Chapter 5

Conclusions

In this thesis, two digital content management issues (content search and content protection) were investigated. We proposed two techniques aiming at solving the aforementioned two issues. We also conducted several experiments to examine their performance. The technique for image search is based on the multiple low-level features extracted from the multiple user-input instances. It incorporates the relevance feedback to interact with users to improve acquisition accuracy. The technique for scalable media content protection is an integration of three techniques: encryption, watermarking, and scalable coding. It integrates encryption and robust watermarking concepts and embeds them into scalable coding architecture to provide layered protection. Below we summarize our work and major contributions.

Contributions of the Search Scheme

In this scheme, we proposed three concepts that use the low-level image features and the relevance feedbacks.

1. We propose two distance-based methods to estimate the user perception based on the given positive instances. One is a geometric approach and the other is a statistical approach;

2. We generate consistent pseudo images particularly when the query set is too small; and

3. We prune irrelevant outcomes based on the given negative images.

The first concept is realized by examining the scattering factor of the query instances in the feature space. Our conjecture is that a scattered feature implies less importance in deciding the perceptual similarity. The second concept is realized through the notion of feature stability. Our conjecture is that a stable image feature (for a particular image) would have similar numerical values (small scatter numbers) at different spatial or SNR scales of the same image. Therefore, pseudo images are created by scaling the original image at various spatial resolutions and SNR levels. The third one is realized by creating pruning regions in the combined feature space. Our conjecture is that negative instances carry only the information of the undesired image feature values. Namely, the desired images should not look like the negative images. Because negative images may be close or far away, they are only suitable for pruning out undesired images and not used for distance estimation.

All the preceding concepts can be integrated into one algorithm using the same basic structure. We examine the performance of our scheme using the ANMRR criterion. Simulations show that multiple instances are helpful in achieving better query accuracy. In the case that the user input set is small, the synthesized pseudo images improve the results in most cases. As we conjectured, negative feedback used for pruning performs better than those used for weight estimation.

Additional conclusion remarks are:

1. The SNR multi-scaled images generally perform better than the spatial multi-scaled ones for pseudo images purpose;

2. Although the distance normalization is conceptually useful for weight estimation, simulations show that normalization is not always needed for producing good results;

3. Our method does not require *a priori* information about the data distribution in the database, which not only reduces the computational complexity but also makes it more suitable for searching in a distributed networking environment.

Contributions of the protection scheme

In this scheme, we proposed a recursive structure that integrates content protection with content scalable representation.

1. We propose an architecture that offers intellectual property protection on the layered (or scalable) content;

2. By combining cryptographic and scalable coding techniques, we can provide a group-based access control on various layers of the content;

3. By incorporating robust watermarking techniques, the keys for decrypting enhancement-layer data can be securely embedded into the content without changing the coding specification.

In the proposed scheme, the encryption concept guarantees the access control, keeping away malicious eavesdroppers. Also, the embedding concept solves the key-content synchronization problem. Comparing to the conventional cipher-block chaining encryption, the robust watermarking concept increases the key robustness against transmission errors and distortion. Therefore, it gives a higher data integrity protection on the keys than on the contents. To provide such features, this architecture requires more computing power than a multiple of single-layer encryption and watermarking system. For example, in addition to the decryption operations, additional complexity is needed to regenerate the keys at the receiver. The decryption keys are derived from the extracted watermarks, and the watermark extraction process can be costly.

We implement two application systems based on our proposed architecture, one for spatial scalability and the other for temporal scalability. The experiments results show that our proposed structure is feasible and promising.