ANIMATION FOR THE STUDY OF RENAISSANCE TREATISES ON ARCHITECTURE. FRANCESCO DI GIORGIO MARTINI’S CORINTHIAN CAPITAL AS A SHOWCASE

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Abstract

This paper reports preliminary results of ongoing interdisciplinary research in digital humanities and animation. This research explores visualisation techniques (e.g., motion graphics, 3D animation, Non-Photorealistic Rendering) to empower the study of depicted objects in Renaissance treatises on architecture and engineering. The aim is to pioneer a method that can be adopted by both scholars in the humanities and practitioners in animation to 1) take advantage of available editions and scholarship via interactive online systems (e.g., Engineering Historical Memory); 2) map and decode visual information and knowledge embodied in manuscripts; 3) create philologically correct 3D models and storytelling to unfold narratives embedded in drawings. As a showcase, this paper used Francesco di Giorgio Martini’s drawings of the Corinthian capital in the manuscripts Ashburnham 361 (Biblioteca Medicea Laurenziana, Florence) and Saluzzo 148 (Musei Reali, Turin).

Keywords

Digital Humanities, 2D Depicted Objects, 3D Animation, Motion Graphics, Visual Narrative, Non-Photorealistic Rendering (NPR), Francesco Maurizio di Giorgio di Martino, Renaissance Treatises on Architecture, Science and Technology Manuscripts

1. Introduction: Research Background, Research Focus and Aims, Choice of the Case Study, and Structure of the Paper

Italian Renaissance saw the introduction of drawings in treatises on civil and military architecture and engineering (Scaglia, 1992, 9-11). This practice re-joined the prestigious ancient tradition of Marcus Vitruvius Pollio’s De Architectura (“On Architecture”, 1st cent. BCE; refer to Corso, 1997) and Apollodorus of Damascus Πολιορκητικὰ/Poliorketikà (“Siege Engines”, 2nd cent. CE; refer to Ridley, 1989), whose texts were both complemented by technical drawings (formaें, in Latin, and σχήματα/schēmata, in Greek; refer to Corso, 2018, 49). In the case of Vitruvius, the manuscript tradition does not preserve the drawings. Early and still-extant examples of this revival of technical drawings can be seen in the thirteen-century sketchbook by Villard de Honnecourt (refer to Barnes, 2009), Guido da Vigevano’s Texaurus regis Francie (dated 1335; refer to Settia, 2004); Giovanni de la Fontana’s Bellicorum instrumentorum liber, cum figuris et fictitiis literis conscriptus (ca 1420; refer to Birkenmajer, 1932; Sparavigna, 2013), Mariano of Jacopo, also known as il Taccola’s De ingeneis (1419-1449; refer to Shelby, 1975; Prager, & Scaglia, 1971) and De Machinis (1449; refer to Shelby, 1975; Scaglia, 1971), Roberto Valturio’s De re militari (1460; refer to Valturio, 1472; Fiore, 1978, 33-34); Antonio of Pietro Averulino, also known as Filarete’s Libro architettonico (“Architectonic book”, ca 1464), and Francesco Maurizio di Giorgio di Martino’s manuscripts of the Trattato di architettura, ingegneria e arte militare (“Treatise on architecture, engineering and warfare”; refer to Fiore, 1978; Galluzzi, 1991, Fiore, 1992; Biffi, 1997, 532-535: Il corpus martiniano).

Francesco di Giorgio Martini’s Trattato was one of the major works of the Italian Renaissance (Promis, & Saluzzo, 1841, 5-10; Maltese, & Maltese Degrassi, 1967, xi-1xvi; Fiore, 1978, 142-152; Marani, 1979, xi-xv; Mussini, 1991, 58-136; Merrill, 2013; Tapinassi, 2016, 33-62). This treatise focused on both civil and military architecture. It not only fully acquired the theoretical knowledge of antiquity transmitted by Vitruvius but also complemented the manuscripts with drawings that demonstrate a practical and didactic purpose (Bertocci et al., 2019).
Martini’s work is a career-long endeavour dated between 1472 and 1495 (refer to Papini, 1946, I; Luigi Firpo, in Marani, 1979, vii-ix; Scaglia, 1991; Mussini, 1991, 82-89; Payne, 1999, 89-110). The extant manuscripts are filled with practical guidance and theoretical exempla that construed architecture as a discipline rooted in arithmetic and geometry, and implemented through drawing (“disegno”), creativity (“ingegno”) and invention (“invenzione”); refer to Filippo Baldinucci (1681, 183-184, 265, 270, respectively). The architect, according to Martini, is an artist, inventor, and technician, and can earn this title only after years of study and on-site training (Scaglia, 1991, 62). Notwithstanding the numerous studies on Italian Renaissance treatises on architecture (see a literature review in Payne, 1999), in general, and Francesco di Giorgio Martini’s manuscripts on civil and military architecture and engineering, in particular (refer to Saluzzo, 1841; Reti, 1963; Maltese, & Maltese Degrassi, 1967; Scaglia, 1970; Marani, 1979; Mussini, 1991; Mussini, 1994; Biffi, 1997; Merrill, 2013; Lugli, 2015; Tapinassi, 2016); a comprehensive study that compares the drawings in different manuscripts is still lacking. This comparative study is needed to fully appreciate the value of the visual knowledge embedded and transmitted in the manuscripts and their relationship with the texts.

The authors of this paper filled this research gap developing an interactive application for *Engineering Historical Memory* (EHM), whose research team has been working on interactive on-line systems to empower Digital History with Artificial Intelligence and Machine Learning since 2007\(^1\). This paper approaches manuscript materials that have depicted objects, which is one of the main EHM research foci, and aims to pioneer a method that can be adopted by both scholars in the humanities (e.g., codicology, palaeography, history, architecture, art history, philosophy) and practitioners in the creative industry to unlock and map the complex and usually complementary relationships between texts and images in science, technology, and medicine manuscripts.

In this context, the current paper presents the preliminary results of the ongoing research started by the authors in Florence and Singapore to study the objects depicted in Renaissance Treatises on Architecture in 2019. For a synopsis on the relationships among all extant Martini’s manuscripts—which contain the translation of Vitruvius’ *De architectura* and original works on civil and military architecture and engineering—we refer to the study published by Marco Biffi in the *Annali della Scuola Normale Superiore di Pisa. Classe di Lettere e Filosofia* (Biffi, 1997, 532-535: *Il corpus martiniano*, which is based on and updates Maltese, & Maltese Degrassi, 1967, I, xvi-lxiv). On the next page, we propose a diagram to elucidate this matter (Fig. 1).

The project uses as a showcase Francesco di Giorgio Martini’s drawings of the Corinthian capital depicted in the non-autograph manuscripts Ashburnham 361 (Fig. 2; ff. 13v-14r; *Biblioteca Medicea Laurenziana*, Florence; dated ca 1482-1486; refer to Marani, 1979 and Mussini, 1994, with facsimile edition with diplomatic transcription; Scaglia, 1992, 154-160; Biffi, 1997, 535, for the date; Vecce, 2017, 93-95) and Saluzzo 148 (Fig. 3; ff. 14v-15r; *Musei Reali*, Turin; dated ca 1482-1486, with autograph corrections by Martini; refer to Maltese, & Maltese Degrassi, 1967 for the edition and the facsimile of the folios with drawings; Scaglia, 1992, 189-192; and Biffi, 1997, 535, for the date).

This second manuscript is of exceptional importance also because it was annotated by Leonardo da Vinci on folios 13v, 15v, 25r, 27v, 32r, 41r, and 44v between 1502 and 1504 (refer to Papini, I, 219-222; Vecce, 2017, 94-95). This is the only extant manuscript annotated by Leonardo that has been identified so far. However, Giuseppina Scaglia doubted that “Leonardo could have acquired a vellum manuscript. His library comprised mostly printed books, excepting a few manuscripts on paper” (Scaglia, 1997, 155). She argues that the manuscript was annotated by Leonardo when it was in the scriptorium of Monte Oliveto Maggiore, ca 1504 (Scaglia, 1997, 154).
The two manuscripts are copies of the so-called *Trattato I* (*"First Treatise"*), whose lost archetype was composed between 1478 and 1481 (refer to Biffi, 1997, 533, footnote 4, and 579, footnote 133) when Martini was working for Federico III da Montefeltro (refer to Papini, 1946, I, 127, 161). These are the only two items among Martini’s manuscripts that contain drawings of the Vitruvian narrative of the origin of the Corinthian capital.

The present paper is structured in four sections (including this introductory one and the conclusions) followed by acknowledgements (research collaborations and funding), and bibliographical references. Section 2 presents and discusses the drawings related to the Corinthian capital that are depicted in the two copies of *Trattato I* by Francesco di Giorgio Martini. Section 3 showcases how to create philologically correct 3D models of the drawings and decode their embedded narratives. Section 4 draws the conclusions about the pioneering of an interdisciplinary method to create 3D animated models and storytelling for both scholars in the humanities and practitioners in animation.

Fig. 1: Diagram of the corpus of the manuscripts of Francesco di Giorgio Martini drawn on Adobe Illustrator® by Zaqeer Radzi in November 2020. The description of the manuscripts is based on the work of Giustina Scaglia (1992, 43-50, 51-52, 53-55, 55, 58, 154-160, 189-192, 210-212, 251-258, 274-277) apart from *Codex Zichy*, whose description along with the structure of this diagram refers to Marco Biffi (1997, 535; Francesco di Giorgio Martini, 2002, *Introduction*). In this diagram, the relationship between *Codex Zichy* and *Trattato I* (refer to Mussini, 1991, 82-89) is labelled with a double-headed arrow accompanied by a question mark to indicate disagreement in scholarship: Scaglia (1992) dates *Codex Zichy* after *Trattato I* while Biffi (1997) dates *Trattato I* after *Codex Zichy*. For the fragments of the sketchbooks (entitled *Taccuino di viaggio* by Bartoli, 1914, I, pls. VI-IX), which is not included in Biffi’s diagram, also refer to Papini (1946, I, 46, and II, with the reproduction of all drawings in Figg. 16-26, 28, 29, 32-34, 36-40, 42, 43, 59-63, 65-68), Orfanos, 1973, 4-10, and Burns, 1994.
Fig. 2: Reduced-size image of folios No. 13, verso, and 14, recto, of Francesco of Giorgio Martini’s *Treatise on Civil and Military Architecture* (*Trattato I*) ink on parchment, held in the *Biblioteca Medicea Laurenziana* of Florence (MS Ashb. 361, ff. 54, 38.2-38.5x26.5cm) with a fragment in the *Biblioteca Civica* “Antonio Panizzi” of Reggio Emilia (MSS Reggiani A 46/9 bis, ff. 4, 35.2x26cm). Folio 13v has a note written by Leonardo da Vinci about the cylinder, which is dated ca 1504 (Scaglia, 1992, 154; Swetz, 2010): *El cilindro è un chorpo di fighura cholon-/ nale e lle sua opposite fronte son due cierchi / d’interpositio parallella. E infra li lor cientri / e infra li lor cientri s’asstende una linia [pa] / retta che passa per il meco della grossetta // del cilindro e termina nelli cientri / d’essi cierchi, la quale linia è ddetta / linia cie[n]trale e dalli antichi è detta assis* (“The cylinder is a shape of columnar form, and its opposite ends are two circles / parallel to each other. And between their centres a straight line stretches through the centre of its thickness // and ends in the centres / of the circles; this line is called / the ‘central line’, and ‘axis’ by the ancients”; critical transcription by Andrea Nanetti and English translation by John Melville Jones; for a diplomatic transcription, refer to Marani, 1979, 115). Folios 13v and 14r are endowed with 16 and 9 drawings, respectively, which are disposed along the left margin, below the text as well as in the right margin of both folios. The drawings refer to the classical architectonic orders described in chapters LII and LIII of the treatise: *l’origine e ragione de le chollo[ne] (the origins and characteristics of columns”*; f. 13r, Ch. LII, ll. 1-2). The proportions of the Corinthian order are represented in the four columns on the upper left and in the head in the bottom right of f. 13v. The four columns show the design of the modular scheme of the order (refer to Migliari, 1994). One column shows the module (M) referred to the diameter of the column itself: base ½ M; barrel 7+½ M; capital 1M; for a total of 9 modules in height. The method for drawing the double entasis of the shaft of the column is represented in another drawing which shows how the entire column is proportionate to the human figure (base = feet; shaft = body; capital = head). — The digital photographic documentation (RAW files) was made by the University of Florence in 2019 (DIDALABS, photographer Matteo Bigongiari; refer to Bertocci, Pivetta, & Bigongiari, 2019); NIKON D850. Adobe Bridge Camera Data of the original .nef files acquired in the visible spectrum: camera NIKON D850, lens 24mm f/1.8, f/9.0 1/60, ISO100, Untagged RGB, 48.49 MB, 300dpi, 8256 x 5504; Data Time Original 09/08/2019). The image reproduced here has been colour calibrated with Adobe Camera Raw® and resized on Photoshop® by Oen Weng Wah Nicholas at the School of Art, Design and Media in Nanyang Technological University, Singapore in 2020. Adobe Camera Raw allowed to tweak the colours and other properties of the image. Thus, the user experience of the reduced-size images is closer to the original manuscript in its library setting under natural lighting. This colour calibration is based on the Color Rendition Chart (CRC) placed by the photographer on the right side of the original digital image of the manuscript, which has been cropped in this reproduction. © Florence, *Biblioteca Medicea Laurenziana*. Published with permission (“su concessione del Ministero dei beni e delle attività culturali e del turismo, MIABCT - BML - Prot. 2709/28.13.10.01/2.29”). See Saluzzo, 1841; Maltese, & Maltese Degrassi, 1967; Marani, 1979; Mussini, 1991; Mussini, 1994; Biffi, 1997.
2. Analysis of the relationship between texts and drawings related to the Corinthian capital in “Trattato I” by Francesco di Giorgio Martini

In the first century BCE, the Roman architect, civil and military engineer Marcus Vitruvius Pollio (ca 80-70 BCE – post ca 15 BCE) reported about the origin of the Corinthian architectural order in his De architectura libri decem (“The Ten Books on Architecture”, Book IV, Ch. 1. The Origins of the Three Orders, and the Proportions of the Corinthian Capital, 8-12; English translation by Morgan, 1914; based on Vitruvius Pollio, 1912). Francesco di Giorgio Martini embedded the translation of these excerpts in Chapter LII of Trattato I (Fig. 2, MS Ashb. 361, ff. 13v-14r; Fig. 3, MS Sal. 148, ff. 14v-15r; Marani, 1979, 28-29) and added to the page several drawings related to the Corinthian capital.

According to Martini’s translation of Vitruvius, “[8.] Ma el terzo [ordine], el quale corinzio si chiama, virginali imitazione di sottilità ha, perché le fanciulle per la tenera età con più sottili membri figurate e l’effetto più venusto innello ornato riceve”³ (Figg. 4c, 5c, 6).

³ [8.] Tertium vero, quod Corinthium dicitur, virginalis habet gracilitatis imitationem, quod virginis propter aetatis teneritatem gracilioribus membris figuratae effectus recipient ornatus venustiores. ”[8.] The third order, called Corinthian, is
The translation continues. “[9.] D’esso capulo la prima invenzione si commomora essere fatto. Una fanciulla cittadina a Chorintio, già da marito, amalata mori; doppo la sua sipoluita in un orto innel quale lei, in vita, si dilettava, la balia assettata e conposta, in un piramidale canestro, di terra pieno, alla sipulitura la portò e pòsela in sommità; acciò che llei più longo tempo al sereno stesse cor una sopra posta tegola coverse. E questo cesto a caso e fortuna posto sopra alla radice d’un erba chimata l'acanto, in questo mezzo, oppressa la radice per lo sopra posto peso, le foglie e mmezzo a’ ramustelli, sicondo la larghezza dell’acanto dagli angoli e peso de la tegola con ristretti piegamenti inell’estreme parti degli angoli e voluti fero” 4. (Figg. 4c, 5c, 6).

Martini’s drawing of a female body (Figg. 4c, 5c) reflects and combines in one single image both the maiden’s slenderness of the Corinthian architectural order (paragraph 8) and the iconographic element of the calathus that inspired this new architectural order to the Greek architect and sculptor Callimachus (paragraph 9). To do so, the basket is represented in an elongated form to be able to hold the entire figure of the maiden. In Vitruvius the calathus (Greek κάλαθος/κάλαθος, a vase-shaped basket with a flat top, made by weaving together reeds or twigs; refer to the Oxford English Dictionary, online), which was put on an acanthus root by the dead maiden’s nurse incidentally, contained “a few little things that used to give the girl pleasure while she was alive”. Instead, in Martini’s translation, the “basket in the shape of a pyramid” (piramidale canestro) is “full of dirt” (di terra pieno). Thus, it makes sense that the acanthus leaves sprout from inside out the entire length of the basket and give the idea that the plant was growing inside the basket itself.

Comparing the Latin text and Martini’s Vernacular Italian translation to the drawings of

the capital, we can highlight the misunderstanding that fed Martini’s visual interpretation of the Corinthian capital. In Martini’s drawings (Figg. 4b, 5b), the acanthus leaves grow between the abacus and the ovolo, from inside the basket, following his translation (el cesto colle foglie che d’esso escia), “the basket with the leaves coming out of it”), instead of growing around a calathus as described in Vitruvius (eum calathum et circa foliorum nascentem teneritatem, “the basket with the tender young leaves growing round it”).

This interpretation seems to be due to the Corinthian capitals that Martini saw around him. In Martini’s time, Vitruvius’ description of the Corinthian capital was usually associated with both Corinthian and Composite capitals. The differentiation among these two architectural orders, already identified by Leon Battista Alberti, was formalised by Sebastiano Serlio later in the sixteenth century (Serlio, 1537, vi, five orders; Ch. VIII, Corinthian order; Ch. IX, Composite Order).

Before and during the composition of Trattato I, as documented by his sketches of antiquities preserved in the Galleria degli Uffizi (Florence), Martini saw ancient Corinthian capitals, among others, close to Spoletto (Temple of Clitumnus; Uffizi, 321 A, verso; reproduced in Papini, 1946, II, 22), and in Tivoli (Hadrian’s Villa; 319 A, recto; Papini, 1946, II, 38).

In Rome, Corinthian capitals were visible in the temples of the Roman imperial fora, which were a must for anyone who visited the eternal city (e.g., Filippo Brunelleschi, 1402-1404; Bruschi, 1998). However, numerous models were available also in Siena and Florence, where the reuse of classical finds in construction sites widespread since the Middle Ages. This practice occurred especially in Florentine Romanesque architecture where, in addition to the reuse, ancient discoveries were also taken as a model and replicated with the

an imitation of the slenderness of a maiden; for the outlines and limbs of maidens, being more slender on account of their tender years, admit of prettier effects in the way of adornment”.

4 [9.] Eius autem capituli prima inventio sic memoratur esse facta. Virgo civis Corinthia iam matura nuptiis implicata morbo decessit. Post sepulcraum eius, quibus ea virgo viva pupulis delectabatur, nutrix collecta et composita in calatho pertulit ad monumentum et in summo conlocavit et, uti ea permanerent diutius subdiu, tegula text. Is calathus fortuito supra acanthi radicum fuerat conlocatus. Interim pondere presa radix acanthi media folia et cauliculus circum vernum tempus profudit, eiusi cauliculi secundum calathii latera crescentes et ab angulis tegulae ponderis necessitate expressi flexuras in extremas partes voluturar facere sunt coacti. “[9.] It is related that the original discovery of this form of capital was as follows. A free-born maiden of Corinth, just of marriageable age, was attacked by an illness and passed away. After her burial, her nurse, collecting a few little things which used to give the girl pleasure while she was alive, put them in a basket [i.e., calathus], carried it to the tomb, and laid it on top thereof, covering it with a roof-tile so that the things might last longer in the open air. This basket happened to be placed just above the root of an acanthus. The acanthus root, pressed down meanwhile though it was by the weight, when springtime came round put forth leaves and stalks in the middle, and the stalks, growing up along the sides of the basket, and pressed out by the corners of the tile through the compulsion of its weight, were forced to bend into volutes at the outer edges”.
consistency of shapes and proportions. For instance, in Florence, in the Baptistery of St John, there are reused Corinthian capitals (De Angelis d’Ossat, 1962). In the nave of the Basilica di San Miniato al Monte, there are large Corinthian capitals that come from remains of Roman Florentia and eleventh-century replicas of pseudo-Corinthian capitals that are similar to the classical ones (Gurrieri et al., 1988, 39-41). In the façade of the same basilica (Fig. 7a), in the basement order, there are capitals similar to the drawings of the two earliest copies of Trattato I.

The translation goes on with the tale of Callimachus. “[10] Allora Chalimacco el qual’è per la leganza de l’arte marmoria, passando a questa Callimachus, whom the Athenian s called κατατηξἱτεχνος for the refinement and delicacy of his artistic work, passed by this tomb and observed the basket [i.e., calathus] with the tender young leaves growing round it. Delighted with the novel style that inspired him the Corinthian capital was finished as they ought to be”.

The two following paragraphs are about the proportions of the capital. “[11] La misura d’esso capulo così è da fare, che quanta sarà la grossezza della colonna tanto sia l’altezza del capulo co la tavola dell’abaco. L’altezza dell’abaco tanta due sonno quanta è la stremitè di dentro della sommità de l’angolo a l’angolo, con si giuste fronti abbinò verso le fronti della larghezza missura di dentro dalli stremi angoli dell’abaco. (Figg. 4a, 4b, 5a, 5b, 7). “[12.] E tanta grossezza della larghezza di sua fronte a uno capulo quanta alla somma colonna. E la gola dell’abaco grossezza settima de l’altezza del capulo; tolto la grossezza dell’abaco si dividi l’altra in parti tre, le quali a le foglie si dia mezza latitudine. Tenghi innegli angoli quelle de’ voluti che l’una a l’altra precorre. E i mmezo la curvatura dell’abaco e fiori vi si scolpischino in quatro parti quanto serà la grossezza d’esso abaco. In queste misure e capuli corinti abbinò e suoi tratti e misure”.

The practical information about the proportions of the capital provided by Vitruvius in the above two paragraphs is reflected in the drawing where a hairless head of a man is superimposed on the capital to stress the derivation of the canonical architectural orders

contrariamente, a destra per le prove del pianto. [12] Omitting the height of the abacus , the height of the capital, including its abacus, be given to the lowest leaf. Let the second leaf occupy the middle part of the height of the capital. “[12.] Omitting the height of the abacus, let the rest be divided into three parts, of which one should be given to the lowest leaf. Let the second leaf occupy the middle part of the column. Let the breadth of the abacus be proportioned so that diagonals drawn from one corner of it to the other shall be twice the height of the capitals, which will give the proper breadth to each face of the abacus. The faces should curve inwards, by one ninth of the breadth of the face, from the outside edge of the corners of the abacus. At the bottom the capital should be of the thickness of the top of the column omitting the congé and astragal. The height of the abacus is one seventh of the height of the capital.” [11.] The proportions of this capital should be fixed as follows. Let the height of the capital, including its abacus, be equivalent to the thickness of the base of a column. Let the breadth of the abacus be proportioned so that diagonals drawn from one corner of it to the other shall be twice the height of the capitals, which will give the proper breadth to each face of the abacus. The faces should curve inwards, by one ninth of the breadth of the face, from the outside edge of the corners of the abacus. At the bottom the capital should be of the thickness of the top of the column omitting the congé and astragal. The height of the abacus is one seventh of the height of the capital.” [12.] Omitting the height of the abacus, let the rest be divided into three parts, of which one should be given to the lowest leaf. Let the second leaf occupy the middle part of the column. Let the breadth of the abacus be proportioned so that diagonals drawn from one corner of it to the other shall be twice the height of the capitals, which will give the proper breadth to each face of the abacus. The faces should curve inwards, by one ninth of the breadth of the face, from the outside edge of the corners of the abacus. At the bottom the capital should be of the thickness of the top of the column omitting the congé and astragal. The height of the abacus is one seventh of the height of the capital.” [12.] Omitting the height of the abacus, let the rest be divided into three parts, of which one should be given to the lowest leaf. Let the second leaf occupy the middle part of the column. Let the breadth of the abacus be proportioned so that diagonals drawn from one corner of it to the other shall be twice the height of the capitals, which will give the proper breadth to each face of the abacus. The faces should curve inwards, by one ninth of the breadth of the face, from the outside edge of the corners of the abacus. At the bottom the capital should be of the thickness of the top of the column omitting the congé and astragal. The height of the abacus is one seventh of the height of the capital.” [12.] Omitting the height of the abacus, let the rest be divided into three parts, of which one should be given to the lowest leaf. Let the second leaf occupy the middle part of the column. Let the breadth of the abacus be proportioned so that diagonals drawn from one corner of it to the other shall be twice the height of the capitals, which will give the proper breadth to each face of the abacus. The faces should curve inwards, by one ninth of the breadth of the face, from the outside edge of the corners of the abacus. At the bottom the capital should be of the thickness of the top of the column omitting the congé and astragal. The height of the abacus is one seventh of the height of the capital.”
from the proportions of the human body (Figg. 7f, 7g, 7h). These drawings of the capital can be associated with the four representations of the general proportion of the whole column compared to the whole human body (Figg. 2, 3, upper left).

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**Fig. 4**: Enlarged-size detail of folio 13, verso, of Francesco of Giorgio Martini’s *Treatise on Civil and Military Architecture*, ink on parchment, held in the Biblioteca Medicea Laurenziana of Florence (MS Ashb. 361) with five drawings related to the Corinthian capital as described in chapter LII of the text of the treatise. **Fig. 4a. Pseudo-prospective view of the upper part of a column with a Corinthian capital**: from the bottom, we can see the upper part of the shaft with caption *Trochilo superficiale* (“Superficial trochile”, i.e., scotia, a concave moulding; refer to Shute 1563, sig. Diii). This element separates the shaft from the calathus (i.e., basket, aka inverted bell, with caption *I nudi de la champa[n]a*). (“The naked [volumes] of the bell”, i.e., the basic volume of the capital without acanthus leaves), where the leaves of acanthus typical of the Corinthian capital are not represented), an ovolo which is not present in classical Corinthian capitals but is typical of Roman capitals, defined later as Composite (refer to Fig. 8), and a concave abacus with the standard rosette in the middle. This drawing highlights the modular design of the composition of the capital and its details. **Fig. 4b. Pseudo-prospective view of the upper part of a column similar to the previous one**: this drawing is like Fig. 4a, except that the external acanthus angular volutes, which are a standard presence in Corinthian capitals, are placed above the ovolo and grow from inside the calathus. **Fig. 4c. The burial of the Corinthian maiden that, according to Vitruvius, inspired the Corinthian capital to Callimachus**: drawing of a rectangular oblong bier with short convex sides, topped by a typical flat Corinthian tile (refer to Corso, 2005). The naked corpse of a maiden lies in a bier made from a basket: she has both arms crossed on the belly. Leaves of acanthus surround both the bier and the tile. In the caption, *Ciesto de la supulta fanciulla posta sopra alla radicie de l’acanto* (“basket of the buried girl placed above the acanthus root”), on the right of the drawing, she is identified with the Corinthian girl who died before her wedding and whose tomb inspired the Corinthian capital to the sculptor Callimachus (refer to Vitruvius, *De architectura*, IV, 1, 9-10). Antonio Corso suggests that this figure is inspired by the statue of the so-called Medici Venus reproduced in Fig. 6. **Fig. 4d. Ideal portrait of the late-fifth-century-BCE sculptor Callimachus**: he is represented while he is striding, passing by the tomb of the Corinthian girl, which will suggest him the creation of the first Corinthian capital (refer to Wesenberg, 1999; Schhil, 1997). The caption near the mouth of the sculptor (*Chalimacco da Chorintio*) clarifies that character is Callimachus and specifies that he was a Corinthian: the latter information is not known from ancient testimonia and may have been argued from the location of the episode at Corinth. This geographical information is not reported in MS Saluzzo 148 (refer to Fig. 5d). The ancient sculptor appears as a Tuscan nobleman of the fifteenth century who holds his tunic the right hand and points the left hand to the maiden who inspired him the Corinthian capital. This representation of the episode may be the first of a long series of visual recreations of this anecdote throughout the Renaissance (refer to Giuliano, 1994). **Fig. 4e. Capital with superimposed head**: this drawing is made with different ink and possibly by another hand. In MS Saluzzo 148 (Fig. 3), it is placed in the next folio (Fig. 7g). The calathus is endowed with the canonical three rows of acanthus leaves. Between the calathus and the abacus, we see the angular volutes with the ovolo. A hairless head of a man is superimposed on the capital to stress the derivation of the canonical architectural orders from the proportions of the human body. Horizontal and vertical lines are superimposed as well. The capital and the head compose a modular grid to help the architect and give the ‘correct’ measures to the different parts of the capital.
Fig. 5: Enlarged-size detail of folio 14, verso, of Francesco of Giorgio Martini’s *Treatise on Civil and Military Architecture*, ink on parchment, held in the Musei Reali of Turin (MS Saluzzo 148) with four drawings related to the Corinthian capital as described in chapter LII of the text of the treatise. © Turin, Musei Reali. Published with permission (“Convenzione, 6 ottobre 2020”). **Fig. 5a. Pseudo-prospective view of the upper part of a column with a Corinthian capital:** for this drawing see the description in Fig. 4a. The captions are different: *Xofaro; Churvatura; Chanpana hover tanbuuro del chapulo* (“Zoophorus; Curvature; Bell or the capital as a modular element of the column”). As highlighted by Corrado Maltese and Livia Maltese Degrassi, the term *zofaro* (sic, read *xofaro*, i.e., *zophorus* or *zoophorus*, a continuous frieze bearing figures of men and animals carved in relief) is used improperly (Maltese, & Maltese Degrassi, 1967, I, 257).

**Fig. 5b. Pseudo-prospective view of the upper part of a similar column:** for this drawing see the description in Fig. 4b, except for the captions *cicrami* (“fronds”; refer to Giardini Pedro, 2011, 164, Figura 25, Figura 26) on the side of the left acanthus leaf and *Trochilo* (“trochile”, i.e., *scotia*, a concave moulding; refer to Shute, 1563, sig. Diii) below the lower astragal, which in MS Ashb. 361 is in Fig. 4a. **Fig. 5c. The burial of the maiden that, according to Vitruvius, inspired the Corinthian capital to Callimachus:** for this drawing see the description in Fig. 4c. The captions are different from the ones on MS Ashb. 361: *Tegola; Voluti; Chanestro piramidale; Radice et herba dell’achanto* (“Tile; Volutes; Basket in the shape of a pyramid; Root and plant of the acanthus”). **Fig. 5d. Ideal portrait of the late-fifth-century-BCE sculptor Callimachus:** for this drawing see the description in Fig. 4d, except for the caption *Chalimacco* (“Callimachus”) that is missing the reference to Corinth, and adds a stick in the right hand.
Fig. 6a: Enlarged-size image of the maiden from MS Ashb. 361. Fig. 6b: Enlarged-size image of the maiden from MS Saluzzo 148. Antonio Corso suggests that these drawings described Vitruvius, *De architectura* (IV, 1, 10) analytically may be inspired by the so-called Medici Venus presented in the following Fig. 6c. As highlighted by George Hersey (1998, 80, 83, figure 37), this rush basket drawing might have inspired one of the thirty monumental doors published by Sebastiano Serlio later in mid-sixteenth century (refer to Serlio, 1551, *Porte rustiche*, XX, in whose caption the author mentions that “in place of columns are herms dressed in woven rushes/in luogo di colonne sono termeni vestiti di gionchi tessuti”). *Fig. 6c*: marble statue (height 1.53m) of a naked Aphrodite *anadyoméne* (ἀναδυομένη, i.e., rising up) from the sea with a dolphin, which has the same configuration of the statue that, according to the *Commentarii* by Lorenzo Ghiberti (3.56, ed. Morisani), had been discovered in Siena in the fourteenth century, with an ancient inscription declaring that the statue is a copy from a work of Lysippus. The subject of the statue had been declared *inhonestum* (i.e., inappropriate) and thus, following a public decree of the republic of Siena, dated 7 November 1357, the statue had been removed from the territory of Siena and placed in that of Florence. Probably it should be identified with the marble statue of naked Aphrodite with an arm brought near her breasts and another toward her pubes, which in the 1370s was kept in a house of Florence, where it had been seen by Benvenuto Ramhaldì da Imola (*Comentum super Dantis Aldigherij Comœdiam*, Purgatorio, X, 32). In Florence, the statue, clearly brought from Siena without the base with the signature of Lysippus, was attributed to Policleitus or Praxiteles. Ghiberti specifies that a drawing of this statue by Ambrogio Lorenzetti was available in Siena still in the 1440s (refer to Cittadini, 1997). The description of the Siena statue made by Lorenzo Ghiberti is corroborated Benvenuto Ramhaldì da Imola. It seems to be a Medici-type Aphrodite because the dolphin near the leg was explicitly mentioned by Ghiberti and Benvenuto reports the posture of the arms of the statue. This type statuary derives from the Aphrodite of Sicione by Lysippus (refer to the coin published by Cittadini, 1997, 64, Figure 17), and is known from several Roman copies found in Italy whose most famous example is precisely so-called Venus de’ Medici or Medici Venus. The commentary about this figure has been provided by Antonio Corso in November 2019. © Florence, Galleria degli Uffizi (refer to Mansuelli, 1958-1961, I, 71-73. The image comes from a postcard retrieved from Arstore via the online Library Services of Nanyang Technological University Singapore on 30 October 2020, URL: https://library.artstor.org/#/asset/SS35428_35428_39710260;prevRouteTS=160336668192
Fig. 7: **Comparisons and associations** between Martini’s drawings, visual experiences, and construction sites related to the Corinthian/Composite capital. The capitals drawn in these manuscripts are not the exact visual representation of the Corinthian capital as described analytically by Vitruvius, *De architectura* (IV, 1, 11-12). Francesco di Giorgio Martini could have seen ancient Corinthian and Composite capitals in the places in which he was before and during the composition of *Trattato I* (refer to Fig. 1), not only in Tuscany (e.g., Siena, Florence), but also, for example, in Spoleto (Temple of Clitumnus) and Tivoli (Hadrian’s Villa) as witnessed by the fragments of his sketchbooks (refer to Papini, 1946, I, 46, II, 16-29, 32-40, 42, 43). **Fig. 7a:** *Detail of a Composite capital from the façade of the Basilica di San Miniato al Monte (Florence, Italy)*. Image retrieved on 30 October 2020 from the ArtStor web repository via the online Library Services of the Nanyang Technological University Singapore, URL: https://library.artstor.org/#/asset/SCALA_ARCHIVES_1039779756;prevRouteTS=1604122305890. **Fig. 7b:** *Detail of a Composite capital from the Cloister of Sixtus IV* dated 1474-1476 (by Baccio Pontelli, disciple and collaborator of Martini, refer to De Fiore, 1963; Fiore 2019; *Basilica di San Francesco*, Assisi, Italy). Photograph taken by Stefano Bertocci, with permission. **Fig. 7c:** *Detail of a Composite capital from the Cortile del Palazzo Ducale di Urbino* (Italy) dated 1478-1481 (designed by Martini, refer to Papini, 1946, I, 143-159, II, 145-151, III, Tav. XXVII). Photograph taken by Stefano Bertocci, with permission. **Fig. 7d:** *Enlarged-size image of the capitals from MS Ashburnham 361, f. 13v* (for a detailed description see **Fig. 4a, 4b**). **Fig. 7e:** *Enlarged-size image of the capitals from and from MS Saluzzo 148, f. 14v* (for a detailed description see **Fig. 5a, 5b**). **Fig. 7f:** *Capital with superimposed head (profile view)* from MS Ashburnham 361, f. 13v (for a detailed description see **Fig. 4e**). **Fig. 7g:** *Capitals with superimposed heads (profile and three-quarter views)* from MS Saluzzo 148, f. 15r. On the relationship between the capital ([Greek κεφάλιον/kephálion, κεφαλίς/kephalís, head]) and the human head in Vitruvius’ *De Architectura* (III, 1, 2) and in Francesco di Giorgio Martini’s *Trattato I*, refer to George Hersey (1998, 88). **Fig. 7h:** *Capital with superimposed head (three-quarter view)* associated with the above technical drawing of a full column (plan and front view, with caption *Missure e proporzion dell’ forma del capitello, “Measures and proportions of the formation of the capital”*, from MS Ashburnham 361, f. 15r (N.B.: in MS Saluzzo 148, f. 16r, the drawing of the same column does not have the profile view of the head below, which is in f. 15r). In the drawings, horizontal and vertical lines show that the different mouldings of the order follow ideal proportions of the human head (chin-nose, nose-eyes, eyes-front). The capital and the head compose a modular grid to help the architect and give the ‘correct’ measures to the different parts of the capital.
Fig. 8: Drawings for the interpretation of the decoration of the Corinthian and Composite capital by Stefano Bertocci that has been used as a base to decompose the volumes for the 3D modelling. Francesco di Giorgio Martini, in line with the fifteenth-century literature, depicts capitals that will be called Composite in the sixteenth-century treatises on architecture (refer to Serlio, 1537, vi, for the five orders; Ch. VIII, Corinthian Order; Ch. IX, Composite Order).

3. Creating philologically correct 3D models, decoding their embedded narratives, and connecting knowledge via EHM

To create a philologically correct 3D model of this capital, the authors applied the method (i.e., systematic procedure) developed and tested by Andrea Nanetti and Davide Benvenuti to generate 3D animated visualisations able to improve upon 2D visualisation methods of the ships depicted on the Fra Mauro’s map of the world (Nanetti, & Benvenuti, 2019, 37-41).

This method—which took into consideration the most recent best practices in the field of digital representation of historical architectural elements (e.g., De Paoli, & Capone, 2015; Luo et al., 2018; Piñero Vega et al., 2019; Valzano, Negro, & Lucarella, 2019)—was designed to create 3D models able to visualise different sets of information embedded in drawings and stimulate the discussion without inferring any final interpretation of the picture itself.

However, as demonstrated in Section 2, Martini’s drawings have further elements of complexity. They reflected information retrieved from both classical texts and ancient architectures and served as theoretical foundation for real artefacts that he realised in his construction sites (Fig. 7). As a starting point to investigate this series of relationships visually, the authors chose one drawing of a capital depicted in MS Ashb. 361 (Fig. 4b) and explored it through the following consequential series of complementary 3D models and animations.
1) Visual translation of Vitruvius’ narrative of the origin of the Corinthian capital (De Architectura IV, 1, 9; refer to the commentary here above in Section 2) to be used as a preliminary and tentative template.

2) Visualisation of the decomposition of the basic volumes of ideal Corinthian and Composite capitals (Fig. 8) to be used as preliminary and tentative templates.

3) Non-Photorealistic Rendering (NPR) of the drawing as it is depicted in MSS Ashb. 361 (f. 13v; Fig. 4b) and Sal. 148 (f. 14v; Fig. 5b).

4) Visual translation of the proportions of the ideal Corinthian capital as described in Vitruvius’ De Architectura (IV, 1, 11-12) and translated into Vernacular Italian by Martini in Trattato I (Ch. LII).

5) Photo-realistic visualisation of still-existing Corinthian capitals on which Vitruvius possibly based his description (e.g., late-fourth-century-BC Corinthian capitals of the Skopas-temple in Tegea, temple of Zeus in Nemea, Peloponnes, Greece).

6) Photo-realistic visualisation of still-existing sets of ancient capitals available in the Basilica di San Miniato al Monte (Florence; see Section 2).

7) Photo-realistic visualisation of still-existing sets of capitals available from construction sites of Martini’s disciples and collaborators (e.g., Cloister of Sixtus IV dated 1474-1476 and made by Baccio Pontelli’s Cloister of Sixtus IV dated 1474-1476 in Basilica di San Francesco, Assisi, Italy; Fig. 7b).

8) Finally, a short-format animated film, which can be construed as a video knowledge aggregator, shows all the information about the Corinthian capital investigated by the research team (see storyboard in Fig. 10).

Each of the above products is available on the website of the Engineering Historical Memory (EHM) project, where the user can explore the earliest copies of Martini’s Trattato I (MSS Ashb. 361 and Sal. 148) and its related scholarship, activate the 3D objects, aggregate relevant secondary resources (publications, images, videos, and news) in real-time, and save the results on a personalised notebook.

Fig. 9a: Screenshot of the Autodesk® Maya® Viewport 2.0 interface showing the 3D geometry and topology of the assembled Corinthian capital with all the basic volumes as drawn in MS Ashb. 361, f. 13v (refer to Fig. 4b). Fig. 9b: Screenshot of the Pixologic® ZBrush® interface with the image of the 3D model that interprets the acanthus leave on the top-left of Fig. 4b. Fig. 9c: Screenshot of the Autodesk® Maya® Viewport 2.0 render showing at work the Maya Non-Photorealistic Rendering (MNPR) plug-in developed by Santiago Montesdeoca (Montesdeoca, 2018, 131-140), which, here, is applied to the model in an early iteration to simulate a 3D interpretation of the Fig. 4b.
Fig. 10: Storyboard that aggregates information about the Corinthian capital collected by the research team from heterogenous sources, such as the drawings of MS Ashb. 361, f. 13v (Fig. 4), some still-existing artefacts available to Martini (Figg. 6c, 7a), designed by Martini and his collaborators (Figg. 7b, 7c), and the text of Vitruvius’ *De architectura* (IV, 1, 10).

4. Conclusions

For the modelling of the volumes of the Corinthian capital, the research team collected, analysed, and compared different sources of information (texts, drawings, monuments) with philological, art historical, and animation methods visually. The results of this research have been shared in the present paper and merged into digital products available online in the interactive system *Engineering Historical Memory* (EHM).

In EHM, these digital objects are empowered by the EHM search tool, which automatically links them to relevant secondary sources of information (scholarly publications, images, videos, and news) in real-time. The EHM system is also a tool to automatically trace the provenance and validate the information aggregated in the digital products.

Since its initial stages, the research highlighted that the drawings could not be construed as a simple visual interpretation of Martini’s translation into Vernacular Italian of Vitruvius’ excerpts. Thus, to map and decode the visual information and knowledge embedded in the drawings, the authors undertook an investigation on what Martini might have absorbed from both monuments available in the places in which he lived and visited, and the
experience of the construction sites in which he was involved.

The 3D visualisation of the drawings related to the Corinthian capital in two of the earliest copies of Francesco di Giorgio Martini’s *Trattato I* (MS Ashburnham 361, Fig. 2; MS Saluzzo 148, Fig. 3) demonstrated that digital animation could be an effective tool to visually investigate and reverse engineer their creative process and produce philologically correct 3D models of the depicted objects. This kind of objects can not only be displayed in different creative platforms but also contribute to the advancement of learning in the study of Renaissance treatise on civil and military architecture.

The interdisciplinary method described in this paper can be adopted by both scholars in the humanities and practitioners in animation to map and decode the knowledge embedded in drawings depicted not only in Renaissance treatises on architecture but in science, technology, and medicine manuscripts at large.

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