Handling Sub-Image Queries In Content-Based Retrieval of High Resolution Art Images

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ABSTRACT
The paper describes work which is part of the Artiste project to develop a distributed database of Art Images from four major European art galleries. One aspect of the project involves the development of content-based retrieval and navigation facilities. A particular objective is to provide a facility for retrieving an image from the collection or navigating to related information in the database, given a query image which may be only a part of a particular image in the collection. The query sub-image may be a poor quality reproduction of part of the original and may be digitised under significantly different conditions. The paper outlines one of the recent approaches we have developed to facilitate such modes of retrieval and navigation. It is based on the use of colour coherence vectors extracted from image patches for the query and target images at a range of scales with multiple vector matching in order to find the best sub-image matches. Some results of the application of the technique are described and its success at sub-image location from a collection of images, including many at very high resolution, is demonstrated.

KEYWORDS: Multi-scale, sub-image matching, colour coherence vectors, content-based retrieval.

INTRODUCTION
ARTISTE is an EC funded project under the IST work programme and aims to develop an Integrated Art Analysis and Navigation Environment hosted on a distributed database and accessed via the World Wide Web. The environment will include, amongst other things, facilities for searching and analysing digital images and will include tools, not only for retrieval using metadata but also for a wide range of content based retrieval activities. Partners in the collaboration include NCR Systems Engineering Copenhagen, Giunti Interactive Labs, Centre de Reserche et de Restoration des Musées de France, the National Gallery London, the Uffizi in Florence, the University of Southampton and the Victoria and Albert Museum London.

Content-based image retrieval is a challenging and active research area with the potential to provide powerful facilities for image searching. But although many techniques have been described in the research literature, it is probably not an exaggeration to maintain that the capabilities of content matching alone are still relatively basic as general purpose approaches although some powerful applications specific methods can be developed. General techniques based on such features as colour distribution, texture, outline shape and spatial colour distribution have been popular in the research literature and in content based retrieval systems but many techniques only work on complete images, will not allow the query image to be a sub-image of the image to be retrieved and require similarity in image resolution between query and target.

In this paper we describe in more detail some of the problems of content based retrieval using colour matching and present an approach to sub-image retrieval for collections which include large numbers of very high resolution art images.

CONTENT-BASED RETRIEVAL

Several extensive general reviews of content-based image retrieval techniques have appeared in recent years [4]. CBR has been applied to Art images since the 1980s with the Morelli project [6] and IBM's QBIC system for example has been applied to such images in a collaboration with UC-Davis [1]. Previous approaches usually applied a generic CBR system to a group of Art images to see how useful it would be. In Artiste our aim is to solve specific CBR problems in addition to producing generic solutions for queries.

Use of the colour histogram [5] for comparing images has been popular primarily because it is easy to compute, is fairly insensitive to small variations between images and is relatively efficient in terms of computation speed and storage requirements. It has the disadvantage that it does not capture any information about the distribution of the colours spatially within the image and various techniques to capture such information have been proposed including the colour coherence vector approach (CCV) [3]. In the multi-modal neighbourhood signature (MNS) method, developed by Matas *et al.* [2], signatures representing the colours in different bimodal sub-regions are used as a cue for image and sub-image retrieval.

SUB-IMAGE MATCHING AND THE M-CCV METHOD

In this part of the project, the aim is to develop a robust technique to retrieve database images of an artwork given a query image which represents all or part of the target artwork. The query image may have been captured at a different resolution from the database image, may only represent a fragment of that image and may be distorted or degraded in some way. For example, the query image may be a fragment from an image captured prior to restoration of an artwork and the target image may represent the painting after restoration.

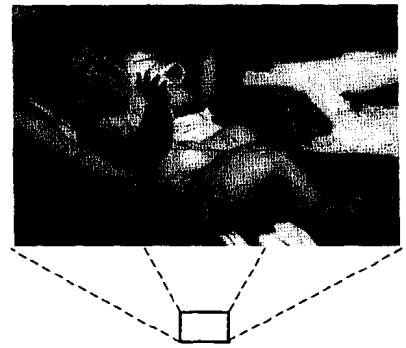
In general, global techniques such as the colour histogram are not effective for sub-image matching in their basic form. Some attempts have been made to retrieve sub-images using colour histograms by dividing the target images into pyramids of patches and recording the colour histogram for each. However, in our approach called the Multi-scale Colour Coherence Vector

(M-CCV) method, we use the colour coherence vector (CCV) rather than the basic colour histogram as the representation of the individual image patches as it carries some useful local spatial information. The colour coherence vector records the numbers of coherent and incoherent pixels of each colour in the patch where a coherent pixel is one which belongs to a patch of similar coloured pixels whose relative size is above a certain threshold. We pre-compute the colour coherence vectors for overlapping patches for each database image, repeating the process at reduced resolution until the reduced image corresponds to a single patch. The query sub-image is also sub-divided into patches and the best match is obtained by combining the CCV match scores. The CCVs are coded for rapid matching and can be compared at an average rate of 265,000 CCVs per second.

Results

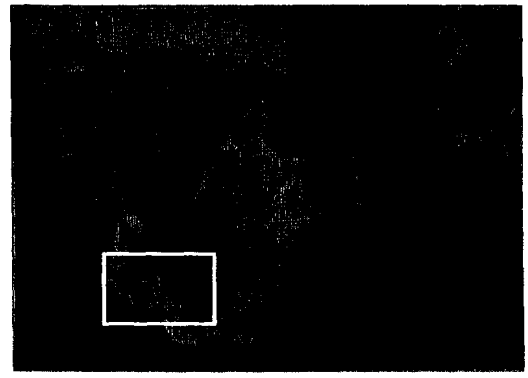
In figure 1 we show a query image which is a fragment of the Moise présenté à Pharaon by Orsel Victor captured before restoration work at the C2RMF.

The best match is shown in figure 2, and it can be seen that the best match is with the correct parent image but after restoration. (The before restoration image was not in the database). Note that the position of the match is highlighted, a necessary facility when dealing with ultra high resolution images. This particular parent image is 6328 by 4712 pixels. It should be stressed that the parent image was scanned at 1.47 pixels per mm of the original painting whereas the sub-image query was captured at a quite different resolution, 0.92 pixels per mm. There were over 1000 images in the database varying in size from 440,000 pixels to 30,000,000 pixels and the retrieval process took about 46 seconds on a Pentium III 600Mhz PC. No multidimensional indexing has been used so far although it is intended that the process will be accelerated by its introduction.



Query

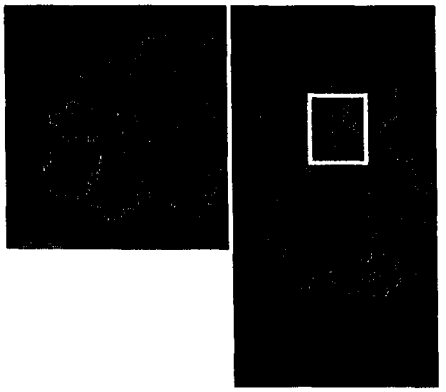
Figure 1: The image of the baby represents a query. The small box below the image represents the scale in relation to its corresponding parent image in the database



Retrieved result

Figure 2: The result of sub-image matching is shown as a white boundary in the Moise présenté à Pharaon image (Orsel, Museum of fine arts, Lyon). The rectangular box beneath the query represents the relative size of the query image to the retrieved image

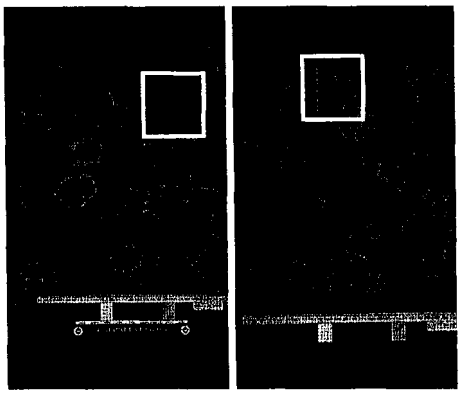
In figure 3 we show a further example of the multi scale CCV retrieval in action. The query image is a selection from a fabric from the V&A collection and the best retrieval shows the parent tapestry.



Query Result 1

Figure 3: A query image of a flower pattern. The first result of the retrieval locates the correct image and sub-region

In figure 4 we show the next two best matches for the same query. The retrieved results show tapestries with a similar motif to the sub-image query pattern. The retrieval process took 14 seconds to complete for the same database.



Result 2 Result 3

Figure 4: The next best retrieved results

CONCLUSIONS AND FUTURE WORK

In this short paper we have shown that the multi-scale colour coherence vector (M-CCV) technique can provide effective sub-image retrieval and is also applicable when the sub-mage and target are captured at different resolutions. The technique will form part of a battery of content-based retrieval and navigation tools which, together with integrated metadata based retrieval and navigation, will constitute the Artiste art image retrieval and analysis system.

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NARCISSE Project in Telematics). Head of the Information and digital image department of the C2RMF in 1994, he installed an Intranet for access to the scientific documentation and high-resolution images of the laboratory and conservation-restoration department. His department participated to EU collaborative projects under the 4th Framework programme: VISEUM (ACTS - DGXIII), MENHIR (ESPRIT - DGIII), ACOHIR (ESPRIT - DGIII) and CRISTAL (Rafael DGX).
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