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The HERON Project — Multimedia Database Support for History and Human Sciences

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The HERON Project — Multimedia Database Support for History and Human Sciences

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Abstract

The interdisciplinary HERON project investigates the impact of multimedia applications from the humanities, in particular heraldry, on future database technology. We present first evaluation results of querying image databases by visual content. Also the requirements of a digital workbench for art historians are described. Here we present an approach how to tackle the complex problem of exchanging multimedia documents over the internet.

1 Introduction

Images were always used to bear complex information. Though they tend to be even the most intuitive kind of information, image interpretation requires a lot of semantic knowledge and consequently is a time-consuming, difficult task. According to their complexity, so far little database support for image retrieval and evaluation has been established. Currently research efforts draw upon two orthogonal approaches for the retrieval of images based on their content: The conservative way is to manually index an image's content using predefined vocabulary. Queries then are specified using the predefined vocabulary [OS95, BWK97]. A more recent approach attempts an automatic content-based image retrieval based on generic features like color, texture, shape or spatial layout. There are numerous projects and (commercial) systems dealing with database support for multimedia data and content-based retrieval, such as QBIC [FBF$^+$94], Photobook [PPS94] or Virage [Inc97]. This emerging technology opens up the opportunity for challenging applications in the humanities, where large and precious collections of images exist.

At the University of Augsburg computer scientists and art historians have initiated the interdisciplinary research project HERON[1] (HERaldry ONline). Today the use of digital libraries in arts, history and humanities is still exceptional. Though images are essential in almost all historic sciences, their use in heraldry is outstanding. The HERON project is set up with the target of building a very large multimedia database for heraldic research in art history. Heraldry is one of the oldest ancillary sciences and useful for the classification of a wide variety of medieval historical documents, epitaphs, paintings or other pieces of art. Especially when it comes to the identification of particular persons or personal possesions, results can often only be achieved by the means of heraldry. To classify coats of arms depicted on historical objects, historians still have to go through various large works of reference, some containing more than 100,000 different shields [Sie56, Rie50]. Thus existing technologies for content-based image retrieval have to be evaluated seriously w.r.t. the requirements of heraldry.

The integration into the internet together with efficient online access is crucial for HERON. From an art historian's viewpoint the WWW can be characterized as a world wide compound of multimedia document servers delivering historical documents relevant to his/her work. However, the art historian's requirements dramatically influence the profile of online multimedia databases: The intensive use of multimedia documents in a variety of formats and at different levels of quality demands an optimized storage of multimedia documents, together with the integration of knowledge on multimedia formats into web servers and clients.

The rest of this paper is organized as follows: An overview of the science of heraldry together with new challenges for heraldic databases is presented in Sect. 2. First results on the retrieval by image content are presented in Sect. 3. Section 4 discusses the impact of an art historian's requirements on the design of HERON's prospective server architecture and its integration into a networked environment. We will draw conclusions in Sect. 5 and point out future research directions of the HERON project.

2 Heraldic databases

Though images are essential in almost all art historic and historic sciences, their use in heraldry is exceptional. When it comes to the identification of particular persons or personal possessions, results can often only be achieved by the means of heraldry. The beginnings of heraldry date back to the late eleventh century when nobles began to fight in armour, and each led his particular body of retainers into the field. As it became more and more impossible to recognize strongly armoured fighters, pictorial representations were used to identify individuals, and later on entire families. In the year 1095 shields emblazoned with heraldic emblems (charges) appear for the first time in history and early on, heraldry took its place as an integral part of warfare. Since the 12^{th} century

[1]Since the beginning of 1998 HERON is funded by the DFG (Deutsche Forschungsgemeinschaft) as part of the DFG program "Verteilte Verarbeitung und Vermittlung digitaler Dokumente".

first attempts were made to lay down laws for its guidance and to collect a wide variety of different bearings of knights. These rolls of arms were the first references containing images or prose descriptions (blazonings) of bearings at various periods (cf. Figure 1). By the Middle Ages heraldry had blossomed into a complex system with the growing tendency to crystallize vague guiding principles into exact rules [Bou58].

2.1 Issues in heraldry

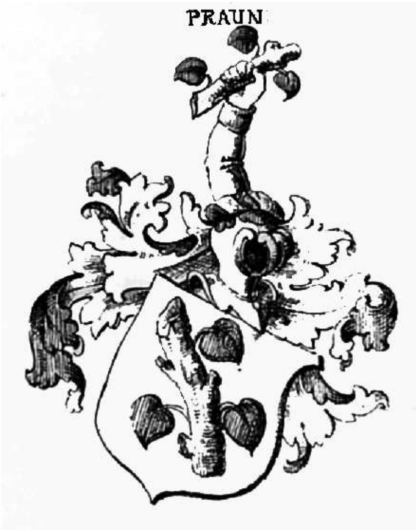
2.1.1 Composition rules for heraldic shields

As the acceptance of heraldry grew, the depictions of arms - together with the refinement of arts - became more and more individual. Not only the form of the shield itself varied, but shields were decoratively surrounded by some form of drapery, helmets, crowns, crests or other badges. Nonetheless these outer ornaments are of minor interest. In general there are three principal elements that characterize a coat of arms:

- the field,
- the tinctures: metals, colors and furs,
- the charges.

The field is the ground of the shield and may be divided by horizontal, perpendicular or diagonal lines and by any combination of these. Thus smaller partitions arise that can be divided or emblazoned with charges like the original shield. Each partition or charge is of a specific tincture. The tinctures comprise two metals - gold and silver (often represented by yellow and white), seven colors - red, blue, green, purple, black, orange and brown and three furs - ermine, vair and potent. In drawings or engravings tinctures are mostly represented by dots or differently arranged lines (hatchings). There are lots of charges or symbols that can emblazon a shield, even overlaying several partitions. One of the main rules in heraldry is that metal must not be placed on metal, or colour on colour. For instance, if the field is of gold or silver, the charges thereon must be of colour or fur. However, many exceptions are allowed and occasionally even arms violating this rule are found.

During the Middle Ages arms became a common way to identify not only noble families, but also personal possessions, and the ways to resume armorial bearings had to be restricted. Therefore heralds had to be appointed to make grants of arms and generally to observe the compliance with heraldic regulations. As heraldry spread all over Europe and the number of arms as well as charges to distinguish rapidly grew, a technical terminology had become absolutely necessary. The art of correct blazonings is a very complex matter, which requires a specific vocabulary. Not only partitions, colors and charges had to be named individually, but also particular postures and several ways of depiction.



Praun (Tafel 125)
schweizerischer Uradel, hiessen dort »die Prunen von Schenwerd« und sassen bereits im XIII. Jahrhundert im Rathe der Stadt Zürch. Einer des Geschlechts siedelte im XIV. Jahrhundert nach Nürnberg über, wo das Geschlecht mit der Zeit auch ins Patriziat kam.

Ihr Stammwappen zeigte in S. einen r. Stern, und auf dem Helm einen ebensolchen, an den Spizen mit g. Kugeln besteckt. Dies Wappen wurde den Nürnberger Praun i. J. 1474 von Kaiser Friedrich verändert, aus welchen Ursachen unbewusst, und bildet diese Umänderung ein merkwürdiges Beispiel in der Geschichte der Heraldik.

Das neue, jezt noch übliche Wappen zeigt in S. einen abgehauenen Ast mit drei r. Lindenblättern, oben 2, unten 1. — Auf dem Helm ein r. und s. Wulst, daraus hervorwachsend ein s. Arm, mit dem Ast in der Hand. — Decken: r. und s. Im vorigen Jahrhundert führte die Familie auch die beiden Wappen vereint in einem gevierteten Schilde mit zwei Helmen, wie die Abbildung auf der Tafel zeigt.

Figure 1: Image of a shield with blazoning from [Sie56]

2.1.2 Problem statements in heraldry

The interpretation of arms, that is the assignment of arms to their bearers, can help to confirm identities of persons as well as the ownership of particular objects. If an identity has already been verified correctly, e.g. names are explicitly mentioned on portrays or tombstones, the blazoning of arms painted just completes the exact description of an object. The by far more demanding case is that a coat of arms depicted is the only chance to identify particular persons.

Considering for instance the portrait shown in Figure 2, the identity of the person portrayed is not apparent. The only realizable hint is given by the coat of arms painted in the upper right corner, which is supposed to be the bearing of the person depicted.

Using one of the main works of reference [Sie56] for German heraldry, the manual search for this bearing produced the result shown in Figure 1. Though the form of the shield differs, the charge and colors used are the same. Besides the illustration of the arms, there is a short text containing genealogical information as well as the blazoning. In this case the coat of arms was borne by a family named "Praun".

Having identified the arms, further analysis of provenance, time of origin, artist or comparisons to other portraits showing the same coat of arms, can verify that the bearer of the arms identified really is the person portrayed. A similar case is shown in Figure 3. Again there is no hint that helps to identify the portrayed person besides two different arms. A more exact analysis of the painting shows that the arms in the upper right corner was inserted about a hundred years later. Thus it is most likely to be the shield of an owner, in this case the Prauns as seen before (cf. Figure 1). In fact as far as this painting is concerned, neither the bearer nor the origin of the arms on the left had been ascertained by now.

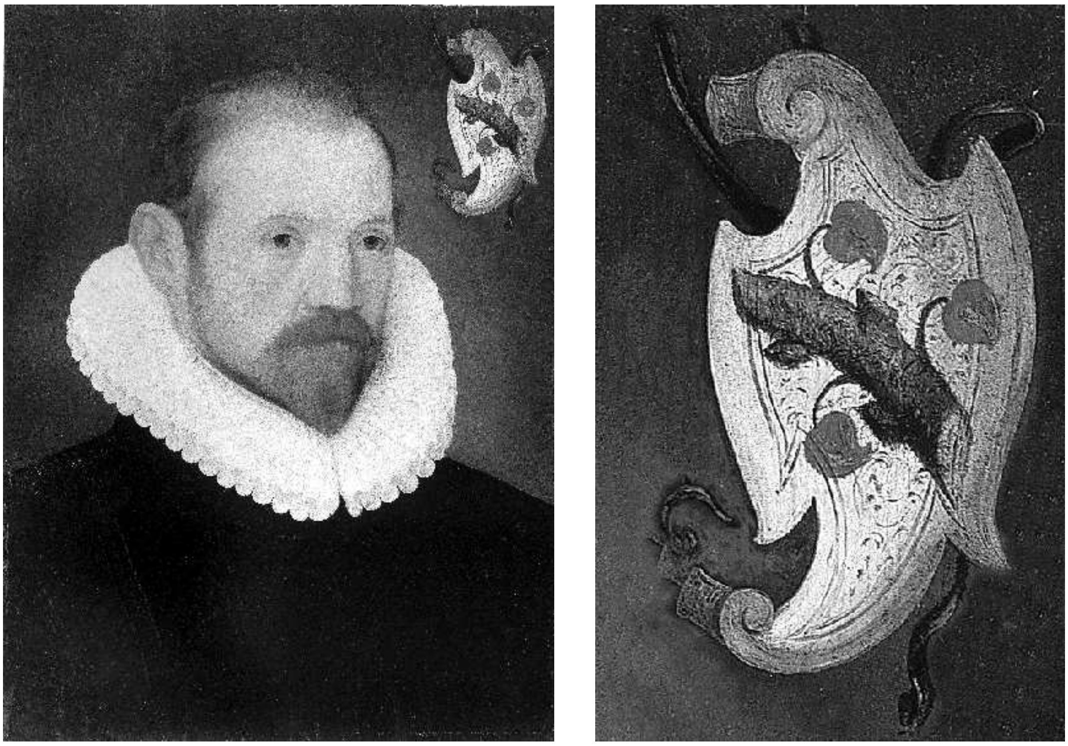


Figure 2: 17^{th} Century portrait and magnification of the upper right corner

Finding particular coat of arms in works of reference has been a difficult matter so far, because most works are ordered by topographic aspects, i.e. any volume only contains arms of a regionally restricted area. Furthermore there are far too many different collections of arms, preventing a complete sequential scan. For instance "Siebmacher's groes Wappenbuch" [Sie56] consists of more than a hundred volumes, together containing about 130,000 different arms. So it is easy to verify assumptions, but finding arms without any knowledge of their provenance or the bearer's name is far too often - despite time consuming searches - unsuccessful. Therefore art historical descriptions of objects frequently contain blazonings, but the identification of the arms still remains to be obtained by accident.

2.2 Challenges for heraldic databases

Recently promising efforts were made to build a world wide net of digital libraries and document exchange systems to supply users all over the world with almost every information required [Heu92]. But the retrieval of images that are basic parts of most scientific projects, especially in the field of art history, has still to be improved considerably.

Figure 3: 16^{th} Century painting showing the arms of the person portrayed (upper left corner) and the later inserted arms of a collector (upper right corner)

2.2.1 Querying heraldic databases

Indexing vs. content-based retrieval

Although multimedia database technology offers a wide variety of possibilities to store and manage image information efficiently, all the traditional digital image archives have in common that they only allow conventional query by keyword or full text search on only a few categories (name of the artist, iconographic subject, depository or even physical attributes like format or size). Mostly there is even a standardized vocabulary of graphical elements occurring, but present systems can merely be used by experts in the specific field concerned. From the beginning of image processing standardized grammars like ICONCLASS [vR94] have been used for description of almost any kind of images, but for any searches using unanticipated keywords or subjective descriptions - e.g. shades of colors - good results cannot be expected. Though blazonings are standardized by particular rules, which could be translated into a specific grammar, major experiences in describing images correctly would be absolutely necessary, due to the extreme complexity of art historical sciences. However, present retrieval systems are rather using these descriptions than the specific contents of images.

In times of growing image archives and multimedia databases a more natural access using graphical features in addition to traditional text or keyword searches is needed.

Retrieval by image content has the potential to make archives accessible to a far larger group of users, as only the visual impression and not the exact definition of what is shown is needed to retrieve certain images. However, experts in the field may still want to use traditional retrieval capabilities as full text search on blazonings. Therefore a combination of both conventional and visual approaches of retrieval will be taken into account by the HERON project.

Multilingual issues

Using language-bound descriptions only is far too obstructive to interdisciplinary research as well as to queries in other languages. In most cases the descriptions are done without using a standard vocabulary or thesaurus and even if so, the problem of specialized terminology in each discipline remains as a barrier to interdisciplinary communication. Multilingual descriptions are offered rarely, at best an English translation is given in addition to the particular native language description. As seen before, verbal description always involves a lot of time and therefore has to be kept short to save costs.

2.2.2 Multimedia document exchange

A major drawback of the popular WWW is its often complained lack of bandwidth. Caching of documents by proxy servers and establishing of hierarchies of such servers can only mitigate this nuisance by reducing wide area network accesses. On the other hand, the information exchanged and stored within the web is frequently redundant: for documents stored and exchanged in the web there are many multimedia data formats differing in aspects such as resolution, sampling rate, and compression. However, data formats are not independent from each other but interrelated by conversion tools.

This holds even more in the HERON context: for the purpose of art historic research the efficient access of historical multimedia documents in several formats and at different levels of quality is mandatory. As it is not necessary to have a high quality for just quickly browsing the images, low quality images or thumbnails are sufficient to choose the relevant ones. Due to the importance of details of the original, it is necessary to get at least an average quality image on the screen, which must also be available in high quality for zooming or printing. Furthermore, there are different web browsers, the data formats they support, and their network access.

Given a set of tools for multimedia format conversion in general there is more than one way of partitioning the formats into physically represented and computed ones. By applying an adequate cost function considering aspects such as storage consumption, network bandwidth, and complexity of the conversions an optimal choice can be determined. This optimization is a non-trivial task that cannot be done manually and must be performed periodically since the parameters of the cost function may change depending on the access profile, e.g. the server can use statistical data for this purpose. Section 4 will examine this issue mere closely.

3 Query by image content in heraldic databases

3.1 Building a heraldic database

The general approach towards retrieval by image content is to extract graphical properties, so called features, of digitized images or even parts of these, including information on attributes such as colors, textures, shapes or layout. Thus queries like "Select all images that show red lion-shaped charges" can be processed. Another useful application is to compare the similarity of given images, a problem which is often referred to as query by visual example [HK92]. The system evaluates the similarity between the visual example chosen and each image in the database automatically and displays a list of the most similar images as query result. Content-based searches can only be approximate, thus there is no exact match, but a ranked list as result. The user will always have to discard false retrievals ultimately.

The major problem in content-based querying is to determine the exact set of appropriate attributes or features that describes the content of each image in the database adequately. Once determined, the most useful representation of each attribute has to be found. In general every feature can be extracted into a high-dimensional feature vector. The complete process is illustrated in figure 4.

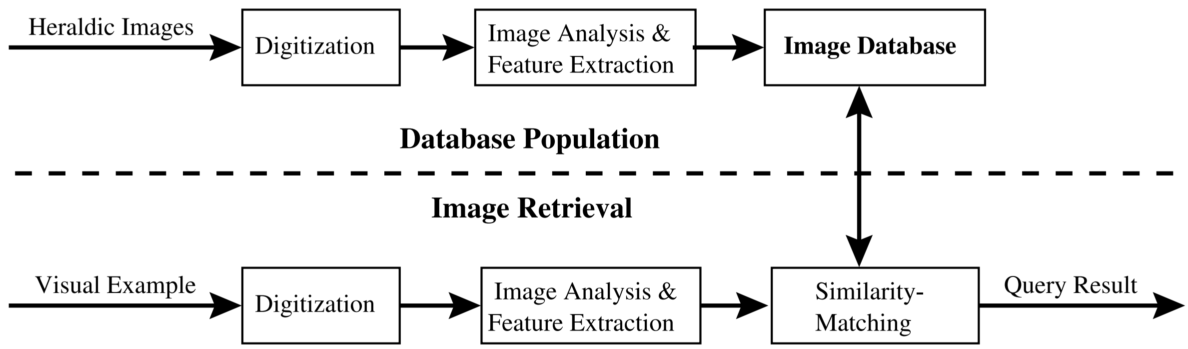


Figure 4: Image processing and retrieval

The future HERON database will consist of images of about 32,000 coat of arms. High quality scanners are used for the monochrome digitization of images. As it is not necessary to have high quality for just fastly browsing the images, low quality images or thumbnails are sufficient to choose the relevant ones. Due to important details of the original, it is necessary to get at least an average quality image on the screen, which must also be available in high quality for zooming or printing. The high quality images (original size about 1.5×2 inches) are scanned at 600dpi using TIFF5.0 format. Every coat of arms is divided in two heraldic images, one showing the complete coat of arms, the other one presenting the shield only. About twelve coat of arms per person and hour can be scanned and postprocessed on the average. Furthermore thumbnails (50dpi) and the images in medium quality (300dpi) of all those images showing shields only, will be stored in the online retrieval database together with full text blazonings of the corresponding coat of arms resulting in a database at the total size of approximately 9GB. For the purpose of zooming, the high quality images can be stored in a nearline CD-ROM database with a size of about 50GB.

3.2 First results

There are lots of different features, algorithms and similarity measures that have been proposed, but an optimal set can only be chosen with reference to the field of application. To get a first feeling about the specific problems in heraldry, a small database containing 100 shields has been created using IBM's Ultimedia Manager [FBF+94, BFH+94]. The Ultimedia Manager offers a variety of different features including color - histograms as well as average color -, texture, position and shape of images and the objects they contain. In heraldic applications the importance of features is ranked as follows:

1. shape,
2. color, texture and positions of particular objects.

Since charges are essential to compare coats of arms, shape has proven to be the by far most important feature for heraldic databases. Secondary are colors and textures that are both used to determine tinctures and position features that can be used to compare regionally restricted areas of shields. In [Bal97] these features have been analyzed.

3.2.1 Shape features

Retrieval by shape is known to be one of the most complex problems in image retrieval. A wide variety of shape features have been proposed in machine vision literature, but similarity strongly depends on the particular field of application. Shape description techniques can be categorized into boundary-based and region-based methods. While the first concentrate on the contour or border of the object depicted and entirely ignore the interior, the latter take into account internal details (holes, etc.) besides boundary details. Simple boundary-based feature descriptors are for example chain codes, corner points, Fourier descriptors and attributes such as area or perimeter. Classical region-based descriptors are e.g. wavelet transform, Euler number or moment invariants. Today most commercial systems use a combined approach. Considering the IBM Ultimedia Manager shape features are determined by area, circularity, eccentricity and major axis orientation as well as algebraic moment invariants [TC92]. We have studied the retrieval of both simple geometric structures (circles, rectangles, etc.) and complex shapes (lions, eagles, etc.). A retrieval result of a simple shape is shown in Figure 5. The sample of a cross in the upper left corner is compared to all images in the database and clearly distinguished from the cross moline (lower left) or the indented cross (second row, second image).

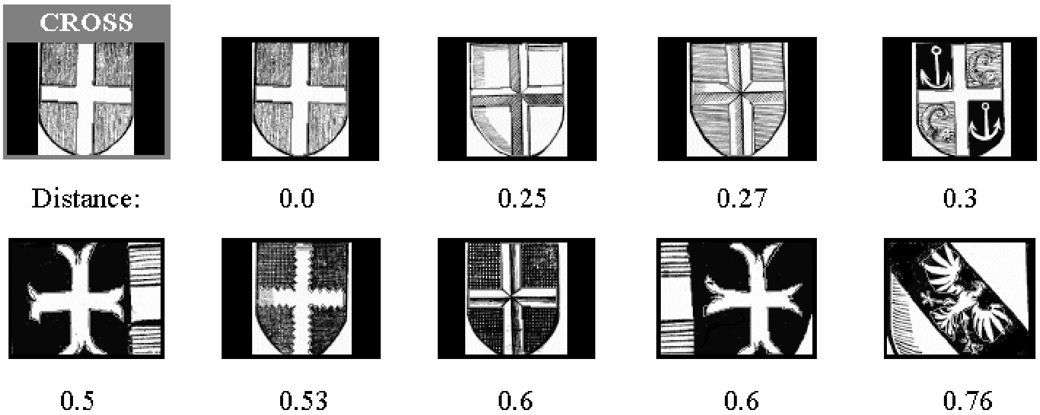


Figure 5: Query by shape: simple shape

Unlike simple structures, complex shapes are far more difficult to retrieve. Especially when it comes to the retrieval of shields showing animals in different postures, the quality of retrieval may strongly differ with the sample chosen. An example of a query result concerning complex shapes is shown in Figure 6. Again the visual example is shown in the upper left corner. Obviously there are much more false retrievals here. But all images of lions in the database are retrieved within a tolerable distance.

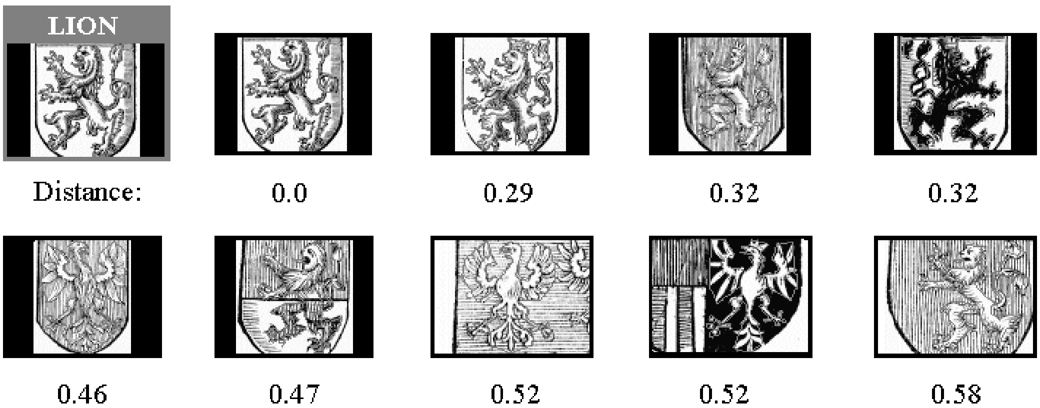


Figure 6: Query by shape: complex shape

Although there are lots of quite similar but different charges in heraldry to emblazon a shield, their planarity, stylized depiction and clear recognizable borders encourage the further use of query by shape.

3.2.2 Color features

In many applications best content-based query results have been achieved using color features, which are widely understood by now. But whereas histogram color has proven to be rather useful, average color has no real application in heraldic databases, because it is impossible to distinguish clearly between shields only using their average color, e.g. a crest containing red and blue parts may have the same average color values as a purple one. Histogram color uses histograms to represent the percentage of each color applied. Though comparing these histograms is an effective way to distinguish between even similar shields, the relevancy of mere colors in heraldry is quite limited. Thus queries by color will only be useful in combination with additional features, such as shape or texture. Unfortunately colors can not be used directly for querying, because most books of reference merely reproduce monochrome prints of shields, where each color is shown as a certain hatching. Therefore the problem of segmentation - in particular the distinction between areas of different color - is going to become more and more important, since this is the only way to take advantage of queries by color in heraldic applications.

3.2.3 Texture features

The main application of texture features in heraldry is to find areas covered by furs. In the case of the Ultimedia Manager contrast, coarseness and directionality features are evaluated to represent textures of images. A sample query result is shown in Figure 7. A visual example of an area covered with ermine (upper left) is compared to all images of the database. The distance towards this example is denoted below each image. Since the example was taken from the database, the original image has been found first, followed by all those containing areas covered with ermine. The last image shown does not contain any ermine. Note that the distance measured for the last retrievals displayed in Figure 6 and Figure 7 have the same value. But the latter image is a false retrieval, whereas the former image is relevant. This is due to the meaning of absolute values of distances strongly differing with respect to the particular feature.

3.2.4 Contour of objects

Whereas color and texture features are extracted automatically, in most present systems the contour of any object has to be outlined manually to extract shapes or any other feature restricted to a specific object. This manual identification is time-consuming, expensive and an inhibition to a more widespread use of digital image libraries. To segment shields by manually outlining the shape of charges, an average of merely 3-4 shields can be processed per person and hour. Thus advanced capabilities of auto-segmentation of shields are absolutely necessary. Especially when it comes to segmentation of monochrome prints of crests, the representation of different colors by particular hatchings prevents the use of ordinary algorithms for auto-segmentation.

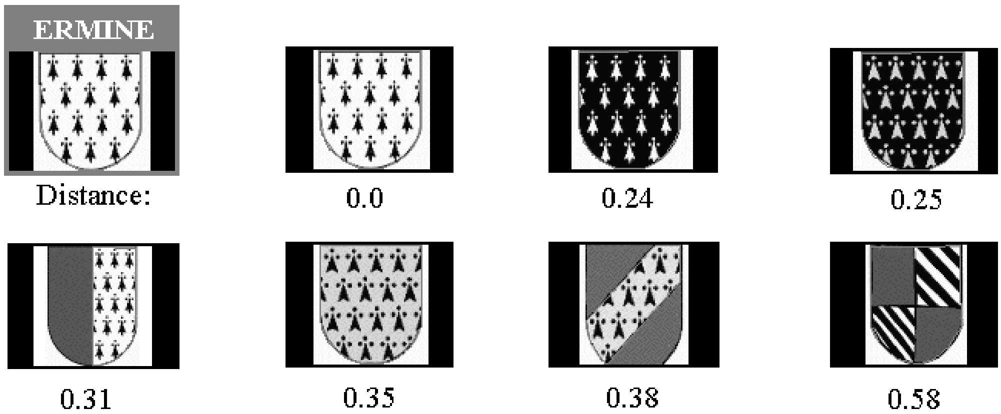


Figure 7: Query by texture

3.2.5 Invariance to rotation

At the first glance it seems to be possible to solve the problem of auto-segmentation of charges by texture features, since colors are coded by hatchings. But even if an area containing a particular hatching could exactly be determined, the conversion of this monochrome area into a colored one would still be a problem. Parallel to human perception both texture and shape features have generally been implemented invariant with respect to affine transformations such as translation, scaling and rotation [FBF+94]. Though invariance to scaling and translation is necessary in heraldic applications, invariance to rotation causes some serious problems, as neither the direction of hatchings nor the orientation of ordinaries and subordinaries as well as the specific posture of animals, etc. that is a relevant part in retrieving most similar images, can be recognized. Considering for instance the moon as a charge, unless the moon is shown full - blazoned as moon in plenitude -, the horns can point in different directions. The exact orientation is also blazoned differently as shown in Figure 8.

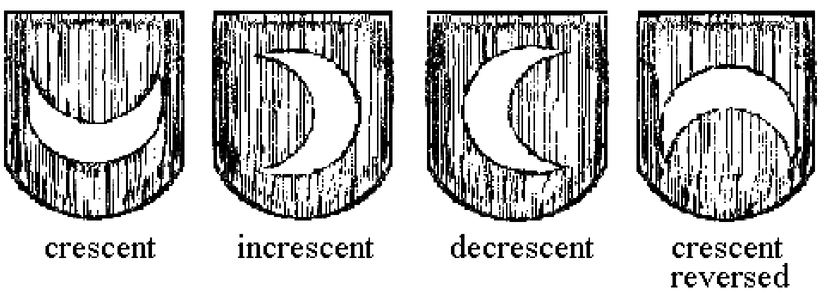


Figure 8: Different Bearings due to Rotation of a Charge

3.2.6 Positional and topological aspects

Though the position of charges relative to the shield is generally important, it is not sufficient to use only spatial aspects of an image, because the ground may be divided into several parts. Thus the relevance of charges shown "upper left" is hardly determinable, because charges depicted in a special partition may have quite a different meaning from those emblazoning a distinctly divided or even undivided shield though they all may be shown upper left.

Another necessity is to determine the position of specific charges towards each other, since in heraldry the exact topological arrangement of charges is important to distinguish between coats of arms. For example, there are different ways to arrange three lions: they may be arranged one above two, two above one or three in a row. All these coats of arms would be different, although showing three lions.

3.2.7 Additional aggregation

Considering heraldic applications, charges often have to be counted. For instance, shields containing five stars have strictly to be distinguished from those containing only three or even just a single star. Therefore an additional aggregation capabilities on all images retrieved is required.

4 Heraldry Online

In this section we dicuss the impact of an art historian's way of work on networked multimedia databases and the design of HERaldry ONline. What sets the research of an art historian apart from other humanities is an extremely intensive and varied use of images. Therefore, designing the profile of future image databases and multimedia databases, it is useful to consider the requirements of art historians as a representation of the demands of humanities in general at the most sophisticated level.

4.1 A Digital Workbench for Art Historians

Art historical research is based on voluminous reference works containing high quality reproductions of art collections like museum catalogues or on numerous monographies. Additionally photographic material in various forms (transparencies, reverse prints, etc.), either collected and archived by the individual researcher himself or by public art institutions, represent an important source. Scientific analysis of works of art is not conceivable without permanent use of reproductions primarily for the purpose of comparison. Unless an image of special content or containing an interesting iconographic detail relevant for researchers question is already known to the researcher the chances of retrieval are

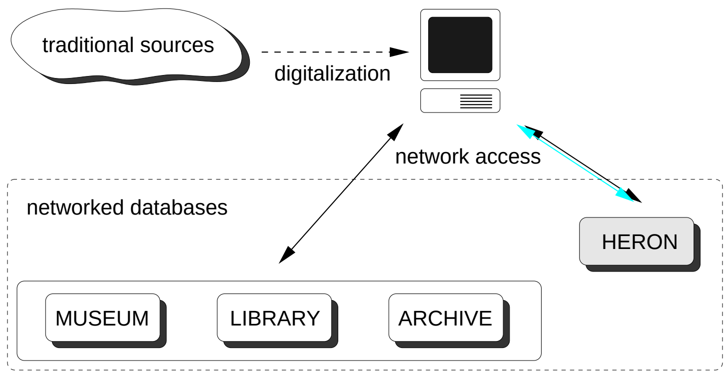


Figure 9: A digital networked workbench for art historians

limited. Therefore, it seems promising to use the possibilities of new media in art research at a large scale: a plurality of different material either printed, photographic or on continuous media can be stored in online multimedia databases.

Today large systematically arranged image archives especially addressed to art historians or historians, which allow research at any computer with internet-connection, are built up just to a small extent. They are available more often offline (CD-ROM) than online , e.g. "REAL Digital Image Research" [URLa], "Bildarchiv zur Kunst und Architektur in Deutschland" [URLb]. The future "digital workbench" for art historians, consisting of a personal computer usually fed with digitalized material from traditional sources which is connected to a network of (multimedia) databases, is depicted in Fig. 9. HERON is intended to line up with existing online databases, but it is strongly tailored to the needs of art historians by providing an intuitive visual query engine for the retrieval of a very large stock of historical multimedia documents together with a storage optimization for the digitized material aiming at a good quality of service.

4.2 Optimization of Document Delivery Costs

4.2.1 Problem statement

The success of networked multimedia databases not only depends on the creation of valuable information, but also on the speed, efficiency and convenient delivery of this information to the consumer. As described above future HERON users will extensively use image material in a large variety of formats. However, image formats are not independent from each other but interrelated by conversion tools and may differ in some aspects such as compression (none, lossless, or lossy), color depth and resolution.

PPM300	=	gif2ppm(GIF300)	GIF300	=	ppm2gif(PPM300)
PNG300	=	ppm2png(PPM300)	PPM300	=	png2ppm(PNG300)
JPG300	=	png2jpg(PNG300)	PNG300	=	jpg2png(JPG300)
GIF150	=	gifreduce(GIF300)	GIF150	=	ppm2gif(PPM150)
PNG150	=	pngreduce(PNG300)	PNG150	=	ppm2png(PPM150)
JPG150	=	jpgreduce(JPG300)	JPG150	=	png2jpg(PNG150)
PDF	=	ps2pdf(PS)			
PS	=	ppm2ps(PPM300)			

Figure 10: Multimedia format interrelation

4.2.2 The Optimization Problem:

There is a growing number of alternatives for (inter-)networked database servers to store some formats or to transfer them via the network and to compute the remaining ones by applying conversion tools. To determine an optimal choice of stored image formats is a non-trivial optimization problem subject to parameters such as query profile, available disk storage, server load and network bandwidth. In [KKK97] we have addressed this problem formally and proposed to integrate the conversion tools into database and proxy servers aiming at a dynamic optimization of multimedia document exchange.

Format interrelations between images are modelled as functional constraints. Given for instance the set of functional constraints in Fig. 10, an image of format `GIF300`, i.e. a picture of format GIF at 300dpi, can be converted into a picture of format `JPG300`, i.e. a picture of format JPEG at 300dpi, by successively applying the conversion functions `gif2ppm`, `ppm2png` and `png2jpg`. Note that the set of functional constraints above contains cycles, e.g. an image can be converted from `PPM300` to `GIF300` and vice versa. Dropping the right column of our example table leaves us with an acyclic set of functional constraints. Then every computed format has a unique functional composition. A set of functional constraints with these characteristics is called a functional base. Since the number of potential functional bases grows exponentially in the number of functional constraints, determining an optimal functional base is non-trivial. Functional bases allow storage optimization by partitioning multimedia formats into physically stored and computed ones: Let the left column of our example table be our functional base of choice. Then `GIF300` is the only format which is physically stored. All remaining formats will be computed on the fly. Figure 11 graphically animates the format partitioning by the example functional base.

A prototypical implementation using the most popular HTTP server Apache has shown first promising results in the reduction of multimedia storage costs and the increase of server performance. The results, incorporating also the Squid proxy server, will be published elsewhere.

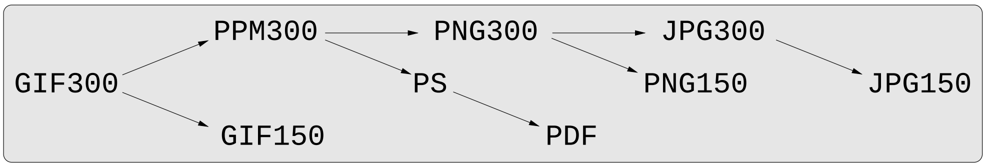


Figure 11: Example functional base

5 Summary and Outlook

In this paper we have outlined the goals of the interdisciplinary HERON project at the University of Augsburg. The necessity of combining database technology with advanced content-based query methods was pointed out regarding the requirements of art history. Given the capabilities of modern internet technology, an efficient integration of the HERON into the WWW is mandatory.

First results concerning heraldic queries by image content and client-server optimization of multimedia documents have been presented. Currently we are continuing these investigations by the evaluation of commercially available products like Excalibur Image DataBlade Module by INFORMIX Software Inc. and DB2 Relational Extender by IBM Inc. on IBM RS6000/AIX. Query by image content uses similarity measures, hence content based searches can only provide a ranked list of query results. This set of successful matches can get very large and will ultimately have to be refined by the user. Therefore a crucial aim will be to minimize false retrievals in query results by fully exploiting all semantic knowledge in heraldry.

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