# DATA PROCESSING OF "THE DECAMERON" BY GIOVANNI BOCCACCIO – FOR THE 700th YEAR OF HIS BIRTH

Tamara Bellone [(1)], Luigi Mussio [(2)], Chiara Maria Porporato [(1)]
[(1)] Politecnico di Torino – DIATI – Corso Duca degli Abruzzi, 24 – 10129 Torino
Tel. 011-564-7709 – Fax 011-564-7699 – e-mail tamara.bellone@polito.it / chiara.porporato@polito.it
[(2)] Politecnico di Milano – DICA – Piazza Leonardo da Vinci, 32 – 20133 Milano
Tel. 02-2399-6501, Fax. 02-2399-6602, e-mail luigi.mussio@polimi.it

**Introduction**

The Authors, in the 700th year from the birth of Giovanni Boccaccio, intend to celebrate the event by their proper means: statistical, numerical, computing, cartographic techniques, as used in Geomatics.

As the Decameron novels record time, places, itineraries, it's easy to put in evidence the latter (with further evolution of synthesis of results).

Boccaccio's world, from the cartographic viewpoint, is not the one of T-O maps, but the one of portolanos for travelers and merchants.

Most of the medieval maps have a general "TO" shape. The "O" means the outer ring of waters, the Ocean, which encloses the lands; the "T" is the general shape of the three continents, as related to the three sons of Noah. Indeed, in the Middle Age, the Earth was thought of as a globe mainly covered with water, with a number of islands comparatively small, a part of which was Oekoumene. So, it was thought as possible a plane representation of Oekoumene. This type of maps is clearly related to the views of Augustine about the City of God: evidently, the will of God has placed Christians at the centre of Oekoumene, as non- Christian peoples are relegated in outer spaces, even at boundary of non-human beings.

Boccaccio's world is the one of Florentine merchants. Ptolemy's Geographia had been translated from Greek to Arabian language in the IX century; later a latin translation was made available in the early XIV century. Obviously Boccaccio could not know about Geographia, however, in the period of Napolitan apprenticeship, he was very interested to Mathematics and Astronomy, having as instructors Andalò del Negro and Paolo dell'Abaco, respectively. So, Boccaccio also wrote about Geography (*De Canaria et insulis reliquis ultra Hispaniam in Oceano noviter repertis* (1342), and *De montibus, silvis, fontibus, lacubus, fluminibus, stagnis seu paludibus et de diversis nominibus maris* (1374).

However, we also mean to have an interface between Geomatics and Humanistics, for hybridation of different areas.

## GEOGRAPHY

### Places and travels [1]

1th day:

1th tale: Prato, Paris, Burgundy, Tuscany
2nd tale: Paris, Rome, Paris
3rd tale: Babylon, Alexandria
4th tale: Lunigiana
5th tale: Monferrato, Genoa, France, Genoa
6th tale: Florence

[1] In addition to reading the tales, the following web page has been consulted: http://it.wikipedia.org/wiki/Struttura_del_Decameron.

7th tale: Paris, Cluny, Verona, Paris
8th tale: Genoa
9th tale: Gascony, the Holy Land, Cyprus
10th tale:Bologna

2nd day:

1th tale: Treviso, Florence
2nd tale: Asti, Bologna, Ferrara, Castel Guglielmo (province of Rovigo), Verona
3rd tale: Florence, England & London (with several returns to Florence), Florence, Rome, Bruges, Florence, Paris, England and Cornwall, Florence, Scotland
4th tale:Reggio Calabria, Gaeta, Salerno, Ravello, Amalfi, Cyprus, Aegean Sea, Sea of Constantinople, Kefalonia, Island of Gurfo (present-day Corfu), Brindisi, Trani
5th tale: Perugia, Naples, Sicily, Palermo, Agrigento, Perugia (with several returns to Siciily), Naples, Perugia
6th tale: Sicily, Benevento, Naples, Lipari, Ponza, Mouth of the Magra & Lunigiana, Genoa, Alexandria, Sicily & Palermo, Lerici
7th tale: Babylon, Gharb (Island of Malta), Alexandria, Sardinia, Majorca, Peloponnese (Chiarenza, Empire of Romania), Athens, Aegina, Chios, Smyrna, Cappadocia, Rhodes, Cyprus with Paphos and Famagusta, Armenia, Jerusalem, Alexandria, Crete, Acquamorta (present-day Monte di Procida), Borgo San Lorenzo
8th tale: Antwerp, Calais, London, Stanford, Wales, Ireland, London, Paris
9th tale: Paris Genoa, Albissola, Acre, Alexandria
10th tale:Pisa, Ravenna, Leghorn, Monaco, Pisa

3rd day:

1th tale: Florence, Lamporecchio (province of Pistoia)
2nd tale: Pavia, Lombardy
3rd tale: Florence, Genoa
4th tale: Florence, Paris
5th tale: Pistoia, Milan
6th tale: Naples
7th tale: Florence, Ancona, Cyprus, Lunigiana and Pontremoli
8th tale: Tuscany, Purgatory (as believed, being alive)
9th tale: Narbonne, Paris, Montpellier, Roussillon, Florence
10th tale:Barbary (modern-day Tunisia) with Capsa, deserts of Thebais (Egypt)

4th day:

1th tale: Salerno
2nd tale: Imola, Venice, Assisi, Flanders
3rd tale: Provence and Marseilles, Spain, Crete and Candia, Rhodes
4th tale: Sicily, Barbary (modern-day Tunisia) with Tunis and Carthage, Sardinia, Granada, Messina, Ustica
5th tale: Messina, Naples
6th tale: Brescia
7th tale: Florence
8th tale: Florence, Paris
9th tale: Provence
10th tale:Salerno, Amalfi

5th day:

1th tale: Cyprus, Rhodes, Crete
2nd tale: Lipari, Tunis, Sousse (in Tunisia), Granada
3rd tale: Rome, Anagni, Rome
4th tale: Valbona (hamlet of Berceto, province of Parma, or of Collagno, province of Reggio Emilia)
5th tale: Pavia, Cremona, Romagna and Faenza, Fano
6th tale: Procida, Scalea, Ischia, Palermo
7th tale: Trapani, Armenia, Trapani, Rome
8th tale: Ravenna, Classe (province of Ravenna), Hell, Ravenna
9th tale: Tuscany, Campi Bisenzio, Florence

10th tale:Perugia

6th day:

1th tale: Florence
2nd tale: Rome, Florence
3rd tale: Florence, Barcelona
4th tale: Florence, Venice
5th tale: Mugello, Florence
6th tale: Florence
7th tale: Prato
8th tale: Florence
9thtale: Florence
10thtale:Certaldo, Venice, Florence, (imaginary) lands of Truffia, Buffia and Menzogna, Abruzzo region, India, Florence

7th day:

1th tale: Florence, Fiesole, Florence
2nd tale: Naples
3rd tale: Siena
4th tale: Arezzo
5th tale: Rimini
6th tale: Florence
7thtale: Paris, Bologna
8th tale: Florence
9th tale: Argos (Peloponnese)
10th tale:Siena, Hell

8th day:

1th tale: Prato, Milan, Genoa
2nd tale: Alexandria, Avignon, Florence
3rd tale: Florence, Berlinzone (the imaginary Land of Bengodi), Faenza
4th tale: Fiesole
5th tale: Florence
6th tale: Florence
7th tale: Paris, Florence, Valdarno, Paris
8th tale: Siena
9th tale: Florence, Forlimpopoli, Laterina (province of Arezzo), Bologna
10th tale:Palermo, Salerno, Monaco, Naples, Florence, Ferrara

9th day:

1th tale: Florence, Pistoia
2nd tale: Lombardy
3rd tale: Florence
4th tale:March of Ancona, Buonconvento (province of Siena), Siena, Torrenieri (hamlet of Montalcino), Corsignano (hamlet of Pienza)
5th tale: Florence, Camaldoli, Florence
6th tale: Florence, Romagna, Florence
7th tale: Molese (the area of Mola di Bari), Florence
8th tale: Florence
9th tale: Jerusalem, Antiochia, Lajazzo (today Ayas in Turkey)
10th tale:Barletta, Tresanti (province of Florence), Bitonto

10th day:
1th tale: Tuscany, Spain, Tuscany
2nd tale: Cluny, Rome, Siena, Radicofani (province of Siena), Rome
3rd tale: Genoa , Cathay (today China)
4th tale: Bologna, Modena, Persia, Bologna

5th tale: Friuli, Udine
6th tale: Florence, Castellammare di Stabia, Naples, Apulia
7th tale: Sicily, Aragon, Palermo, Arezzo, Paradise
8th tale: Rome, Athens, Rome
9th tale:Babylon, Lombardy, Milan, Pavia and the river Ticino, Cyprus, Paris, Alexandria, Pavia, Genoa, Acre, Alexandria, Crete, Sicily, Pavia
10th tale:Saluzzo, Bologna, Rome, Saluzzo, Bologna

**Places of the "Hearth"** [2]

| | |
|---|---|
| | Abruzzo |
| | Acquamorta (present-day Monte di Procida) |
| 2 | Acri (1) |
| | Agrigento |
| | Albissola |
| 8 | Alexandria (2) |
| 2 | Amalfi (3) |
| | Anagni (4) |
| | Ancona (5) |
| | Antiochia (6) |
| | Antwerp |
| | Aragona |
| 2 | Arezzo |
| | Argo (Peloponnese) |
| 2 | Armenia (7) |
| | Assisi |
| | Asti (8) |
| 2 | Athens (9) |
| | Avignone |
| 3 | Babylon |
| 2 | Barberia (modern day Tunisia) |
| | Barcelona |
| | Barletta (10) |
| | Benevento |
| | Berlinzone (Land of Bengodi) |
| | Bitonto (11) |
| 8 | Bologna (12) |
| | Borgo San Lorenzo |
| | Burgundy (13) |
| | Brescia |
| | Brindisi |
| | Bruges |
| | Buonconvento (province of Siena) (14) |
| | Calais (15) |
| | Campi Bisenzio |
| | Candia (Island of Crete) |
| | Cappadocia |
| | Capsa (Tunisia) (16) |
| | Carthage |
| | Castel Guglielmo (province of Rovigo) |
| | Castellammare di Stabia (17) |
| | Cathai (today China) |
| | Cephalonia (18) |
| | Certaldo, Garbo (province of Florence) |
| | Chiarenza (Romania, Peloponnese) (19) |
| | Chios (20) |
| 6 | Cyprus (21) |
| | Classe (province of Ravenna) (22) |
| 2 | Cluny (23) |
| | Corfu (formerly island of Gurfo) (24) |
| | Cornwall |
| | Corsignano (hamlet of Pienza) (25) |
| | Constantinople (Sea before … ) (26) |
| | Cremona |
| 4 | Crete (27) |
| | deserts of Thebais (Egypt) (28) |
| | Aegina (29) |
| 2 | Faenza (30) |
| | Famagosta (31) |
| | Fano (32) |
| 2 | Ferrara (33) |
| | Flanders |
| 2 | Fiesole (34) |
| 45 | Florence (91) |
| | Mouth of the Magra |
| | Forlimpopoli |
| | France (35) |
| | Friuli |
| | Gaeta |
| | Weles (36) |
| 8 | Genoa (37) |
| 2 | Jerusalem (38) |
| | Gharb (Island of Malta) (39) |
| 2 | Granada |
| | Gascony (40) |
| | Imola (41) |
| | India |
| 2 | The Hell (42) |
| 2 | England |
| | Ireland (43) |
| | Ischia (44) |
| | Laiazzo (today Ayas in Turkey) (45) |
| | Lamporecchio (province of Pistoia) (46) |
| | Laterina (province of Arezzo) |
| | Lerici (47) |
| 2 | Lipari (48) |
| | Livorno |
| 3 | Lombardy |
| 3 | London (49) |
| 3 | Lunigiana (50) |
| | Majorca (51) |
| | Mar Egeo |
| | Marca d'Ancona (52) |
| | Marseilles (53) |
| 2 | Messina (54) |

[2] The places of "Heart" is a common locution, recently adopted by Thematic Cartography to mean "preferences". Places are listed according to Italian alphabetical order (as Boccaccio wrote them).

3 Milan (55)
Molese (the area of Mola di Bari)
Modena (56)
2 Monaco (57)
Monferrato (58)
Montpellier
Mugello (59)
8 Naples (60)
Narbonne
Paphos
6 Palermo (61)
Paradiso
15 Paris (62)
5 Pavia (63)
Persia
4 Perugia (64)
2 Pisa (65)
2 Pistoia (66)
Pontremoli
Ponza (67)
3 Prato (68)
Procida (69)
2 Provence
Apulia (70)
The Purgatory
Radicofani (province of Siena) (71)
Ravello (72)
2 Ravenna (73)
Reggio Calabria
Rimini
3 Rhodes (74)
11 Rome (75)
2 Romagna
Rossiglione (Rossillon, France) (76)
4 Salerno (77)
2 Saluzzo (78)
2 Sardinia
Scalea
Scotland
7 Sicily
5 Siena (79)
Smirne
2 Spain (80)
Stanford
Susa (in Tunisia) (81)
The Holy Land (82)
Truffia, Buffia &Menzogna Territory (83)
Ticino (river near Pavia)
Torrenieri (a hamlet of Montalcino)
5 Tuscany (84)
Trani (85)
2 Trapani (86)
Tresanti (province of Florence)
Treviso (87)
2 Tunisi (88)
Udine
Ustica (89)
Valbona (a hamlet of Berceto or Collagno, province of Parma or province of Reggio Emilia)
Valdarno
3 Venice (90)
2 Verona

Needless to say, Florence comes out on top, followed, some way behind, by Paris (with roughly a third of the mentions of Florence) and by:

- Rome;
- Alexandria, Bologna, Genoa, Naples;
- Cyprus, Palermo, Sicily;
- Pavia, Siena, Tuscany;
- Crete, Perugia, Salerno,

(with between nearly one-quarter to one-tenth of mentions, approximately), with at last many items, triple, double or single.

Some absences are noteworthy::

- in Tuscany, Lucca (a town of tricksters, in Dante's Divine Comedy, Hell, canto XXI);
- in the Emilia Romagna region, Parma, Piacenza and Reggio Emilia;
- in Veneto, Padua and Vicenza (besides Trieste in Venezia Giulia region);
- in Lombardy, Bergamo, Como, Crema, Cremona, Lodi, Monza and Mantova (that is, only Brescia, Milan and Pavia);

- in Piedmont, all but Monferrato, Asti and Saluzzo (and especially Turin);
- in Apulia, Bari, Lecce and Taranto;
- in Sicily, Catania, Enna and Syracuse.

Other facts are remarkable:

- Boccaccio's geography is limited to Europe, the Mediterranean sea, North Africa and Near East, going into Asia and reaching Armenia, Persia, India and China, though making no mention of Tibet, or Siam (today's Thailand) or Japan, which are in turn mentioned by Polo;
- Africa (Saharian and sub-Saharian) is never cited, despite the growing concern for its circumnavigation, as evidenced by the unsuccessful journey of the Vivaldi brothers from Genoa as well by the imaginary journey of Dante's Ulysses (Comedy, The Hell, canto XXVI);
- In Europe, no mention for German and for Slavonic worlds (in that age, only Scandinavia and Russia could be regarded as marginal): of its peripheral areas, all ports of British Isles are recorded, as is Ireland, though not Portugal;
- In the Mediterranean Sea, almost all its islands are mentioned, though not Elba (nor any other small island off Tuscany), nor even Corsica, despite these being the nearest to Florence and Tuscany [3] ;
- Two places are pure imaginary: the Terre di Menzogna (the Lands of Lies) and the Lands of Berlinzone, which, );
- Three novels deal with Hell[4], Purgatory and Paradise (along the lines of the cantos in the Divine Comedy [5]), and the garden in the Decameron Cornice resembles the Paradise on Earth depicted in Dante's masterpiece;
- Nothing is said about travels to the Moon [6].

Here follow five images showing:

- the frequency diagram of the so-called "Places of Heart";
- the geographical location of the said "Places of Heart" in Italy (in two different depictions, natural and anamorphic [7]);
- the location of the same "Places of Heart" in Boccaccio's world (with both modes of representation).

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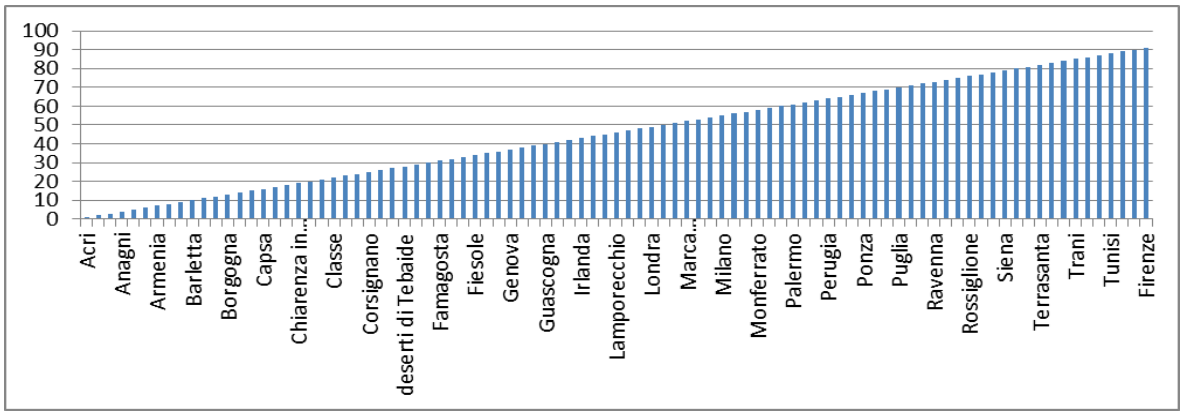
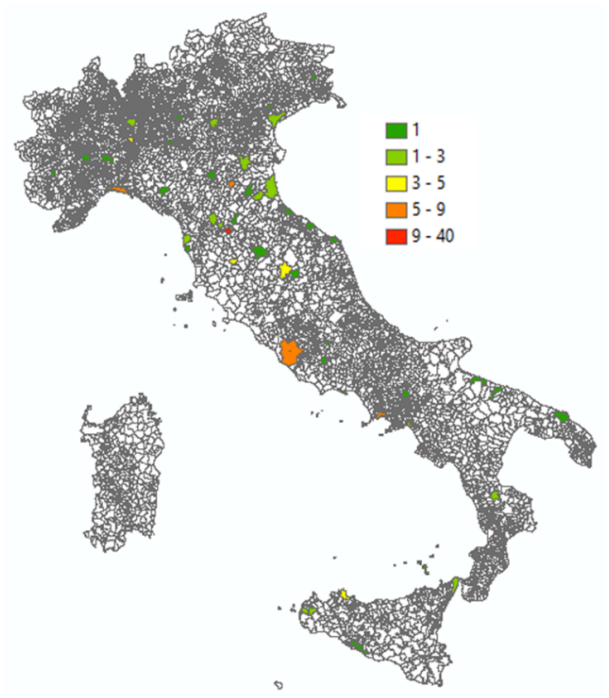
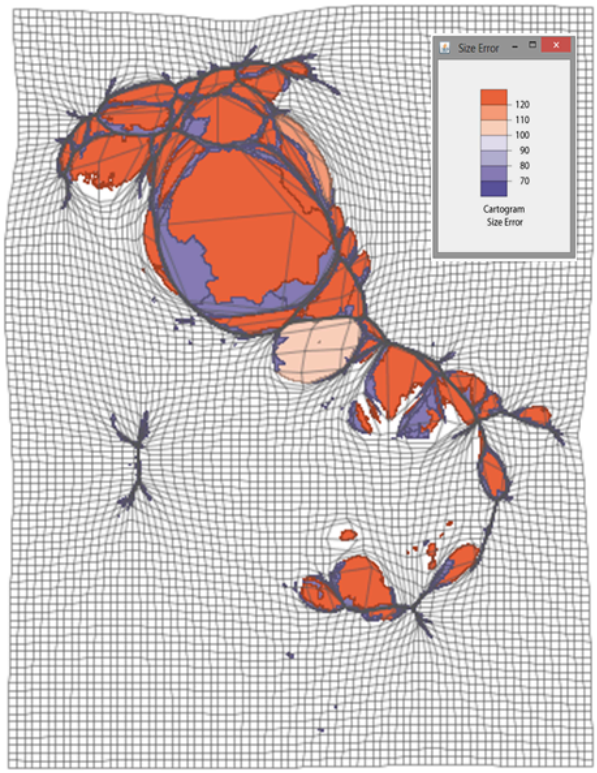
[3] A comment regarding political geography: the islands of the Tuscan archipelago never belonged to Tuscany, before the Congress of Vienna (1815).
[4] Descents to Hades are recorded in Odyssey and Aeneid, as well as constituting the first part of the Divine Comedy.
[5] Dante's Comedy is later quoted at length by Galilei himself, when, in 1588 he gives two lectures at the Florentine Academy on the subject of the build, shape and size of Dante's Inferno, developed from studies by Antonio Manetti, a mathematician and architect from the Florence of the XV century, concerning the site, shape and measure of Inferno, and also the size of giants and of Lucifer, as shown by the testimony (not absolutely consistent) of the humanist Cristoforo Landino and of the Renaissance poet Girolamo Beniveni, both Florentines .
[6] Fanciful voyages to the Moon are also described in antiquity by Lucian from Samosata. In "Orlando Furioso" (by Ludovico Ariosto) Astolfo too goes to the Moon.
[7] Anamorphic maps are well suited to highlighting the places of the "Heart". Indeed, Florence is scarcely visible on a "natural" map (being comparatively small in area), but is clearly indicated on an anamorphic map of Italy.

As far as Boccaccio's world is concerned then, it is confined, apart from India and China, solely to part of Europe, to the Mediterranean Sea, to North Africa and the Near East. For this reason too, a normal map (with its meridians and parallels) would include large areas with no involvement in the novels (since only Italy, France and a few other countries are spoken of, the overall result would make the map difficult to read). When, however, all the territories (or proper groupings of the same, if too small singularly) are given at an unitary (and non-zero) weight, and one unit is added to all counties involved, so as not to distort the result, the resulting sum gives an anamorphic chart much less deformed than the natural map, and hence much easier to read. Moreover, this procedure does not alter data, but simply transfers the digits representing them, that is a shift of origin (a standard procedure, together with the change of scale, in Cartography).



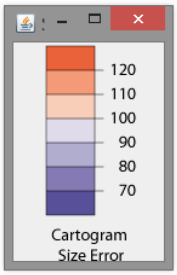

The places of heart in Italy of the Decameron: a frequency diagram

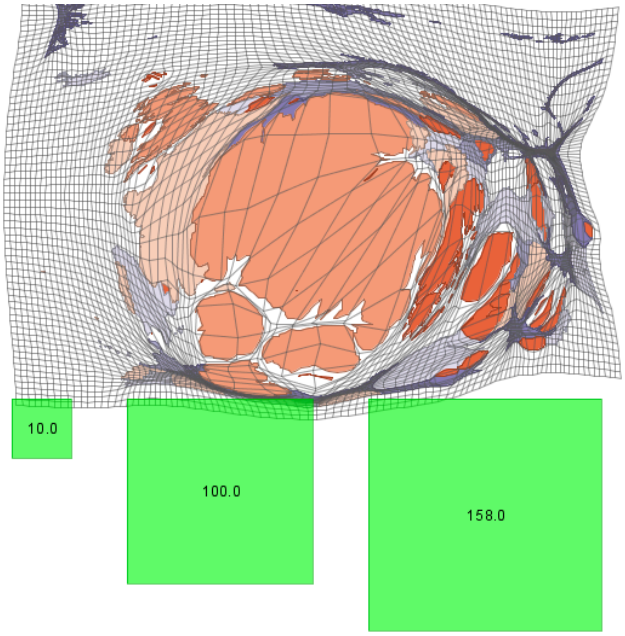


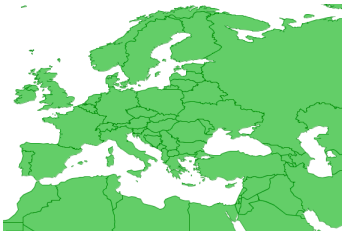




The places of heart in Italy of the Decameron: a classical thematic map

The places of heart in Italy of the Decameron: an anamorphic chart



The places of heart in Boccaccio's world: a classical thematic map

The places of heart in Boccaccio's world: an anamorphic chart

Further proof of the non - randomness of the "Places of Heart" is provided by Boccaccio himself, as seen if we examine the giornate (days), in the columns, and the order of narration of the novels, in the rows, by the ten storytellers, whose names -1 to 10- are in alphabetical order. Indeed, connection analysis, performed by calculating the contingencies and Bonferroni indices, by itself shows the almost complete independence among giornate (days of tales) and the order of narration. It must be borne in mind, moreover, that the contingencies and Bonferroni indices merely serve to reject independence, computing the differences between double frequencies and the product of corresponding marginal frequencies (equality of these values is the condition of independence). Elementary computation gives rather low values for all Bonefrroni's indices (unilateral and bilateral).

| | 1ª | 2ª | 3ª | 4ª | 5ª | 6ª | 7ª | 8ª | 9ª | 10ª |
|---|---|---|---|---|---|---|---|---|---|---|
| 1ª | Panfilo | Neifile | Filostr. | Fiamm. | Panfilo | Filom. | Emilia | Neifile | Filom. | Neifile |
| 2ª | Neifile | Filostr. | Pamp. | Pamp. | Emilia | Pamp. | Filostr. | Panfilo | Elissa | Elissa |
| 3ª | Filom. | Pamp. | Filom. | Laur. | Elissa | Laur. | Elissa | Elissa | Filostr. | Filostr. |
| 4ª | Dioneo | Laur. | Panfilo | Elissa | Filostr. | Neifile | Laur. | Emilia | Neifile | Laur. |
| 5ª | Fiamm. | Fiamm. | Elissa | Filom. | Neifile | Panfilo | Fiamm. | Filostr. | Fiamm. | Emilia |
| 6ª | Emilia | Emilia | Fiamm. | Panfilo | Pamp. | Fiamm. | Pamp. | Filom. | Panfilo | Fiamm. |
| 7ª | Filostr. | Panfilo | Emilia | Emilia | Laur. | Filostr. | Filom. | Pamp. | Pamp. | Pamp. |
| 8ª | Laur. | Elissa | Laur. | Neifile | Filom. | Emilia | Neifile | Fiamm. | Laur. | Filom. |
| 9ª | Elissa | Filom. | Neifile | Filostr. | Fiamm. | Elissa | Panfilo | Laur. | Emilia | Panfilo |
| 10ª | Pamp. | Dioneo | Dioneo | Dioneo | Dioneo | Dioneo | Dioneo | Dioneo | Dioneo | Dioneo |

Table of speakers by day (columns) and order of narration

| | 1ª | 2ª | 3ª | 4ª | 5ª | 6ª | 7ª | 8ª | 9ª | 10ª | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1ª** | 10 | 8 | 6 | 4 | 10 | 5 | 3 | 8 | 5 | 8 | 67 |
| **2ª** | 8 | 6 | 9 | 9 | 3 | 9 | 6 | 10 | 2 | 2 | 64 |
| **3ª** | 5 | 9 | 5 | 7 | 2 | 7 | 2 | 2 | 6 | 6 | 51 |
| **4ª** | 1 | 7 | 10 | 2 | 6 | 8 | 7 | 3 | 8 | 7 | 59 |
| **5ª** | 4 | 4 | 2 | 5 | 8 | 10 | 4 | 6 | 4 | 3 | 50 |
| **6ª** | 3 | 3 | 4 | 10 | 9 | 4 | 9 | 5 | 10 | 4 | 61 |
| **7ª** | 6 | 10 | 3 | 3 | 7 | 6 | 5 | 9 | 9 | 9 | 67 |
| **8ª** | 7 | 2 | 7 | 8 | 5 | 3 | 8 | 4 | 7 | 5 | 56 |
| **9ª** | 2 | 5 | 8 | 6 | 4 | 2 | 10 | 7 | 3 | 10 | 57 |
| **10ª** | 9 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 18 |
| | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 550 |

The same table with numerical values (according to the alphabetical order of the names of the speakers)

**The travel routes**

The list of travel routes will show the basic unity of Boccaccio's world (Italian and otherwise), detecting in it a unique cluster, albeit, to varying degrees, a jagged one.

Day 1

| Tale | Route |
|---|---|
| 1 | A: Prato – Burgundy; B: Burgundy – Tuscany |
| 2 | Paris – Rome – Paris |
| 5 | France – Monferrato – Genoa |
| 9 | Gascony – The Holy Land – Cyprus |

Day 2

| Tale | Route |
|---|---|
| 1 | Florence – Treviso – Florence |
| 2 | Asti – Bologna – Ferrara – Asti |
| 3 | A: Florence – London – Florence; B: Florence – London – Rome – Florence – London – Florence |
| 4 | Ravello – Cyprus – mare davanti a Constantinople – Cefalonia – Corfù – Trani – Ravello |
| 5 | Perugia – Rome – Perugia |
| 6 | A: Palermo – Lipari – Ponza – Lunigiana – Lerici – Palermo; B: Palermo – Lipari – Ponza – Genoa – Lunigiana – Lerici – Palermo; C: Palermo – Lipari – Ponza – Lerici – Palermo |
| 7 | Alexandria – Majorca – Peloponnesus – Athens – Egina – Chios – Rhodes – Cyprus – Famagosta – Alexandria – Gharb (island ofMalta) |
| 8 | Paris – Calais – London – Weles – Ireland – Weles – London – Paris |
| 9 | A: Genoa – Paris – Genoa – Alexandria – Genoa; B: Genoa – Alexandria – Genoa |
| 10 | A: Pisa – Monaco; B: Pisa – Monaco – Pisa |

Day 3

| Tale | Route |
|---|---|
| 1 | Lamporecchio (province of Pistoia) – Florence – Lamporecchio (province of Pistoia) |
| 3 | Florence – Genoa – Florence |
| 4 | Paris – Florence |
| 5 | Pistoia – Milan – Pistoia |
| 7 | Florence – Ancona – Cyprus – Ancona – Florence |
| 9 | A: Rossillon (in France) – Paris – Florence ; B: Rossillon (in France) – Paris – Rossillon (in France) – Florence |
| 10 | Capsa (in Tunisia) – deserts of Thebais (in Egypt) – Capsa (in Tunisia) |

Day 4

| Tale | Route |
|---|---|
| 2 | Imola – Venice |
| 3 | A: Marseilles – Crete; B: Marseilles – Crete – Rhodes |
| 4 | A: Messina – Ustica – Messina; B : Tunisi – Ustica |
| 5 | Messina – Naples |
| 8 | Florence – Paris – Florence |
| 10 | Salerno – Amalfi – Salerno |

Day 5

| Tale | Route |
|---|---|
| 1 | A: Cyprus – Rhodes – Crete – Cyprus; B: Rhodes – Crete – Rhodes |
| 2 | A: Lipari – Tunisi – Lipari; B: Lipari – Susa (in Tunisia) – Tunisi – Lipari |
| 3 | Rome – Anagni – Rome |
| 5 | Fano – Faenza |
| 6 | A: Ischia – Palermo; B: Procida – Ischia – Palermo |
| 7 | A: Armenia – Trapani – Armenia; B: Armenia – Trapani – Rome – Trapani – Armenia; C: Trapani – Armenia |
| 8 | A: Ravenna – Classe (province of Ravenna); B: The Hell – Classe (province of Ravenna) |

Day 6

| Tale | Route |
|---|---|
| 2 | Rome – Florence |
| 5 | Mugello – Florence |
| 10 | Venice – Florence –(imaginary) countries of Truffia, Buffia and Menzogna – Florence |

Day 7

| Tale | Route |
|---|---|
| 1 | Florence – Fiesole |
| 7 | Paris – Bologna |
| 10 | Siena – The Hell – Siena |

Day 8

| Tale | Route |
|---|---|
| 1 | Milan – Genoa – Milan |
| 7 | Paris – Florence |
| 10 | Florence – Salerno – Palermo – Naples – Palermo – Florence – Ferrara |

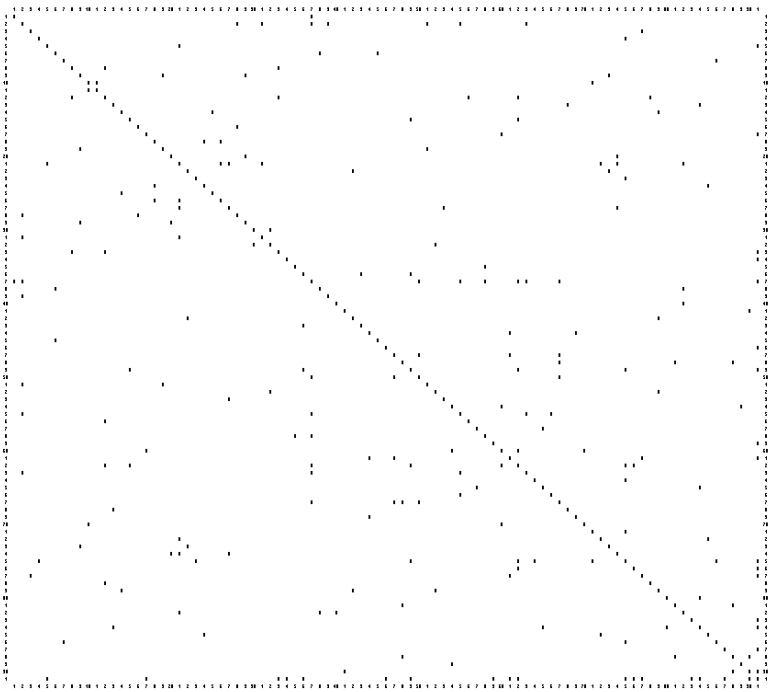
Day 9

| Tale | Route |
|---|---|
| 4 | A: Marca d'Ancona – Siena – Buonconvento (province of Siena) – Siena; B: Siena – Buonconvento (province of Siena) – Corsignano (hamlet of Pienza) |
| 9 | Laiazzo (today Ayas in Turkey) – Antiochia – Jerusalem – Antiochia – Laiazzo (today Ayas in Turkey) |
| 10 | Barletta – Bitonto |

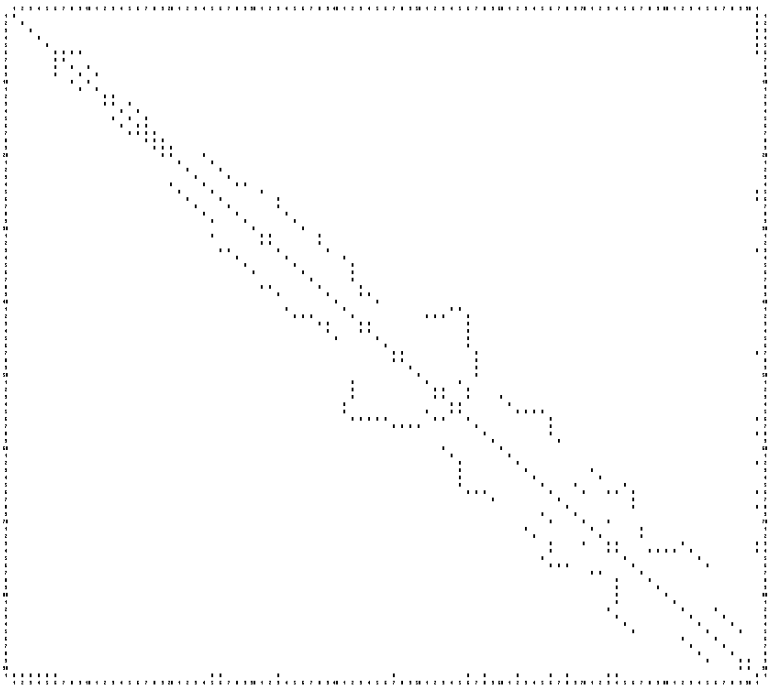
Day 10

| Tale | Route |
|---|---|
| 1 | Spain – Tuscany |
| 2 | A: Radicofani (province of Siena) – Rome; B: Cluny – Rome – Radicofani (province of Siena) – Rome |
| 4 | Bologna – Modena – Bologna – Modena – Bologna |
| 6 | A: Florence – Castellammare di Stabia; B: Castellammare di Stabia – Naples – Apulia |
| 8 | Rome – Athens – Rome |
| 9 | A: Alexandria – Milan – Pavia – Alexandria; B: Pavia – Genoa – Acri – Alexandria – Pavia (by magics) |
| 10 | Saluzzo – Bologna – Saluzzo |

Switching from the connection matrix (putting places in alphabetical order, while keeping Florence at the bottom of the list and dissecting it, in order to highlight its centrality[8]) to the re-ordered one (by Graph Theory), having recognized some regional affiliations (Florence and Pisa in Tuscany, Fano in the Marche region, Bitonto in Apulia, Jerusalem in the Holy Land, and the deserts of Thebaid in Egypt), the clearly resulting sole cluster representing Boccaccio's world stands out.



Connection (alphabetical) matrix



Connection re-ordered matrix

[8] The numbered list is presented beside the alphabetically-ordered list of places of the "Heart": numbers are in parenthesis on the right.

## CONCERNING REPRESENTATION

### Diffusion-based method for density-equalizing maps: the theory

Traditional thematic mapping, unlike standard reference maps which only show natural features, highlights the spatial distribution of a given item or of a specific characteristic (temperature, agricultural-related items, population density, etc.). It also shows variations in data over time, such as the history of a migration or the spread of a disease.

In short, a thematic map combines geographical data and the time variable linked to the relevant items. In addition, it makes plain relationships among the most important features and aids correlation analysis of geographical data.

In the actual creation of any thematic map, once both a specific physical area and a suitable cartographic projection have been selected (usually, from equivalent projections, which preserve dimensional stability of the tested area) it is fundamental to perform an analysis of a number of sets of statistical data and to choose an appropriate method for representation of the variables.

Colour, for instance, is a major element in producing clear and effective maps.

However, the last few decades have seen an increase in the the use of cartograms in which the tested area is not stable, but may be distorted in order to convey information relating to the feature itself (anamorphic maps). Indeed, an anamorphic map is easier to understand and provides a better overview of a specific geographical question.

Many scholars have generated cartograms in which the dimensions of a given region would be proportionate to its population or to any other feature (or a statistical variable). However, this type of graphical rendering of statistical data makes it hard, at times, to recognize the areas under examination, as the constraints for assembling adjacent regions produce distortions, which may result in the map being difficult to use.

Moreover, drawing such maps is a difficult computational task, requiring considerable time for calculations to be performed.

In view of this fact, M.T. Gastner and M.C. Newman of the Physics Department & Center for the Study of Complex Systems of University of Michigan, in Ann Arbor, have presented a simple algorithm, based on Elementary Physics, which allows easy-to-read cartograms to be produced [9].

The algorithm is based on the Theory of Diffusion, and, for this reason, the cartograms are also known as “diffusion-based” or “anamorphic maps”.

For a distribution-based cartogram, distribution must be necessarily uniform and after resizing areas so that they are proportionate to the variable, by definition, density is equal everywhere,

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[9]Gastner M.T., Newman M.E.J. (2004): Diffusion-based method for producing density-equalizing maps. Proceedings of the National Academy of Sciences of the United States of America. Vol.101 n.2

Given a particular distribution, one way to create a cartogram is to let the elements “flow” from areas of greater density to areas of lesser density, with the aim of equalizing overall density, as in any diffusion process of Elementary Physics (it can be easily proven that linear diffusion is simply a density equalization).

Moreover, since areas of interest have boundaries or coastlines (beyond which density is unknown or insignificant), interest often regards particular areas of the globe and not the entire globe itself. Here, a neutral threshold condition is applied, ensuring that the area of interest floats in a kind of sea of uniform density, equal to the average of the densities of the entire area of interest (the tested area should remain constant during the diffusion process).

These intuitive considerations complete the description of the method used ( the algorithm implementation, in contrast, requires computing operations which must be carried out in a relatively short time). Be this as it may, this remains a highly interesting tool for the representation and analysis of geographic data.

## Anamorphosis

The following text is a brief history of anamorphosis, a word first used in the 17th century, although the process itself had been experienced long before.

In fact, perspective, discovered in the 15th century, offers the third dimension and, while it is often taken to represent a type of realism, it remains an artifice, and, as such, it lends itself to different uses, including the creation of optical illusions or even deformations of ordinary reality. Indeed, the distinction between art-copy and art-evocation goes back to Plato, with reflections on the difference between object and vision fascinating scholars, philosophers and artists throughout history.

Lorenzo Ghiberti, Tommaso di ser Giovanni di Mone Cassai, known as Masaccio, Leon Battista Alberti, Piero della Francesca, Leonardo da Vinci, Albrecht Dűrer, Jacopo Barozzi da Vignola are the best exponents of compositions and artifices based on Optics and Geometry.

In the history of art, of the variety of ways of representing three dimensionality on a flat surface, perspective is often taken to be that closest to reality, though also as being a symbolic technique like any other. Ernst Gombrich and Erwin Panofsky, respectively, are major proponents of these two opposing views: the former (Art and Illusion, 1960) bases his ideas on the psychology of perception (Gestalt), developed from Husserl and from Kant’s theory of knowledge: Kant states that Euclidean space is a priori human knowledge (obviously, he knows nothing of new aspects of non-Euclidean geometries, discovered long after his lifetime).

Panofsky, in contrast, works from theories about human vision: indeed, as Kepler already knew in his day, some straight lines may be perceived as curves, due to the curvature of our retinae (Odifreddi, 2011). In this case, Euclidean space a-priori is left behind: if any space is an a priori concept for the perception of the world then this may be an elliptic space (specifically a spherical one), or a hyperbolic one. Panofsky may be right in this (taking the classical perspective to be a symbolic process): it is useful to remember what contemporaries thought of the early works of Van Gogh, Degas or Cézanne, as these masters depict what they really see, far removed from what they would paint following the classical rules of perspective. Consequently, a certain

degree of rejection on the part of the general public was to be expected at the time, because the rules of perspective had already penetrated the public unconscious (Odifreddi, 2011).

According to Martin Kemp (Kemp, 1999) both views are valuable: different types of perspective do exist: an image on the retina is indeed a central one, but only at horizontal middle distances; images are, in contrast, deformed for objects which are either very close or very distant.

Artists in antiquity, indeed, used deformations for specific purposes: a statue by Fidias, which would appear unnatural at ground level, could be appreciated in all its splendour when placed at the exact height envisaged by the sculptor (even if this caused Plato to object since the “corrections” distanced the work from reality).

Early interest in anamorphosis is associated with Leonardo's experience of examining issues posed by distortion at the periphery of vision concerning the necessity to paint curved surfaces when the viewpoint is oblique (Gian Paolo Lomazzo describes these as problems of “inverse perspective”).

Anamorphic applications become more frequent towards the end of the 16$^{th}$ century, and while the first anamorphic pictures come from North Europe, theoretical studies are largely developed in Italy, by Leonardo and others.

'Costruzione legittima' is one of two applications of perspective, since the system can work in both ways. Indeed, a square in perspective becomes a trapezoid, but there is nothing to stop a trapezoid appearing to be a square, by an inversion of the viewpoint (which is shifted to a position above the principal point, at an appropriate height, equal to the distance between the distance point and the principal point).

Once the principles have been calculated, a number of developments may follow, including specular, conical or cylindrical anamorphosis. At any event, here we are dealing with images that, when viewed head on, are hard to understand and sometimes disturbing but which appear understandable and even harmonious when looked at from a specific angle.

Later, in the seventeenth century, Jean François Niceron, Marin Mersenne and Emanuel Maignan, three scholars, monks of the Order of Minims, expert in optics and geometry and on good terms with Descartes, assert that what appears at first strange and fanciful is not due to chance or to supernatural phenomena, and that, furthermore, techniques used to record and describe and imitate the real world do not serve merely to represent reality, but also to reveal it.

According to Descartes, optical illusions can be constructed, as well as deconstructed and unmasked, by the laws of vision: indeed, the subject of illusion is at the heart of his thought.

For Niceron, anamorphosis is not merely a trick of the light, but rather a way to detect the presence of something hidden or unclear. *La perspective curieuse* (1638) and *Thaumaturgus opticus* (1646) are the masterpieces of this enfant prodige who, at the age of 18, is already writing about Optics, and who dies at only 33 years of age.

The first of these works begins with a description of the principles of perspective, starting with the first five regular solids, before proceeding to discuss more complex composite, irregular or hollow solids.

Even more interesting is the part outlining the rules for producing images, which at first sight appear deformed, but which acquire harmonic proportions when seen from a particular viewpoint (the first example is a chair). Lastly, catoptric anamorphosis is described (images viewed in a mirror), together with elements of Dioptrics.

Figures of Saints on the walls of the Minim monastery in Paris, at times hard to perceive, viewed from a different angle, suddenly reveal their magnificence and remind us of worldly vanity (Baltrušaitis, 1978).

Matters regarding the illusion of the senses captivated Descartes just as they had Plato. In his "*Discourse on the Method"*, the former says "I have ever remained firm in my original resolution …..to accept as true nothing that did not appear to me more clear and certain than the demonstrations of the Geometers had formerly appeared".

At a certain point, in the "*Dioptrique*", Descartes observes that, when one holds a little ball between crossed fingers, our senses deceive us, making us believe there are two balls; he also finds other cases of the senses being tricked ( distorted images, too, deceive when not viewed from the correct angle).

Both painters and philosophers are wont to reflect upon illusion and truth, and consequently we have many (totally or partially) anamorphic pictures.

As an example, we present below a portrait of Edward VII of England, clearly distorted by anamorphosis, to be compared with the normal proportions, when seen from the right viewpoint.

"The Ambassadors" a famous painting by Holbein, shows two French ambassadors, standing and looking to the front, leaning against the upper of two shelves, on which a celestial globe, some astronomical instruments, a book, and a sundial are to be seen, while on the lower shelf there is a terrestrial globe, a square and compass, two books and a lute. These objects symbolize the liberal arts, from astronomy to geometry, from mathematics to music, but, at the same time, evoke the art of perspective, since they feature regularly in treatises on perspective. At bottom right, a strange object lies on the floor: it is a skull, recognisable as such, however, from a single viewpoint alone. The anamorphic image of the skull (which completes the evocation of perspective already seen in the aforementioned objects) represents the vanity of the arts, of the sciences, of power, and is in keeping with the Nordic tradition of the "Triumph of Death".

However, anamorphosis can also be used for playful ends (mainly, the spherical and cylindrical ones), such as for Chinese illusionist tricks.

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