An Introduction to Digital Video Data Compression in Java

Fore June

Chapter 1 Introduction

1.1 The Value of Knowledge

Not long after the birth of the Web, multimedia has become an inseparable part of it. As the growth of the Web accelerates, the demand of multimedia applications and the knowledge of this field explodes. Data compression is the soul of the engine that drives the rapid development of these applications. Audio and image data can be effectively transmitted across the Web or saved in a digital storage medium (DSM) only after they have been compressed.

Video compression can be considered as an extension of audio and image compression, whose applications go well beyond the Web. As one might have noticed, in recent years video compression products have experienced rapid growth in a variety of consumer products like iPods, iTune, mobile phones, digital cameras, TV games, and many kinds of hand-held devices. All these products have employed video compression technologies to save storage space or transmission bandwidth. Moreover, as the cost of computing drops rapidly, sophisticated video compression technologies begin to seek its way into toys, hand-held devices and many innovative low-end new consumer products that add video features to attract customers. These low-end products are usually sold in very large volume and their production cost becomes a sole factor in determining the adoption of a technology. Very often, these products are built using embedded systems and the computing power and memory space of them are relatively limited. To develop data compression programs in such an environment, one must have a thorough understanding of the technology.

After many years of research by a large number of scientists and engineers, the methodologies of producing high-quality compressed video have become mature and well known. However, surprisingly, a few years ago when we began to help implement a video compression engine in a product for a toy manufacturer, we could hardly find any literature discussing the programming and implementation of it. People who were familiar with this technology were also scarce compared to the demand of it. Therefore, a book explaining the principles and implementation of video compression could be helpful and beneficial to the workers in this field.

Even though the book presents the materials at an introductory level, some readers may still find the materials difficult, depending on their background and willingness of paying efforts in learning. But your knowledge is valuable only if you need to pay effort to gain it. Topics that are easy to you are also easy to your competitors. In the coming decades, the competition between nations will be a competition of acquiring knowledge. The more effort you pay to acquire knowledge, the wealthier and happier you will be.

Renowned management specialist Peter Drucker (1909 - 2005) had long advocated the emergence of knowledge society and the importance of knowledge workers. The social transformations from an industrial society to a knowledge society would be the most significant event of the century and its lasting legacy. Science and technology have been advancing so rapidly that manufacturing becomes irrelevant in the modern society. A DVD containing certain data that you pay twenty dollars to purchase may just cost a few cents to manufacture. Though it is very rare for the productivity between two labour workers differ by a factor more than two, the productivity of a good knowledge work can be easily a factor of 100 or higher than that of an average knowledge worker. To become proficient in a certain field, one must learn with his or her heart, overcoming difficulties, barriers and frustrations. After enduring the hard work, one would enjoy the pleasure of understanding difficult materials and acquiring valuable knowledge. While the position of a labour worker can be easily substituted by another one with little training, it is very difficult to replace a specialist of a field in the knowledge economy, for the new worker must also go through the same learning barriers and hard work to acquire the knowledge.

1.2 MPEG-4 and H.264 Video Compression Standards

The work on video compression was mainly developed in the 1980s by a numerous number of researchers, mostly working in universities and academic institutions. Effective and close-to-optimal generic compression models began to emerge from the researching results. These models eventually became today's compression standards, which allow different parties to develop individual applications and communicate with each other seamlessly. The standardization has been mainly done by the International Organization for Standardization (ISO) in cooperation with the International Telecommunications Union and the International Electrotechnical Commission (IEC). ISO/IEC Joint Photographic Experts' Group (JPEG) and Moving Picture Experts' Group (MPEG) produced the well-known JPEG, MPEG-1, MPEG-2 and MPEG-4 standards that form the basis of most image and video compression standards today. MPEG-4 was introduced in late 1998 and designated as a standard for a group of audio and video coding formats and related technologies under the formal standard ISO/IEC 14496. Uses of MPEG-4 include compression of AV data for web (streaming media) and CD distribution, voice (telephone, videophone) and broadcast television applications. **H.264**, also known as *MPEG-4 Part 10/AVC for Advanced Video*, is the latest video compression standard, resulting from the work of a joint project between MPEG and the Video Coding Experts Group (VCEG), a working group of the International Telecommunication Union (ITU-T) that operates in a way similar to MPEG. ITU-T has helped set a series of telecommunication standards and is the sector that coordinates telecommunications standards on behalf of ISO and IEC. H.264 is the name used by ITU-T, while ISO/IEC refers it to as *MPEG-4 Part 10/AVC* since it is presented as a new part in its MPEG-4 suite, which includes MPEG-4 Part 2, a standard used by IP-based video encoders and network cameras. It tries to improve upon the weakness of previous video compression standards including:

1. Reducing the average bit rate by 50%, compared with any other video standard for a specified video quality,
2. Using straightforward syntax specification that simplifies implementations,
3. Defining exactly how numerical calculations are to be made by an encoder and a decoder to avoid errors from accumulating,
4. Improving robustness so that transmission errors over various networks are tolerated, and
5. Increasing low latency capabilities and achieving better quality for higher latency. (Latency refers to the time to compress, transmit, decompress and display a set of video data.)

H.264 can support a wide variety of applications with very different bit rate requirements. For example, in entertainment video applications including broadcast, satellite, cable and DVD, an H.264 encoder-decoder (codec) may yield a data rate between 1 to 10 Mbit/s with high latency, while for telecom services, H.264 can deliver bit rates of below 1 Mbit/s with low latency.

MPEG-4 Visual, also referred to as *MPEG-4 Part 2*, is an earlier standard developed by MPEG that has significantly different goals from H.264. Though both standards deal with video data compression, MPEG-4 Visual emphasizes on flexibility whilst H.264 stresses on efficiency and reliability. MPEG-4 Visual provides a very flexible toolkit of coding techniques and resources that allow users to code a wide range of data types including traditional rectangular frames, video objects with arbitrary shape, still images and hybrids of real-world and computer-generated synthetic visual data.

Both MPEG-4 and H.264 are 'open' international standard. The term 'open' here means any individual or organization can purchase the standards documents from ISO/IEC, or ITU-T. Sample code of implementation are also available on the Web:

http://www.mpeg.org/MPEG/video/mssg-free-mpeg-software.html

The documents specify exactly what is required for conforming to the standards. Ironically, any implementation of these 'standards' utilizes certain methods that fall into the scope of a number of related patents. Any software developer who implements the standards needs to pay a certain royalty fee to a number of organizations coordinated by MPEG LA, which is regarded as the 'Standard of Standards' (*http://www.mpegla.com*), a leading packager of patent pools for standards used in consumer electronics, as well as eCommerce, education and other technical areas. It is fairly sad to see that we have to pay royalty fees to use a 'standard'. But the world itself, being in and around us has never been perfect. We have to accept this imperfectness in order to move on. Moreover, we have the freedom of choice of using the 'standards' in our applications.

The principles and methods discussed in this book are similar to those 'standards' as they are the results of a numerous number of researchers and have been published in various scientific and technical journals. However, to avoid any possible royalty dispute, our methods deviate in many minor aspects and the implementations could be very different from the 'standard' code. Readers are free to use part or all of the code presented in this book. However, whether the implementationis have used any algorithm that falls into the scope of any patent is beyond our knowledge. If you use the code for any commercial product, you do that at your own risk.

1.3 This Book

This book, *An Introduction to Digital Video Data Compression in Java* is written based on the author's other book *An Introduction to Video Compression in C/C++*. The materials are discussed at an introductory level and the code is presented in Java. The implementations of more advanced topics are not included. Also, we have only considered image compression; audio compression is omitted. The programs presented are mainly for illustrating the principles of video compression and how to implement them; very often error checking and handling are not included. For the purpose of making the materials easy to understand, sometimes the parameters are hard-coded. Nevertheless, the programs can be used as a starting point for further development. More advanced topics on video data compression are presented in the last chapter without actual implementation.

We have to admit that the programs were written over a period of time and thus the notations may not be very consistent. Also, we have not optimized the code for memory usage or computing time. However, coding is always relatively the easy part compared to understanding the algorithms. All the code presented in this book can be found at the site:

http://www.forejune.com/jvcompress/

and you can download the programs using the password 'nobel_peace_prize'. The programs have been compiled and tested. The version of Java we have used is **1.6.0_20**. The java programs of this book reside in subdirectories with numbering reflecting the related chapter. For example, the programs discussed in Chapter 5 will be in directory **5/**. If the programs of another chapter need to use the classes developed in Chapter 5, we just need to point the CLASSPATH to **5/**. We also put most of the sample data files in the directory **data/**.

We hope you enjoy reading this book.

Other books by the same author

Windows Fan, Linux Fan

by *Fore June*

Windws Fan, Linux Fan describes a true story about a spiritual battle between a Linux fan and a Windows fan. You can learn from the successful fan to become a successful Internet Service Provider (ISP) and create your own wealth.

Second Edition, 2002.
ISBN: 0-595-26355-0 Price: $6.86

An Introduction to Video Compression in C/C++

by *Fore June*

The book describes the the principles of digital video data compression techniques and its implementations in C/C++. Topics covered include RBG-YCbCr conversion, macroblocks, DCT and IDCT, integer arithmetic, quantization, reorder, run-level encoding, entropy encoding, motion estimation, motion compensation and hybrid coding.

January 2010
ISBN: 9781451522273

An Introduction to 3D Computer Graphics, Stereoscopic Image, and Animation in OpenGL and C/C++

by *Fore June*

November 2011
ISBN-13: 978-1466488359