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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

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11 Conclusions

11.1 Final Remarks

In contrast with the early years (Section 1.1), we have witnessed a major shift from global feature representations for images, such as colour histograms and global shape descriptors, to local features and descriptors, such as salient points, region-based features, spatial model features, robust local shape characterizations and deep learning. It is not hard to imagine this shift to have been triggered by a realization that the image domain is too deep for global features to reduce the semantic gap. Local features often correspond with more meaningful image components, such as rigid objects and entities, which make association of semantics with image portions straightforward.

Many years of research have made it clear that emulating human vision is very challenging, nonetheless, practical approaches can help to build useful systems. While the endeavour to characterize vision will likely continue, particularly in the core field of computer vision, practical approaches (e.g., fusion of local and global representations for top-down as well as bottom-up representations) will potentially improve retrieval performance and user satisfaction in such systems. The availability of 3D and stereo image data should be exploited to extract features more coherent to the human vision system. In summary, reducing the sensorial gap in tandem with the semantic gap should continue to be a goal for the future.

All the time we expect that computers will operate with images as effectively as humans. There have appeared works which compared and tried to evaluate which tasks in terms of image processing better complete a computer than a man [278].

11.2 Future Challenges and Open Problems

In spite of many aspects have been covered so far, a number of substantial problems remain. The prime task is to find better ways of modelling human similarity perception at the high-level features as we have signaled in sect. 2.2.

The next aspect is to effectively improve retrieval beginning from the improvement of methods of query formulation and refinement and ending on the results presentation [275].

Additionally, depending on the scale of the key content or pattern, an appropriate representation should be chosen. In this sense, hybrid representations may sometimes be more attractive, but this may come at the cost of additional complexity. While segmentation is intended to recognize objects in a scene, precise segmentation still remains an open problem. Therefore, alternative approaches to characterize structure may be more suitable. However, such a representation may lose the charm of clear interpretability. Among the different approaches to segmentation, there is often a trade-off between quality and complexity which might lead to a difference in the eventual search performance and speed. Hence, the choice of image signature to be used should depend on the desirability of the system [275].

The subjectivity in similarity needs to be incorporated more rigorously into image similarity measures, to achieve what can be called a personalized image search. This can also potentially incorporate ideas beyond the semantics, such as aesthetics and personal preferences in style and content.

A long-term goal of research should therefore also include the ability to render high-resolution, high-dimension, and high-throughput images searchable by content. Meanwhile, we do hope that the quest for robust and reliable image understanding technology will continue. The future of CBIR depends a lot on the collective focus and overall progress in each aspect of image retrieval, and how much the average individual stands to benefit from it.

Although we can manage with the simpler cases, there still remain many open problems:

- in terms of features, we move from the low features, understood by computer, to the high ones, perceived by the humans:
 - Low – level
 - Middle – level
 - High – level
- in terms of media, the more complicated content the more information is provided by the media :
 - Image
 - Video
 - Website
 - 3D object
- in terms of the matching strategy, we have commenced from target searching among images and now we tend to retrieve images semantically:
 - Target searching
 - Similarity searching
 - Semantic retrieval

There are still many images impossible to segment Fig. 11.1 a) – colour layout causes a fragment of the roof to be divided into many inconsistent fragments, classification Fig. 11.1 b) – many details generate ambiguous or false

classification, interpretation (reality and image reality) Fig. 11.1 c) - the problem of “image into image” has not been solved by the AI community yet, or similarity Fig. 11.1 d) – semantically all these images present a swan, but the shape differences are too big to show them as similar objects.



Fig. 11.1 Examples of images which remain open problems in CBIR.

Finally, an important problem little discussed in the literature but of much importance, is the validation of retrieval results. For example, how can we justify calling one set of shape retrieval results better than another? How can we compare results among different shape representations and similarity measures? We addressed this problem in sect. 7.2 and described the obtained results (subsect. 9.9.1) because still images are evaluated based on the universal image similarity index (SSIM).

The validation of the query results in either a quantitative sense or with a non-quantitative approach that will justify confidence in the results using a particular method remains a critical issue for many works.

Generally speaking, future trends lead towards the unification of image services. It means that, for instance, the user will send their new sets of images, privately or professionally, to an already trained cloud which will offer

classification services. These image services will function for different users like contemporary plug-and-play services.

In the distant future images and videos will be processed and retrieved using quantum computers, which will change our understanding of systems in terms of time and complexity of algorithms. In means that whole DBs comprising images in a high resolution will be analysed simultaneously.

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