Some Important International Standards and Organizations in Visual Telecommunications

I serien "NORSIGnalet hjelper deg" presenterer vi denne gangen andre del av til sammen tre (opprinnelig: to) deler om internasjonal standardisering i visuell kommunikasjon. Skulle du ha gått glipp av den første, så finner du den i forrige utgaven.

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Introduction

The reader became familiar with the world of international standardization organizations in Part I. I mentioned the most important groups and explained their hierarchies and collaborations. This time, the focus is on the standards themselves. I will now try to cover the standards' history and their relationships to each other. Again, technical issues are not discussed; this is beyond the scope of this article. Books of hundreds of pages each have been written about one single standard, please refer to them. I hope you have learned all the acronyms from Part I by heart such that I can arbitrarily make use of them.

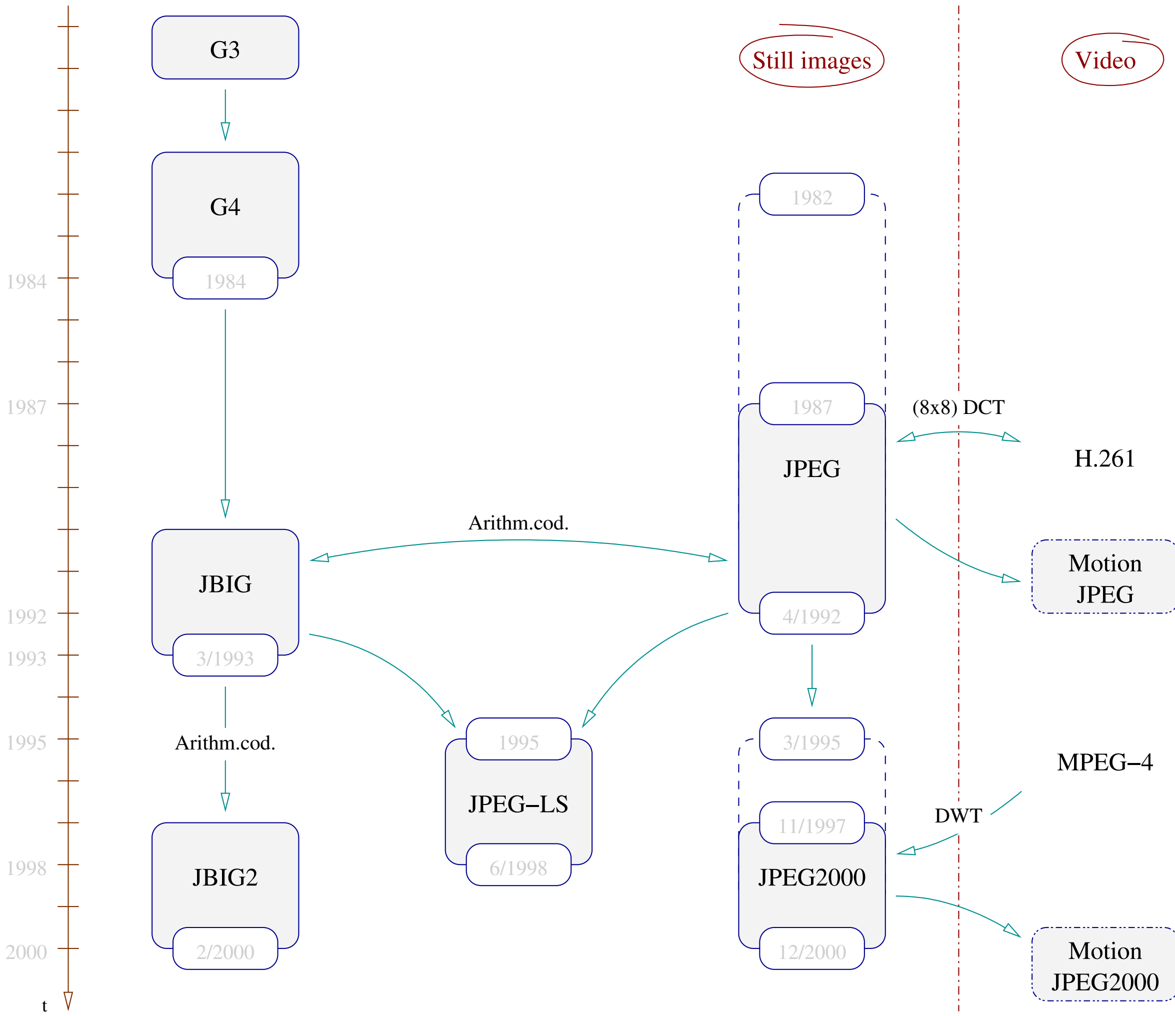
Still-image coding standards

Comparing the similarity of early still-image compression standards to those for video coding, one would expect that the standardization development started with still images due to the relatively low complexity of compression algorithms for the temporally non-changing pictures. For instance, the specification of JPEG's (8x8) DCT, its quantization tables and Huffman coding is almost identical to the specification of intra-frame pictures in H.261, but the latter standard compounds additionally of complexity-increasing motion estimation and compensation for moving picture material. It may therefore be a little surprising that the history of standardization of visual information began with systems for image sequences; two video standards (H.120 and H.261) were already finalized (1984 and 1990, respectively) when the first still-image standard JPEG saw the light of the day in 1992.

We can conclude that first there was the need for conversational communication/*transmission* like e.g. video conferencing (covered by ITU-T's H series), then also the *storage* of visual data became more and more important (addressed by ISO/IEC's MPEG and JPEG standards). The evolution of technical standards also reverses the evolution of visual information in the history of human kind, which has been from two dimensions to three.

Still images like early stone carvings or cave paintings have existed for thousands of years before paintings came up, followed by photography and, finally, television with moving pictures. However, video stimulates the human visual system to a larger degree than pictures do, which explains the high interest for moving pictures; there are only five important still-image standards compared to eight to ten video standards, depending on the point of view. The most common still-image standards at the time of writing are JBIG, JBIG2, JPEG, JPEG-LS, and JPEG2000.

The JPEG standard is the first and probably most famous one. It is the result of a joint effort of ISO/IEC and ITU-T and thus standardized both as IS 10918-1 and Recommendation T.81 with the title 'Information technology - Digital compression and coding of continuous-tone still images - Requirements and guidelines'. More specific, this refers to Part 1 which was finalized in April 1992. Other parts exist (IS 10918-2,3,4 or T.83,84,86) which address additional specifi-



Evolution of still-image standards

cations like compliance testing, extensions, and profiles, and which evolved later. The standardization started not before 1987 with a CfP even though the need for such a standard became obvious as early as 1982. The JPEG standard is heavily influenced by the H.261 development, with the (8x8) DCT as the backbone of both standards. A typical compression ratio is 2:1 for lossless, and 20:1 for lossy operation mode [1]. I would further like to mention its extension to the unofficial (industry) standard Motion JPEG which defines video as a sequence of succeeding still images. Motion JPEG achieves approximately 1/3 of the compression ratio of MPEG-1 [1]. The lack of an official standard was much to the industry's regret, therefore there will be an official extension to the successor of the JPEG standard, JPEG2000, with the name Motion JPEG2000. JPEG is quite versatile, it can be applied in all kinds of multilevel imagery, from desktop publishing and graphic arts to medical and scientific imaging.

Parallel to the JPEG standardization, JPEG and JBIG worked also on an effort for lossless compression of bi-level imagery (like facsimile), JBIG. In fact, the arithmetic coding engine proposed for the JBIG standard can optionally also be used in the JPEG standard. The official references to the JBIG standard are ISO/IEC IS 11544-1 and ITU-T Rec. T.82, its title is 'Information technology - Coded representation of picture and audio information - Progressive bi-level image compression'. The first part of the standard was finalized in March 1993; however, several amendments (extensions) were added later. The target applications of JBIG are half-tone images (binary renditions of continuous-tone images), facsimile, and computer-generated imagery. The JBIG standard evolved from the ITU-T (former CCITT) standards T.4 and T.6, more commonly known under their names G3 and G4, referring to the classification (G for group) of documents for which they were developed. The standard performs in sequential operation mode 30% better than G4 [1], and the compression ratio is 8:1 for binary half-tones where G3/G4-coded documents likely lead even to data expansion. Compared to JPEG, and when coding one to three pixel bit planes, the JBIG standard outperforms JPEG. With four to six bit planes, both standards are approximately equal, and with more than 6 bit planes, JPEG (with arithmetic coding enabled) is superior to JBIG [1]. However, JBIG is more complex than G3 or G4; software implementations are two to three times slower on general-purpose processors [1].

The standardization of JBIG2, finalized in February 2000, improved the performance of the JBIG standard further. JBIG2 is the common name of ISO/IEC IS 14492-1 or ITU-T Rec. T.88 with the name 'Information technology - Coded representation of picture and audio information - Lossy/lossless coding of bi-level images' and addresses, as the title says, not only lossless but also lossy compression. The performance increase comes at the price of higher complexity and memory requirements. Unfortunately, I could not find performance comparisons to other standards in the literature.

In performance evaluations, the lossless mode of JPEG achieved only moderate results. In addition, this operation mode was not widely known, so based on the standards JPEG and JBIG, a new specification, JPEG-LS, was developed by the known groups between 1995 and June 1998, the title being 'Information technology - lossless and near-lossless compression of continuous-tone still images - Baseline'. The reference numbers are ISO/IEC IS 14495-1 and ITU-T Rec. T.87. JPEG-LS was developed primarily for medical imagery and non-natural image content like graphics and text. Lossless compression for most natural sources is achieved at a compression ratio of 1.7:1, for artificial sources the ratio increases to 4.3:1. JPEG-LS allows also for lossy compression, but its performance on this field is far from other standard like JPEG or JBIG (more than 5 dB difference). However, JPEG-LS outperforms JPEG2000 in the lossless operation mode.

So, having mentioned the successor of the JPEG standard a couple of times, it is about time to introduce it eventually. JPEG2000 standardization was - not surprisingly - carried out by JPEG and started in November 1997, even though the actual efforts were prepared already since 1995. So far, 'JPEG2000 Image Coding System' is only an ISO standard, namely ISO/IEC 15444-1. Its development is not yet finished; however, Part 1 was finalized in December 1998. The standard consists of a number of extensions of which I would like to mention Motion JPEG2000 which will become IS 15444-3. JPEG2000 was among others influenced by the MPEG-4 development with regard to the employment of the digital wavelet transform. JPEG2000 is an extremely versatile. It can be applied to both continuous-tone and bi-level images, allowing for 16 or more bit-per-pixel representations. Further, a lossless scheme is specified besides lossy compression. At high rates (i.e. imperceptible coding artifacts), JPEG2000 accomplishes a 20% compression advantage over JPEG [3]. The subjectively viewable advantage is significant especially at low bit rates [3]. For the same visual fidelity, one can observe a bit rate reduction between 11% and 53% from 1.0 bit/pixel to 0.25 bit/pixel [3]. Considering equal rates, my own observation is that JPEG2000 pictures have on the average 13% - 15% higher PSNR than JPEG pictures. JPEG2000's performance is comparable to that of the G4 standard for binary images [3].

As wee see, there is unfortunately no universal image compression algorithm. We have to choose one of the aforementioned standards according to our requirements. The performance comparisons might help for an evaluation. More elaborate comparisons, together with detailed descriptions of the standards are covered by the three books which I wish to recommend.for further reading for those interested. Which concludes this part on still-image standards.

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gory, and builds upon previous work in this field. One of the most well-known approaches to transformation based model adaptation is the maximum likelihood linear regression (MMLR) approach. Although well suited for use within wide a range of mismatched conditions, MLLR is known to have several shortcomings, in particular a sensitivity to the amount of adaptation data needed to safely estimate a transformation.

The approach presented in this work is an attempt to take the MLLR framework a step further, at the same time addressing some of the problems. This is achieved by introducing the Bayesian paradigm, where maximum likelihood estimation is replaced by maximum a posteriori estimation using hierarchical prior distributions. It is well known that the Bayesian paradigm enables us to obtain better and more robust estimates, but only if the prior distributions used are relevant for the problem at hand. The hierarchical prior distributions allows us to obtain informative priors in an fully automated manner using only the adaptation data.

Model adaptation experiments indicate that this approach performs as well as, or better than MLLR, while being more robust with respect to the amount of available adaptation data. The cost of the increased performance and robustness is an increase in memory consumption and computational cost. The problem of increased complexity is addressed by introducing a simpler transformation embedded in the same hierarchical prior framework. Experiments show that the performance of the this approach is comparable to the use of full transformations, while having a simpler implementation and lower computational requirements.

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