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Digital Heraldry

The State of the Art and New Approaches Based on Semantic Web Technologies

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From their emergence in the twelfth century, coats of arms gained an increasing presence in European culture, and became a central means of communication for pre-modern societies. They were used by individuals such as princes and noblemen, as well as women, clerics, town-dwellers, and peasants; they were utilized by institutions like cities, churches, abbeys, as well as all kinds of communities, like guilds and brotherhoods. But they did not only function to identify their bearer. They also conveyed messages of kinship and proximity, social and political claims and aspirations, and worked as a means of self-conceptualisation. Through their various uses they could evoke presence and cause *memoria*, express honor and degradation, provide protection and authority; presented in groups, by adding a spatial component they could also express relationships and hierarchies and, by doing so, fairly complex ideas about political order and political concepts.[3] In the Middle Ages, coats of arms were considered so important that they were attributed to people who had lived long before the emergence of this sign system, from Alexander the Great and Julius Caesar to the heroes of romances, like King Arthur and the Knights of the Round Table. Coats of arms also served to identify the personification of abstract ideas like virtues, sins or death, and finally even the saints, Jesus Christ, or God himself.[4] For contemporaries in this period, no one of importance could remain without a coat of arms.

In representing all of these figures and ideas, coats of arms could be produced in all kinds of material, in the most private as well as in the most public spaces. We find them in manuscripts and on clothes as well as on walls, windows and objects of all kind. They could be executed in stone, wood, and metal,

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[3] For a general overview, see Werner Paravicini, 'Gruppe und Person. Repräsentation durch Wappen im späteren Mittelalter', in *Die Repräsentation der Gruppen. Texte - Bilder - Objekte*, ed. by Otto Gerhard Oexle and Andrea von Hülsen-Esch, Veröffentlichungen des Max-Planck-Instituts für Geschichte, 141 (Göttingen: Vandenhoeck & Ruprecht, 1998), pp. 327–89. The different aspects of medieval heraldry and the use of coats of arms in medieval communication are currently studied by the 'Die Performanz der Wappen' project on coats of arms in practice, at the University of Münster. For further information see: <http://heraldica.hypotheses.org/> [accessed 21 December 2017].

[4] Wolfgang Augustyn, 'Fingierte Wappen in Mittelalter und früher Neuzeit. Bemerkungen zur Heraldik in den Bildkünsten', *Münchner Jahrbuch der bildenden Kunst*, 56 (2005), pp. 44–82.

glass, or leather: painted, carved, sculpted, or itched. With the help of a mould, they could even be baked into waffles and other kinds of food. To sum up, coats of arms were about everywhere in the late Middle Ages.

The prominent role coats of arms played in medieval and Early Modern communication and society should resonate within historical research, where further appreciation of such heraldic devices could open up an essential source for better understanding of past societies and cultures. However, in historical research as well as in related disciplines like history of art and literary studies, coats of arms have yet to play a significant role. Previously these visual devices were only regarded as a tool to identify the makers, patrons or owners of documents, art objects, and archaeological remains, and as a means to dating such artefacts. Thus for a long time they have been seen as a matter exclusively for the auxiliary sciences, as a marginal field of research only of interest to a few specialists, rather than as a valuable source for the study of medieval and Early Modern cultures.

Causes of the lack of interest in coats of arms

Restrictions on the focus of research by the limited availability of media

Figure 1: Dedication picture in Hektor Mülich's copy of the "Augsburger Stadtchronik" (1457), Augsburg, Staats- und Stadtbibliothek, Codex Halder 1, fol. 4v. (image: BSB Munich).

This disregard for heraldry was certainly also fostered, amongst other causes, by technical and also conceptual limitations of editions of historical sources in the era of print, where there were critical technical restrictions in editing and reproducing large numbers of visual sources. Over the last one hundred years historical research conceived itself predominantly as a text-centered science, likely to the detriment of heraldic studies. This text-centricity has in recent years been challenged, and is slowly (and finally) being replaced by a much more open perspective, incorporating visual representations and the materiality of objects into the study of historical cultures and societies. This change in approach has been stimulated, in our opinion, by the new accessibility of these sources, made possible due to the benefits of digitisation and the new possibilities of the digital reproduction, storage and analysis of images.

The impact of these technical and conceptual restrictions on historical research shall be illustrated through the example of the *Augsburger Stadtchronik* of Sigismund Meisterlin. Contemporary copies of this text contain a frontispiece with an extremely illuminating miniature, which features particularly elaborate

and significant heraldic program (fig. 1).[5] In this image we see the counsellors of the city, identified by their respective coats of arms as members of the most important families of the town, gathered around the coat of arms of the city itself which their hands seem to touch and support. Thus, the miniature, and the heraldic representations within it, add relevant information to the content of the chronicle itself. It should therefore be seen as an integral part of the chronicle and treated as such. However, a detailed discussion of the illustrations accompanying a text source is seldom given, and the eventual discussion of heraldic content is even less likely.[6] It is only due to the digitisation of this manuscript that we have become aware of the additional layers of information which it contains.

The lack of a more detailed analysis of heraldic information in descriptions of the *Augsburger Chronik* made in the past reveals that there must be more cause for this reluctance than merely the restrictions in the media of reproduction.[7] The problem lies within the heraldic material itself. Heraldry is a complex field of research difficult to apprehend and to cover, for three reasons: the sheer mass of evidence, the heterogeneity of its sources, and the complexity of its subject.

Mass of evidence

According to some rough estimates, there may have been more than one million different coats of arms in the Middle Ages alone.[8] Printed repositories covering the Middle Ages to the nineteenth century, like the Siebmacher for the German-speaking area and the Rietstap for the whole of Europe, contain 130,000 and 120,000 different coats of arms respectively[9]. Looking to the digital resources at our disposal, the 'Ordinary of Medieval Armorials' by Steen Clemmensen includes more than 87,000 references for the Middle Ages, relating to more than 33,000 individual coats of arms.[10] It should be clear from those numbers that the identification and interpretation of a given coat of arms is not that

[5] Augsburg, Staats- und Stadtbibliothek Augsburg, Codex Halder 1, fol. 4^{v}. For the digitized version of this image see: <http://daten.digitale-sammlungen.de/bsb00090375/image_12> [accessed 21 December 2017].

[6] The present example is to some extent an exception, since the partial edition of this manuscript is part of a larger study of late medieval historiography in the city of Augsburg: Dieter Weber, *Geschichtsschreibung in Augsburg. Hektor Mülich und die reichsstädtische Chronistik des Spätmittelalters* (Augsburg: Mühlberger, 1984). The last part of the text is edited as an annexe on pp. 263–73, followed, in an exemplary fashion, by the reproduction of a large number of black-and-white illustrations of relevant miniatures. The dedication depiction itself is briefly discussed on pp. 59-61, mostly to date the copy by the members of the council shown in the illumination, recognisable by their coats of arms. However, most of the late medieval municipal chronicles have been edited in the series "Die Chroniken der deutschen Städe" from 1862 onwards, which does not feature any illustrations. The same is true for other kinds of chronicles and also for charters, which could be illuminated as well, see: Martin Roland, Andreas Zajic, 'Illuminierte Urkunden des Mittelalters in Mitteleuropa', *Archiv für Diplomatik*, 59 (2013), pp. 241-432.

[7] There are studies like, for instance, Zita Ágota Pataki, 'Bilder schaffen Identität. Zur Konstruktion eines städtischen Selbstbildes in den Illustrationen der Augsburger Chronik Sigismund Meisterlins 1457-1480', in *Identität und Krise? Zur Deutung vormoderner Selbst-, Welt- und Fremderfahrungen*, ed. by Christoph Dartmann and Carla Meyer (Münster: Rhema, 2007), pp. 99–118, which explicitly deals with the construction of the city's identity within the miniatures in Meisterlin's Chronicle, but does not take into account the role the coats of arms played in this context. The dedication depiction mentioned above serves here only as an indication that the copies of this chronicle may have also performed a public function: ibid., p. 115.

[8] Michel Pastoureau, *L'art héraldique au Moyen âge* (Paris: Seuil, 2009), p. 42.

[9] Hanns Jäger-Sunstenau, *General-Index zu den Siebmacher'schen Wappenbüchern 1605–1961* (Graz: Akademische Druck- und Verlagsanstalt, 1969); Johann Baptist Rietstap, *Armorial général précédé d'un dictionnaire des Termes du blason*, 2 vols (Gouda: G. B. van Goor Zonen, 1884–87; repr. London: Heraldry Today, 1972).

[10] Steen Clemmensen, *Ordinary of Medieval Armorials*, ms access database, vs. 2.1 (July 2017), <http://armorial.dk/> [accessed 21 December 2017].

easy, and that it is near to impossible to gain a full overview of this field and the range of possibilities which it contains.

Heterogeneity of the supporting media

This mass of evidence is further met by the wide range of sources which are able to convey coats of arms. Due to their nature as a sign system not bound to any particular material or context, coats of arms can be found in manuscripts and on charters, on seals, coins, mural paintings, sculptures, and funerary monuments, in stained glass and panel paintings, as well as on almost every other kind of object.[11] These objects and corresponding information about them are collected and conserved in such varied repositories as libraries, archives, museums, institutions for the preservation of historical monuments, or even *in situ*. Thus to be able to deal with coats of arms, it is necessary to know about the particularities of all these different media, and kinds of sources and the way they are described and registered in various repositories.[12]

Complexity of coats of arms and the blazon as its language of description

Figure 2: The coat of arms of "Sir Ernoun of Appelby": Azure, semy of martlets Argent, in the Powell Roll, Oxford, Bodleian Library, MS Ashmole 804, pt. IV, p. 37.

After accessing the heraldic sources, which survive in large numbers and in very different contexts, one is finally confronted with a third possible reason for the general reluctance to work with them: the complexity of heraldry itself. To properly describe a coat of arms, a special language called blazon is required. This language, at least on a theoretical level, assures that the depiction of a coat of arms can be described in a standardized way so that from this description it can be represented anew, containing the same information as the first portrayal. In order to do so, it is necessary to observe a given vocabulary which consists of several hundred specific terms for specific features, and a certain set of rules dictating how to apply them.[13] For instance, if one wants to describe the coat of arms represented in figure 2, one has to know that birds without feet are called *martlet* and that from a certain number onwards they aren't counted anymore, and that from this point the term *semy of* has to be applied. Those terms and their use also differs from language to language. So in French, *martlet* is called *merlette* and in German *gestümmelte Amsel* – though some heraldists are currently discussing whether those terms describe the same thing, or whether there are differences in small details which should be used to tell them apart.[14]

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[11] See below, p. ###.

[12] On this topic, see the forthcoming *Organization, Representation and Description through the Digital Age. Information in Libraries, Archives and Museums*, ed. by Christine M. Angel and Caroline Fuchs (Munich: De Gruyter Saur, 2018 [forthcoming]).

[13] See for instance Gaston F. L. Stalins, *Vocabulaire-atlas héraldique en six langues* (Paris: Société du grand armorial de France, 1952); Gert Oswald, *Lexikon der Heraldik* (Leipzig: Bibliographisches Institut, 1984); or Emmanuel De Boos, *Dictionnaire du blason* (Paris: Le Léopard d'or, 2001).

[14] See Maximilian Gritzner, *J. Siebmacher's grosses und allgemeines Wappenbuch, Einleitungsband, Abteilung B: Grundsätze der Wappenkunst verbunden mit einem Handbuch der heraldischen Terminologie* (Nürnberg: Bauer & Raspe, 1890), p. 91, who claims that there is a difference between Merletten and gestümmtelte

Besides this, certain ordinaries, (i.e. geometrical figures within a coat of arms) and charges, (i.e. objects, animals, plants or persons depicted on a coat of arms) have different properties to differentiate them further. Besides its color a lion, for instance, is represented in a particular posture. Furthermore, the color of its tongue and claws can differ, alongside the number of tail(s) it has, and even the way in which these tails are represented. The meaning and importance of these properties, to make things more complicated, may differ from region to region and may have changed over time. Sometimes, it is also difficult to establish whether some feature in a coat of arms is part of the coat of arms itself, or just the result of artistic licence.

Coats of arms can also consist of a combination of several distinct coats of arms in what is called 'marshalling', which can be rendered in different ways. Finally, a coat of arms can be accompanied by several different elements of para-heraldry like a helmet, a crest, a crown, supporters, etc., which add further meaning to the representation and enhance the complexity of the coat of arms and its blazon.

All of these features and particularities have to be described with specific terms, which differ from language to language but sometimes also within the same language, from author to author. In the end, we have to state that blazon is rather a convention than a set of rules.

Printed repositories

In order to be able to work with these coats of arms and to identify them, there are, of course, already several printed repositories. But they are not easy to use. When confronted with a lack of space, some authors of the printed repositories use blazon but with various abbreviations, making the handling of the terms even more difficult. Furthermore, from a scientific perspective, many of them are marked by severe shortcomings. Often, the different entries lack references to the sources used, so the reader is not able to corroborate the given information. Ordered by the names of the supposed bearers of the respective coats of arms, most of the more comprehensive repositories are only useful in verifying presumptions of identification. They render the task of identifying an unknown coat of arms almost impossible, as well as studies in the use of specific heraldic figures or colors.[15] The inadequacy of the existing printed tools may thus add to the limited interest and consideration of coats of arms in the broader field of historical research.

As a result we can conclude that in the current state the extensive range of sources, distributed over different media hosted and documented in different repositories, as well as the complexity of the coats of arms and the language used to describe them, combined with the insufficiencies of existing tools, all together make it difficult to deal with coats of arms as a source for historical research. Thus we have to look for new approaches to achieve better utilisation of heraldry in this field, and to understand that it is only through the use of the relatively new methods and techniques of computer sciences that we will be able to open up this treasure of sources, for research in the varied disciplines of the humanities in all their diversity.

Amsel, which would feature different kinds of beaks and the stumps of legs. Others go even further, claiming that the martlet would also be distinguished from those other two, and interpreting the martlet as a swallow, the merlette as a duck, and the gestümmelte Amsel as a blackbird, see: <https://heraldik-wiki.de/wiki/Merlette> [accessed 21 December 2017].

[15] Notable exceptions are the *Dictionary of British Arms. Medieval Ordinary*, ed. by Anthony Wagner and Thomas Woodcock, 4 vols (London: The Society of Antiquaries of London, 1992–2014) and Théodore Comte de Renesse, *Dictionnaire des figures héraldiques*, 7 vols (Brussels: Société Belge de Librairie, 1894–1903).

The current state of Digital Heraldry

As an essential part of our cultural heritage, different standards for the description and encoding of texts and images already feature the possibility to register the presence of coats of arms and to register further information on them. Besides these standards, specialized databases also exist to collect heraldic information; they are either established to give a description of particular object, or created with the view to obtaining heraldic data. In the following paragraphs, we will review the possibilities for the digital registration and encoding of heraldic data and establish the current state of the art methods in the field.

Text encoding standards and iconographical thesauri

First of all, let's look at the ways to encode the occurrence of heraldry in texts. The only standard we can acknowledge here is the one carried by the Text Encoding Initiative (TEI). Since coats of arms can be mentioned or described in texts, the TEI offers the possibility to indicate the presence of heraldic information within a text.[16] In order to do so, it provides the element <heraldry>, which, as it is noted in the guidelines, refer to 'descriptions of heraldic arms, supporters, devices, and mottos'.[17] For this reason, it operates with a very unspecific definition of heraldry. The element <heraldry> can indicate a detailed blazon of a coat of arms as well as the simple mention of a motto, which belongs to the field of para-heraldry rather than heraldry as such. The TEI standard doesn't provide any further specification to encode more detailed information concerning the heraldry mentioned in a text.

Coats of arms are a regular part of medieval and early modern artworks, where they indicate the possessor or donator, or identify the person depicted, ranging from historical individuals and heroes of medieval romances to personified allegories. Thus, heraldry is also part of a standardized classification system within art and iconography. The most comprehensive and important systems of classification for heraldry in these fields are Getty's *Art & Architecture Thesaurus (AAT)* and *Iconclass.* Both offer hierarchically ordered collections of definitions of objects, people, events, and concepts to describe an image or a piece of art. They allow for the creation of harmonized and interoperable descriptions of artworks, which can be used to jointly retrieve and analyse iconographical descriptions from different resources, such as inventory catalogues and iconographical databases (within the Linked Open Data cloud).[18] Getty's AAT is part of the Getty Vocabularies, which provides cataloguers, researchers, and data providers with a structured terminology for art, architecture, decorative arts, archival materials etc. Within this framework, the AAT presents the structured vocabulary (thesaurus) for the various concepts necessary to describe artwork.[19] Within its hierarchical structure, the class 'devices (symbols)' contains a subclass 'coats of arms and coat of arms elements' (ID 300138225), that again features the subclasses 'coat of arms' (300126352), and 'coat of arms elements' (300138226).[20]

According to its specification, the class 'coat of arms' (300126352) refers to the full display of armorial bearing, including helm, crest, etc. It features two more specific (sub-)elements: 'family arms' (300411429), for the 'full display of armorial bearing of a family or clan', and 'alliance coats of arms' (300411528) for the depiction, as it is specified in the the AAT, of a combination of the coats of arms

[16] <http://www.tei-c.org/release/doc/tei-p5-doc/en/html/ref-heraldry.html> [accessed 21 December 2017].
[17] <http://www.tei-c.org/release/doc/tei-p5-doc/en/html/ref-heraldry.html> [accessed 21 December 2017].
[18] For this concept, see below, p. ##.
[19] <http://www.getty.edu/research/tools/vocabularies/aat/about.html> [accessed 21 December 2017].
[20] <http://vocab.getty.edu/aat/300138225> [accessed 21 December 2017].

of a husband and his wife.[21] The class 'coat of arms elements' (300138226), on the other hand, refers to single elements within the coats of arms. It contains the (sub-)terms 'abatements (coats of arms)', 'escutcheons (coats of arms)' and 'mantling'. The term 'abatements (coats of arms)' (300265409), according to the AAT, shall be used to identify modified representations of shields or coats of arms meant to demonstrate misconduct or dishonor. The term 'escutcheons (coats of arms)' (300138227) shall only be used for the depiction of coats of arms as a shield or on a shield-like surface, and 'mantling' (300266216) shall apparently indicate the cloth hanging from the helmet as a further part of a heraldic achievement. Much more important terms like 'crest', on the other hand, are totally omitted.

Since we are talking here specifically about the possibilities of registering the presence of heraldry and heraldic information as data, this is not the place to discuss the idea of heraldry which underpins this system of conceptualisation. However, it should be noted that it is incomplete and barely adequate for its purpose. Furthermore, it is easily misleading, since it mingles form and interpretation, leaving aside the idea that the same form can convey different information. Take for example the use of the term 'alliance coats of arms' (300411528). Here we first have to clearly identify the individual coats of arms being depicted in this way, to be able to say that these are the coats of arms of a married couple in the form of alliance coats of arms, in order to use the term according to its specification in the AAT. It is important to identify their bearers because the same form of depiction can also be used to portray the coats of arms of friends, brothers or different territories held (or claimed to be held) by a particular person.[22] The same is true, for instance, of 'abatements (coats of arms)' (300265409). Here, the interpretation of a certain manner of depicting a coat of arms is driven by context, rather than the form of the depiction itself. We only are able to understand the meaning of using a certain way of depicting coats of arms when we understand the context and purpose of this depiction.[23]

On the other hand, in its current state, it is impossible to use the AAT to encode the presence of a single helmet or crest beyond the more general term 'coat of arms elements' (300138226). The same is true for the depiction of a heraldic device on certain items, for instance on a horse blanket, if it doesn't take the shape of a shield. Thus, we can conclude, Getty's *Art & Architecture Thesaurus* offers the potential to indicate the presence of heraldic information, but provides an incomplete and sometimes misleading means to do so.

Iconclass is another often-used classification system. It was construed to provide a specialized thesaurus to describe the subject of the iconography of artwork.[24] Here, heraldry turns up in different places. Firstly, it appears as '46A122 - armorial bearing, heraldry'[25] under the class '46A12 - nobility and patriciate; chivalry, knighthood'. Here, further specification is possible. Doubling the letter in the ID indicates that the bearer of the coat of arms is a woman (46AA122). Furthermore, one can add the

[21] <http://vocab.getty.edu/aat/300411528> [accessed 21 December 2017].

[22] On this topic see the upcoming study: 'Kulturgeschichte der Wappen im Mittelalter' by Torsten Hiltmann.

[23] See for instance the different descriptions used in Laurent Hablot, '"Sens dessoubz dessus". Le blason de la trahison', in *La Trahison au Moyen Âge. De la monstruosité au crime politique (Ve–XVe siècle)*, ed. Maïté Billoré and Myriam Soria (Rennes: Presses Univ. de Rennes, 2009), pp. 331–47, and in Gustav Adalbert Seyler, *Geschichte der Heraldik (Wappenwesen, Wappenkunst, Wappenwissenschaft)* (Nürnberg: Bauer & Raspe, 1890; repr. Neustadt an der Aisch: Bauer & Raspe, 1970), pp. 513-514.

[24] <http://www.iconclass.org/> [accessed 21 December 2017].

[25] <http://www.iconclass.org/rkd/46A122/> [accessed 21 December 2017].

name of the bearing family in brackets behind the number, and by adding another number after the brackets, one can finally specify the precise part of the armorial bearing that is depicted (coat of arms[1], crest[2], device or motto[3]), or the medium through which it is depicted (banner[5], seal[6]), since the specification doesn't differentiate between the two.[26] Heraldry is further contained within the system as '44B194 - coat of arms (symbol of sovereignty)' in the class '44B19 - insignia and symbols of sovereignty (crown, diadem, scepter, orb, seal, standard, cloak, pectoral)', and once more as '44A1 coat of arms (as symbol of the state, etc.)', being here part of the class '44A symbols of the state (in general)'. In the last case, it is possible again to specify the information given by adding a number describing whether this state is '(+1)' a league of nations, '(+2)' a nation, '(+3)' a province, '(+4)' a city or municipality, '(+5)' a society or '(+6)' a church or a monastery. Finally, there are at least two more categories which encode information about heraldry, in these cases for very specific coats of arms: '11F13 coat of arms of Mary' and '48B411 coat of arms of Guild of St. Luke'. These references to heraldry can be explained by the fact that some parts of the Thesaurus are more deeply defined than others, so they include here further information about a specific subject ('11F the Virgin Mary', '48B41 Guild of St. Luke').

Iconclass thus offers the possibility to encode much more information about coats of arms, and even provides a standardized form to indicate the bearer of a given coat of arms. But this only applies if the arms belong to a family, and if this family is part of the nobility or the patriciate. If the coat of arms belongs to a family of artisans, following the structure of *Iconclass*, '46A122 - armorial bearing, heraldry', it wouldn't apply as a armorial device. Thus *Iconclass*, in its current state, acknowledges coats of arms only as a sign of nobility, a sovereign or a state. Essentially we are here dealing again with the same issues raised in the case of the AAT: that is, the lack of separation between form and meaning, and additionally the problem that in heraldry, depending on context, the same depiction can mean different things, sometimes even at the same time. Thus, a coat of arms *Azure, three fleurs de lis Or*, a blue shield with three golden fleurs-de-lis, can refer to the Kingdom of France (as a state) in the same way as to the King of France (a sovereign), the royal family (a family), or even the monarch as an individual. With *Iconclass*, the cataloger or researcher has to try to distinguish the meaning of a coat of arms, which, in some cases, is just not possible.

To sum up, on the level of established standards which provide vocabulary or thesauri to annotate or describe textual and visual sources, there are different ways to encode heraldic information, allowing for different levels of detail. However, they all have comparable problems in incompleteness and inconsistency, so that it may sometimes be difficult for the encoder to decide which term to apply without falsifying the result. Moreover, only *Iconclass* provides – under certain circumstances – a standard to also encode information about the actual bearer of the coat of arms; but this requires a correct interpretation and identification of the coat of arms in the first place. None of these standards and thesauri, however, allow us the possibility to encode information about the coat of arms itself, i.e. to describe or blazon it in the way it presents itself in the source.

The encoding of Heraldic information in Heraldry-centered projects

For the next step, we will take a look at the practice. How is heraldic information currently described and encoded in digital databases and catalogues, such as inventories of museums and databases for seals and stained glass? Some of them, like the *Corpus Vitrearum Medii Aevi (CVMA) Digital,* a

[26] <http://www.iconclass.org/rkd/46A122/> [accessed 21 December 2017].

repository for images of medieval stained glass, use *Iconclass* to classify the images. Others do not yet rely on this type of classification system.

In the *Objektkatalog of the Germanisches Nationalmuseum*, the database which describes the holdings of the National Museum in Nuremberg, for instance, heraldic information is mentioned only as part of the general description of an item, often without any particular specification. Taking object n° A 1266, a tile, as an example, only the textual description contains information on the coat of arms portrayed on the item, only mentioning that it must signify a tailors' guild without specifying the features of the heraldic design which may have led to this conclusion.[27] The *Deutsche Inschriften Online*, the online catalogue for medieval and Early Modern inscriptions in the German-speaking area, features a separate field entitled *Wappen* (coat of arms), to indicate the identification of the coats of arms represented, for instance, on tombstones. However, the degree of detail varies in the records. Sometimes, the identification of the coat of arms is only given by returning to the name of the assumed bearer of the coat of arms.[28] In other cases the coats of arms are described extensively, but only in a footnote attached to the name, not in the corresponding field as such.[29]

In seals, coats of arms are an extremely common feature. In sigillographic databases, the registration of heraldic information should thus garner more attention. This is indeed the case, though the manner of the records vary. The database of the French project *Sigilla* contains a field *Héraldique* which provides the heraldic information concerning a given seal. Here, the coat of arms is sometimes described in more detail, but is also occasionally only identified by the name of its bearer.[30] All heraldic seals are accompanied by a graphical representation of the coat of arms, which for the interpretation of the heraldic description, if given, is very helpful. In the database *Welfensiegel*, finally, the coats of arms are always blazoned in detail, which is actually a good thing. Unfortunately this is not done in a distinct and specific field, but only as part of the general iconographical description, so that the user cannot easily retrieve specific heraldic data.

Heraldic Databases

In the last step, we will turn our attention to databases which were explicitly created to register and describe coats of arms. Finally here, detailed blazons of coats of arms are to be expected. This is the case, for instance, for the website *Palisep* which contains several heraldic databases, where the description of the coats of arms is provided in a field named either *Blasonnements* or *Armes*.[31] Here, the coats of arms are described in detail with the according vocabulary in plain text. However, sometimes the same field returns different blazons of the same coat of arms. In the *Armorial historique & monumental européen* database, for instance, we read for the family of Aragon:

[27] <http://objektkatalog.gnm.de/objekt/A1266> [accessed 21 December 2017].
[28] <http://www.inschriften.net/odenwaldkreis/inschrift/nr/di063-0007.html> [accessed 21 December 2017].
[29] <http://www.inschriften.net/odenwaldkreis/inschrift/nr/di063-0027.html> [accessed 21 December 2017].
[30] <http://www.sigilla.org/fr/sgdb/sceau-type/12689> [accessed 21 December 2017];
<http://www.sigilla.org/fr/sgdb/sceau-type/2924> [accessed 21 December 2017].
[31] <http://europe.palisep.fr/recherche> [accessed 21 December 2017] (*Blasonnement*),
<http://www.livre2.palisep.fr/recherche_photo> [accessed 21 December 2017],
<http://europe.palisep.fr/recherche> [accessed 21 December 2017] (*Armes*).

écartelé en sautoir, aux 1 et 4 d'or à quatre pals de gueules qui est Aragon, au 2 de gueules au château donjonné de trois tours d'or, au 3 d'argent au lion de gueules. (P.Anselme) d'or à quatre pals de gueules. (Tous armoriaux).

The text of the blazon given in this database is thus not standardized. The field *Blasonnements* (or *Armes*) serves as a container for full-text descriptions of the coats of arms, as one could expect them also in printed collections.

The most advanced project in this field is the *Ordinary of Medieval Armorial* database by Steen Clemmensen.[32] This is the first attempt in a published database to register coats of arms in a significantly more formalized way. For this purpose, Steen Clemmensen invented a new system with the objective to separate the different parts of the blazon, and to concentrate on brevity and clarity. Breaking with the usual customs, he separates tinctures and charges. In one field, he registers the tinctures of the coats of arms, in a second one its charges. The relationship between them is expressed by order of the corresponding elements, which are mostly offered as a set of given abbreviations. The coat of arms of the French king, *Azure, three fleurs de lis Or*, is thus encoded in Field 1: 'B O' and Field 2: '*3 fleurs-de-lis*'.

If one is well acquainted with the system, this approach makes it much easier to retrieve a particular coat of arms based on its design. But this means that one first has to learn how this systems works, which is not easy even with the necessary heraldic knowledge. Moreover, it rapidly becomes quite complex, for instance when it comes to multi-colored elements. Taking the blazon 'Per pale Argent and Gules a lion Vert within a border Sable' as an example, it would be transcribed as 'XVS-AG' for the tinctures and 'per pale & lion & border' for the charges.

Working with a given set of abbreviations, he comes much closer to a standardized vocabulary. Containing all the necessary information on the content of the different coats of arms in a formalized way, this system provides the potential to retrieve the data and to work with it. However, this doesn't mean that the data is always clean and consistent. Since there is no procedure to control the correct use of the vocabulary, especially in matters of spelling, mistakes creep in here as well.

Theoretical approaches in the computer sciences

Beyond the practice described in the preceding paragraphs, very early there were also theoretical reflections concerning the possibilities of encoding blazon to allow for the manipulation of heraldic information with computer-based methods. These endeavours were fostered by the idea that coats of arms are built on a strict and precise system.

The first attempt we know of dates back into the year 1974, in an article written by N. Michael Brook. Already at this early stage he realized that the language of blazon is less structured and coherent and much closer to natural language than is often thought.[33] Thus, he states, blazon relies rather on conventions than rules, and that there are some practical problems which stem from the potential complexity and grammatical informality of blazon.[34] However, assuming that these conventions are

[32] See above, n. ###. For the documentation on the database, see <http://www.armorial.dk> [accessed 21 December 2017].
[33] N. M. Brooke, 'The Computer and Heraldry', *Coat of Arms*, n. s., 1.92 (1974), pp. 112–16; n.s., 1.93 (1975), pp. 137–43; n.s., 1.94 (1975), pp. 172–80.
[34] Brooke, 'The Computer and Heraldry', p. 116.

based on an underlying structure, he was convinced that it would be possible to devise a coded form of a blazon library. The main interest of his study lies in the way we might translate blazon into a computer-readable code. In order to keep things easily approachable for the users, he postulates that 'whatever code is used within the computer, the blazon text should if possible therefore remain the language of communication with the machine'.[35]

Thus, he was looking for a way to formalize the textual heraldic description in a way that a computer could parse it. The emphasis of this study was on the syntax of heraldic descriptions. The order and arrangement of the different words used in a description was of importance, not the semantics. The description of a component should be between a numeral and the descriptor for the color, which should serve as 'delimiters'. Furthermore, the parser should scan for connecting words like between, on, charged with, within, etc. In order to verify the input, it was planned that the computer should generate a picture of the coat of arms from the coded form of the blazon text. Overall, this system became very complex. In 1991 M. Newton, a pupil of Brookes, tried to develop this system into an application called XHERALD, which would have been able to automatically draw pictures from a registered description.[36] But there is no more information available about this project.

The latest published study in this field that we know was completed by Pascal Manoury from the University of Paris VII, who also sets out to formalize the language of blazon in such way that a machine might understand it, and convert this text into the image it encodes.[37]

Karl Wilcox holds the same goal as his target with his application 'drawshield', which apparently began in 2010 and has been in continuous development until at least as recently as 2014.[38] The application aims to parse a natural language blazon and to render it into a graphical representation. In order to do so, it uses an XML schema called BlazonML as an intermediate format, which also serves to map the text of the blazon to a standardized vocabulary of the different charges and elements of the blazon.[39]

Observations

What can we conclude from all of this, so far? General standards to describe textual and iconographical sources are very limited. They allow us to indicate the presence of a coat of arms and, in the case of the art thesauri, also make some statement about the way the coat of arms is depicted. However, mostly this information is already based on an interpretation of these depictions, which in some cases can be misleading. It is only possible in one case to additionally encode more detailed information about a coat of arms itself, in this case, concerning its bearer. But here as well, this is only possible after the coat of arms has already been interpreted and identified. The registration of the essential information given by the coat of arms, which is its design, is not possible. There is no standard, no vocabulary or thesaurus to do it.

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[35] Brooke, 'The Computer and Heraldry', p. 115.

[36] M. Newton, 'Computer Analysis of Blazon' (final year project dissertation, University of Bath, School of Mathematical Sciences, 1991).

[37] Pascal Manoury, 'De l'interprétation algorithmique du blason', in *Actes des journées francophones des langages applicatifs (*2010) <http://jfla.inria.fr/2010/actes/PDF/manoury.pdf> [accessed 21 December 2017]. For some examples see <https://www.irif.univ-paris-diderot.fr/~eleph/Recherche/Hrld/img-dbs/index.html> [accessed 21 December 2017].

[38] <https://code.google.com/archive/p/drawshield/> [accessed 21 December 2017].

[39] <https://github.com/PQYPLZXHGF/drawshield/blob/master/BlazonML.xsd> [accessed 21 December 2017].

With the databases, we have seen that they record statements on coats of arms in different ways: either by naming their assumed bearer, or by giving a more extensive description, the blazon. The latter is done in one of two ways. Either it is completed in the same way it would be done in a printed book, using the respective field of the database as some kind of drop off for a traditional textual description; or, as Steen Clemmensen does it in his 'Ordinary of Medieval Armorials', the authors look for a way to formalize the entry of heraldic data so that it can be more easily entered and retrieved. The efforts in the theoretical discourse are concentrated on the question of how to formalize the language, or more precisely the syntax of blazon, so that the computer can more easily parse it, in order to treat and analyse it with computer-based methods. Or, as N.M. Brooke phrased it back in 1975: 'A more satisfactory approach is to omit semantics from the rules of the grammar and defer their consideration to a later stage'. However, none of these procedures have become in any way a common standard to register coats of arms in a database, let alone to exchange data between different systems.

Almost all the implemented solutions mentioned above share, in our opinion, the same shortcomings. Putting one or more descriptions in one field or segmenting the description into two fields, in order to store the data, they all rely on the blazon as a more or less formalized linear textual description.[40] This entails a series of disadvantages, at the least if one wants to process and analyse these data using computer-based methods:

- Since those systems work with plain text descriptions without a controlled vocabulary and routines to check the entries for consistency, they are very error-prone. The smallest typo can deface an entry in such a way that the information it contains can no longer be retrieved from the system.
- Since the terms used in those descriptions are not specified, there may be a different understanding of the single terms by the author and the different users of the databases, which may also lead to errors and misinterpretation. The same is true already in the process of data entry between different data authors.
- Since the systems rely on natural language, they also depend on a specific language. This means that such a system can only be used in a particular language (e.g. French or English), which may have to be learned anew in order to allow usage.
- Finally, the data collected in the systems described above cannot, or can only in a very limited way, be processed with computer-based methods. This means that it is impossible or at least far more difficult and error-prone to extract more information from the collected data than from the simple heraldic descriptions, e.g. if one wants to analyse the frequency of recurring combinations of charges and colors, or the complexity of the coats of arms.

Thus, even though the data collected contains much more information than the simple description of the coats of arms, the use of the existing systems is quite limited. If the computer shall serve not only as storage for heraldic information (as in the case for Palisep, for instance) but also as a tool to process and analyse the data for more sophisticated and explorative research, we have to turn to other solutions.

[40] Exception is Karl Wilcox who also standardized the entries (see above, note 42#). However, the basis he uses is as well the given blazon.

Semantic Web technologies

In order to overcome the shortcomings of the existing technical solutions and to enhance the potential for analysis, we are convinced that Semantic Web technologies, and more precisely Ontology engineering and Linked Data, may provide a solution.[41] It allows us to tackle the three leading issues which have hindered a broader use of heraldry so far, that is: the mass of evidence; the heterogeneity of the supporting media; and the complexity of coats of arms and their description. In doing so it immensely enhances our analytic capacities, allowing us to use the collected data not only to identify unknown coats of arms in a very efficient manner, but also for far more advanced research schemes, even those we may not even have thought of yet.

The idea behind the use of ontology engineering is to encode coats of arms on a conceptual level beyond words and strings and specific languages.[42] Thus, the collected data are not only machine-readable, which means that the machine can process the data, but machine-understandable. This means that the computer is not only able to read but also interpret the data correctly within a given framework. By the use of a hierarchical model as background for the interpretation, the data become analysable on different levels of abstraction, enabling us to gain knowledge from it which has not been registered before. By the use of the Linked Data principle, it is possible to exchange data between different systems, for instance from the various databases of the repositories holding heraldic sources, and to combine them in data retrieval and analysis.[43] It allows us to integrate further data from those and other data collections into our scholarship, which enhances the possibilities for further research considerably. Both the handling of the complexity of heraldic data through a hierarchical conceptualisation of those data, and the combination of different data sources using the Linked Data principles, finally enables us to cope with the immense mass of heraldic evidence, and provides us with new prospects for analysis and research.

Distributed data within the World Wide Web

To understand this technique, we have to take a step back and take a look on the broader image: that is how the internet, and more specifically, how the use and exchange of data on the internet works.[44] While the internet started first as a network of computers, meaning that you had to connect one machine to another in order to search the file system for a document you may have been interested in, and to download it in order to be able to process it (e.g. to display and read it), this had changed

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[41] Semantic Web Standards: <https://www.w3.org/standards/semanticweb/> [accessed 21 December 2017]. For a general introduction into the use of Semantic Web technologies for Historical sciences see: Albert Meroño-Peñuela et al., 'Semantic Technologies for Historical Research. A Survey', in *Semantic Web* (2014), pp. 1–27. <http://www.semantic-web-journal.net/content/semantic-technologies-historical-research-survey-0> [accessed 21 December 2017].

[42] The research field of knowledge engineering is reflected by a large number of used and approved methodologies. Standardizations in the context of the Semantic Web also support knowledge engineering through reasoning and collaborative engineering technologies. An overview of methods and technologies is provided by the publications of the series of the International Conference on Knowledge Engineering and the Semantic Web (KESW).

[43] Tom Heath and Christian Bizer, *Linked Data. Evolving the Web into a Global Data Space*, Synthesis Lectures on the Semantic Web: Theory and Technology, 1.1 (Milton Keynes: Morgan and Claypool, 2011).

[44] The history of the World Wide Web is documented by the World Wide Web Consortium (<https://www.w3.org/History/> [accessed 21 December 2017]). The fundamentals have been described in Tim Burners-Lee, 'Information Management: A Proposal', CERN, 1989/1990 (<https://www.w3.org/History/1989/proposal.html> [accessed 21 December 2017]).

with the introduction of Hypertext and internet browsers. By this, the Web of machines became the Web of interlinked documents. Now it was no longer the machines but rather the documents that were linked to each other, so that one could go from one document to another via hyperlinks. However, the content of the different documents didn't matter. The important thing was that there was a formally correct link in the document that referred to another document on the internet. Furthermore, using the anchors within the document it was possible to point to a part of the linked documents.[45] This basic concept requires an interpretation of the document to understand the information it contained and the meaning of the link to the other documents. This situation changes with the idea of Semantic Web, which is to directly link the data and the information itself, and thus to create a Web of Data. [46]

For the moment, most of the data are stored in single databases or documents. In order to gather data from different databases, you have to access those bases, one after the other, often in a specific and different manner. Those databases thus work like silos: each one has its individual data access interface and its individual procedure to retrieve data and information from it. The idea of Semantic Web is to provide a technique that gets rid of those silos and that allows us to access the data from different collections all at once. The result is a web of linked data that transforms the internet into a huge distributed database.

Expressing facts using statements based on subject, predicate and object

How can this be done? The most basic technique of the Semantic Web is described by the Resource Description Framework (RDF).[47] It expresses information through statements that are phrased within simple declarative sentences consisting of only three elements (triples): subject, predicate, and object. For example, in the sentence 'Lucas Cranach was born in Kronach', 'Lucas Cranach' is expressed as the subject, was born in' as the predicate and 'Kronach' as the object. This data representation is different to documents and relational databases as data can be represented by a single statement. The same information which is provided by documents and databases may be distributed on different servers within the network.

In order to make these statements interoperable, every part of this statement has to refer to a single resource on the Internet, representing the concept it stands for. Those resources are defined as Uniform Resource Identifiers (URI), in the form of an URL (Uniform Resource Locator) that is used for Hyperlinks. An URI exists precisely once, and makes those references unambiguously identifiable on the Internet. Such URIs are, for instance, provided for resources by the project DBpedia, where 'Lucas Cranach' is referenced by the URI http://dbpedia.org/resource/Lucas_Cranach_the_Elder, 'died in' by the URI http://dbpedia.org/property/birthPlace, and 'Weimar' by the URI http://dbpedia.org/resource/Kronach.[48] All these links provide a specification about what they

[45] An anchor can be addressed by using the symbol # followed by a mark that has had to be defined in the linked document.

[46] On the principles of the Semantic web see: Tim Berners-Lee, James Hendler, and Ora Lassila, 'The Semantic Web', *Scientific American*, 284.5 (2001), pp. 34–43.

[47] <https://www.w3.org/RDF/> [accessed 21 December 2017].

[48] DBpedia provides extracted structured information from Wikipedia as Linked Open Data: <http://dbpedia.org> [accessed 21 December 2017].

represent, in order to facilitate a common understanding of the concepts that these URI represent. Thus, to say 'Lucas Cranach died in Weimar', we make the following statement:

Listing 1: RDF statement to express 'Lucas Cranach was born in Kronach.'

```
http://dbpedia.org/resource/Lucas_Cranach_the_Elder
http://dbpedia.org/property/birthPlace http://dbpedia.org/resource/Kronach.
```

By using URIs as references, and not an expression in natural language, the representation of the concepts works independently from natural language. This doesn't stop you from stating that strings like 'Lukas Cranach der Ältere', 'Lucas Cranach l'Ancien', 'Лукас Кранах Стари' or '루카스 크라나흐' are representing this very concept as strings and are labels assigned to this concept in the different languages (German, French, Russian, Korean).

Expressing concepts based on classes and properties

But there are more things we can state about Lucas Cranach. For instance, that Lucas Cranach was a painter. By doing so, we can refer to the concept 'painter' in a given ontology, i.e. an explicit, formal specification of a shared conceptualization of a certain domain of knowledge.[49] Thus, in this ontology, it may be said that every painter is an artist, and that every artist is a person, and that every person carries a certain set of properties, like a date of birth and a birthplace. That means that we refer to an established and well-documented model of a part of the world (as we conceive it). In this case, the model may say that 'Painters' 'paint' and 'Paintings' may be 'located' in a 'Museum', that the concept 'Painter' is a subclass of the concept 'Artist' and thus that all instances of 'Painter' share all the properties of the class 'Artist'. The same is true for the class 'Artist' as a subclass of the class 'Person'.

Such an ontology can come with different degrees of expressivity. It may just consist of a controlled vocabulary or, as a glossary, also include more detailed definitions. This is the working level of Linked Data where a shared vocabulary or glossary is defined within an authority file for disambiguation and linkage. But it can also consist of a hierarchized model of different classes (taxonomy), which may also feature statements about further relationships between different classes beyond the strict hierarchy (thesaurus), which can be completed by the addition of logical rules and value restrictions to define it. The Semantic Web standards provide the RDF-Schema (RDF-S) and the Web Ontology Language (OWL) to describe classes and properties to define such vocabularies.[50]

It is through reference to such formal models of a domain of knowledge that machine-readable data become machine-understandable. Following such a model with rules and restrictions, the machine can deduce, by logical inference, that if Lucas Cranach is a painter, he is also an artist and a person, and if he is a person, that he must have a date of birth and a birthplace. What can be retrieved by this is implicit knowledge. Nowhere is it explicitly said that Lucas Cranach is an artist or a person, but by using

[49] Thomas R. Gruber, 'A Translation approach to portable Ontology Specifications', in *Knowledge Acquisitions,* 5 (1993), pp. 199–220; also Nicola Guarino, Daniel Oberle, and Steffen Staab, 'What is an Ontology?', in *Handbook on ontologies* (Berlin: Springer, 2009), pp. 1–17.

[50] RDF-Schema 1.1 (2014): <https://www.w3.org/TR/rdf-schema/> [accessed 21 December 2017] and OWL 2 Web Ontology Language Document Overview (Second Edition, 2012): <https://www.w3.org/TR/owl2-overview/> [accessed 21 December 2017].

the model of the ontology and logic inference, the computer deduces that he necessarily must be an artist and a person as well.

Inferences and querying

The same can be done with the birthplace of Lucas Cranach, 'Kronach', which is an instance of the class 'City', which is a subdivision of a 'Federal State' (in this case 'Bavaria'), which again is a subdivision of a 'Country' (Germany). The ontology and logical inference allow us then to combine these statements and to formulate more sophisticated and far-reaching queries, such as our questioning which painters were born in Kronach or which artists died in Bavaria. By doing so, we can analyse and query the data on different levels of abstractions (classes and subclasses), and we are also able to combine those different levels of abstraction with logical rules and value restrictions. In this way we can ask, for instance, the following question, combining information about painters, paintings and museums: Can you give me all paintings exhibited in a museum in the very city where the artists was born?[51] This is a question that would take quite some time to answer in the traditional way, but which would be solved immediately by the use of Semantic Web technologies, provided that there are sufficient data – a condition, though, which also applies to the conventional procedure. The SPARQL[52] Protocol and RDF Query Language is used to query a set of statements. Listing 2 shows the example described above to query on DBpedia. The main concept of SPARQL is to match patterns on a set of statements. Furthermore, to use SPARQL on research of distributed data you have to establish an triple store, that caches the data from different Linked Data endpoints.

Listing 2: SPARQL query to retrieve paintings exhibited in a museum at the birthplace of its painter

```
PREFIX dbo: <http://dbpedia.org/ontology/>
PREFIX dbyago: <http://dbpedia.org/class/yago/>

SELECT ?person ?painting ?museum ?birthplace WHERE

{
?person a dbyago:Painter110391653 .
?person dbo:birthPlace ?birthplace .
?painting dbo:author ?person .
?painting dbo:museum ?museum .
?museum dbo:location ?birthplace .
?birthplace a dbyago:City108524735 .
}
```

Applying semantic web technologies to medieval heraldry

The question is now, how can we use this technique for the registration and analysis of heraldic data? Before we can answer this, we must first know more about the very nature of coats of arms.

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[51] This example can be explored using the DBpedia SPARQL endpoint on Wikipedia data. http://dbpedia.org/snorql/?query=PREFIX+dbyago%3A+%3Chttp%3A%2F%2Fdbpedia.org%2Fclass%2Fyago%2F%3E%0D%0ASELECT+%3Fperson+%3Fpainting+%3Fmuseum+%3Fbirthplace+WHERE+%0D%0A%7B+%0D%0A%3Fperson+a+dbyago%3APainter110391653.%0D%0A%3Fperson+dbo%3AbirthPlace+%3Fbirthplace.+%0D%0A%3Fpainting+dbo%3Aauthor+%3Fperson.%0D%0A%3Fpainting+dbo%3Amuseum+%3Fmuseum.%0D%0A%3Fmuseum+dbo%3Alocation+%3Fbirthplace.%0D%0A%3Fbirthplace+a+dbyago%3ACity108524735.%0D%0A%7D%0D%0A.

[52] SPARQL 1.1 Query Language (2013): https://www.w3.org/TR/sparql11-query/.

Coats of arms as combinations of concepts

Coats of arms can be expressed just as well in images as in texts. As mentioned above, using the particular language of blazon, we can describe a coat of arms in such a way that, starting from this description, it can be represented again as an image without any loss of information. Both forms of expression, picture, and text, are interchangeable. This is because, to use the words of Michel Pastoureau, a coat of arms is an *image fortement conceptuelle*.[53] Or to put it in another way, they are a combination of concepts, a code of different colors and forms. As a matter of fact, in the case of coats of arms, it is not important what kind of red or blue you use. The important thing is that the concept of blue or of red is discernible. The same is true for the charges, like a lion or an eagle. In particular representations they can look very different – large or small, more abstract or more natural – but as long as they can be recognized for the concept they represent, this doesn't matter (fig. 3)[54].

Figure 3: Several medieval depictions of heraldic lions and colors.

As combinations of different concepts, coats of arms combine a limited number of colors or tinctures (six or seven colors and two or three different furs, depending on region and time), a limited number of geometric figures (the ordinaries) and/or an unlimited number of different charges (like animals, plants, or objects like the cross). These ordinaries, charges, but also furs can be further differentiated by a given set of properties, which may be particular to a specific charge or groups of charges. Ordinaries like a fess, for instance, can feature particular lines of partition (i.e. shapes), while lions can be differentiated by the color of their claws and/or tongue (*armed*, *langued*) or by their posture.

The coats of arms as stratified images

As Michel Pastoureau has shown already, in the Middle Ages at least, coats of arms are structured like Romanesque paintings that are organized in different layers, which can be read from the back to the front.[55] In the background is the color (or partition) of the field, on a second layer a charge or ordinary, and if necessary there may be a third and even fourth layer with further elements, most often some kind of cadency to differentiate the coat of arms from others within the same family.

To demonstrate through a practical example, in a fifteenth-century armorial we find the representation of the coat of arms of the family de Villequier, accompanied by the following text: *Le seigneur de Villequier, de guelles a le croix d'or pommelees et fleuronnee aux bouz, billetee de mesmes*. In modern English, it would be blazoned as follows: *Gules, a cross pommy and flory Or, billety Or*. In

[53] Michel Pastoureau, 'L'armoirie médiévale. Une image théorique', in *Iconographie médiévale. Image, texte, contexte*, ed. by Gaston Duchet-Suchaux (Paris: CNRS Editions, 1990), pp. 121–38, p. 122.

[54] For a good overview of how the different styles heraldic charges could be represented in over time, see: Walter Leonhard, *Das große Buch der Wappenkunst. Entwicklung, Elemente, Bildmotive, Gestaltung*, 2nd edn (Munich: Callwey, 1978).

[55] Pastoureau, 'L'armoirie médiévale', p. 122.

other words, the coats of arms of the seigneur de Villequier is made up of a red field, a golden cross with balls and fleur-de-lis at its endings, and over that another layer of golden shingles, which represent the three levels of the coat of arms as depicted in figure 4.

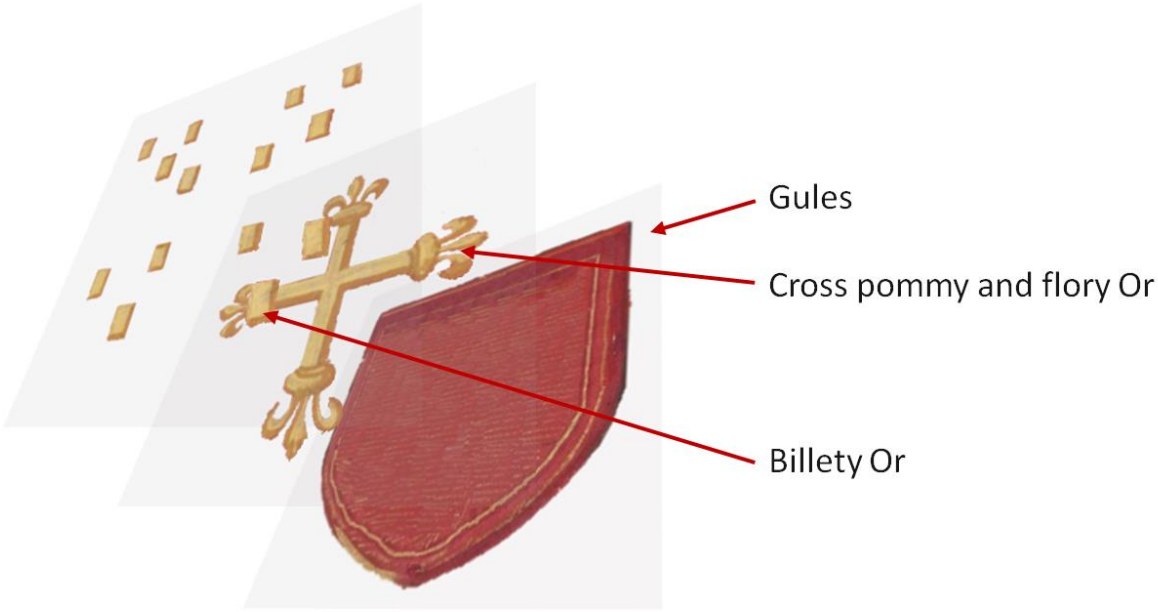

Figure 4: The different layers of the coat of arms of the family de Villequier.

The Ontology

In the Palisep database mentioned above, this coat of arms is registered by its blazon in one field with the string: *De gueules à la croix fleurdelisée d'or, cantonnée de douze billettes du même*[56] (which, as a matter of fact, cites the blazon given in the Armorial général by Johannes Rietstap[57]). In the 'Ordinary of Medieval Armorials' database by Steen Clemmensen we find the description of the same coat of arms, based on a the *Rôle de la campagne de Kuinre en Frise* (as part of *Armorial Beyeren*), divided in two separate fields: one with the string 'GOO' to represent the tinctures, and another with the string 'cross patonce, billety' to represent the charges.[58] Both use different languages (Palisep French, Steen Clemmensen English) and give a slightly different description. A high level of understanding on the matter is required to realize that both are describing the same coats of arms. It would require quite some more understanding to retrieve the identification of the coat of arms as those of the family de Villequier if there were only the image of the coat of arms as a starting point.

Thus, what could the registration or digital representation of coats of arms with Semantic Web Technologies look like, based on the idea that coats of arms are a combination of a given set of concepts organized in different layers?

We need, in the first place, a conceptualisation of coats of arms and their structure. As a first step, we would establish a controlled vocabulary for all the different concepts that can be part of medieval coats of arms and their description and provide for each of them a specific and well-documented URI.

[56] <http://www.heraldique.palisep.fr/recherche> [accessed 21 December 2017].
[57] Rietstap, *Armorial général*, II, p. 1006.
[58] Clemmensen, *Ordinary of Medieval Armorials*, tblBranches, BranchID: 5357.

Therefore, we would establish a namespace like `http://digitalheraldry.org/ontology/` for the ontology with the different concepts that have to be described and specified, hereafter abbreviated as '`dho:`'.

So, for instance for a heraldic cross as a charge (since there are also crosses as ordinaries, depending whether they touch the border or not), we would have a URI like **`dho:CrossCharge`**, for which one can specify that in German it is called *Kreuz*, in French *croix* or in Spanish *cruz*. The same is true for the different properties, which are used to further differentiate the charges and ordinaries. For the cross, this could be properties like 'voided throughout', 'latin', 'rayonnant', and 'gyronny', or even 'pommy' and 'flory' which would get the URI **`dho:Pommy`** and **`dho:Flory`**. For them, we have to specify as well to what kind of charges they apply, whether they are valid as a differentiation only for **`dho:CrossCharge`** or also for **`dho:CrossOrdinary`**. Furthermore, we can state that the concept **`dho:CrossCharge`** is a subclass of **`dho:CommonCharges`**, and that **`dho:CommonCharges`** is a subclass of **`dho:Charges`**. The same has to be done for lions, eagles, and all the other charges, ordinaries, tinctures and their particular properties used in heraldry. One could state, for instance, that **`dho:Lion`**, **`dho:Leopard`**, **`dho:Bear`**, **`dho:Fox`**, **`dho:Wolf`**, **`dho:Hound`** etc. are instances of the subclass of **`dho:Carnivores`**, which is a subclass of **`dho:Quadrupedes`**, which is a subclass of **`dho:Animals`**, which is a subclass of **`dho:CommonCharges`**, which is a subclass of **`dho:Charges`**.

On the other hand, we specify as well the ways the properties of a certain charge or concept are linked to this concept, like **`dho:hasStyle`** and **`dho:hasTincture`**. Eventually, this would allow us to model a digital representation of the field of heraldry, which could be used, afterwards, to represent coats of arms digitally.

But we also need to store the actual data. Therefore, we would use a namespace like `http://digitalheraldry.org/data/` for the data, hereafter abbreviated as '`dhd:`'. Here, we represent the different coats of arms, each one with a unique identifier such as **`dhd:CoatOfArms1`**, but also the different charges within a given coat of arms get unique identifiers such as **`dhd:Charges1`**. Thus, we have a particular namespace for the terms we will use to describe the coats of arms and for the actual coats of arms and their elements, that are encoded using those terms.

In order to encode a specific coat of arms, we would then use a combination of those concepts, structured by the idea of coats of arms as stratified images. For the coat of arms of the Seigneur de Villequier (fig. 5), for instance, we would first state that our coat of arms number one (**`dhd:CoA1`**) is in fact a coat of arms (**`dho:CoatOfArms`**). We further state that it has a ground (**`dhd:Ground1`**) which is of the type plain (**`dho:Plain`**) and has the color red (**dho:Gules**). We would add that our coat of arms has a charge (**`dhd:Charge1`**) of the type cross (**`dhr:CrossCharge`**) in a golden color (**`dho:Or`**), which is styled pommy (**`dho:Pommy`**) and flory (**`dho:Flory`**). Finally, we would state that our coat of arms has another charge, which is of type billetty (**`dho:Billety`**), again in the color gold (**dho:Or**), which has been put above (**`dho:covers`**) the first charge (**`dhd:Charge1`**).

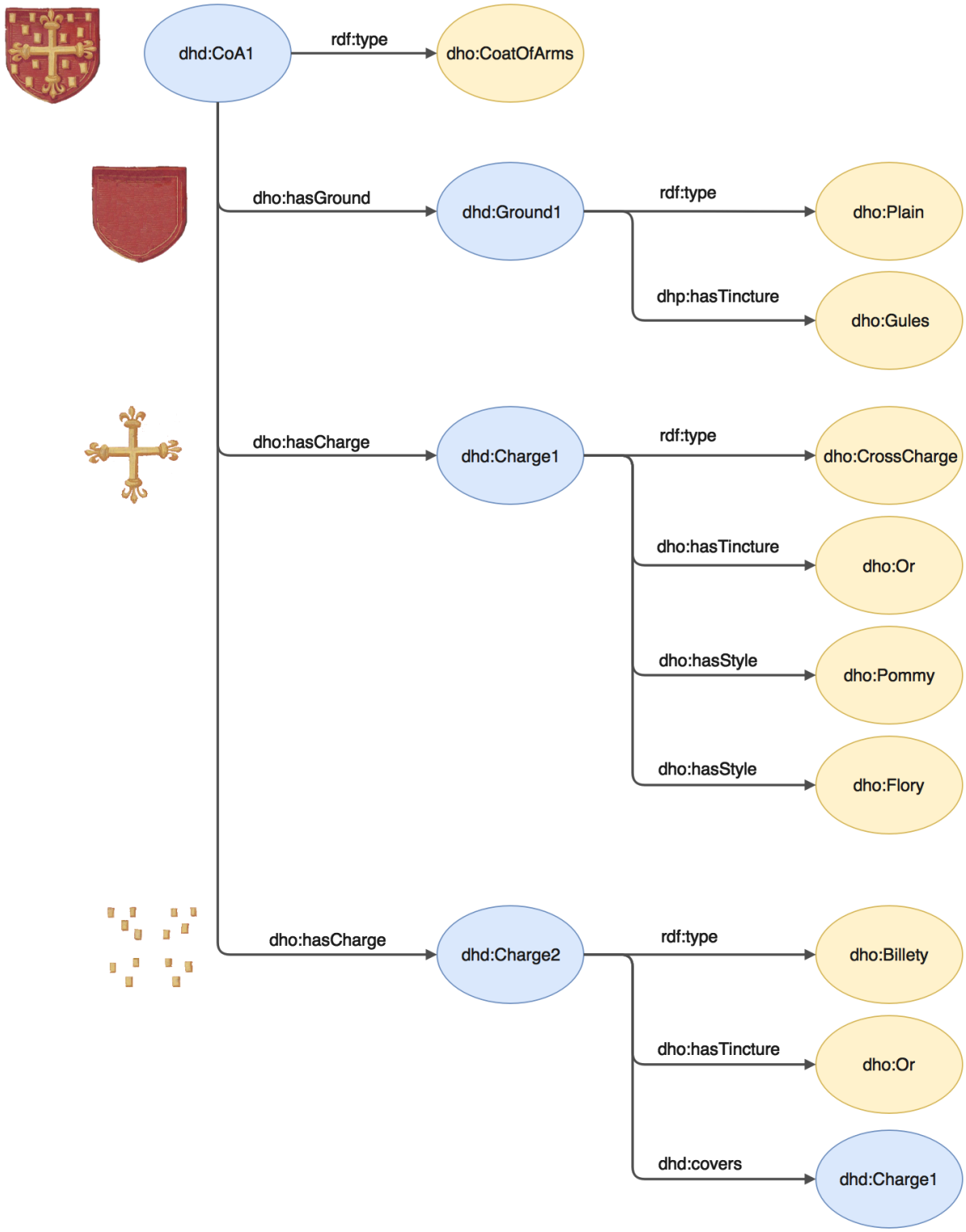

Figure 5: The digital representation of the coat of arms of the family de Villequier, provided by the means of Semantic Web technologies.

Listing 3: RDF statements that describe the ontology depicted in Fig. 5

```
@base <http://digitalheraldry.org/data/> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix dho: <http://digitalheraldry.org/ontology/> .
@prefix dhd: <http://digitalheraldry.org/data/> .

dhd:CoA1 rdf:type dho:CoatOfArms .
dhd:CoA1 dho:hasGround dhd:Ground1 .
dhd:CoA1 dho:hasCharge dhd:Charge1 .
dhd:CoA1 dho:hasCharge dhd:Charge2 .

dhd:Ground1 rdf:type dho:Plain .
dhd:Ground1 dho:hasTincture dho:Gules .

dhd:Charge1 rdf:type dho:CrossCharge .
dhd:Charge1 dho:hasTincture dho:Or .
dhd:Charge1 dho:hasStyle dho:Pommy .
dhd:Charge1 dho:hasStyle dho:Flory .

dhd:Charge2 rdf:type dho:Billety .
dhd:Charge2 dho:hasTincture dho:Or .
dhd:Charge2 dho:covers dhd:Charge1 .
```

New possibilities for enquiry and analysis

What we have established this way is not a description of a coat of arms per se. It is not a textual portrayal, but a digital representation of the very idea and concept of the particular coat of arms. As such, it can be queried and studied in a completely different manner.

First, looking for an unknown coat of arms will be much easier. Independent from a specific language, we can use terms from different languages like 'cross', *croix*, or *Kreuz* in German which all refer to the concept **`dho:CrossCharge`** to retrieve coats of arms featuring a cross. Since the data is stored by the combination of URIs and not by strings, there are no typos as well which could distort the results. Moreover, we can start from whatever information we have. We can query, for instance, for coats of arms which feature a golden cross and a red field. As one of the results, among others, the coat of arms of the *Seigneur de Villequier* would be returned.

Thanks to the thesaurus and its hierarchically modelled structure, we can also query and analyse the data on different levels of abstractions. If we have only a fragment of a coat of arms so that just a field of gold and the paw of a quadruped carnivore such as a lion, wolf or hound etc. is discernible, we can look for coats of arms with a quadruped carnivore on a golden field without having to test all the possibilities. This is true as well for plants, which are very similar in appearance but have quite different names. Instead of trying out all the different names such as trefoil, quatrefoil, cinquefoil, rose or others, to retrieve the coat of arms with a flower, we could look for coats of arms with a flower.

Finally, it would also be possible to generate fuzzy searches. Within the model we are establishing, it is possible to state specific rules concerning the similarities of concepts that are difficult to differentiate and thus are often mixed up. So, we could state that 'bars' and 'barry' are similar to each other, as are, from a certain number onwards, 'billets' and 'billety', or again 'fleurdelisé' and 'patonce' as further

specifications of a cross. In our query, we could decide then whether to apply those rules or not in a search, meaning whether the machine should search for strictly what we entered, or also include any results that are similar to what we are looking for.

Those new possibilities are even more far-reaching when it comes to the analysis of the gathered data. This implementation would, for the first time, allow us to study the composition of coats of arms in-depth with the help of a computer, since those data are not only machine-readable but also machine-understandable. Thus, we could analyse the distribution of different combinations of colors and charges and colors and groups of charges, calculate the percentage of differentiations, for instance, 'langued' for lions, or the proportion of such further differentiation for charges.

This becomes particularly powerful in the context of linked data, when we can study those particularities of coats of arms and their distribution combined with the metadata of the objects those coats of arms have been found on, such as that pertaining to time and place. This could be done by mapping the coat of arms in our database to the unique identifiers of the different entries in databases such as the *Corpus Vitrearum Medii Aevi (CVMA) Digital*, the *Deutsche Inschriften Online*, *Sigilla* or *Welfensiegel* or the *Ordinary of Medieval Armorials*, and to automatically retrieve the data on dating and location. Alternatively, it would also be possible to include the URI for a particular coat of arms directly in the respective entries of a database, which would make the data retrieval even easier. Such an interlinkage of different entries in different databases, featuring a coat of arms with the same design, would enhance our potential to identify unknown coats of arms considerably. It would enable us to cross-reference data from complementary data sources and to place the different results in context. Moreover, it would allow us to combine data from additional sources. Seals and gravestones, for instance, often provide information about the bearer and the time and place of use but not about the tinctures used in the coats of arms, while armorials, on the other hand, provide information about the tinctures but no specific data on time and place and the particular bearer of a coat of arms. From the perspective of cultural history, this system would give us the opportunity to gather information about the use of heraldry and specific coats of arms (or groups of them) in very different media and contexts. This way, we could follow, for instance, the use of the coats of arms of the Nine Worthies in manuscripts, on wall paintings and objects of all kind, potentially (depending on our data) whole over Europe.[59] This would allow us to establish a more accurate idea of the formation, transfer and dissemination of such groups of coats of arms, and thus of certain representations of literary concepts and ideas in medieval Europe. Finally, as part of the web of data, the data on coats of arms could also be studied in combination with data on persons, places and events.

Challenges

However promising this may sound, this approach of course faces some severe challenges. In the last part of this paper, we want to mention some of them.

For starters, we have to propose a model of heraldry, specifically one which has the potential to be accepted and shared by many specialists in the fields, in order to allow this new system to work. Since heraldry is an international concern, this is not an easy task, because heraldry has developed

[59] See, for instance, Wim van Anrooij, *Helden van weleer. De Negen Besten in de Nederlanden 1300–1700* (Amsterdam: Amsterdam Univ. Press, 1997).

differently in different countries.[60] For this reason there are concepts in one given language and culture which do not exist in others. Furthermore, in different heraldic cultures the same coats of arms may be conceived of very differently. Finally, this is also true on the level of individuals. Even the individual understanding of specific concepts may differ significantly, which makes it more challenging to work with sources or heraldic descriptions from different sources and authors.

Since we are dealing with a historical phenomenon, changes over time have also occurred. This doesn't matter when we only work with modern descriptions of coats of arms, but raises particular problems when we include the study of historical texts and historical blazon (as it is the case for armorials which do not feature any images but only textual descriptions). The term *sinople* in Middle French, for instance, indicated in the thirteenth century the color red, but changed its meaning from the fourteenth century to signify 'green'.[61] Depending on time and space, certain details in the depiction of a coat of arms could bear a certain meaning, or they could not. This is the case, for instance, for the color of the tongue of a lion, or how his tail is shaped.[62] Those details didn't convey any meaning in the thirteenth century, but became meaningful in the fourteenth and fifteenth century. Closely related to this is the problem of differentiating between artistic liberty and the representation of significant features. It is sometimes difficult to decide whether a specific detail is set to add to the meaning of the coat of arms, or only stems from the artist's manner in depicting it. In the end, different individuals can interpret differently in different times and places, since they do not share the same model of heraldry.

Finally, there are also coats of arms which defy the rules of blazon, i.e. which break with the idea of coats of arms being combinations of concepts. For instance, when the coat of arms in question is a picture rather than a coat of arms, or when heraldic devices stem from other sign systems like merchant marks, combinations of strokes and circles with no regulated language to describe them. In the end, heraldry and coats of arms are not that regular a system, nor are they based on transtemporal rules as it has been claimed all too often.

How can we deal with those challenges and overcome them? On the one hand, ontology engineering provides us with some possibilities to express vagueness and blurriness, and the possibility to limit the validity of a certain concept in space and time. Some of them can be directly adopted, but for other problems appropriate solutions to deal with vague, incomplete, and ambiguous historical data and the dynamics of historical development may still have to be developed. On the other side, we have to know more about the historical development of heraldic practices and heraldry as such, of temporal and geographic or cultural differences and changes. Thus, this approach to digitally represent heraldic data reveals the necessity of further basic research within the field of digital humanities, and the application of methods and techniques from Computer Sciences to the context of historical studies. But also the

[60] Torsten Hiltmann, 'Heraldry as a Systematic and International Language? About the Limitations of Blazonry in Describing Coats of Arms', in *Heraldica nova. Medieval Heraldry in social and cultural-historical perspe*ctives (blog on Hypotheses.org), 25 May 2016, <http://heraldica.hypotheses.org/4623> [accessed 21 December 2017].

[61] Gérard J. Brault, *Early blazon. Heraldic terminology in the twelfth and thirteenth century with special reference to Arthurian literature*, 2nd edn (Woodbridge: Boydell, 1998), p. 275.

[62] Georg Scheibelreiter, *Heraldik,* Oldenbourg Historische Hilfswissenschaften, 1 (Wien: Böhlau, 2015), p. 49.

approach has an impact on heraldry as an auxiliary science, where it is necessary for us to no longer look for (assumed) universal rules, but rather for actual practices in their historical contexts.

Conclusion

To sum up: In the first part of this paper, we identified different reasons why heraldry, despite its prominent role in medieval culture and communication, is still rarely included in studies on medieval and Early Modern culture and society. The mass of evidence, the heterogeneity of the media and the complexity of coats of arms and heraldry as such are apparently important obstacles to this. These obstacles are supplemented by the fact that the tools at our disposal are often difficult to use and outdated: a problem which heraldry shares with many other auxiliary sciences, such as sigillography or numismatics.

The solution to this may lie in the use of the methods and techniques of Computer Sciences. Thus, in the second part of the paper, we established the current state of the art concerning the use of computer-based methods to describe and register heraldic information in historical sources. We started with standards and thesauri to describe and annotate texts and images, continued with general databases on cultural heritage, and finally studied different specific databases on coats of arms and heraldry themselves, as well as the theoretical discussions about possible ways to use computer-based methods for this. As a result, we have to conclude that there is no common standard and no sufficient way to digitally register coats of arms and their depiction. In thesauri and general databases, no distinction is made between information provided by the coat of arms (by its design and the way it is depicted) and the interpretation of this information (e.g. to read a certain way of representation solely as an abatement, or to identify the coat of arms without mentioning any reference). This may very easily lead to misunderstandings and mistakes in the analysis and further processing of those data. It is only in the databases explicitly construed for the registration of heraldic data that we find the design of the coats of arms registered in detail in a separate field, so that these data can be more easily extracted. However, the different approaches we reviewed here focused on the use of natural language in order to store and process heraldic data in the computer system, trying to formalize the syntax further to improve the possibility to parse these descriptions into computer-readable data. Mostly with the goal to transform the collected data in images again, to facilitate the entry and retrieval process, or just to store the data in a more accessible medium. We have shown that any approach using natural language has several shortcomings, that it is likely to be more error-prone, that it lacks practicability since it depends on a given natural language (English, French), and that its options for data retrieval and analysis are insufficient.

Thus, in the last part of the paper, we proposed a new approach by using Semantic Web technologies. Seizing coats of arms not as texts but as concepts, this method allows us to overcome the described obstacles and shortcomings. This technique offers the possibility to study large amounts of complex data coming from different systems and repositories. In doing so, it opens up the collected material for new and exciting opportunities for analysis and research. This is true for the identification of unknown coats of arms as well as for studies in the perspective of cultural history. Stimulating new research in the field of Digital Humanities and creating a new need for more detailed studies in heraldry, focusing henceforth on the historical dynamics of heraldic practice instead of an assumed general system of rules with universal validity, this approach may eventually also give a significant push to the study of heraldry in particular and to auxiliary sciences in general.