INSTITUTO SUPERIOR TÉCNICO
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EagleEye

Large photoset visualization

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Dissertação para a obtenção de Grau de Mestre em

Engenharia Informática e de Computadores

Júri

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	Nome do Vogal 3

Mês e Ano

Dedicated to someone special...

Acknowledgments

A few words about the university, financial support, research advisor, dissertation readers, faculty or other professors, lab mates, other friends and family...

Resumo

Inserir o resumo em Português aqui com o máximo de 250 palavras e acompanhado de 4 a 6 palavras-chave...

cenas

Palavras-chave: palavra-chave1, palavra-chave2,...

Abstract

Insert your abstract here with a maximum of 250 words, followed by 4 to 6 keywords...

Keywords: keyword1, keyword2,...

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UI user interface

SOM self organising map

CBIR content based image retrieval

MP megapixel

FEP Feature Extraction Plugin

Chapter 1

Introduction

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1.1 Motivation

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Chapter 2

Related Work

There has been a lot of discussion about the organisation and retrieval methods of large image libraries and some interesting and relevant are summarised here.

2.1 Visual guided navigation for image retrieval

Qiu et al. explore in Qiu et al. (2007) the requirements of a system intended for visualising large photo collections. They identify as the two most important requirements, the first being an easy to use UI, that gives clean information to the user and helps to create a mental image of the whole collection helping him to navigate on the collection. The second requirement is responsiveness because while image processing can be an heavy task, the user needs to be able to interact with the interface and he won't use the application if it's slow.

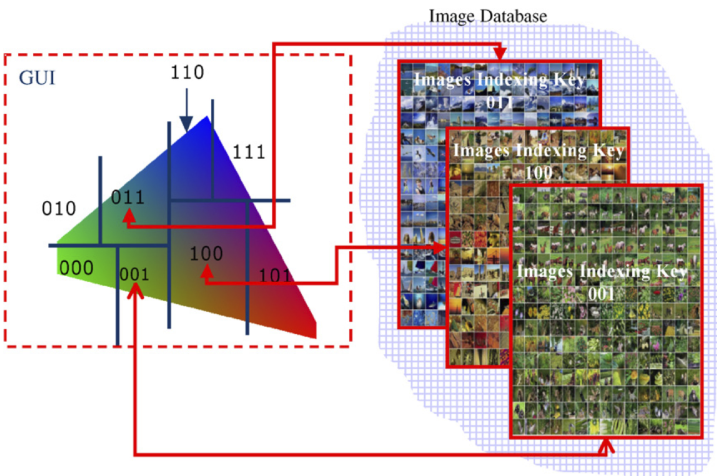

Figure 2.1: The chromacy diagram is split in parts and each image belongs to one of this parts. The diagram is part of the UI and when navigating through the diagram, only the images related to that part are shown.

The system shows all the photos arranged by colour, just as many others like it. The difference is the process in use. Instead of calculating distance vectors based on the histogram of each image, this approach classifies each image with a simple description, like a mean of its colours, and arranges them by that value, on a colour map (fig. 2.1). The process is much faster but is also more error prone, specially on photos without a clear main colour.

Their tests show they achieved good responsiveness and better results than using a file explorer.

2.2 Does organisation by similarity assist image browsing?

Figure 2.2: Three arrangements of 100 images of Kenya, based on visual similarity. On the left is the arrangement with overlap, in the middle a 12x12 grid (which removes the overlap while preserving some of the structure), and on the right a 10x10 grid (which maximises the thumbnail size).

The aim of Rodden et al. (2001) by Rodden and Sinclar was to evaluate how photo organisation by similarity (fig. 2.2) could benefit a user looking for images. Some users tested an application that could show the same images both in a random and in an organised by similarity way. This organisation by similarity was based on a rough description of the images but it could be other descriptors.

The results differ if the user knows what he's looking for or not. In case he does, being able to filter only the relevant images makes it quick to find the ones that matter. This obviously depends on the quality of the labelling. Users reported that sometimes the similar images appear to merge.

In case the user doesn't know what he's looking for, the random approach might be helpful because the strong images usually contrast to their neighbours and thus appear to stand out.

For some people, having access to different arrangements of the same set of images is useful, although the source of the individual differences still needs to be determined.

2.3 Browsing large collections of images through unconventional visualization techniques

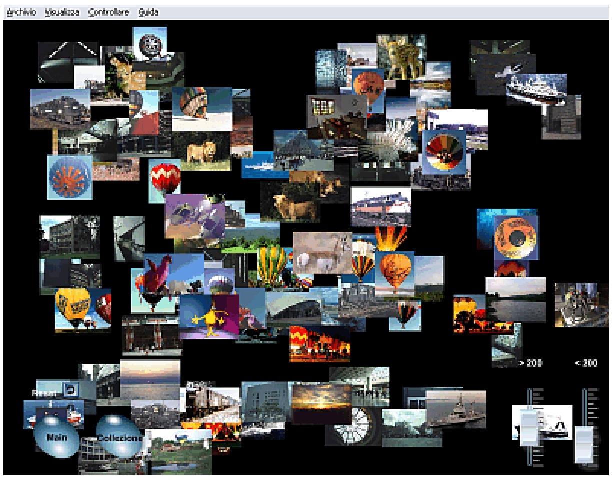

Figure 2.3: Spot display.

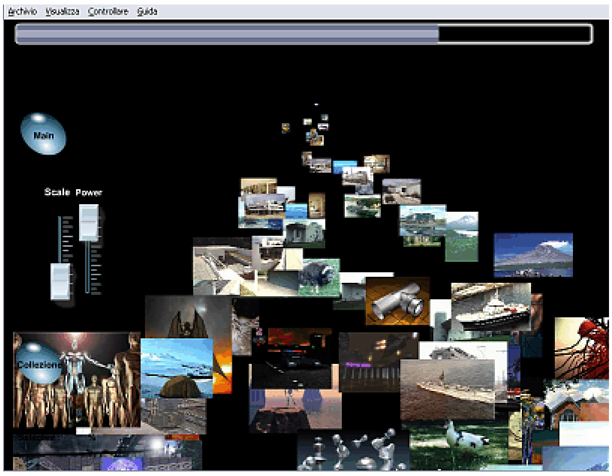

Figure 2.4: Shot display.

Porta describes in Porta (2006) a few visualisation methods for large collections of images and tests them with users. The purpose it to find ways or metaphors that provide a good visualisation experience in terms of time spent and quality of the visualisation.

Some of the various techniques were the simple image grid view, a grid view with variable and independent height and width (EIB), a view that animates images like they were shot from a distance and get closer to the user called Shot (fig. 2.4), a view where images quickly appear on random positions on screen named Spot (fig. 2.3), and some other less commons like one that simulates an cylinder created with images (Cylinder), and others less relevant (Rotor, Tornado and Tornado of Planes).

The testing was based on the efficiency of users searching for specific images on a collection of a thousand photos. The Spot view was the best, followed the Shot, Cylinder finally the common grid view. The other views got scores near or below the grid view.

2.4 A comparison of static and moving presentation modes for image collections

This paper Cooper et al. (2006) by Cooper et al. is not about large libraries but about what kind of interfaces for image showing has greater success of user recognition and preference (fig. 2.5).

With the help of eye-tracking techniques and user preference, the authors determined that static images are better than moving ones because makes them easier to recognise and avoid some user confusion.

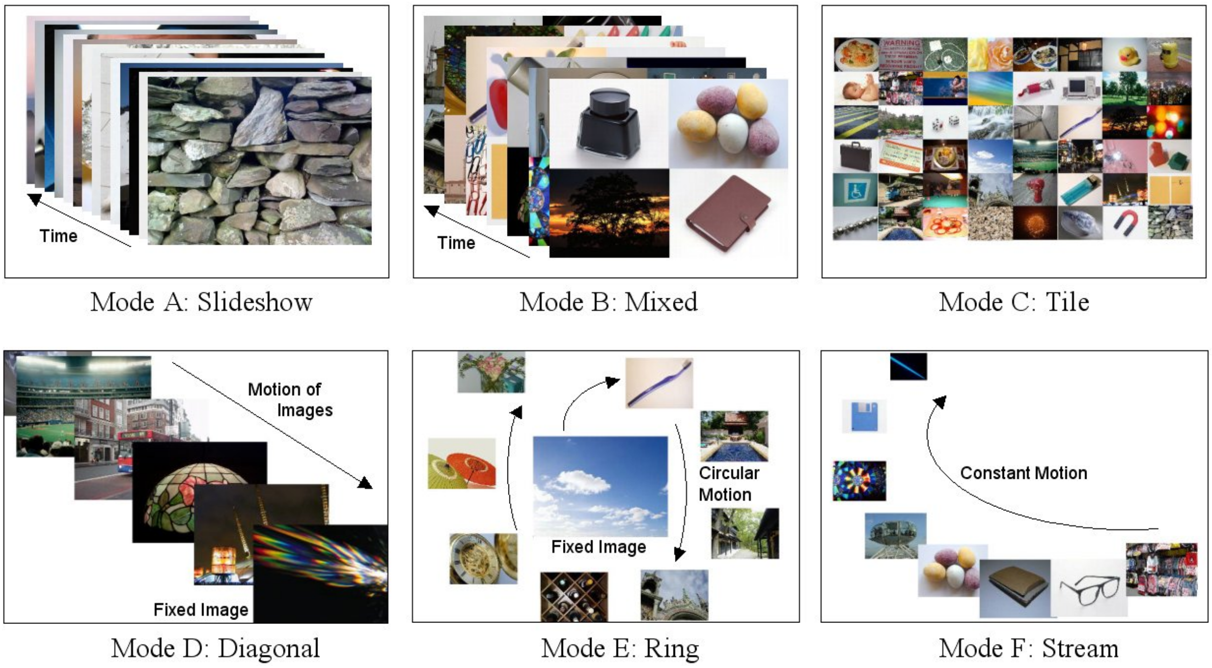

Figure 2.5: The six rapid serial visual presentation modes used in the experiments

2.5 Organizing and browsing photos using different feature vectors and their evaluations

Although it doesn't mention why, Strong Strong and Gong (2009) focuses on the better experience provided by colour organisation of a large image collection (fig. 2.6).

A self organising map (SOM) is used to display the images on the screen featuring zooming, panning and sorting capabilities. The work is then based around the various methods used to determine the images' similarity.

Simpler methods are based on colour histograms, which aren't affected by rotations or scales but, by not having spacial information on colours, allows very different images be closer together.

Other methods rely on gradients which contain spatial information and, therefore, are sensitive to image contents but not colour. In general, the best methods were found to be the hybrid ones, where both colour histograms and gradients are used to classify the images. No user testing is made in this project, neither is the speed of image categorisation referred about the methods used.

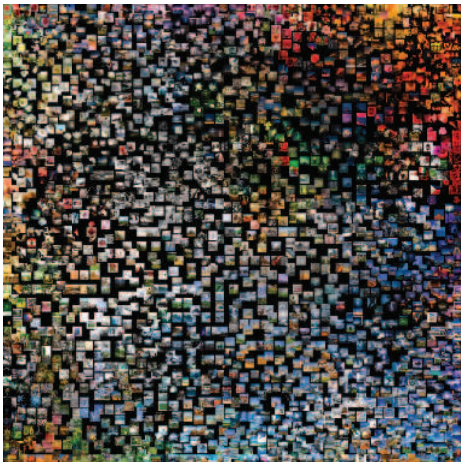

Figure 2.6: The result obtained for organizing 2200+ photos using colour autocorrelogram feature vector, using Strong and Gong (2009)

2.6 An evaluation of colour-spatial retrieval techniques for large image databases

Tan et al. Tan et al. (2001) present an evaluation of three colour-spatial image retrieval techniques.

The signature-based technique creates a signature for each image, based on the most frequent colours, according to a threshold, of each subdivision, or bin, of that image. The comparison between images is made by comparing the main colours present on each bin. It is possible to assign more weight to specific bins according to the user's interest.

The partition-based approach is also based on bins, each having it's own colour histogram. The similarity between images is given by the distance of the histograms of the corresponding bins.

The cluster-based method bases on the fact that humans focus on large patches (clusters) of the same colour and, therefore, two images will appear similar if both have similar coloured clusters on at roughly the same location. This method extracts the larger clusters and their colour from each image. The similarity is calculated by the amount of overlap between clusters.

This techniques were tested with a collection of 12,000 images and, besides the colour information, the brightness was also analysed for increased performance. The authors conclude the signature method was generally better on both effectiveness and efficiency.

2.7 Automatic organization for digital photographs with geographic coordinates

In this paper, by Naaman et al. Naaman et al. (2004), is described a system that organises digital photographies accordingly to location and date embedded on the metadata.

The objective was trying to mimmic the the way people think about their collections. Photos are usually bursts separated by some time. Based on this and on the different places, events can be created to agglomerate photos from the same bursts. Location naming is done by calculating the most relevant places, like parks or cities, and then mixing the more precise locations with the more important neighbour cities to create a relevant and identifiable name. This was specially important since this work didn't involve showing any maps but only the location names and events.

The authors showed good results and, nowadays, some common applications use similar features although including maps.

2.8 Similarity pyramids for browsing and organisation of large image databases

Chen et al. present in Chen et al. (1998) a method for designing a hierarchical browsing environment called a similarity pyramid. The similarity pyramid groups similar images together while allowing users to view the database at varying levels of resolution. Each level is organised such that similar images are in close proximity on a two-dimensional grid (fig. 2.7). Images are first organised into a binary tree through agglomerative clustering based on colour, edge and texture similarities. The binary tree is transformed into a quadtree, a tree in which each node has four children instead of only two.

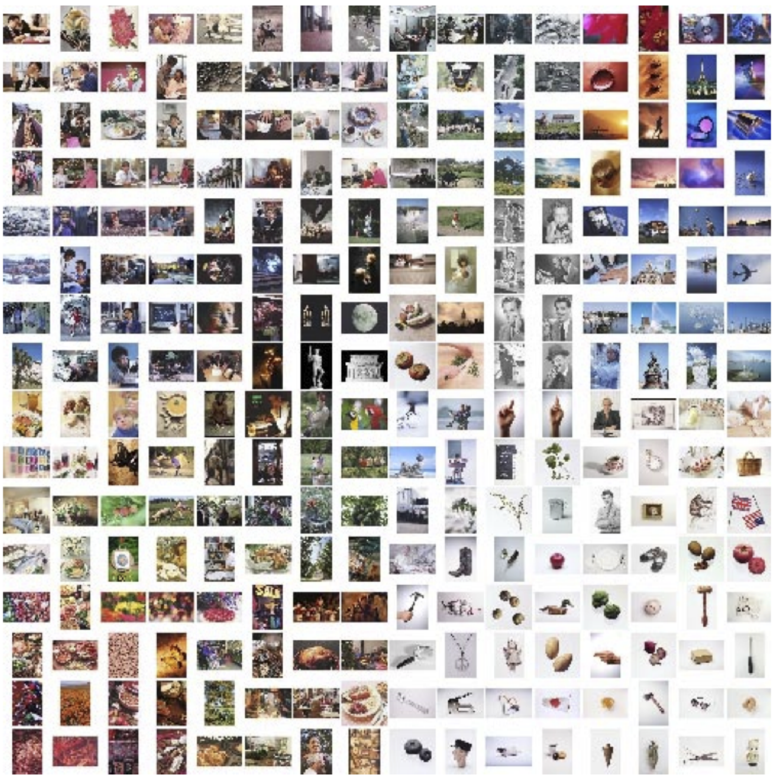

Figure 2.7: Images organised with Chen et al. (1998). Images with similar colour and texture are spatially adjacent.

The similarity pyramid is best constructed using agglomerative (bottom-up) clustering methods, and a fast-sparse clustering method is presented which dramatically reduces both memory and computation over conventional methods. This method is based on the flexible agglomerative clustering algorithm, but using only a sparse proximity matrix and exploiting the author's approximate branch and bound search algorithm.

The authors found that the method for mapping the clustering to a pyramid can make a substantial difference in the quality of organisation. Finally, a dispersion metric for objectively measuring pyramid organisation was proposed, and found that it correlated well with the author's subjective evaluations of pyramid organisation.

2.9 NN^k networks for content-based image retrieval

Heesch describes in Heesch and Rüger (2004) a different interaction technique for content based search in large image collections. Each image is a vertex in a graph and arcs are established between images if there exists at least one combination of features for which one image is retrieved as the nearest neighbour of the other. Each arc is weighted by the proportion of feature combinations for which the nearest neighbour relationship holds. By integrating the retrieval results over several feature combinations, the resulting network helps expose the semantic richness of images.

The interface reflects the vertexes and respective arcs, allowing to browse between the related images (fig. 2.8) in the network.

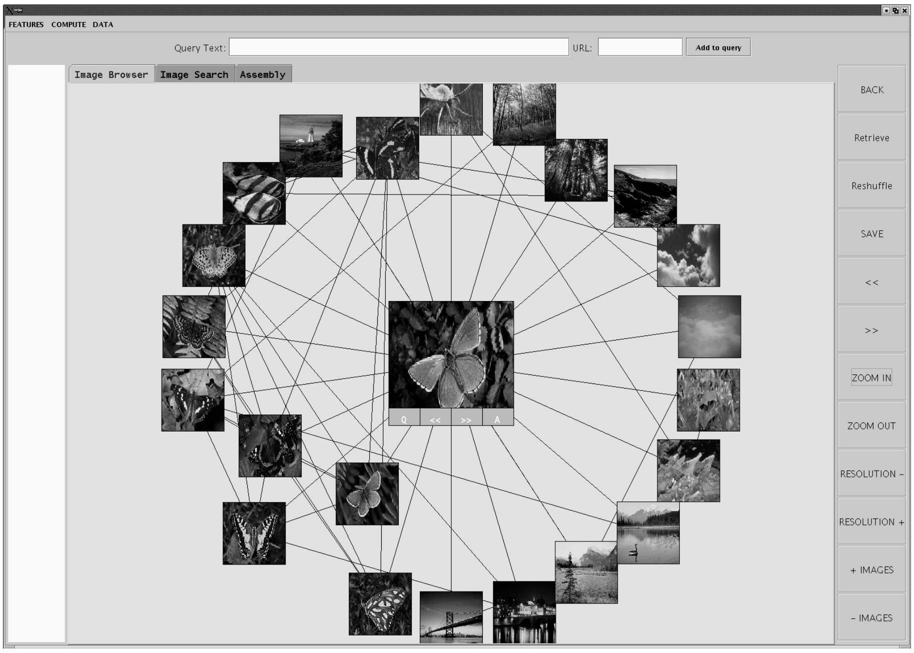

Figure 2.8: Local network around the chosen butterfly image depicted in the middle.

Seven low-level features are used for the classification of the images. HSV Global Colour Histograms maps the images by colour, saturation and brightness; Colour Structure Descriptor maps the distribution of colours by dividing each image in 64 windows, the colour space in 184 bins and associating colour bins with image windows; Thumbnail feature compares identical images by saving the grey value of each pixel from a scaled down version of the image; Convolution filters discovers very selective features by reapplying 25 filters three times; Variance feature calculates standard deviations within a sliding window; Uniformity Feature is another statistical feature, calculating the grey level of an image split in 64 parts; Bag of words is the last feature and weights words associated to each image.

Tests showed great results using a mix of search, relevance feedback and browsing, and even only browsing was considerably better than other, more restrictive, approaches.

The technique helps avoid the problem of image polysemy by showing all gathered meanings of the images to the user. The feature network is pre-computed, allowing for quick realtime browsing. The authors claim it took 50 hours to process 32000 images but make no reference to the possibility adding images to the collection, after the computation.

2.10 Phorigami: A Photo browser based on meta-categorization and origami visualization

Hsu et al. Hsu et al. (2009) try to ease the browsing problem by analysing the collections and identifying groups of related pictures. Each type of group is visualised in a specific way, inspired by the Origami art.

Groups of similar or related photos were manually classified based on camera movement and subject movement, creating different types of groups static view where both camera and subject are fixed and is presented as a panorama; multi-view where the subject is fixed but the camera is moving and is shown as a presentation; if the subject is moving, the photos are categorised as motion capture and can be shown as an animated photo (fixed camera) or a presentation (moving camera); finally group photos, where different groups of people are photographed, are shown as a folding presentation.

This covers various cases where the photographer takes a few similar photos of the same subject because it's either a panorama, various angles or just to be sure the photo was well captured.

The interface implements the different presentation types as different metaphors, easy for the user to understand, like a folded paper on a wide panorama that can be expanded (fig. 2.9). Although some of them appear to be a little hard to distinguish in its compressed form, it shouldn't be difficult to make it clearer. Other possible problem is the use of different touch interactions for each presentation type that might confuse users on what gesture should they use.

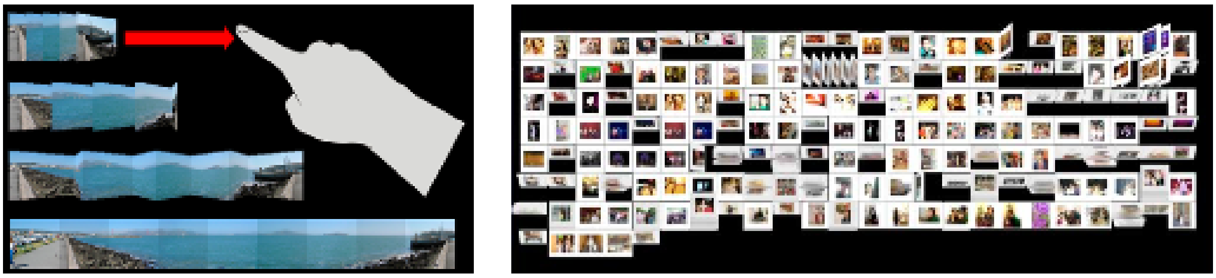

Figure 2.9: On the left, an example of an interaction on a group of photos that makes a panorama. On the right, a visualisation on 537 photos with some groups.

2.11 A next generation browsing environment for large image repositories

Figure 2.10: Hue sphere of a dataset

Schaefer Schaefer (2010) tries to take similarity based organisation of images from the 2D space to a 3D sphere, which allows interaction from the users. Rotating the sphere reveals images with different colours while tilting it reveals brighter or darker images.

Large image collections are handled through a hierarchical approach that brings up similar, previously hidden, images when zooming in on an area.

The description of the colour is retrieved by calculating the image's median colour for it's efficiency over other methods like histograms. This two features are directly mapped onto the sphere's coordinates and the entire structure is pre-calculated so browsing can be performed in real-time. Image overlapping is also avoided (fig. 2.10).

The work was tested on a 4500 image collection with no evaluation as to its performance and a weak and subjective user testing.

2.12 Flexible access to photo libraries via time place, tags, and visual features

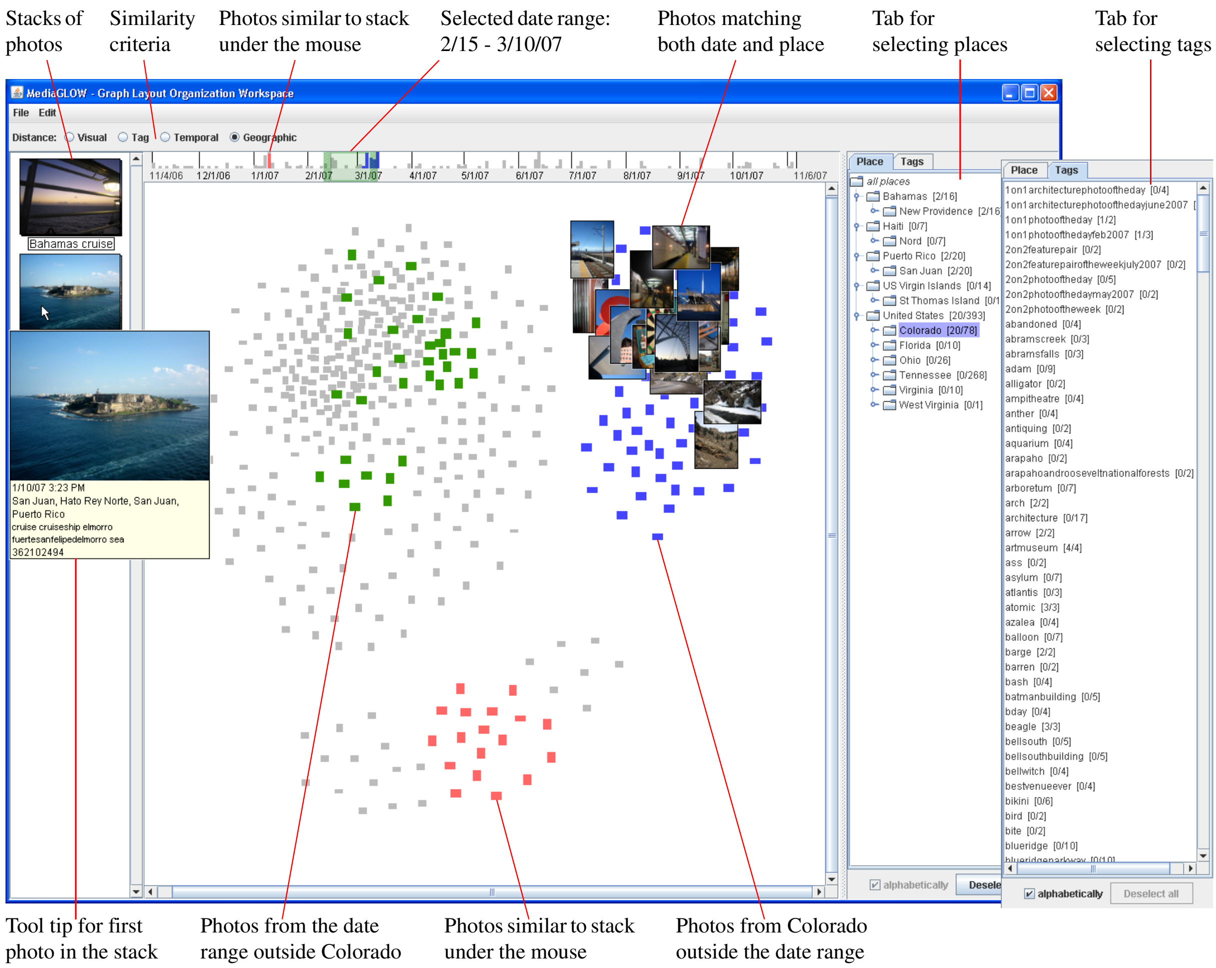

Figure 2.11: Photos Grouped by Geographic Similarity and Filtered by Date and Place.

MediaGLOW by Girgensohn et al. Girgensohn et al. (2010) is the application discussed in this paper. It's a content based image retrieval (CBIR) system with multiple ways to filter and sort the image collection.

The interface allows selecting a range of dates, places and tags at any time to filter the collection and the display will show the photos that match the filters, alongside indications of the existence of photos that match some of the filters. This display can then be arranged by four similarity criteria: temporal (by photo creation time), geographic (distances between places), tags (photos with similar tags are shown closer together) and visual (fig. 2.11).

The time is selected using a timeline on the top of the screen while tags and places are shown on the right side sorted alphabetically, by frequency of, in case of places, as a tree. Multiple selections are allowed to show more photos.

The photo display is graph based, allowing for overlapped images. Various metaphors were developed to ease the navigation of the collection. Zooming is allowed and changes both thumbnail positions and size for better experience, allowing the photos to spread away from each other but also increasing the size so the user can have a better look at them. The authors think that bigger thumbnails and a correct grouping of related photos is more important than spreading them to avoid the overlapping problem.

Colour coding is used throughout the interface to help the user understand better what is being selected. For instance, on the timeline blue and grey are used to distinguish photos that match or not the selected location/tag. On the photo display, besides the photos that are actually shown are coloured blocks: blue for photos that match location only, green for time only and grey for those that didn't match anything.

Detailed user testing was performed and the importance of the multiple ways to organise and search the collections was emphasised since many systems are designed to have a single form of access. Some users also pointed the importance of being able to have a non overlapping view of the photos for part of the task.

Each view was found to have different levels of usage, the geographic being the most used and temporal the least, since it's very similar to the timeline. Visual similarity was less used than expected, even on collections where it was relevant.

2.13 Discussion

Currently there are a lot of approaches to image organisation and each has its own differences as demonstrated on Table 2.1.

Our survey revealed various methods for extracting the features of each image, from simple to complex.

One of the main problems is obtaining useful information from low level feature extraction of the image contents. Some try to get the most out of each image, with a variety of complex and time consuming procedures. Others try to focus on avoiding the complex computations by only getting simple but somewhat useful information. To contrast with this methods, Girgensohn's work Girgensohn et al. (2010) has found that users prefer other ways to filter the collection, like tags, dates and locations. It's still used, but probably isn't worth to spend much time on it with heavy processing.

Date and location are simple similarity measures and can be used to group the collections by events and locations like Naaman did on Naaman et al. (2004). Current mainstream software like Apple's iPhoto[1] and Google's Picasa[2] are already doing it in a semi-automatic way.

Textual metadata like tags and descriptions are also widely used both on our survey and possibly on all major mainstream software. The problem with tags and descriptions is that people usually don't assign them to the their photos but that's not a problem we're interested here.

The 3D Sphere from Schaefer (2010) is also interesting but doesn't provide a better interface to the collection than expanding the sphere surface grid view to a full screen grid view, keeping the zoom

[1] http://www.apple.com/iphoto

[2] http://picasa.google.com

Table 2.1: Different browsing methods

Work	Organisation				Visualisation	Focus
	visual	date	gps	tags		
2.1 Qiu Qiu et al. (2007)	simple colour measures	—	—	—	Grid	Simplicity and Efficiency
2.2 Rodden Rodden et al. (2001)	—	—	—		Grid	Similarity usefulness
2.3 Porta Porta (2006)	—	—	—	—	Spot (and others)	Unconventiona visualisations
2.4 Cooper Cooper et al. (2006)	—	—	—	—	Static and animated	Usefulness of animations
2.5 Strong Strong and Gong (2009)	colour histograms and gradients	—	—	—	SOM	Evaluation of different feature
2.6 Tan Tan et al. (2001)	colour histograms of subdivisions	—	—	—	—	Evaluation of different feature
2.7 Naaman Naaman et al. (2004)	—			—	—	Organization based on even
2.8 Chen Chen et al. (1998)	colours, edges and textures	—	—	—	—	Efficient fast-sparce clustering
2.9 Heesch Heesch and Rüger (2004)	six different features	—	—		Radial	Complex similarity netwo
2.10 Hsu Hsu et al. (2009)	—	—	—	—	Grid with groups	Interaction on grupped photo
2.11 Schaefer Schaefer (2010)	colour histograms of subdivisions	—	—	—	3D Sphere	3D mapping ar interaction
2.12 Girgensohn Girgensohn et al. (2010)	—				Overlapped graph	Having the bes way to find phot

function. The Phorigami work Hsu et al. (2009) introduces some interesting metaphors for manipulating groups of photos, although some clutter the view and could, therefore, be improved.

An interesting work is the Girgensohn's Girgensohn et al. (2010) visualisation approach, where images can be organised by various features and can be filtered down, displaying matched photos alongside placeholders for photos that are only match partially. It has some problems like image overlap and capacity for showing large collections.

Chapter 3

Eagle Eye

After having analysed the related work in the previous section, we will now detail our vision for the solution of the problem, followed by our implementation of that same solution.

3.1 Requirements

Our survey was based on various types of previous work from the last ten years. Image browsers and technology has evolved a lot from those years until today but there still isn't a definitive way for a user to look at its photo collection and understand its content and evolution.

The vision we have is a system that takes the digital photographs residing in the user's computer, and display them all on the screen in various arrangements, revealing the patterns, similarities and differences between them.

For this to happen, the system must be able to handle tens of thousands of images and display them all on the screen while maintaining responsiveness. The system's UI should be clear easy to use, allowing the user to navigate through the display of photos, by zooming and panning, and to to reorganise the photos in a number of ways. The system should gather as much information as it can from the photos for instance, date and time, relevant colours, presence of people, type of photograph, location. While some of this information is already embedded in digital photographs as metadata, written by the digital camera when the photo was taken, others are usually not and need to be calculated or extracted. Faces and relevant colour information are an example of that and the system must be prepared to extract this features from the image. The system must allow other feature extraction methods to be easily added in the future. All this information will then be used by the user to reorganise the photos in display.

3.2 Backend

1

3.3 Interface

Chapter 4

Evaluation

Chapter 5

Conclusions

Insert your chapter material here...

5.1 Achievements

The major achievements of the present work...

5.2 Future Work

A few ideas for future work...

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