Chapter 1

Introduction

With the advances of technologies in the recent two decades, we have wide spread communication networks, massive digital data storage devices, and portable digital capturing devices, for producing a vast number of different type of digital contents. Furthermore, compression technology reduces digital media size drastically to enable efficient storage or transmission. On the other hand, the amount of digital content grows at an amazingly fast pace, due to the increased media storage, cheap content generation devices, and wide-band distribution networks. Thus, a new term "pervasive multimedia" emerges.

To reach a large variety of terminals, a pervasive multimedia system uses a hybrid network mixed with high and low bandwidth links. For example, a personal computer receives contents from a wired Ethernet; a notebook computer or a PDA receives contents from a wireless network; a set-top box receives content through broadcast or cable channels; and a mobile phone receives contents from its dedicated air channels. On the one hand, different network channels have different bandwidth and error rates. On the other hand, different receivers have different playback capabilities. These factors greatly impact the quality of the rendered contents. The above issues lead to the need of multiple-grade content service. One necessary component in this kind of service is scalable coding. Scalable coding divides the content into several "layers", the more layers we retrieve for rendering, the

better reconstructed quality we have.

As the number of digital items becomes huge, the management issue becomes critical. We investigate two content management issues related to content consumption in this thesis. The first management task is to locate a desired content for consuming. In other words, multimedia searching technology is necessary to facilitate the usage of contents. Unlike keyword based textual document search, multimedia search is much more complicated. We need to find appropriate descriptions of a content (analogy to the keywords of a textual document), and to design a good matching strategy to search for similar contents. The second critical task is content right protection. Therefore, the digital rights management (DRM) technology is developed. The goals of content protection are twofold: to protect a digital item from unauthorized access, and to protect a digital item from illegal use. The former is often accomplished by using cryptographic schemes, and the latter is often achieved by verifying the watermarks or licenses associated with the content.

The aforementioned searching and protection tools are becoming the must-have technologies, due to the rapid growth of pervasive multimedia systems. There are two major topics in this thesis, one for content searching and the other for content protection.

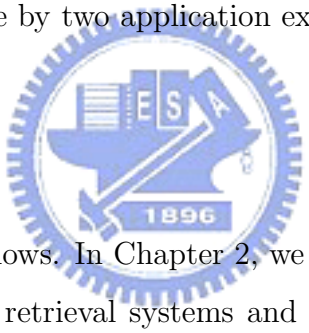
Topic 1: Image Search

Our focus is a CBIR (Content-based Image Retrieval) system with user feedback. The key idea is to estimate the user intention (perception) based on the user-supplied few samples. We develop an algorithm using the low-level image features only. The first feature of our proposal is that we keep the algorithm independent of the distribution parameters to reduce computational cost of collecting global parameters. The second feature is a feature-weight adjustment algorithm that uses the multiple instances provided by the user. In a common case that the sample size is too small, the third feature, pseudo images are created. Furthermore, unlike several other CBIR weight adjustment algorithm, the negative feedback is used for pruning

undesired objects (not used to adjust the weights).

Topic 2: Layered Protection

There are two issues in delivering encrypted contents over a broadcast environment. The first one is that the decryption key needs a strong protection to overcome transmission errors. The other problem is that the keys and contents may be received out of their sequential order. The synchronization between contents and their associated keys can become an issue. To meet these two requirements, we propose an intellectual property protection scheme that combines multi-layer content encryption and key-content synchronization. The basic idea is to hide the higher layer decryption key in its lower layer content using the watermarking technology. We demonstrate the feasibility of this structure by two application examples.



Organization

This thesis is organized as follows. In Chapter 2, we describe the fundamental concepts of content-based image retrieval systems and relevance feedback operations. We also provide an overview of digital rights management concepts and a few techniques used in our proposal. In Chapter 3, we describe the proposed image search scheme, show the simulation results, and discuss the performance. Then, in Chapter 4, we describe the proposed layered protection scheme, simulate the scheme using one spatial and one temporal scalability examples, and discuss the results. Finally, we conclude our works in Chapter 5.

Contributions

The major contributions of this thesis are summarized below.

- Image Search

1. Propose a distance-based multi-feature multi-instance relevance feedback scheme for low-level feature matching;
2. Propose a pruning method to use negative instances;
3. Propose the pseudo image concept to reduce the impact of few-sample problem;
4. Prove by simulation that the scheme has higher accuracy than the previous schemes designed for the same purpose when enough query samples are provided;
5. Prove by simulation that negative instances are suitable for pruning rather than for estimation;
6. Prove by simulation that pseudo images effectively reduce the impact under few-sample conditions.

- Layered Protection

1. Propose a layered protection architecture that combines encryption and scalable coding;
2. Propose a novel use of robust watermarking, which solves the key-content synchronization problem;
3. Prove the feasibility of the scheme by constructing one image application example and one video application example;
4. Simulate both applications and examine the key error probability at different channel error rates.