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Content-based image retrieval tools and techniques

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Content-Based Image Retrieval Tools and Techniques

In the beginning was an image.

To my mother
who inspired me
to develop intellectually

Contents

8 Graphical User Interface

8.1 Introduction

Each CBIR system needs to be asked a query by the user, hence the user requires an interface to specify the image elements. We would like to emphasize the fact that CBIR systems are used and judged by their users. The limitations of CBIR systems include both the image representations they use and their methods of accessing those representations to find images.

The first role of the user interface, now usually the graphical user interface (GUI), is to enable the user to define their query. Whether the user's query can meet their requirements depends on the level of abstraction in the attributes used. When the simple, textual user interfaces were adopted from the DB front-ends to CBIR systems, they proved inadequate. The first Graphical User Interface (GUI) was proposed by Flickner et al. [16] in 1995 who provided the user with a very simple graphical editor with basic shapes and different colours. Their followers offered operations only on primitive features, such as colour, texture or shape, as this is what most CBIR systems rely on. Now, we can handle derived features, such as separate objects, object classes or prototypes. Some researchers [179] attempt to use abstract attributes, such as abstract names of events, types of activities or emotions. In fact, the higher level of abstraction, the more difficult it is to build a user-friendly interface.

The second role of the user interface is to present the results in an appropriate manner. Generally, the CBIR technology suffers from a lack of accepted benchmarking methodology in general, and so it does in parts of systems. Actually, in most cases the user is ignored, despite the fact that CBIR systems are used and judged by their users. This emphasizes the need for the incorporation of user interface aspects into the present analysis.

One of the most significant analyses of the user perception in terms of image visualization by multi-dimensional scaling (MDS see sect. 9.2) has been conducted by Rodden et al. [202]. The user study was conducted using target search on a randomly assorted grid of images. The researchers revealed/exposed some psychological rules, such as:

- Image retrieval is faster when images are arranged by their mutual similarity
- Users prefer visualizations that do not overlap
- More distinct images are easier to find (it means that images should not be too similar to each other in the DB)
- Images located closer to the centre of the screen are retrieved faster than those located closer to the edge
- Users are generally reluctant to manually annotate images
- Displaying many images thumbnailed at a time decreases the time required for image retrieval

8.2 Query Concept Overview

Systems based on keyword querying are often unintuitive and offer little help in understanding why certain images are returned and how to refine the query. However, keywords can be ambiguous, especially in the situation when a word has several meanings.

Independently of the diversity of methods focused on the retrieval, in particular, search by association, search for a specific image, or category search [202] we can generally divide query methods into:

- Query by keywords [203]
- Query by example [11], [12]
- Query by canvas [204], [17]
- Query by sketches [205]
- Query by spatial icons [206]
- Query by image region [206],
- 3D query [207]
- Designed query for semantic retrieval [208], [209]

Query by keywords: The first method for asking the database a question was using keywords as an analogue to queries in alpha-numeric DBs. This method requires manually added text annotation for images collected in DB. It is still used in WWW image search engines but it is notorious for being incomplete, inconsistent, context sensitive and the ambiguity of meaning of the keywords. In this case [203], the keyword ambiguity is expanded to the selected reference classes most relevant to the query keyword. For example, the keyword 'apple' can mean: 'apple fruit', 'apple computer', 'apple logo', or 'apple tree' from which reference classes are selected. These attempts try to fill in the semantic gap that exists between the description of an image and the image itself.

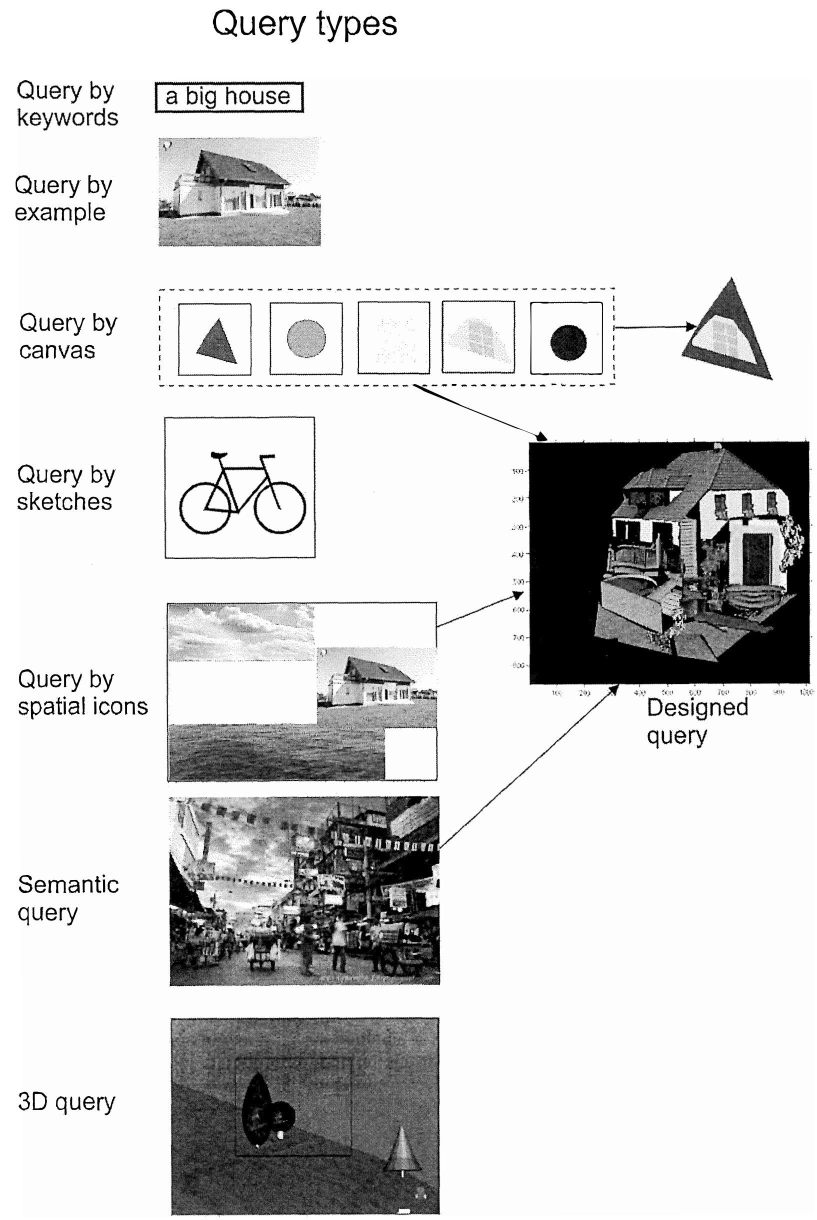

Fig. 8.1 Query types [53].

Query by example: At present, most systems use query by example (QBE) whose major advantage is the capability to determine a set of attributes or features that describe the contents of the user's desired image [204], [12]. In a nutshell, QBE provides a clue regarding the search area for the search engine, and is necessary in all situations when the new images appear constantly and need to be compared with/to those in a DB.

Query by canvas allows the user to compose a visual query using geometrical shapes, colours, and textures. This approach inherently tends to specify objects of interest in an indirect way using primitive features [17]. Moreover, the similarity matching between query and images relies on effective pre-segmentation of regions in the images, which is generally complex and difficult [204].

Query by sketches enables the user to draw the shape of an object as a query but it is not popular, perhaps because most users are rather poor at graphic design [12]. For this reason applications have used a query by sketches in a limited form, only for images of dominant objects in a uniform background [6]. In addition, since users typically have little visual memory of any image content, sketches barely reproduce salient properties of image regions. This requires the matching engines to be tolerant to sketching imprecision, with negative effects on the quality of retrieval.

Query by spatial icons, represented by visual icons with spatial constraints, which specifies a higher-level visual semantic representation and is composed as a chain defining a region which is designated via logical operators, for example, in a Boolean expression [206]. It has also been used for retrieval by spatial relationships. Then application of icons facilitates the task of specifying the spatial arrangement of objects within the image.

Query by image regions [206] is an enhancement of QBE. The query by multiple regions approach [210] allows for the composition of a query from multiple regions from example images with or without spatial layout. It is useful when the user is looking for abstract visual concepts. The visual query term specifies the region where a semantic support region (SSR) should appear, and query-forming chains of these terms, using logical operators. The concept of SSRs possesses the following properties:

- SSRs are extracted directly from images without segmentation and possess semantic power. They can be used to bypass the *semantic extraction problem.*
- Spatial information is retained in the index based on SSRs.
- SSRs are learned and detected from multiscale tessellated image blocks which are generally numerous and statistically significant.

When images are represented as 'bag of concepts' in a DB then comprise perceptually and/or semantically distinguishable color and texture patches from local image regions in a multi-dimensional feature space [211]. In order to explore the correlation between the concepts and overcome the assumption of feature independence in such a model, Rahman et al. propose query by image regions based on local and global analysis.

3D query is a 3D graphic scene built from predefined 3D icons in a preselected background. The user can change shapes, colours, and textures of these 3D icons. This technique is faster and more precise because it skips the process of object segmentation thanks to the use of icons. It is popular as a video query as it gives the possibility to change an occlusion by camera motion [207].

Semantic query is difficult to interpret semantically because computer systems extract only low-level image features when the user expects many different objects in both the foreground and the background of such an image [203]. Hence, the multiple semantic interpretation results in a retrieval problem because it needs to take into account simultaneously: low-level features, object layout and a big number of involved objects. For this reason, recently systems have appeared offering designed queries to the user [208], [212], [209] or independently sampled images. These systems use different procedures to estimate density distribution, for example, as a mixture of Gaussians [186].

8.3 User Designed Query (UDQ) for the Hybrid Semantic System

At present, most systems use query which more or less can be seen as example (QBE), whose drawback is the fact that the user first has to find an image which they want to use as a query. In some situations the most difficult task is to find this one proper image which the user keeps in mind to feed it to the system as a query by example. An evident example is shown in [205] where face sketches are needed for face recognition.

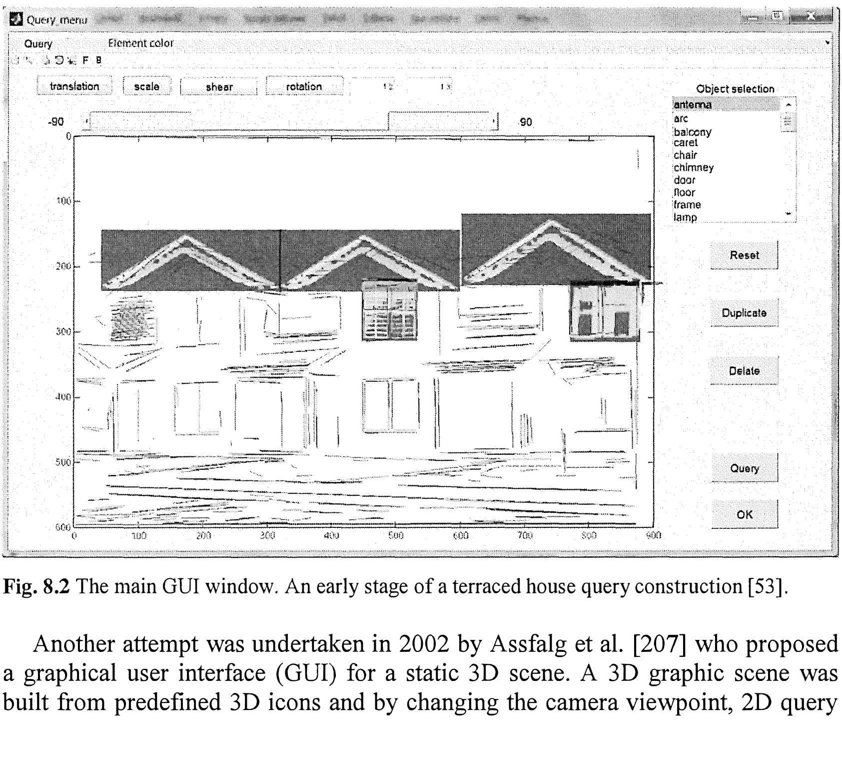

Fig. 8.2 The main GUI window. An early stage of a terraced house query construction [53].

Another attempt was undertaken in 2002 by Assfalg et al. [207] who proposed a graphical user interface (GUI) for a static 3D scene. A 3D graphic scene was built from predefined 3D icons and by changing the camera viewpoint, 2D query images were obtained which displayed different spatial relationships between objects. The actual reproduction of the 3D scene in a 2D image depended on camera operations that were performed while recording the video. Camera motion (panning, zooming, and tilting) determined what part of the 3D scene was actually framed.

The user selected a terrain from a small set of predefined models with different characteristics. Models were built from Digital Terrain Model (DTM) maps of 105×105 points. Objects are selected from a palette and placed in the scene by pointing at their appropriate position. Modifications were obtained interactively by changing the objects' location, size, colour, and texture.

In turn, Jaworska in [53] proposed a graphical editor which enables the user to compose the image he/she has in mind from the previously segmented objects (see Fig. 8.2). It is a bitmap editor which allows for a selection of linear prompts in the form of contour sketches generated from images existing in the DB. The contours are computed as edges based on the Canny algorithm and as a vector model set to the DB during the pre-processing stage. Next, from the list of object classes the user can select elements to prepare a rough sketch of an imaginary landscape. There are many editing tools available, for instance:

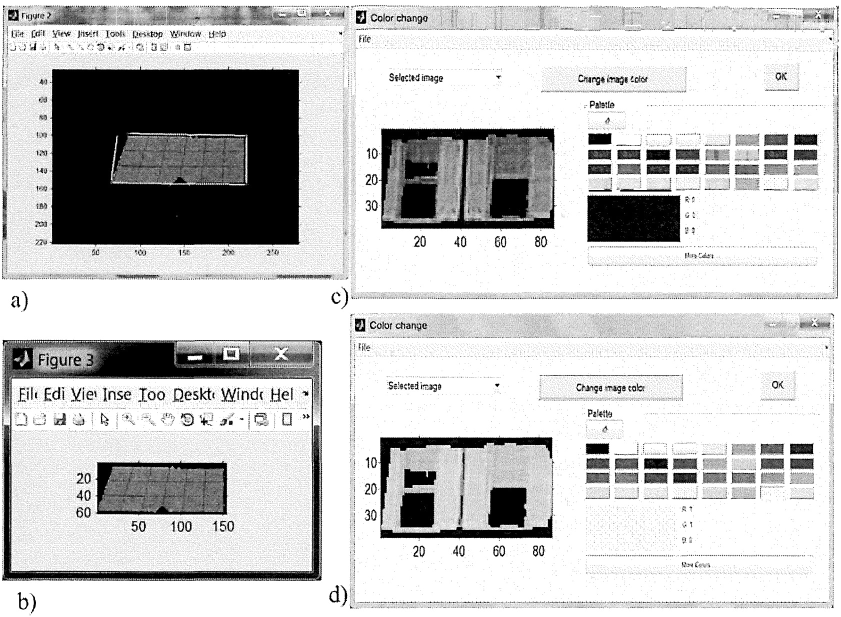

Fig. 8.3 Main components of the GUI. We can draw a contour of the bitmap (see a) and b)) and change the colour of an element (see c) and d)) [53].

– creating masks to cut off the redundant fragments of a bitmap (see Fig. 8.2 a) and b));
– changing a bitmap colour (Fig. 8.2 c) and d));

- basic geometric transformation, such as: translation, scale, rotation and shear;
- duplication of repeating fragments;
- reordering bitmaps forward or backward.

This GUI is a prototype, so it is not as well-developed as commercial programs, e.g. CorelDraw, nevertheless, the user can design an image consisting of as many elements as they need. The only constraint at the moment is the number of classes introduced to the DB, which now stands at 40 but is set to increase. Once the image has been drafted, the UDQ is sent to the search engine and is matched according to the rules described in Chapter 9 sect. 9.9.

However, in case of the absence of UDQ, the search engine can work with a query consisting of a full image downloaded, for example, from the Internet.

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