Chapter VII
Video Coding for Mobile Communications

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ABSTRACT

With the significant influence and increasing requirements of visual mobile communications in our everyday lives, low bit-rate video coding to handle the stringent bandwidth limitations of mobile networks has become a major research topic. With both processing power and battery resources being inherently constrained, and signals having to be transmitted over error-prone mobile channels, this has mandated the design requirement for coders to be both low complexity and robust error resilient. To support multi-level users, any encoded bit-stream should also be both scalable and embedded. This chapter presents a review of appropriate image and video coding techniques for mobile communication applications and aims to provide an appreciation of the rich and far-reaching advancements taking place in this exciting field, while concomitantly outlining both the physical significance of popular quality image and video coding metrics and some of the research challenges that remain to be resolved.

INTRODUCTION

While the old adage is that *a picture is worth thousands of words*, in the *digital era* a colour image typically corresponds to more like a million words (double bytes). While an image is a two-dimensional spatial representation of intensity that remains invariant with respect to time (Tekalp, 1995), video is a three-dimensional time-varying image sequence (Al-Mualla, Canagarajah, & Bull, 2002) and as a consequence represents far more information than a single image. Mobile technologies are becoming omnipresent in our lives with the common mantra to communicate *with anybody, anytime, anywhere*. This has fueled consumer demand for richer and more diverse mobile-based applications, products, and services, and given the *human visual system* (HVS) is the most powerful perceptual sensing mechanism, it has inevitably meant that image and latterly video technologies are the drivers for many of these new mobile solutions.

Second generation (2G) mobile communication systems, such as the *Global System for Mobile* (GSM) started by supporting a number of basic multimedia data services including voice, fax, *short message services* (SMS) and information-on-demand (news headlines, sports scores and weather). *General Packet Radio Service* (GPRS), which has often been referred to as 2.5G, extends GSM to provide packet switching services and afford the user facilities including e-mail, still-image communication, and basic Internet access. By sharing the available bandwidth, GPRS offers efficiency gains in applications where data transfer is intermittent like Web-browsing, e-mail, and instant messaging. The popularity of GSM and GPRS led to the introduction of *third generation* (3G) mobile technologies which address live video applications, with real-time video telephony being advertised as the flagship application for this particular technology, offering a maximum theoretical data rate of 2Mbps, though in practice this is more likely to be 384Kbps. Multimedia communications along with bandwidth allocation for video and Web applications remains one of the primary focuses of 3G as well as the proposed *fourth generation* (4G) mobile technologies, which will provide such functionality as broadband wireless access and interactivity capability, though it is not due to be launched until 2010 at the earliest. Many technological challenges remain including the need for greater coding efficiency, higher data rates, lower computational complexity, enhanced error resilience and superior bandwidth allocation, and reservation strategies to ensure maximal channel utilisation. When these are resolved, mobile users will benefit from a rich range of advanced services and enhanced applications including video-on-demand, interactive games, video telephony, video conferencing and tele-presence, tele-surveillance, and monitoring.

As video is a temporal sequence of still frames, coding in fact involves both single (intra) and multiple (inter) frame coding algorithms, with the former being merely still image compression. Since, for mobile applications only low bit-rate video sequences are suitable, this chapter analyses both high image and video compression techniques. Approaches to achieving high image compression are primarily based upon either the *discrete cosine transform* (DCT), as in the widely adopted *Joint Picture Expert Group* (JPEG) standard or the *discrete wavelet transform* (DWT) which affords scalable and embedded sub-band coding in the most recent interactive JPEG2000 standard. In contrast, a plethora of different inter-frame coding techniques have evolved within the generic block-based coding framework, which is the kernel of most current video compression standards such as the *Moving Picture Expert Group* family of MPEG-1, MPEG-2, and MPEG-4, together with the symmetrical video-conferencing H.261 and H.263 coders and their variants. MPEG-4, which is the latest audio/video coding family member, offers object-based functionality and is primarily intended for Internet-based applications. It will be examined later in the chapter, together with the main features of the newest video coding standard, somewhat prosaically known as H.264 or *advanced video coding* (AVC), which is now formally incorporated into MPEG-4.

All these various compression algorithms remove information content from the original video sequence in order to gain compression efficiency, and without loss of generality the qual-

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