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# THE HISTORY OF HERALDRY REVISITED: INTRODUCING DIGITAL HERALDRY ONTOLOGY TO DESCRIBE, CONTEXTUALISE, AND ANALYSE MEDIEVAL AND EARLY MODERN COATS OF ARMS

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## Introduction

In the Middle Ages and in early modern times, coats of arms were a widely used form of communication. They appeared on a diverse array of objects, executed with a vast variety of techniques on a wide range of materials. Applied in the most public and most private places, they could convey power, property, identity, kinship claims, or political and genealogical concepts – to name but a few, illustrating their ubiquitous usage.[1] As such, heraldry was being used in different regions of Europe, by different social groups and institutions. Above all, heraldry was a very powerful and versatile means of communication throughout much of European history. This begs the question how coats of arms developed from simple identification marks on the armour of knights to the complex means of communication that had evolved by the fifteenth century. This question was examined by the research project *Coats of arms in practice*, which ran from 2013 to 2018. Its research output, which led to a number of publications,[2] revealed the following key observations[3]: firstly, that visual communication via heraldry did not develop separately from written communication, but in parallel with it; secondly, that its ongoing development resulted in increasing complexity and differentiation of usage; and thirdly, that this whole process took place without the intervention or control by authorities of any kind – which means that the study of pre-modern heraldry must be based on research into the practice of its use rather than on normative sources. Finally, it can be assumed that the development of visual communication is closely linked to social and cultural development processes.

The findings of the *Coats of Arms in Practice* project raised new research questions: How did coats of arms as a means of communication differentiate and become increasingly complex over time? What led to the expansion of the repertoire of charges and patterns, and when did this occur? How did the practice of combining different coats of arms by marshalling develop and spread throughout Europe? How were new or altered concepts and forms of representation, such as the usage of cadencies and crests, established, and when did this occur? And how can these changes in visual communication be culturally and socially categorised? In essence, the results of this project indicate the need for a deeper historical perspective on heraldry. This means viewing it not as a fixed system with occasional variations, but as a dynamic system that undergoes continual evolution and change over time, shaped by changing social, cultural, and political conditions.

Thus, the goal of the second phase of the *Coats of Arms in Practice'* project (2019–2023) has been to better understand the history of heraldry. The limited research on this subject is not unexpected given the challenges involved. Firstly, studying the use of heraldry requires working with a large number of heraldic sources, with an estimated


*Figure 1:* Coats of arms as layered, conceptual images.

one million different coats of arms used during the Middle Ages alone.[4] Secondly, the system of visual communication used in heraldry is relatively complex. Thirdly, the widespread use of coats of arms results in a diverse array of sources and repositories, where those sources can be found, ranging from archives and libraries to museums and cultural heritage management. Fortunately, more and more of this material is being made available online, in the form of digital copies of documents, object descriptions, and databases. To tackle those challenges involved in researching heraldry, a digital approach is essential. To that end, we are developing and providing a database that can be used (1) to describe individual coats of arms as well as heraldic sources (2) to find unknown coats of arms, and (3) to research and comprehend the historical development of heraldry as a sign system.

In the following pages, we would like to present this project in more detail. Starting from the current state of research, we will show how the database was designed, and introduce step by step its individual parts on heraldic concepts, blazon, the individual representations of coats of arms in the sources, and finally, the description of these sources themselves. We will then show first examples of what is possible, using this database, before presenting the planned further development.

## State of the art: Heraldry and Computers

The idea of using computers for the study of heraldry is not new. There have been several early adopters of technology in the field,[5] with the most notable being the creation of the *Dictionary of British Arms* in the twentieth century.[6] Today, the largest projects include the databases by Philippe Palasi[7] and Steen Clemmensen,[8] both of whom provide extensive data on the usage of coats of arms both in manuscripts and monumental decoration, including full heraldic descriptions. Conceptually, these databases share a common characteristic of providing their descriptions in natural language.

These projects offer important resources for the heraldic community by providing a large reference tool. But the use of natural language for the blazon in the database comes with a few shortcomings. In particular, it is difficult to search within the data. Since it is possible to describe the same coat of arms in slightly differing ways, it is necessary to be as exact as possible in phrasing a search query. Even minor typing errors can lead to missing the desired outcome. Furthermore, it is difficult to search for the usage of certain charges and tinctures – in particular, when one is interested in how they were combined. A research question, pertaining to the general history of heraldry, like "when did coats of

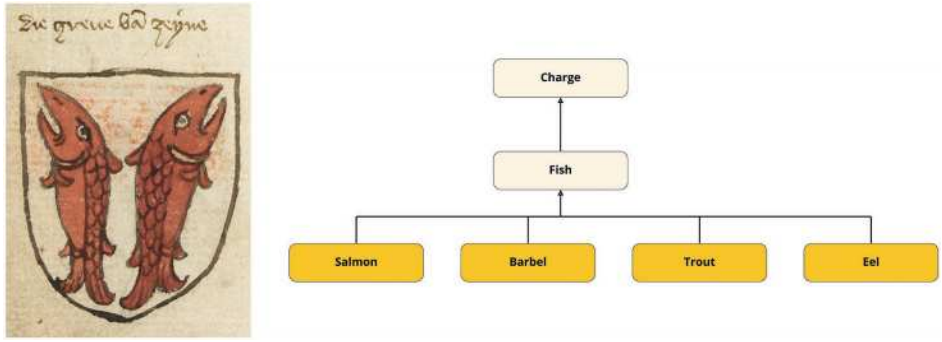


*Figure 2:* Identifying heraldic charges with the help of a class structure.

arms become more complex by using a higher number of charges?" is very difficult or even impossible to answer, based on such data.

To address these difficulties, the *Coat of arms in practice* project relies on AI-based methods to research the history of heraldry. Primarily, this means developing and providing a graphical database, using *Semantic Web Technologies*.[9] This entails, among other aspects, that data is stored in a graphical or network structure, where each node and each connection have a clearly defined semantic meaning. This semantic meaning is structured by an *ontology*, an abstract model which can be read and understood by humans and computer programs alike. Such an approach has a number of advantages compared with other database models: semantic web databases and ontologies rely on concepts rather than natural language to store information, making them language-agnostic. This means they are independent of any particular language.[10] Because ontologies are highly structured hierarchically, searches and analyses in any combination at different levels of abstraction are possible. (e.g. "which coats of arms depict any four-legged animal in conjunction with a label azure or argent?") And lastly, this technological approach makes it possible to easily link the contents of our database to other information, like the historical sources that depicted the coats of arms, or the historical people and institutions who used coats of arms.

## Introducing the Digital Heraldry Ontology

How can such a database be created in practice? To answer this question, we must first clarify what is meant by a "coat of arms" in the context of our database. As Michel Pastoureau once wrote:[11]

> "[...] l'armoirie est une image fortement conceptuelle. [...] Elle n'a aucunement besoin d'être peinte, dessinée ou gravée pour devenir une image véritable. Elle l'est déjà conceptuellement et structuralement."(The coat of arms is a highly conceptual image. It does not need to be painted, drawn or engraved to become a true image. It already is, conceptually and structurally).

A coat of arms, therefore, is firstly understood by us as a *conceptual* and *structural* image. Secondly, it is also understood as a layered image[12], where the charges are imagined as different superimposed layers on top of each other upon the background of the field (**Figure 1**). We are not providing a completely new paradigm on how we


*Figure 3:* Coat of arms, representing the family of Vergy in the Armorial de Nicolas de Lutzelbourg, f. 14r

describe coats of arms, rather, the project is founded on existing and established heraldic and historiographic practices.

An heraldic database that overcomes the challenges mentioned above has to describe more aspects than just the blazons of the coats of arms in question. It must also account for the usage of these coats of arms in their historical contexts, information about the sources which have conveyed them to us, and of the people or other entities that were the bearers of those coats of arms whom the arms identify. This broader perspective is imperative in order to meet our requirement of studying the actual use of heraldry as a historical practice, as outlined in the introduction.

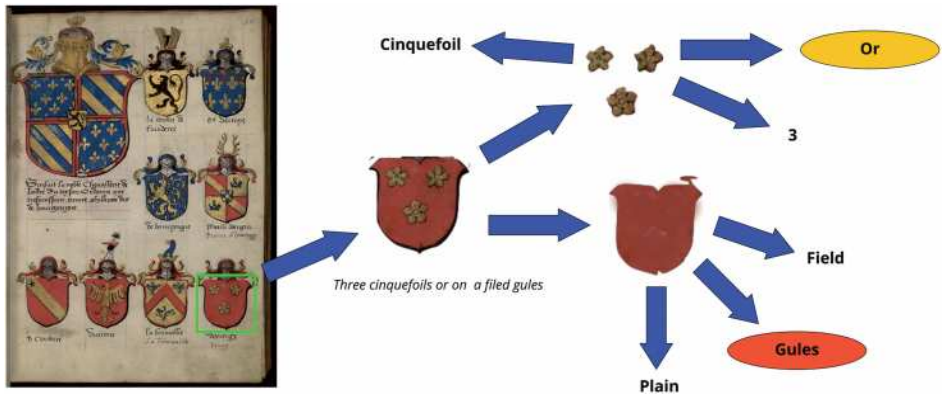


*Figure 4:* Structural elements of a coat of arms.

Accordingly, the *Digital Heraldry Ontology* encompasses those various aspects, and is thus constructed from five different components, each of them modelling different aspects and contexts of heraldic data, and the use of heraldry in historical sources:

- Heraldry:[13] a collection of heraldic terms which are needed for blazoning and how they interrelate,
- Blazon:[14] the conceptual descriptions of coats of arms as heraldic combinations, based on those terms,
- Representation:[15] describing the concrete, material representations of coats of arms in historical sources,
- Object:[16] information about the historical sources that display those *representations* of coats of arms,
- Entity:[17] persons, groups, or other entities that are represented by those coats of arms.

Each of these components will be discussed briefly in the following sections.

## Heraldry

Instead of using concrete images or language-specific words which are different in English, French or German, the ontology describes a coat of arms as a combination of different heraldic concepts, which are all represented by a specific id, consisting of the unique internet address where this concept is defined in detail.[18] Each of these concepts that can be used to describe a coat of arms (e.g. lion, azure, gironny, palewise) represents a so-called "class" in the ontology. To be able to use these classes to describe coats of arms accurately, they have to be as granular as possible, so that they can be combined as needed when describing a coat of arms. To name an example: a heraldic charge like "cross pommy and flory", which is displayed as a single item on the image of a coat of arms, in fact consists of three classes – cross, pommy, and flory – that can be used

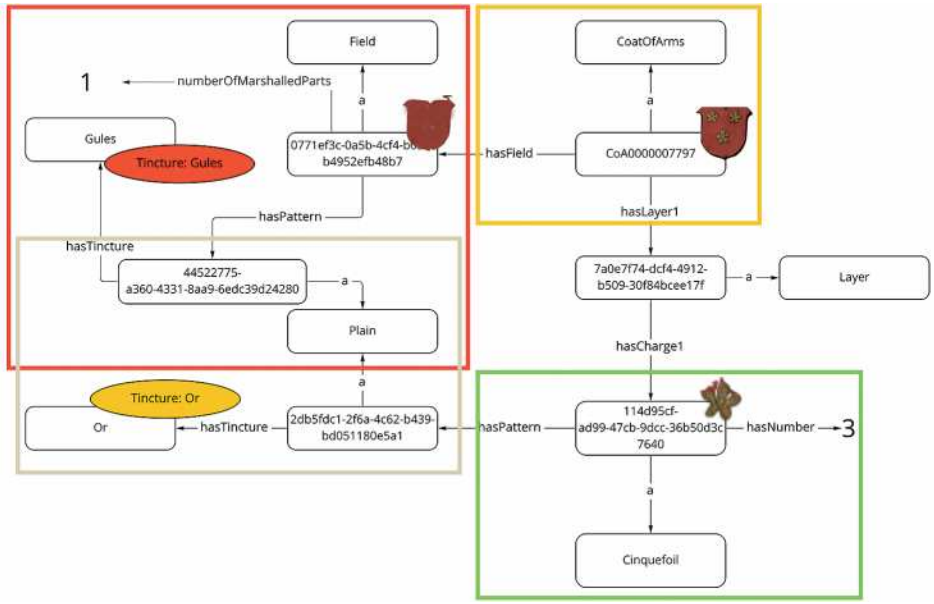


*Figure 5:* Coat of arms of the family of Vergy, as defined in the *Digital Heraldry Ontology*.

together or in conjunction with other classes in the ontology in different descriptions. Only then will we be able to search for coats of arms in the database that, for instance, are charged with any kind of cross. Each of these classes includes multiple definitions from heraldic literature that describe the underlying concept, as well as multiple terms that are used to describe it. Currently, we provide terminologies in English, French, and German.[19] The current version of the ontology contains over 300 classes, which will eventually reach over 1,000 different classes in total.[20] These classes encompass all heraldic charges, patterns, tinctures, lines, and terms to arrange and modify charges that are used to describe medieval and early modern coats of arms.

All of these classes are hierarchically structured; especially charges and tinctures. This way, searching for coats of arms will be much easier. Consider for example the coat of arms in **Figure 2**. Clearly, it shows two fish as charges, but without further context it is difficult to ascertain which type of fish is displayed – it could be interpreted as a *Salmon*, a *Barbel*, or maybe even a *Trout*. In the ontology, all of these classes are modelled as a subclass of *Fish* (which is itself a subclass of *Animal*, which itself is a subclass of *Charge*). As a result, it is possible to simply search for coats of arms that display two *Fish* (instead of trying out different species of fish whose names may not even be known to us) and get the coat of arms in figure 2 as a result nonetheless. All in all, such a deep semantic class structure makes the usage of the *Heraldry* ontology much more accessible and much less error prone.

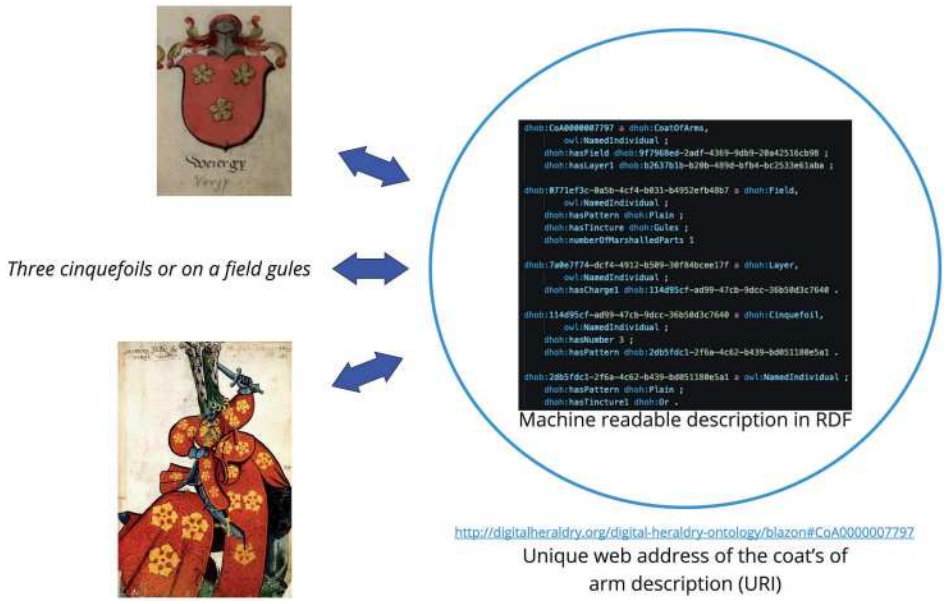


*Figure 6:* the coat of arms ascribed to Vergy as a unique object on the web, independent of its representation in the *Armorial de Nicolas de Lutzelbourg*, f. 14r, or the *Grand Armorial de la Toison d'or*, f. 142r.

## Blazon

How can this structure be used to describe coats of arms as data? That's where the second ontology, called *Blazon*, comes in. This second ontology is more or less a storage of all blazons, i.e. of all the specific combinations of heraldic terms representing the different conceptual images known as coats of arms, that are part of our database.

To illustrate how this works, let's look at the concrete example in **Figure 3**. This coat of arms, taken from the Armorial de Nicolas de Lutzelbourg,[21] and representing the family of Vergy, could be blazoned as *Three cinquefoils or on a field gules*. Such a description in natural language contains two units of information: firstly, the information on the field (here: field gules), and secondly information on its charge (the number, the tincture(s), and the fact that it is of the type "Cinquefoil") (see **Figure 4** for reference).

This linguistic structure as it is shown in the image is of course not machine-understandable and therefore not representable as conceptual data, but only as text (string). But it is immediately transferable into the coat of arms' representation in the *Blazon* ontology, using the different heraldic concepts of the aforementioned *Heraldry ontology* and combining them. The coloured frames in **Figure 5** correspond to the different nodes in figure 4 – essentially the different parts that a coat of arms is composed of. The nodes framed in bold are representing heraldic terms, defined in the *Heraldry ontology* which was described in the last paragraph. The four nodes containing numbers and letters are essentially the entities in our database, actually representing this particular description of a coat of arms and its parts (its charges, fields, patterns, and groups of charges).

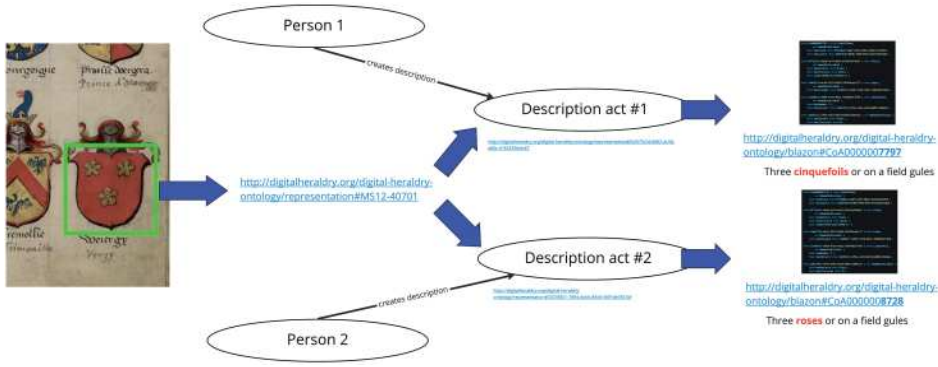


*Figure 7:* Conflicting descriptions of the same instance of a coat of arms in the *Digital Heraldry Ontology*.

The structure described here is of course only a minimal example. It can be scaled up and – by utilising the classes and terms from the *Heraldry ontology* – used to describe any coat of arms of any complexity. Through the graphical structure explained here, it is also possible to easily and accurately describe complex marshalling, by just combining different blazons as part of the same shield.

Note, that everything we talked about up to this point represents the coat of arms as an abstract entity, i.e. existing only conceptually, and not yet either visualised in a material way,[22] attributed any meaning, or linked to a given family. This changes with our next ontology, called *Representation*.

## Representation

In practice, we can encounter different representations of the same coat of arms – like the one of the family of Vergy – in different historical sources. We can find it in a manuscript, on a seal, or in its blazoned form as a textual representation. These three *instances* or *representations* of this coat of arms can be described in the same way – because they refer to the same conceptualisation or specific combination of charges, patterns, and tinctures. And this description or conceptualisation can be represented by the same machine readable structure, as described in the last section, which is referred to by the same URL, identifying this specific combination of heraldic concepts in our database and on the web (**Figure 6**).

To account for these different representations of the same coats of arms in different material contexts, the ontology models each instance of a coat of arms that is represented in a historical source as a unique entity, with a unique URL identifying it. This means that the visual *representation* of the coat of arms in both manuscripts in figure 6 are being represented as two different entities in the database – both referring to the same *Blazon* ("CoA0000007797"), since they depict the same combination of heraldic charges and patterns. But why not just refer to the description of the coat of arms directly? Why do we need this "detour" of modelling the occurrence of a description in a historical source as a unique entity?

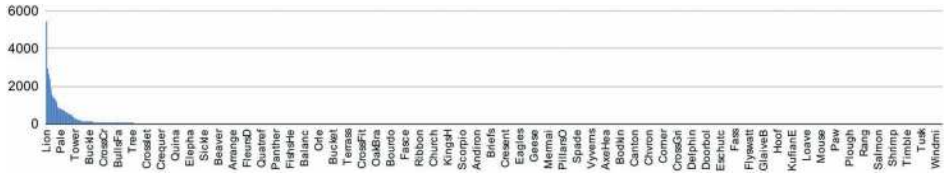


*Figure 8:* Distribution of the commonality of charges in the dataset.

One of the challenges of studying the history of heraldry is having to deal with different descriptions of the same coat of arms by different scholars. Let's assume, that the coat of arms of Vergy, represented in the Armorial de Nicolas de Lutzelbourg, from our example was described by two different people – the first one describing its heraldic charge as a *cinquefoil*, the second one blazoning it as a *rose*. This might just be due to a "reading error", but often such diverging readings can be attributed to other reasons such as damage to the historical object, or its deterioration, making it more difficult to identify a heraldic tincture.[23]

Such differences in interpretation are one aspect of uncertainty, inherent with historical sources.[24] Data must be modelled as explicitly as possible to be able to study it, and so it is imperative to include aspects of uncertainty in our representations of historical sources as data. This is done by introducing a third entity which links the single occurrence of a coat of arms in a source with the different descriptions attributed by different scholars. We call this entity in the middle the *description act* (**Figure 7**). It allows us to store additional information about the *act* of description such as the date when the description was created, or information about the person responsible for the description, plus other attributions he or she linked to this representation. Effectively we are separating the concept of blazon from the concrete act of its representation.

## Objects and entities

How the representation of a coat of arms is to be interpreted as a historical source itself heavily depends on the historical context of its creation, presentation, and usage. Researching coats of arms is only possible when taking the historical context of their use into account. This historical context is modelled in our database by the last two ontologies, *Object* and *Entity*. The *Object* ontology provides information about the physical historical sources that feature the *Representations* of coats of arms. This includes various types of metadata, such as the dates of creation of the source and its further history, the specific usage of the source, places associated with it, owners of the object, artists involved in its creation, among others. Due to the special format of the database, which is based on Semantic Web technologies and on Linked Data, it is possible to directly import these different pieces of information from the databases of libraries, archives, museums, etc. – which significantly facilitates the necessary work of collecting data. Different types of historical sources, such as manuscripts, seals, deeds, and ceiling paintings, require different types of metadata to accurately describe them. By including these different types of metadata in our ontology, we are also able to analyse the use of specific coats of arms across different historical sources.

Finally, *Entity* encompasses all things that can be identified through a coat of arms or to which a coat of arms can be attributed. These can be persons, families, territories,

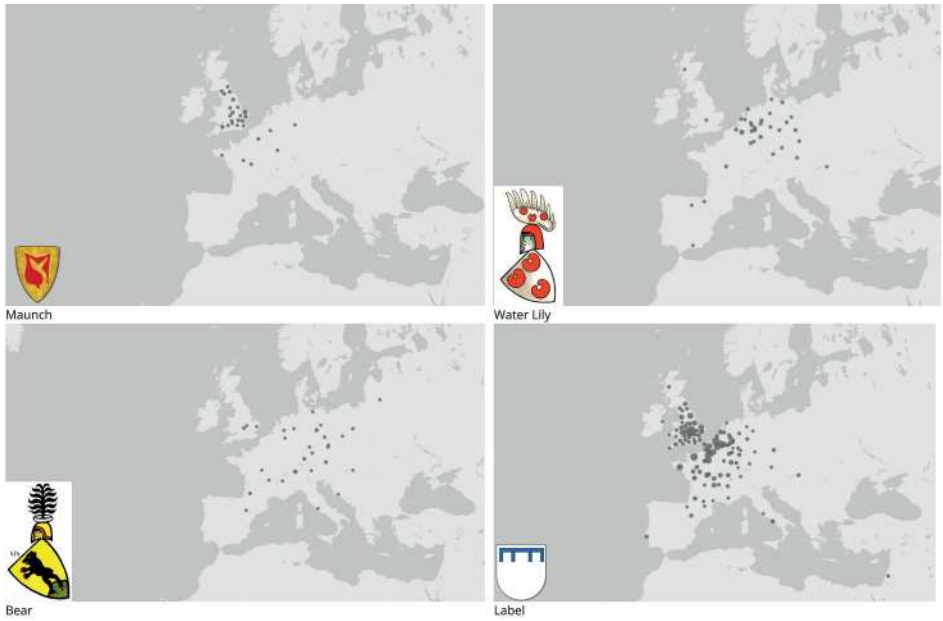


*Figure 9:* Geographical distribution of the use of Maunch, Water Lily, Bear, and Label as charges.

offices, institutions, cities, or abstract concepts and ideas. Like the historical *Object*, *Entities* are also described through metadata in order to place them in their historical contexts, e.g. names, dates, offices, members of a group, or social roles. Again as with the *Objects*, which metadata is being provided depends on the particular type of an *Entity*. The metadata itself will largely be drawn from authority files, like Wikidata, Biblissima, or the *Integrated Authority File* of the national library of Germany.

## Case studies on the history of heraldry, using the *Digital Heraldry Ontology*

The Digital Heraldry Ontology, as described in the previous section, enables users of our database to search, to identify, and to study the usage of coats of arms in their historical contexts. At present this can only be done using code-based queries in the Semantic Web query language SPARQL. However, as we write, we are developing a user interface that will greatly simplify the possibilities to interact with our data. In the following section we will present three preliminary case studies to demonstrate the potential of our database for studying mediaeval heraldry. Our focus will be on the evolution of heraldic practices, specifically with regard to marshalling, as well as the number and variety of charges and brisures.

We will here focus on only one type of source: armorials in mediaeval manuscripts. The data were created by re-using the database "Medieval Armorials"[25] by Steen Clemmensen, which provided us with 87,638 occurrences of coats of arms in mediaeval armorials and 38,970 textual descriptions of different combinations (blazons). We

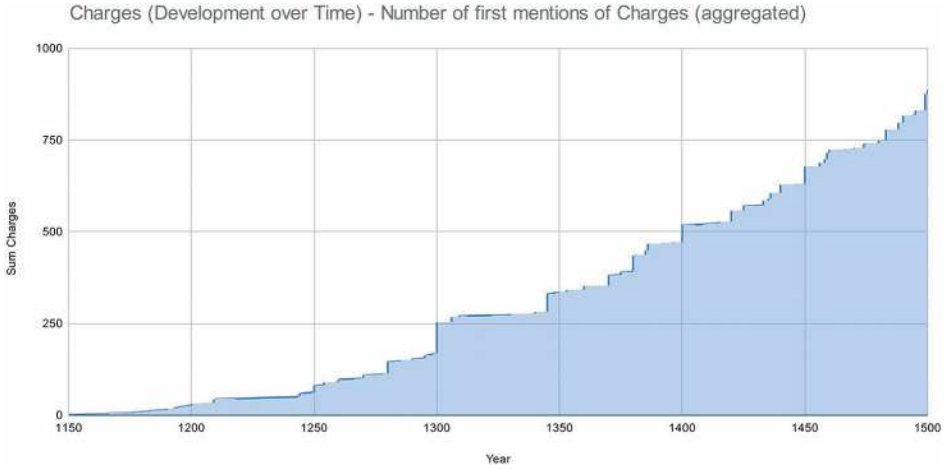


*Figure 10:* Aggregated number of charges over time after their first occurrence in a manuscript.

transformed these textual descriptions into the graph-based Representations according to our *Digital Heraldry Ontology*. The collection is based on 286 manuscripts which were mainly created in France, England, and the Holy Roman Empire between 1150 and 1500 – offering us an extensive and broad corpus of historical sources. Some of the data still has to be checked and revised, so that the results of these case studies can only be seen as preliminary.

For our first example, let us examine the distribution and utilisation of the various charges in coats of arms throughout space and time. The distribution of charges is highly irregular, with only 24 out of 875 charges in the database being used in over 1% of the coats of arms (**Figure 8**). Some charges have been favoured more in certain regions than in others, as shown in **Figure 9**.[26] The number of available charges for use in a coat of arms has steadily increased from 1150 to 1500 (**Figure 10**). This increase in complexity warrants further exploration.

The increasing complexity of heraldry is manifested not only in the increasing number of charges, but also in the practice of marshalling, where multiple coats of arms are combined into one. Marshalling may serve various purposes, such as visually communicating alliances or genealogical relationships (e.g. a married woman's coat of arms which combines the coats of arms of her father and those of her husband), or as a form of political communication to represent multiple dominions and titles held by an individual, or to vaunt claimed origins.

We need to know how the practice of marshalling developed. The earliest examples of marshalled coats of arms in our data can be traced back to the end of the twelfth century, but until the second half of the fourteenth century they were relatively uncommon in newly mentioned coats of arms. As marshalling became more widespread there was a change in practice: the shield was no longer divided into two parts, but into four. Could this indicate an increase in heraldic complexity, or was it just a change in custom? Our

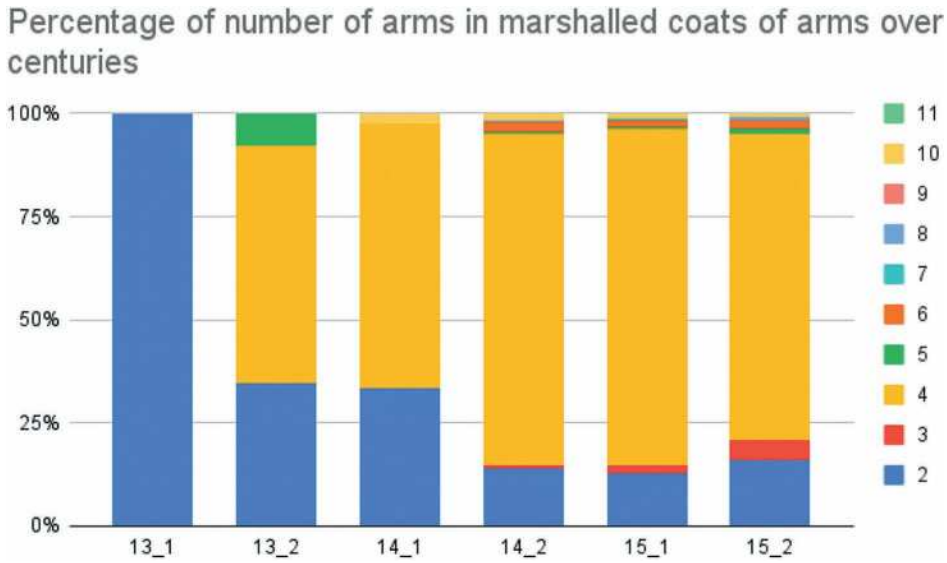


*Figure 11:* Percentage of number of arms in marshalled coats of arms over centuries.

data suggest the latter, as most quartered shields still only show two different coats of arms.

In other respects, however, an increasing complexity can be observed. As can be seen in the **Figure 11**, marshalled coats of arms consisting of more than four different parts were introduced in the fourteenth century. Our database also allows us to compare the number of different layers in the coats of arms. Several such layers in a single coat of arms indicate a more complex heraldic representation. The majority of the coats of arms in our database show only a single layer. During the course of the later Middle Ages, however, we observe a slight increase in the number of layers used **Figure 12**. If we place these coats of arms on a map, we see quite a heterogeneous distribution. The map in **Figure 13** shows the number of layers in coats of arms described in the data from "Medieval Armorials", geolocated as described above. Some heraldic centres can clearly be identified, especially in Burgundy and the Netherlands, England, and northern France. In these regions we find a greater number and a greater proportion of more complex coats of arms, in terms of the number of layers.

These results are far from comprehensive, but can show what a powerful and versatile tool the graph-based database approach in combination with the ontology can provide. We must stress that these are only preliminary results to test the ontology. An important next step will be to include data on the historical context of the sources in which the coats of arms are depicted, and on their use. This will allow for much more nuanced research questions, such as whether and how the increase in complexity developed in the same way in different social groups. The picture seems to indicate that there was indeed a difference in heraldic practice between patricians and nobles. While the former seems to have been characterised by the use of only single layers, and of only a few different charges, and a more frequent use of *naturel* instead of a tincture, most of the

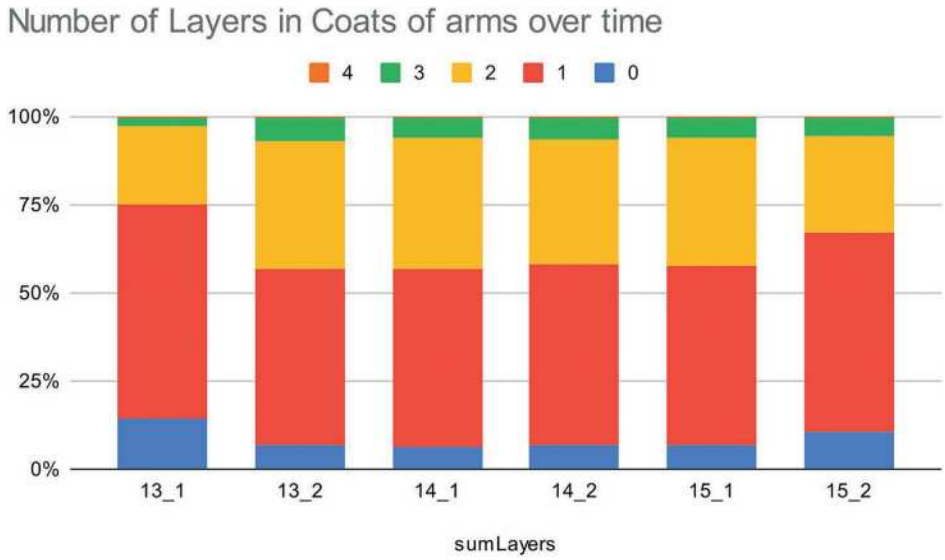


*Figure 12:* Number of Layers in coats of arms over time.

latter examples are the exact opposite from a heraldic point of view. But how widespread were these differences in different cultures and regions? The inclusion of more data on historical, spatial and social contexts will allow us to examine research questions like these more extensively and in a comparative way from a European perspective.

## Outlook

We conclude with an outlook on the ongoing and future work of the project *Coats of Arms in Practice*. Besides the continuous refinement and extension of the ontologies, one of our main goals is to integrate more data, not only from manuscripts, but also from other types of historical sources. An ongoing Ph.D. project is currently focusing on coats of arms on painted walls and ceilings. Here we are not only creating and making available new heraldic data, but also developing an extension of the object ontology that will allow us to model and explore heraldry as part of architecture. In addition, a masters thesis is being written that will integrate heraldic data on inscriptions, gravestones and epitaphs into our database. In a next step, other databases on various objects with coats of arms will be integrated alongside the *Ordinary of Medieval Arms*, in particular the French project *Sigilla* with data on coats of arms on seals. Furthermore, the inclusion of the *Medieval Ordinary* from the *Dictionary of British Arms*[27] will further increase the number of available heraldic descriptions and representations. Finally, in order to integrate early modern collections of coats of arms, we would like to tackle the integration of sources such as the works of Johann Siebmacher[28] and Hozier's *Armorial Géneral de France en 1696*.[29]

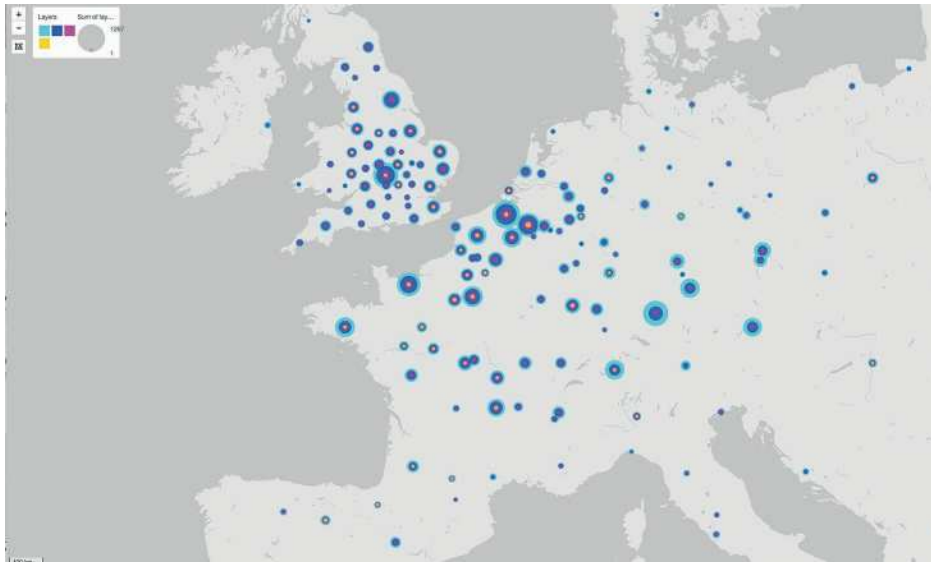

*Figure 13:* Geographical distribution of the number of layers in coats of arms.

In addition to integrating more data, we need to make the existing data more accessible. Currently, all heraldic data already published can be reused and queried, but this requires at least some knowledge of the Semantic Web query language SPARQL. In order to make our data accessible and reusable via a graphical user interface that anyone can easily use, we are currently working on the development of a web app that will allow users to work with both the ontologically structured data and the illustrations for the individual heraldic representations at the same time.

The web app will offer a range of functions. A facet search will enable a complex search for individual coats of arms. This can be done using the heraldic terms of the *Heraldry Ontology*. Such a search will also be possible using flexible combinations of metadata relating both to objects and to persons identified by coats of arms. It will provide users with tools to explore and analyse the results of their search (e.g. visualisation tools with displays of location-based information on maps). Furthermore, it will be possible for users to add to the database (and to edit) new descriptions and representations of coats of arms, and of the objects on which they are represented.

The class structure of the heraldry ontology will make both the input and the query of heraldic data more accessible to people without deeper heraldic knowledge. Accessibility will also be improved by the provision of a similarity search which will allow users to upload the image of a coat of arms to find similar representations with their related details. A crucial aim is that the data, the web application and the ontologies will be freely accessible and usable by everyone. In this respect, the goal of our current work is to provide a tool to (1) identify unknown coats of arms, (2) conduct heraldic research and collect and analyse data, and (3) provide a participatory resource for a community interested in heraldry, enabling them to share their knowledge with others.

[1] Werner Paravicini, 'Gruppe Und Person. Repräsentation Durch Wappen Im Späteren Mittelalter', in *Die Repräsentation Der Gruppen. Texte – Bilder – Objekte*, ed. Otto Gerhard Oexle and Andrea von Hülsen-Esch, vol. 141, Veröffentlichungen Des Max-Planck-Instituts Für Geschichte (Göttingen, 1998), pp. 327–390.

[2] Torsten Hiltmann and Laurent Hablot (edd.), *Heraldic Artists and Painters*, vol. 1, Heraldic Studies (Ostfildern, 2017); Torsten Hiltmann and Miguel Metelo de Seixas, *Heraldry in Medieval and Early Modern State Rooms*, vol. 3, Heraldic Studies (Ostfildern, 2020); Miguel Metelo de Seixas, Torsten Hiltmann, and João António Portugal, *State-Rooms of Royal and Princely Palaces (14th–16th Centuries). Spaces, Images, Rituals* (Porto, 2022); Elmar Hofman, *Armorials in Medieval Manuscripts. Collections of Coats of Arms as Means of Communication and Historical Sources in France and the Holy Roman Empire (13th – Early 16th Centuries)*, vol. 4, Heraldic Studies (Ostfildern, 2021); Torsten Hiltmann and Laurent Hablot, *Heraldry in the City. The Case of Italy in Its European Context*, vol. 5, Heraldic Studies (Ostfildern, 2023); 'Heraldica Nova – Medieval and Early Modern Heraldry in Cultural-Historical Perspectives', https://heraldica.hypotheses.org/.

[3] Torsten Hiltmann, 'Zwischen Grundwissenschaft, Kulturgeschichte und Digitalen Methoden. Zum aktuellen Stand der Heraldik', *Archiv Für Diplomatik* 65 (2019): p. 318.

[4] Michel Pastoureau, *L'Art héraldique au Moyen Age* (Paris, 2008), p. 42.

[5] N. M. Brooke, 'The Computer and Heraldry', *Coat of Arms*, no. 92 (1974): pp.112–16; N. M. Brooke, 'The Computer and Heraldry', *CoA*, no. 93 (1975): pp.137–43; N. M. Brooke, 'The Computer and Heraldry', *CoA*, no. 94 (1975): pp.172–80; Katharina Urch, 'Digitalisierung Und Erschliessung Einer Historischen Wappensammlung. Erfahrungen Im DFG-Projekt HERON (Heraldry Online)', *Bibliotheksforum Bayern* 28 (2000), pp.187–203.

[6] Hubert Chesshyre, 'History of the Project', in *DBA* vol. 1 (London, 1992), pp. viii–xiv.

[7] Philippe Palasi, 'Palisep', https://palisep.fr/home/.

[8] Steen Clemmensen, 'Medieval Armorials', http://www.armorial.dk/.

[9] Aside from that, we are also working with Machine Learning approaches to deal with large amounts of images of coats of arms. Up until now we have created models that detect coats of arms in scans of manuscripts and on images of seals and coins as well as another model for a similarity search, to find and help blazoning unknown coats of arms. In contrast to the Semantic Web approach, this works on a visual rather than a conceptual level. This part of the project is not discussed in detail in this paper.

[10] e.g. a charge like "dhoh: Label", used throughout multiple heraldic descriptions in the database, can be linked to a number of corresponding translations in different languages ("lambel", "label", "Turnierkragen"). Through these links, it is possible to search e.g. for "lambel" in French, which would yield all coats of arms that use a label as one of its charges.

[11] Michel Pastoureau, *Traité d'héraldique*, Grands Manuels Picard (Paris, 1979), p. 315.

[12] Michel Pastoureau, 'L'armoirie médiévale. Une image théorique', in Gaston Duchet-Suchaux (ed.), *Iconographie médiévale. Image, texte, contexte* (Paris, 1990), p.122; Pastoureau, *L'Art héraldique au Moyen Age*, p.131.

[13] http://digitalheraldry.org/dho/heraldry

[14] http://digitalheraldry.org/dho/blazon

[15] http://digitalheraldry.org/dho/representation

[16] http://digitalheraldry.org/dho/object

[17] http://digitalheraldry.org/dho/entity

[18] Such as http://digitalheraldry.org/digital-heraldry-ontology/heraldry#Gironny to denote the concept of *gironny*.

[19] The following heraldic textbooks are being used to provide the definitions and aliases: Arthur Charles Fox-Davies, *A Complete Guide to Heraldry* (London, 1909); James Parker, *A Glossary of Terms Used in Heraldry*, 1st ed. (London, 1894); Johann Baptist Rietstap, *Armorial général precédé d'un dictionnaire des Termes du blason*, 1st ed. (Gouda, 1884); Emmanuel De Boos, *Dictionnaire du blason* (Paris, 2001); Gert Oswald, *Lexikon der Heraldik* (Leipzig, 1984); Maximilian Gritzner, *Handbuch der heraldischen Terminologie in zwölf Zungen* (Nürnberg, 1890).

[20] The documentation of the most current version of the ontology can be accessed at http://digitalheraldry.org/dho/heraldry.

[21] Armorial dit de Nicolas de Lutzelbourg. Nancy, Bibliothèque Municipale, Ms. 1727 ff.14r–115v.

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

[23] Steen Clemmensen, 'Evaluating Armorials (IV) – Grünenberg, the Unfortunate Armorist', Billet, *Heraldica Nova* (blog), https://heraldica.hypotheses.org/1975.

[24] Michael Piotrowski, 'Accepting and Modeling Uncertainty', in Andreas Kuczera, Thorsten Wübbena, and Thomas Kollatz (edd.), *Die Modellierung Des Zweifels – Schlüsselideen Und – Konzepte Zur Graphbasierten Modellierung von Unsicherheiten*, vol. 4, Zeitschrift Für Digitale Geisteswissenschaften / Sonderbände (Wolfenbüttel, 2019); Jennifer Edmond, 'Managing Uncertainty in the Humanities: Digital and Analogue

Approaches', in *Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality*, TEEM'18 (New York, 2018), pp. 840–44.

[25] Clemmensen, *Ordinary of Medieval Armorials*, www.armorial.dk.

[26] The geographical data is based on the coats of arms in our database that can be assigned to marches of arms. For these marches of arms, the corresponding historical (or modern, where not otherwise possible) territories, which also have entries in Wikidata were identified, These entries then provided the coordinates to place them on a map.

[27] *DBA*.

[28] Johann Siebmacher, *New Wapenbuch, darinen deß H. Römischen Reichs Teutscher Nation hoher Potentaten, Fürsten, Herren und Adelspersonen auch anderer Ständt und Stätte Wappen in der Zahl über 3320, beneben ihrer Schilt und Helmkleinoten, mit besonderm Fleiß erkundiget...* (Nürnberg, 1605); Johann Siebmacher, *Johann Siebmachers Wappen-Buch : Faksimile-Nachdruck der 1701/05 bei Rudolph Johann Helmers in Nürnberg erschienen Ausgabe : alle sechs Teile mit Anhang, Register und allen Erweiterungen bis zum Abschluss der Stammausgabe von 1772* (München, 1975); Johann Siebmacher, *Johann Siebmachers Wappenbuch : Faksimile-Nachdruck der von 1753 bis 1806 im Verlag der Raspischen Handlung in Nürnberg erschienen zwölf Supplemente* (München, 1979).

[29] Charles Hozier, *Armorial général de France, recueil officiel dressé en vertu de l'édit royal du 20 novembre 1696* (Paris, 1903).