflects that universal dimension of human thought and the general laws of the mind [...]. (My rough translation of Montecchi, 1998, p. 119)

Not only palaeography as a discipline—from the 1930s with Bischoff at least, onwards—has subscribed to analytical methods amongst other historical and social approaches but more generally the perception of text as divisible entity in opposition to the notion of the ungraspable composition of images has prevailed in humanistic enquiries with few exceptions (e.g. semiotics of art).[6] Computer sciences and image processing techniques offer an *addendum*, a perspective that suits nicely methodological traditions and inclinations of the classificatory minds of palaeographers. Yet, my aim in this article is to identify any transformative aspects (as intended in Table 1). Compared to the tradition of analytical palaeography it builds on and an even longer human wish to explain, contextualize and control writing systems, does digital palaeography affect our conceptualization of handwriting? How is digital palaeography transformative (in the sense of digital+)? or is there a digital + palaeography?

2. Projects Rationales and Self-narratives

As outlined above, uses of the digital range from a mainly representational focus to heavily computational manipulations. All uses within this spectrum can be considered part of what entails digital palaeography, provided transformative operationalizations take place which force one to redefine both the assumptions encoded in the tools being adopted or developed and the epistemology of the palaeographical method. With this respect, the past 15 years of approaches offer a pool of projects rationales and activities to assess once contextualized within the recent history of computing and its increasing widespread use in scholarship and society at large. While it is not my aim in this article to provide a detailed history of the field itself, what follows below is an attempt at identifying some approaches towards the adoption and development of digital tools and resources for palaeography and manuscript studies more generally. The intention is not to present digital palaeography as a scientific domain evolving over time in neat sequential phases of development, but rather to show how such approaches are and have been intertwined with fluctuating cultural attitudes.

I bear the responsibility of having used the term digital palaeography as we intend it today[7]—the study of ancient handwriting supported and enhanced by digital technologies—for the first time in an academic poster presenting my doctoral research (Ciula, 2005b)[8] in 2004 (Ciula, 2004a) and then in an article published in 2005 (Ciula, 2005a).

A dominant attitude and approach towards computational methods in manuscript studies and in the humanities in general until at least the end of 1990s and certainly still when I started my PhD in 2001 was defensive and at times destructive. Such an attitude is not foreign to the sentiment of fear as finely dissected by recent research on the history of computing (McCarty, 2014b; see also Nyhan *et al.*, 2015). As an emblematic example, while describing the impact the advent of computers had on the perception of being human and humanists, the apocalyptic language of Father Busa embodied this sentiment with skilful irony (see also Morando, 1961):

> At that point, the monster of the night came, the triumphant technicism, with its newest creature: automation. Somebody shivered, thinking of it as a raw and harsh bulldozer that advances by roaring, crashing and tearing the flowers. Amongst them, a delicate and gentle victim: humanism. Tomorrow is already here. The future has already begun: a flow of lava floods and burns the green flanks of the mountain. (My translation of Busa, 1962, p. 105)[9]

Since then, the advent of the computer in developed western societies has lost part of its mythical grip; its fearful novelty and otherness have become obsolete or at least obscured by the increasing ubiquity of computers and of digital technology in everyday life. The most famous electronic valve computer of the 1940s—named Colossus—and mainframes of the 50s–70s needed dedicated facilities, workshop garages, laboratories, and trained operators to host and use them, while nowadays it is not uncommon to see toddlers playing with tablets or smart phones—with nicknames such as BlackBerry—in their coats. This social uptake coincided with the rapidly widespread adoption and hence more than often unquestioned embedding of digital technologies in scholarly practices. Evident example is the use of digital images of primary sources for historical and—relevant here—palaeographical research. What I aim to argue is that recent research and debates in digital palaeography revert and challenge this common yet uncritical approach while championing a critical use of digital technology which often departs from engaged modelling exercises and a constructive discussion of the limitations of computational tools.

As the introductory section of the poster I presented in 2004 demonstrates, my use of the term digital palaeography was instrumental to explain a novel approach to palaeography supported by the analysis of digital representations of medieval handwriting:

> This research project focuses on the digital representation of images of handwriting from the 10th to the 12th century. Illustrated here is the functionality of a program called SPI (System for Palaeographical Inspection—University of Pisa 2000) as a means to support palaeographical observation and interpretation. The application of SPI to the corpus of Sienese manuscripts written in Caroline minuscule represents the first case study to test the real support that the software can offer to a palaeographical analysis. The experimentation has produced some results in terms of the analysis of the handwriting and of the clustering of the manuscripts on the basis of their morphological similarity. The poster summarizes these results and the methodological implications of the tool. (Ciula, 2004a)

In the concluding session of my 2004 poster, four points with keywords highlighted in bold stressed indeed the methodological gains beyond the specific case study (Ciula, 2004a):

- The palaeographical comparative method is enriched and changed. Indeed, from the beginning, a **terminological coherence** is needed to carefully describe the models and to compare them.
- What the SPI software is able to compute are some features expressed directly by the letterforms. Yet, the **morphological parameters** gathered from the patterns under study can be computed and recorded on the digital representation.
- The added computational parameters widen the classical system of palaeographical characteristics and facilitate a **terminological categorization** that is **graphically based**. The interpretations are forced to be anchored to digital representations to available measures. The result is a

quantitative approach with considerable representational and descriptive power.
- Moreover, the **comparison** of many models allows us to see the data from new perspectives, by structuring the corpus using multiple criteria.

Some of the statements above—such as the need to emphasize that the digital models incorporate morphological parameters—seem almost naïve today, when digital models are known to embed all kind of data and have reached a high level of sophistication in the sciences, humanities, and everyday life. However, the statement about a graphically based terminological categorization is rather more interesting for the scope of this article, since it clearly contextualized that first exercise in digital palaeography as a symbolic abstract effort—the categorization of types of handwriting—relying on visual models.[10] The PhD thesis brought forward some hypotheses on dating and localization of the corpus of manuscripts under study by making use of the digital models as dynamic representational objects rather than quantitative measures *per se*. Therefore, what emerged in the thesis was not the dominance of a quantitative approach but, on the contrary, the prevalence of palaeographic discourse enhanced in its expressive and synthetic capability by the process of creating and analysing the visual models of letterforms.

If in 2003 the term digital palaeography did not even exist,[11] various events connected to research in digital palaeography took place towards the end of the first decade of 2000 in Europe; in particular, two dedicated symposia on *Codicology and Palaeography in the Digital Age* were hosted in Munich and resulted in two volumes (Fischer *et al.*, 2011; Rehbein *et al.*, 2009). In 2010, the European Research Council awarded a Starting Grant[12] to Peter Stokes for a project on *Digital Resource and Database for Palaeography, Manuscript Studies and Diplomatic*, at the Department of Digital Humanities, King's College London (UK). In the rationale of the project which ended in 2014, the distance from a purely computational approach is very explicit:

> The challenge, therefore, and a significant objective of this project, is to provide a system which presents palaeographical data quickly and easily in a way which scholars can understand, evaluate, and trust. This cannot be done using purely computational methods with the computer as a 'black box', since this simply replaces the palaeographer with the computer as a source of authoritarian statements (Stokes, 2009). Instead, the evidence must be presented in a way that palaeographers and medievalists in general can engage with: images of individual letters and of the manuscript context (Davis, 2007), charts showing frequencies of letter-forms by date (Mundó, 1982; Beneš, 1999; McGillivray, 2005), maps showing geographical distribution (Jessop, 2008), and so on. (DigiPal 2011–2014, project rationale)

In 2011, also following a highly competitive peer-review process, the European Science Foundation (ESF) sponsored an Exploratory Workshop on Digital Palaeography (20–22 July 2011, Würzburg, Germany) convened by Malte Rehbein. This scheme was specifically aimed at opening up 'new directions in research' and at exploring 'emerging research fields'(Exploratory Workshops, 2006–15);[13] thus even if the label seemed established by then, the field was still deemed to be of high novelty and in its experimental stages of development. The ESF workshop also had a follow-up in the Dagstuhl Perspectives Workshop on *Computation and Palaeography: Potentials and Limits* held in 2012[14] which resulted in the publications Hassner *et al.* (2012, 2013), where lexicons adopted from computer sciences (e.g. what does *ground truth* mean for palaeography?) were discussed and criticized at length in the purposeful effort of bridging the diverse epistemic traditions of historical studies and technosciences.[15]

The ethos of these 2001-onwards projects and activities witnessed a critical engagement with digital technology, informed by diverse modelling processes and a constructive discussion of the limitations of computational tools. These approaches signal a renewed return to an 'integral' (Boyle, 1984) perspective which places palaeography within a wider multidisciplinary and interdisciplinary framework (cf. Stutzmann, 2013, p. 85), linking it with philology, linguistics, and even cognitive sciences.[16]

Notwithstanding that it is not the scope of this article to dwell on what is and is not a scholarly discipline and whether digital palaeography should or should not be labelled as such, it is nonetheless interesting to recall here the historical and comparative perspective on the development of the humanities as presented in Bod *et al.* (2012), where the emergence of a new discipline is seen as a form of hybridization rather than specialization:

> The new hybrid reflects ideas from the culture in which it emerges, the values that reign supreme at the place of its emergence (including its specific institutional setting) and from the various fields of study it has borrowed ideas from. All these aspects are put in a mixer and the new substance coming out of it is the new discipline. (Karstens, 2012, p. 105)

Complementary to the analysis on terminology in Section 1, the overview of practices outlined above put the emphasis on a self-reflective approach around the analysis of handwriting beyond strictly computational concerns. It also exhibits a hybridization of the field, not only with respect to computer sciences but with other disciplines engaged with the study of textuality of the past and present.

3. Creating and Deflating Models: A Paradox

If the brief historical account above was useful to taste aims and expectations of practitioners in digital palaeography, to further reflect on the transformative potential of this emerging discipline, it is necessary to dwell on its epistemological dimension. The processes of operationalization mentioned in Section 1 are materialized as part of a central activity in digital humanities and in digital palaeography: modelling. Modelling is widely intended as both the formal data modelling process as well as the imaginative iterative effort of creating and interpreting models.[17] The formal dimension of modelling in digital palaeography might entail, for instance, the identification of features to be extracted from the digital images of the letterforms, as well as the organization of the structural information around the classification of handwriting into a database. This process tends to translate into a back and forth between a scrutiny of and an eye bird engagement with the digital models of the manuscript sources, so as to facilitate the integration of the social and cultural history of the manuscripts under study with the digital models of its letterforms via intermediate stages of analysis (Ciula, 2009, Fig. 8).

While reflecting on modelling in the sciences, Godfrey-Smith (2009) argues that the introduction of the computer in scientific practice has shifted reasoning from analytical theorizations to the manipulation of concrete things. I would force this further by stating that, digital palaeography approaches suffer from a potentially productive dilemma, a dilemma that is made more acute in recent practices compared to the already vivid debates in the 1970s between the historical and Cartesian approach (Gumbert, 1976) and in the 90s (Costamagna *et al.*, 1995, 1996). As happens in any digital humanities research engaged with modelling, on one hand, palaeographers engaged with the digital are busy building things, what Godfrey-Smith (2009, p. 108) would call a specific type of models or imaginary *concreta* (creatures in between reality and fiction, between the schematic and the concrete); on the other hand, they are engaged in reflecting about their own practice and in so doing deflate the same models they build.[18] This cycle back and forth between the idiosyncrasies of the objects of study often minutely examined under the lens of computational tools and the simplification, abstraction, or idealization into rule-bound forms or models can be disorientating, but is surely healthy while it remains a creative cycle. Indeed, formalizing or giving form for the sake of a quest for rigour breaks the productivity of the paradox of modelling. I believe this is what the internationally renowned palaeographer David Ganz warns against in a recent paper questioning the connections between a scriptorium and its products:

> [...] searching for the distinctive details of letter forms shared by scribes may risk the application of an over rigid positivism to the study of manuscripts. (Ganz, 2015, p. 54)

Not to dismiss this concern against positivism in digital humanities[19] nor the danger of reducing

palaeography to the fixed classification of the morphology of handwriting, I claim that what a digital palaeography approach as contextualized earlier on brings to the fore is precisely this awareness and hence the questioning of the mechanics of a topographical or taxonomical analysis. By asking 'what is the unit of handwriting? what we considered it to be?,' a digital palaeographer is aware that even by getting closer to the supposed materiality of the artefact—e.g. through high-resolution images and microscopically segmented image features—she does not lose the lenses palaeographers have being using for interpreting such artefacts in the past, but can consciously decide to put them to test.[20] In this lies one of the paradoxes of the digital and of modelling more generally: it brings perceptual materiality to our scrutiny while taking us away from it. The digital models are used to analyse the objects they are models of, but are also self-reflective tools to question those same models.[21]

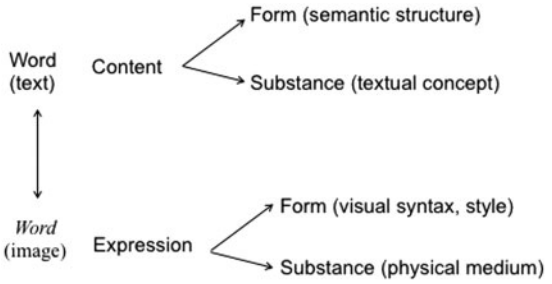

Fig. 1 The interplay between the substance of the expression (the physical medium, the ink on the parchment) and the form of the content (the semantics of the text, its meaning). Palaeography focuses mainly on the two planes of expression, primarily its substance.

4. Cross-modality of Handwriting

The collision between creating and deflating models as outlined above lead to a potential productive paradox characteristic of digital humanities at large. This last section of the article brings the focus back to digital palaeography and, in particular, to its modelling efforts applied to the study and history of handwriting and to its materially oriented approach in modelling textuality. By reflecting on what can be characterized as a special take on texts, a formal position for digital palaeography is drawn with respect to its role in connecting the structures of expression and the structures of meaning of handwriting. My argument aims to theorize a digital palaeography which builds on the tradition of analytical palaeography while, at the same time, carrying out an original approach to modelling textuality that reconnects the morphology of texts to the complex meanings they convey.

4.1 Semantics and materiality

Palaeographic research with its focus on the perception of handwriting in morphological terms is a reminder that the handwriting manifests itself as an artefact that is rationalized and divided (hence constructed) only after it is given. By bringing to the fore the picture of writing or the writing as picture (cf. 'text as shape' versus 'texts as meaning' in Hassner *et al.*, 2012, p. 193), palaeographical studies live on the cross-modal dimension of handwriting. Adopting Elleström's categories and reflections on media products, modes, and cross-modality (cf. for example Elleström, 2017), by cross-modal dimension of handwriting I intend the crossing of the analytical border between the sensorial and the conceptual traits of handwriting, form and meaning, visible and invisible, between token and type, *langue* and *parole*. In material culture terms this cross-modal dimension is often translated into the highly significant hybrid nature of the book as body (codex) and mind (text). An adapted Hjelmslevian semiotic model of language (Fig. 1) exemplifies this cross-modal dimension of writing[22] as the interplay between expression and content. The merit of the Hjelmslevian theoretical framework is to offer a faceted interplay between shape and meaning which is more than simply binary. Indeed, in Hjelmslevian terms, both expression and content of handwriting are inhabited by planes of forms and substance. Beyond the 'blunt dichotomy' (Elleström, 2017) image versus text, this analytical framework visualizes the general cross-modality of language, where the sensorial traits of words—whether handwritten, sounded out, or gestured—are bridged with their meaning. Independently from whether we subscribe

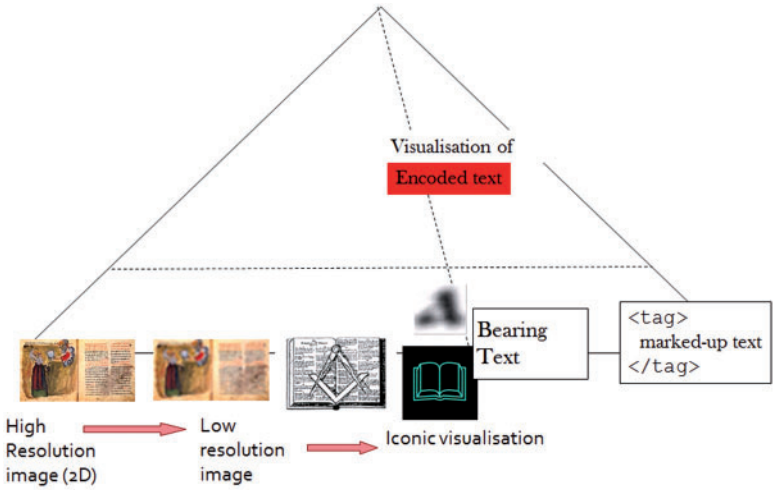

Fig. 2 By following the analogy to McCloud's triangle, the ways of representing a textual object in visual terms can range in form of expression from less to more schematic representations. The base of the triangle on the left side includes a graded *continuum* from more visually resembling to more schematic graphic representations of objects bearing the text (expression of the object bearing the handwriting), while the base of the triangle on the right side includes the graded textual counterpart from simple words transcribing an object to more complex descriptions and narratives (but still considered in their graphical expression or what McCloud calls 'visual vocabulary').

to the Hjelmslevian framework or not, it is on language materialized as image and shape (the substance of expression) that palaeography puts the accent on, revealing the indeterminacy of the relation between the planes of expression (form and substance) and between these and their relation to their content or meaning.[23]

4.2 Stylizing and conceptualizing

The essence of what was discussed above is that palaeographers are engaged in the creation of representations and models of ancient handwriting using as a point of departure the form of expression of texts.[24] In what follows I aim to characterize further this process also with respect to digital representations and models[25] by reflecting on the iconicity of written textual artefacts and language. In (Ciula, 2006) I used McCloud's (1994) triangular map of visual iconography[26] to represent the relationships between cultural textual objects and their digital (visual) representations both in graphical and in textual forms. Following its publication, 'The Big Triangle', as McCloud's semiotic model came to be known, proved to be an interesting tool not only for thinking about comics but also for speculating about visual art and language in general. I used it to contextualize my analysis with respect to digital resources representing material aspects of text-bearing objects as a pretext to estrange readers with a less normative tool to analyse textual objects compared to what we tend to be acquainted with. Indeed, one of the main symptoms of this acquaintance is the perceived symbiosis between the text as a string of types of characters—surely already a first level of interpretation and encoding in itself—and its extant materiality as a physical artefact (codex, roll, early print edition, pixels on a screen, etc.).[27] This symbiosis or even identity is usually enforced by the very common two-dimensional representation of textual objects, whether analogical or digital.

In my adaptation of McCloud's triangle (Fig. 2), the variety of ways of representing a textual object in visual terms can assume both the form of more or less resembling representations—images of the physical object bearing the handwriting in our analysis—or their textual counterpart.

If we consider a medieval codex as our choice of textual object, its representations in the form of

digital images can range from highly faithful digital reproductions to simplified icons recalling, for instance, just the rectangular shape of an opening page. Although '"every form of reproduction can lie, by providing a range of possibilities for interpretation that is different from the one offered by the original" (Tanselle, Reproductions 33) and the process of imaging is a process of interpretation' (Vanhoutte, 2006), in my revisited triangle I assumed a graded range of approximation departing potentially from realistic three-dimensional models of a textual object.

The right-side side of the base of the imaginary triangle as shown in Fig. 2 includes the expression of the textual substance (what for McCoud is the written language of comics facing from the other side of the fence). Like the resembling graphical reproductions of the physical medium bearing the text, it is arduous to claim the objective transparency of any of its editions or descriptive texts, but, again, I assume it possible to agree on a range of representative and hence also interpretative levels, for instance, from the so-called imitative (mimetic) or diplomatic edition to the critical edition.[28] In a way a diplomatic edition is more like a photograph and a critical edition more like an abstract portrait or drawing, not less truthful just different in style.

Far on the right of the base of the triangle, I included any marked-up text considered as more elaborate descriptive level along the given text expression. Following this map, a visualization of an encoded text—that is to say, an encoded text which is not presented as syntax of 'exposed markup' (Coombs *et al.*, 1987) such as crude XML encoding, but rendered via some kind of processing instructions (e.g. via a stylesheet transformation which renders specific configurations into links or with coloured sections representing marked-up chunks of text)—can act as a visual representation of the form of the textual content (its meaning) which belongs to a conceptual level that can then be located a bit further up on the right of the base of the triangular map. When the encoding is somehow transformed from its underlying model syntax into the visualization of the supposed encoded conceptual structure (as in the example in Fig. 3), the semantic structural layers mirroring the textual sequence are made visible in graphic form. What becomes visible is not merely the image of the correspondent folio of a manuscript transcription (a medieval charter in Fig. 3) but the components that the encoder or the editor has considered as structural parts of the meaning of the transcription text (form or structure of the content). This visualization is connected at some level with the graphemic counterpart of the textual sequence of characters. It is more precisely a visual representation of some selected elements of which the user/scholar may already have an image (or model) in mind or, even more interestingly, a new and unusual exposure of the textual structure (new form of the content) generated by the encoding or modelling process and open to further research. The visualization of encoding is an example of structure-oriented visualization which shows how a graphic rendering of the text does not have to relate unequivocally to features of the textual object as expression (whether form or substance of the expression) but can rather represent one or more supposed structures of the textual content. This visualization is not a sign for the object (for example, a manuscript text signifying a charter document) but a chain of signs generating further signification or meaning out of their own form (e.g. the XML encoding) in a productive cycle of conceptual references.[29]

In essence, within this triangular map, a double level of stylization can be visualized with respect to our representational and modelling efforts: the level of representations being more or less realistic along the horizontal base and the level of how conceptually charged our visual models become along the height of the triangle. When made explicit and visible, the structure of the content on the textual-symbolic side can play a fundamental role in the implementation of a thoughtful connection between the image-iconic representation/s of the text and the textual-symbolic content representation/s of a cultural object.[30]

Digital resources which give priority to images of textual artefacts recognize that the images are fundamental interfaces to the text they contain—something well known in print access resources for palaeography that privilege minimal rigorous description against photographs such as Gumbert, 2009, 2011. Digital palaeographic methods can

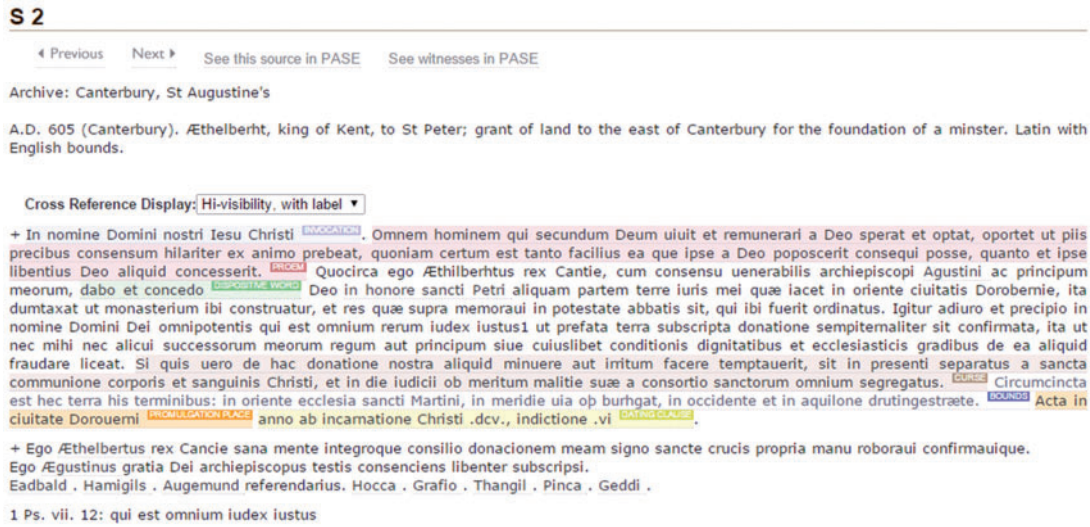

Fig. 3 Screenshot extracted from http://aschart.kcl.ac.uk/charters/s0002.html (Anglo-Saxon Charters) where the TEI/XML encoding of the different segments of text in this Anglos-Saxon Charter (Sawyer number 02) is rendered in colour (in the print version of this article grades of black and white) and labelled with the function of each formula or clause following a predefined semantic model of the document.

enhance this considerably by adding levels of analysis to the graphical representations and by making available multiple layers of interpretations; a step towards semantic stylization and abstraction, but departing from the expression of handwriting.

4.3 Meaning in the form

An example from diplomatic—which studies more specifically historical documents of legal or administrative nature such as charters and diplomas as well as other records—might be useful to contextualize what discussed so far and take the argument one step forward. Even to the uninitiated, the digital surrogate of the physical document shown in Fig. 4 (a papal privilege issued in 1101 and held at the Archivio Segreto Vaticano in Rome) showcases at least three or four different levels of handwriting (the heading at the top, the main text, an isolated line following the main text, two peculiar signs, and a final line of text at the bottom).

A trained palaeographer interested in the diplomatic of this kind of papal documents would possess a more detailed knowledge of how the structure of this type of medieval document can be interpreted based on descriptions, models, and visual representations in the literature. An example of such model of the document structure is the diagram on the right of Fig. 4 which could be drawn from previous knowledge, observation of samples, or the literature. The model in between the image and the diagram is neither only a resembling icon of the document nor only a structural representation, but integrates them both. It could be a digital model generated out of computational layout analysis bridging between the semantics as expressed in the image of the document form and the diagrammatic model of the charter structure.

Passing via all the levels of the semiotic model of handwriting shown in Fig. 1, a digital model which embeds both structure of expression and structure of content of the handwriting can make a unique contribution to reconstruct material textuality of cultural artefacts by bridging visual and symbolic elements of texts, spatial and temporal, and perception and interpretation. Ultimately, digital palaeography can be transformative by bridging the semantics of written artefacts with their materiality contextualized within specific historical periods, sociocultural environments, and places of production.

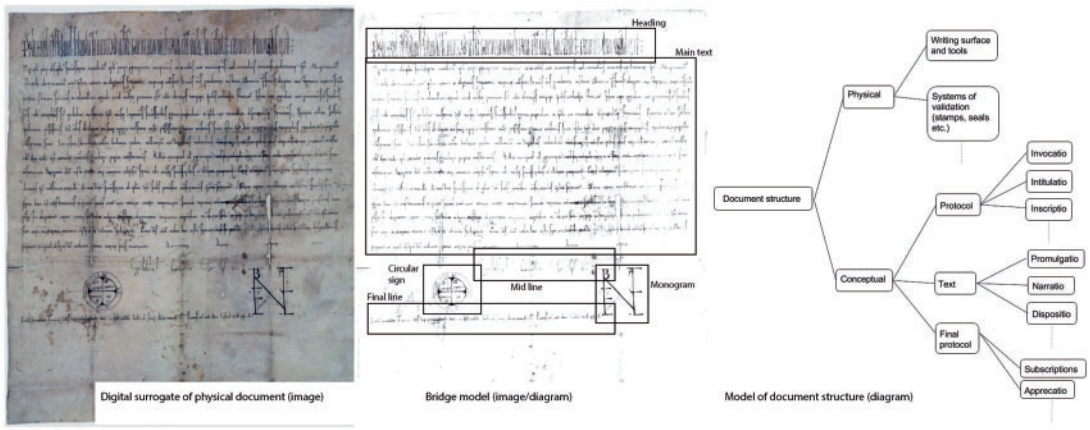

Fig. 4 Three levels of representation of a medieval document (the specific example document was authored by Pope Pasquale III in 1011 and is held at the Archivio Segreto Vaticano, I, 1): (1) on the left end side the digital surrogate as image of the papal privilege (image-like model featuring immediate visual resemblance with the original); (2) on the right end side a possible model of its physical and conceptual structure as it could be extracted from a diplomatic handbook (diagram model based on an abstraction from multiple samples); (3) in the middle a bridge model where the iconic components embed some elements of the diagrammatic structure.

5. Conclusions

By departing from a specific take on the use of the word digital to denote new approaches in paleography, my argument in this article has mainly been methodological in scope while making use also of historical and more extensively formal perspectives on what means and can mean for palaeography to be digital. I summarized some projects rationales and self-narratives from 2001 onwards which claim a critical engagement with digital technology, informed by diverse modelling processes and a constructive discussion of the limitations of computational methods and languages. This enlarged vision for the field translates in approaches that place palaeography within a wider multidisciplinary and interdisciplinary framework, linking it with computer sciences but also with philology, linguistics, and human sciences at large, including anthropology and cognitive sciences. My brief overview of practices put the emphasis on a self-reflective approach around the analysis of handwriting beyond strictly computational concerns, lining up with the emergent sense of what a digital approach to cultural artefacts entails. By testing ontological commitments, categories, classifications of handwriting, models are built and deflated. The collision between creating and deflating models of handwriting or of the contexts where handwriting occurred leads to a productive paradox characteristic of digital humanities at large.

What is, however, a distinctive feature of palaeography—and for that matter of other materially oriented disciplines like diplomatic, codicology and, moving to the print realm, typography and bibliography—is its focus on text as image, individual document, and material expression. By reflecting on this special take on texts, my argument moved to theorize a digital palaeography which builds mainly on the tradition of analytical palaeography while, at the same time, aiming to be transformative. Indeed, when contextualized within an analysis of the border between form and meaning of handwritten sources, digital palaeography approaches can be used to connect the structure of expression of handwriting with structures of meaning. For a digital resource to be inspired by and to promote research based on the material and perceptual aspects of a cultural object, a high-quality graphical representation of the cultural object is essential but not sufficient. In terms that reflect what Buzzetti (2006) says about the symbolic components of textual objects,[31]

I argue that the scope of digital palaeography lies in anchoring the structure of the expression of image–texts to the structure of their content, in other words in bridging the 'semantic model' of a handwritten source to at least some of the material aspects of the artefact. My formal and historically situated analysis makes digital palaeography emerge well positioned to represent the complexity of handwritten objects from an unfamiliar perspective, by departing from the structure of the expression of handwriting or text as shape.

In essence, what is digital + palaeography? Firstly, while uses of the digital in palaeography can range from a mainly representational focus to heavily computational manipulation, one can meaningfully talk about digital + palaeography when processes of operationalization redefine both the assumptions encoded in the tools being adopted or developed and the epistemology of the palaeographical method. Secondly, digital + palaeography is engaged in an effort to extend and hybridize the remit of palaeography putting forward an integral vision for the field. Thirdly, it exploits the paradox of the digital in its practical and at the same time self-reflective approach to modelling, by creating and deflating models, by moving between the material and the conceptual facets of texts as objects. Last but not least, it develops methods which enhance the iconic representations of textual artefacts departing from the unfamiliar perspective of text as shape. Following this analysis, digital paleographic methods—inclusive of image processing, image annotation and conceptual models blending morphology and semantics—are theorized as enhancers of iconic representations of textual artefacts. They can bridge the sensorial/perceptive and structural/conceptual interpretations of handwriting, material and mental knowledge of text, visual and textual, and spatial and temporal.

References

Anglo-Saxon Charters. http://aschart.kcl.ac.uk/ (accessed 18 September 2017).

Bod, R., Maat, J., and Weststeijn, T. (eds) (2012). *The Making of the Humanities*, vol. II. Amsterdam: Amsterdam University Press. http://www.oapen.org/record/429447 (accessed 18 September 2017).

Boyle, L. E. (1984). *Medieval Latin Palaeography: A Bibliographical Introduction*. Toronto: University of Toronto Press.

Busa, R. (1962). L'analisi linguistica nell'evoluzione mondiale dei mezzi d'informazione. In *Almanacco Letterario 1962*. Milano: Bompiani, pp. 103–17.

Buzzetti, D. (2002). Digital representation and the text model. *New Literary History*, **33**(1): 61–88. doi:10.1353/nlh. 2002.0003.

Buzzetti, D. (2006). Biblioteche digitali e oggetti digitali complessi: esaustività e funzionalità nella conservazione. *Archivi Informatici per il Patrimonio Culturale*, vol. **114**. (Contributi del Centro Linceo Interdisciplinare «Beniamino Segre»). Roma: Bardi Editore, pp. 41–75. http://web.dfc.unibo.it/buzzetti/dbuzzetti/pubblicazioni/lincei2003.pdf (accessed 18 September 2017).

Buzzetti, D. (2015). Turing and automated text processing. In Croll, G. J. and Gregory, N. G. (eds), *Explorations, Proceedings ANPA 35*. Ryde: Absoprint, pp. 1–34. doi:10.13140/RG.2.1.1926.0649. http://web.dfc.unibo.it/buzzetti/dbuzzetti/pubblicazioni/turing-eng.pdf (accessed 18 September 2017).

Buzzetti, D. and Rehbein, M. (2008). Towards a model for dynamic text editions. In Opas-Hänninen, L. L., Jokelainen, M., Juuso, I., and Seppänen, T. (eds), *Digital Humanities 2008*. Oulu: University of Oulu, pp. 78–81. http://www.ekl.oulu.fi/dh2008/Digital%20Humanities%202008%20Book%20of%20Abstracts.pdf (accessed 18 September 2017).

Cecire, N. (2011). When digital humanities was in Vogue. *Journal of Digital Humanities*, **1**(1). http://journalofdigitalhumanities.org/1-1/when-digital-humanities-was-in-vogue-by-natalia-cecire/ (accessed 18 September 2017).

Ciula, A. (2004a). Digital palaeography. Poster presented at Digital Resources for the Humanities. University of Newcastle Upon Tyne. http://www.drh2004.ncl.ac.uk/ (accessed 18 September 2017).

Ciula, A. (2004b). Modelli di scrittura carolina. *Gazette du Livre Médiéval*, **45**: 27–38.

Ciula, A. (2005a). Digital palaeography: using the digital representation of medieval script to support palaeographic analysis. *Digital Medievalist*, **1**. http://www.digitalmedievalist.org/journal/1.1/ciula/ (accessed 18 September 2017).

Ciula, A. (2005b). *Paleografia e informatica. L'applicazione del software SPI al corpus di manoscritti senesi*. Ph.D. thesis. University of Siena.

Ciula, A. (2005c). Un progetto di ricerca. L'applicazione del software SPI ai codici senesi. In Pérez González, C. and Valcárcel Martínez, V. (eds), *Estudios de poesia medieval*. Vitoria: Findación Instituto Castellano y Leonés de la Lengua, pp. 305–22.

Ciula, A. (2006). Cultural Objects in Digital Resources: Imagining the Text. *CLiP 2006: Conference Abstracts: Literatures, Languages and Cultural Heritage in a Digital Worldly*. London: Office for Humanities Communication. http://legacy.cch.kcl.ac.uk/clip2006/redist/abstracts_pdfold/paper34.pdf (accessed 18 September 2017).

Ciula, A. (2009). The palaeographical method under the light of a digital approach. In Rehbein, M., Schaßan, T., and Sahle, P. (eds), *Kodikologie Und Paläographie Im Digitalen Zeitalter - Codicology and Palaeography in the Digital Age*. (Schriften Des Instituts Für Dokumentologie Und Editorik 2). Norderstedt: Books on Demand (BoD), pp. 219–35. http://kups.ub.uni-koeln.de/2971/ (accessed 18 September 2017).

Ciula, A. and Eide, Ø. (2014). Reflections on cultural heritage and digital humanities: modelling in practice and theory. In Proceedings of the First International Conference on Digital Access to Textual Cultural Heritage (DATeCH '14). New York, NY: ACM, pp. 35–41. doi:10.1145/2595188.2595207. http://doi.acm.org/10.1145/2595188.2595207 (accessed 18 September 2017).

Ciula, A. and Eide, Ø. (2017). Modelling in digital humanities: Signs in context. *Digital Scholarship in the Humanities*, **32** (suppl 1): i33i46.

Ciula, A. and Marras, C. (2016). Circling around texts and language: towards 'pragmatic modelling' in digital humanities. *Digital Humanities Quarterly*, **10**(3) http://www.digitalhumanities.org/dhq/vol/10/3/000258/000258.html (accessed 18 September 2017).

Codices Electronici Ecclesiae Coloniensis. http://www.ceec.uni-koeln.de/ (accessed 18 September 2017).

Coombs, J., Reaner, A. H., and De Rose, S. J. (1987). Markup Systems and the Future of Scholarly Text Processing. *Communications of the ACM*, **30**: 933–47. http://xml.coverpages.org/coombs.html (accessed 18 September 2017).

Costamagna, G., Gilissen, L., Gasparri, F., and Pratesi, A. (1995). Commentare bischoff. *Scrittura e civiltà*, **19**: 321–52.

Costamagna, G., Gilissen, L., Gasparri, F., and Pratesi, A. (1996). Commentare bischoff. *Scrittura e civiltà*, **20**: 401–07.

Deegan, M. (2000). Introduction: ten years of CTI Textual Studies. In Condron, F., Fraser, M., and Sutherland, S. (eds), *Guide to Digital Resources for the Humanities*. Oxford: CTI. http://users.ox.ac.uk/~ctitext2/resguide2000/intro.shtml (accessed 18 September 2017).

DigiPal: Digital Resource and Database of Manuscripts, Palaeography and Diplomatic (2011–2014). http://www.digipal.eu/ (accessed 18 September 2017).

Dworkin, C., Morris, S., and Thurston, N. (2012). Information as material. http://www.informationasmaterial.org/ (accessed 18 September 2017).

Écriture médiévale & numérique. (2013–2017). http://oriflamms.hypotheses.org/ (accessed 18 September 2017).

Elleström, L. (2017). Bridging the gap between image and metaphor through cross-modal iconicity: An interdisciplinary model. In Zirker, A., Bauer, M., Fischer, O. and Ljungberg, C. (eds), *Iconicity in Language and Literature: Dimensions of Iconicity*. John Benjamins Publishing Company.

Exploratory Workshops, (2006–15). European Science Foundation. http://archives.esf.org/coordinating-research/exploratory-workshops.html (accessed 18 September 2017).

Eyers, T. (2013). The perils of the 'digital humanities': New positivisms and the fate of literary theory. *Postmodern Culture*, **23**(2). doi:10.1353/pmc.2013.0038.

Faulhaber, C. (2015). 28.814 'digital humanities': first occurrence? Humanist Discussion Group. http://lists.digitalhumanities.org/pipermail/humanist/2015-March/012769.html (accessed 18 September 2017).

Fischer, F., Fritze, C., and Vogeler, G. (eds) (2011). *Kodikologie und Paläographie im digitalen Zeitalter 2 - Codicology and Palaeography in the Digital Age 2*. (Schriften des Instituts für Dokumentologie und Editorik 3). Norderstedt: Books on Demand (BoD). http://kups.ub.uni-koeln.de/4337/ (accessed 18 September 2017).

Ganz, D. (2015). Can a scriptorium always be identified by its products? In Nievergelt, A., Gamper, R., Bernasconi Reusser, M., Ebersperger, B., and Tremp, E. (eds), *Scriptorium. Wesen - Funktion - Eigenheiten*. (Veröffentlichungen der Kommission für die Herausgabe der mittelalterlichen Bibliothekskataloge Deutschlands und der Schweiz). München: Bayerische Akademie der Wissenschaften, pp. 51–62.

Godfrey-Smith, P. (2009). Models and fictions in science. *Philosophical Studies*, **143**(1): 101–16.

Gumbert, J. P. (1976). A proposal for a Cartesian nomenclature. In Gumbert, J. P. and Haan, M. J. M. de (eds),

Essays Presented to G. I. Lieftinck, vol. **IV**. (Miniatures, Scripts, Collections). Amsterdam: A. L. Van Gendt and Co.

Gumbert, J. P. (2009). *Illustrated Inventory of Medieval Manuscripts in Latin Script in the Netherlands 1: Utrecht, Museum Catharijneconvent*, Vol. **I**. Hilversum: Verloren b.v., uitgeverij.

Gumbert, J. P. (2011). *Illustrated Inventory of Medieval Manuscripts in Latin Script in the Netherlands 2: Leiden, Universiteitsbibliotheek BPL*. Hilversum: Verloren b.v., uitgeverij.

Hassner, T., Rehbein, M., Stokes, P. A., and Wolf, L. (2012). Computation and Palaeography: Potentials and Limits. Dagstuhl Perspectives Workshop 12382 (Dagstuhl Reports). Dagstuhl: Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik http://drops.dagstuhl.de/opus/volltexte/2013/3890/pdf/dagrep_v002_i009_p184_s12382.pdf (accessed 18 September 2017).

Hassner, T., Rehbein, M., Stokes, P. A., and Wolf, L. (2013). Computation and Palaeography: Potentials and Limits. *Dagstuhl Perspectives Workshop 12382* (Dagstuhl Manifestos). Dagstuhl: Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik http://drops.dagstuhl.de/opus/volltexte/2013/4167/ (accessed 18 September 2017).

Hirtle, P. (2000). Editorial. *D-Lib Magazine*, **6**(4). http://www.dlib.org/dlib/april00/04editorial.html (accessed 18 September 2017).

Karstens, B. (2012). Bopp the builder, discipline formation as hybridization: The case of comparative linguistics. In Bod, R., Maat, J., and Weststeijn, T. (eds), *The Making of the Humanities*, vol. **II**. Amsterdam: Amsterdam University Press, pp. 103–28. http://www.oapen.org/record/429447 (accessed 18 September 2017).

McCarty, W. (2014a). 27.745 digital knowledge. Humanist Discussion Group. http://lists.digitalhumanities.org/pipermail/humanist/2014-January/011672.html (accessed 18 September 2017).

McCarty, W. (2014b). Getting there from here. Remembering the future of digital humanities Roberto Busa Award lecture 2013. *Literary and Linguistic Computing*, **29**(3): 283–306.

McCloud, S. (1994). *Understanding Comics: The Invisible Art*. First HarperPerennial edition. New York: HarperCollins Publishers.

Models of Authority. Scottish charters and the emergence of government, 1100–1250. (2014–17) http://www.modelsofauthority.ac.uk/ (accessed 18 September 2017).

Montecchi, G. (1998). Gli atlanti dei caratteri tipografici: considerazioni preliminari e propeduetiche dagli scritti di Sigismondo Fanti. In Leonardi, C., Morelli M., and Santi, F. (eds), *Modi di scrivere: tecnologie e pratiche della scrittura dal manoscritto al CD-ROM. Atti del convegno di studio della Fondazione Ezio Franceschini e della Fondazione IBM Italia. Certosa del Galluzzo, 11-12 ottobre 1996*. (Quaderni di cultura mediolatina 15). Spoleto: Centro italiano di studi sull'Alto Medioevo, pp. 107–30.

Morando, S. (ed.) (1961). Le due culture - inchiesta. In *Almanacco Letterario 1962*. Milano: Bompiani, pp. 143-144-317.

Muzerelle, D. (2011). À la recherche d'algorithmes experts en écritures médiévales. *Gazette du Livre Médiéval*, **56–57**: 5–20.

Nyhan, J., Flinn, A. and Welsh, A. (2015). Oral history and the hidden histories project: Towards histories of computing in the humanities. *Digital Scholarship in the Humanities*, **30**(1): 71–85.

Pierazzo, E. (2013). A conceptual model of text, documents and work—part 1. *Elena Pierazzo's Blog*. http://epierazzo.blogspot.co.uk/ (accessed 18 September 2017).

Pierazzo, E. (2015). *Digital Scholarly Editing: Theories, Models and Methods*. Aldershot: Ashgate.

Piper, A. (2015). Novel devotions: Conversional reading, computational modeling, and the modern novel. *New Literary History*, **46**(1): 63–98.

Rehbein, M., Schaßan, T. and Sahle, P. (eds) (2009). *Kodikologie und Paläographie im digitalen Zeitalter - Codicology and Palaeography in the Digital Age*. (Schriften des Instituts für Dokumentologie und Editorik 2). Norderstedt: Books on Demand (BoD). http://kups.ub.uni-koeln.de/2939/ (accessed 18 September 2017).

Sahle, P. (2006). What is text? A pluralistic approach. In *Digital Humanities 2006 Conference Abstracts*. CATI, Université Paris-Sorbonne, pp. 188–90. http://www.allc-ach2006.colloques.paris-sorbonne.fr/DHs.pdf (accessed 18 September 2017).

Sahle, P. (2013). *Digitale Editionsformen. Zum Umgang mit der Überlieferung unter den Bedingungen des Medienwandels. Teil 3: Textbegriffe und Recodierung*. [Preprint-Fassung]. Ph.D. thesis. Universität zu Köln. http://kups.ub.uni-koeln.de/5013/ (accessed 18 September 2017).

Stokes, P. A. (forthcoming). Computing and Palaeography in Theory: Some Historical Context for the Future. In Brookes, S., Rehbein, M., and Stokes, P. A. (eds), *Digital Palaeography. Digital Research in the Arts and Humanities*. Aldershot: Ashgate.

Stokes, P. A., Brookes, S., Noël, G., Davies, J., Webber, T., Broun, D., Taylor, A., and Tucker, J. (2016). The Models of Authority Project: Extending the DigiPal framework for script and decoration. In *Digital Humanities 2016: Conference Abstracts*. Kraków: Jagiellonian University & Pedagogical University, pp. 869–99. http://dh2016.adho.org/abstracts/387 (accessed 18 September 2017).

Stutzmann, D. (2013). Ontologie des formes et encodage des textes manuscrits médiévaux. Le projet ORIFLAMMS. *Document numérique*, **16**(3): 81–95.

Stutzmann, D. (2016). Clustering of medieval scripts through computer image analysis: Towards an evaluation protocol. *Digital Medievalist*, **10**. http://digitalmedievalist.org/journal/10/stutzmann/ (accessed 18 September 2017).

Vanhoutte, E. (2006). Prose Fiction and Modern Manuscripts. Limitations and Possibilities of text-encoding for electronic editions. In Unsworth, J., O Brien O Keeffe, K., Burnard, L. (eds), *Electronic Textual Editing*. New York: Modern Language Association of America, pp. 161–180. Preview http://www.tei-c.org/About/Archive_new/ETE/Preview/vanhoutte.xml (accessed 18 September 2017).

Virtual Vellum. (2013). https://hridigital.shef.ac.uk/virtual-vellum/ (accessed 18 September 2017).

Notes

1. Part of the work presented in this article was conducted while the author was based at the Department of Humanities, University of Roehampton, UK (until January 2017).
2. In the first case, the brevity is due to the fact that a comprehensive terminological analysis would be both out of scope for this article and out of reach for the author to elaborate exhaustively on. On the other hand, the historical context, both with respect to the palaeographical debate on the remit and methods of the field as well as with respect to the recent evolution of digital palaeography, is amply discussed elsewhere by the author and others.
3. For this opposition discussed with respect to palaeography, see in particular Hassner *et al.* (2012, pp. 190–91) and Stokes (forthcoming).
4. For a recent discussion on the first occurrence of the term digital humanities and its uptake in the first decade of 2000, see Faulhaber (2015).
5. See, for example, Virtual Vellum (2013).
6. Modern and contemporary art has exploited this cultural conflict between reading practices that put emphasis on symbolic aspects of written text as opposite to the morphological and sensorial aspects of other artefacts. See for example the works of *Information as Material* (Dworkin *et. al.*, 2012) such as the exhibition *Learn to Read Differently*.
7. My thanks to Peter Stokes for having pointed out to me another sense of digital palaeography attributed to Hirtle (2000), who talks about this new 'speciality' as the ability to convert obsolete file formats containing digital information (e.g. HTML, JPEG) into current formats. See Stokes' (forthcoming) overview on the term.
8. He was my then supervisor at King's College London (2003–04), John Lavagnino, to suggest I used the term digital rather than computational in my MA dissertation submitted in 2004. But while being an MA student in the UK, I was also in the process of completing my PhD in Italy, where pressure was for sticking to the term *computazionale* (computational) to describe my approach. This might certainly be an anecdotal and idiosyncratic case; all the same it shows that this was a time where such terms were negotiated and, if not publicly debated, certainly source of methodological questioning at some level. While my PhD thesis in its entirety remains unpublished, its main outcomes were published in several articles (in particular see Ciula, 2004b, 2005a,c, 2009).
9. My thanks to Willard McCarty for recommending and providing access to this and the previous Italian references.
10. For a more specific discussion on iconic and in particular image-like models in a digital humanities context, see Ciula and Eide (2017).
11. Note, however, that there was at least one tool made available by the pioneering Codices Electronici Ecclesiae Coloniensis (CEEC) digital library: http://www.ceec.uni-koeln.de/projekte/CEEC/tools/paleography/paleography.htm
12. This is a competitive and prestigious scheme started under the European Union Seventh Framework Programme (2007–13) to fund individual researchers at the early stages of their careers. See http://erc.europa.eu/about-erc/history
13. See http://www.esf.org/coordinating-research/exploratory-workshops.html.
14. See http://www.dagstuhl.de/en/program/calendar/semhp/?semnr=12382.
15. Similarly, Stutzmann (2016) illustrates a recent experiment of computer vision in the *Ontologie des formes et encodage des textes manuscrits médiévaux*

(ORIFLAMMS) project, a project funded by the French Agence Nationale de la Recherche (ANR) which started in 2012, whereby the interpretation of the clustering of medieval scripts posed challenging difficulties of matching meanings across lexicons: 'Is script a texture? What link can be established between direction (of contour) and slant? What is the consequence of rotation invariance (e.g. are letters p and d one and the same)? Silhouette or skeleton? Local or global analysis? What is the signification of script types and how do they correlate between each other?'

16. The *Qu'est-ce que la paléographie?* section of the ORIFLAMMS project blog (Écriture médiévale & numérique, 2013–17) makes the connection to neurosciences explicit. See also the recently published final report http://oriflamms.hypotheses.org/files/2017/04/Oriflamms-Compte-rendu-final.pdf.'
17. For recent reflections on modelling intended in this way, see Ciula and Marras (2016) and Ciula and Eide (2014, 2017).
18. For a broader adaptation of Godfrey-Smith's 'deflationary view' (Godfrey-Smith, 2009, p. 115) as a '"deflationary account" of modelling practices' in digital humanities, see Ciula and Marras (2016).
19. Beyond digital palaeography, this is a concern expressed repeatedly in the critique of digital humanities approaches in particular with respect to current trends in distant reading; see for example Eyers (2013).
20. Cf. What the palaeographer Denis Muzerelle says with respect to the engagement with a digital palaeography project called Graphem (funded by the French funder ANR from 2008 to 2011): '[. . .] pour tenter de passer outre les écueils sur lesquels achoppe encore l'analyse automatique, il est indispensable d'approfondir notre connaissance des propriétés géométriques et mécaniques des écritures' (Muzerelle, 2011, p. 18); my rough translation: 'In an attempt to bypass the pitfalls which still make automatic analysis fail, it is essential to deepen our knowledge of geometrical and mechanical properties of handwriting', and further again in my translation: 'With respect to paleography, this project has undoubtedly engaged us in the deepening of a number of basic concepts, in a redefinition of our questions, in a critique of our techniques of observation' (in its original version: 'En ce qui concerne la paléographie, ce programme nous a incontestablement engagés dans l'approfondissement d'un certain nombre de notions de base, dans une redéfinition de notre problématique, dans une critique de nos techniques d'observation.') (Muzerelle, 2011, p. 20).
21. A similar point with respect to computational modelling of literary novels was made recently by Piper (2015, p. 68): 'We not only gain insights into the specific subset of texts identified by the model, as the model provides the interpretive horizon through which these texts assume new meanings. But we recursively gain insights into the computational model itself through the detailed analysis of the texts it has identified'.
22. While this model can be applied to handwriting and non-manuscript writing alike, the variety of grades of expressions as demarcated in handwriting tends to be more diverse (because potentially traceable to the individual hand) than, for instance, in printed documents or other non-individual means of production.
23. On the characteristics of the relation between expression and content as dependent and indeterminate, see in particular Buzzetti (2015, pp. 13–14): 'In essence, it can be said that "the expression plane refers to the material aspect of the linguistic sign," and "the content plane to the semantic aspect, there not necessarily being a one-to-one correspondence between both aspects of the linguistic sign" (Bussman, 1996, p. 425). This lack of correspondence can be accounted for by considering that the material aspect, or for that matter "the image" (Segre, 1988, p. 315) of the literary text, is not unique, but only one of the possible expressions of its content, just as, if you consider a given expression or "image" of the text, the content that is being associated with it from time to time is only one of its possible interpretations. [. . .] In specific linguistic terms, this relationship between expression and content, or to be precise "between [linguistic] form and meaning," can be described as a relationship of mutual dependence between the two phenomena, characteristic of every natural language, of synonymy, i.e. "more than one form having the same meaning," and polysemy, i.e. "the same form having more than one meaning" (Leech, 1981, p. 94). This relationship presents all the characteristics of an indeterminacy relation: if the expression is fixed, the content remains undetermined, as well as, if the content is fixed, the expression remains undetermined. So, if the meaning of a word depends on its rules of use (Wittgenstein, 1958, 2009), and on its potential relationship to all other terms, it is quite clear that its specification remains open and potentially undetermined. The shortcomings of formalization and the absence of a one-to-one correspondence between the syntactic and the semantic structure of natural languages confirm the objective presence of phenomena of indeterminacy in the processes of association of semantic contents to linguistic signs of material nature'.

24. In parallel, the same could be said of codicology which privileges the form and substance of the expression of the codex as primary interface to a text and not independent from its content.
25. I am in debt to the rich conceptualizations on the digital representation of texts by Buzzetti (2002) distinguishing between the structure of the expression of texts and the structure of their content.
26. See http://www.scottmccloud.com/4-inventions/triangle/: the lower left corner of McCloud's triangle includes visual resemblance (e.g. photography and realistic painting), while the lower right includes the products of what McCloud called iconic abstraction, of which cartooning is the main emblem. The height of the triangle on the other hand represents for McCloud grades of abstraction from the resemblance to a reference object at the bottom towards conceptual art at the top of the triangle, where an image (form of expression) and its meaning (form of the content) are but one thing. In an earlier version of McCloud's website dedicated to explain his 1993 book and some of his theories, he stated: 'The move from realism to cartoons along the bottom edge was a move away from resemblance that still retained ''meaning,'' so words, the next logical step in the progression, were included at far right, thereby enclosing anything in comics' visual vocabulary between the three points. And at the top were the denizens of the picture plane (''pure'' abstraction) which ceased to make reference to any visual phenomena other than themselves' (http://archive.is/Vg6OQ).
27. Cf. Deegan (2000): 'We have become so used to the book as textual mediator that for the most part we scarcely notice its artefactual state and how it imposes its ''machinery'' on what we read; we accept a kind of synonymity between text and book. There is some sense in this, since the book (individually as well as generically) has proved a robust machine for text dissemination, while one of the current anxieties about electronic storage media is their rapid obsolescence (Sutherland, 1997, introduction passim)'.
28. Pierazzo (2013, in particular see post of the 1st of August; Pierazzo, 2015, p. 52) drew two graphs collocating, respectively, editorial theories and editorial formats on a continuous axis with respect to their relationship with the materiality of text. In both of her graphs by 'document materiality' she means in fact the substance of the expression of texts (i.e. physical media which live outside McCloud's Big Triangle and my redrawn version, where only visual representations are included); however, the arrows in Pierazzo's two graphs operate explicitly on two different levels. In the first graph the move towards 'textual immateriality' of editorial theories refers to their stand with respect to how conceptualized and away from the original content of the source their editorial models are (a move away from representing a physical textual instance or a document to an ideal and abstract scheme of the text), while in the second one the immateriality of the editorial formats refers to the form of the expression of texts (a move away from fidelity to the form of expression in the document to a looser correspondence). An alternative circular graph representing the multidimensionality of text encompassing the whole spectrum from physical medium (substance of the expression) to semantics (form of the content) can be found in Sahle's wheel of text (Sahle, 2006, 2013).
29. Cf. The idea of a 'linkemic approach' (Vanhoutte, 2006) where portions of the text explain themselves at an exponential rate.
30. Visualizations of dynamic editions (Buzzetti and Rehbein, 2008) integrating textual expression (form or structure of the expression) and semantic model (form or structure of the content) could also exemplify this connection. The ORIFLAMMS project mentioned in Notes 15 and 16 above aims to provide interfaces that bridge forms and signs at the level of granular as well as layout features of a wide corpus of medieval scripts; a further project which is attempting to reveal visually the deep connections between the palaeography of specific texts (handwriting styles of Scottish charters in this case) with the textual content (the representation of authority) is Models of Authority (2014–17; see Stokes *et al.*, 2016).
31. My translation: 'The challenge with respect to the representation in digital form of any kind of information and to its adequately exhaustive and functional preservation is therefore given by the possibility of representing the text as a digital complex object and by the ability to reproduce in functional terms the forms of interaction between the structure of the expression and the structure of the content of textual information'. The original Italian version reads as following: 'La sfida per la rappresentazione in forma digitale di ogni tipo di informazione e per la sua conservazione adeguatamente esaustiva e funzionale è' dunque costituita dalla possibilita? di rappresentare il testo come un oggetto digitale complesso e dalla capacità di riprodurre funzionalmente le forme di interazione tra la struttura dell'espressione e la struttura del contenuto dell'informazione testuale' (Buzzetti, 2006, p. 55).