Recommendation on the Strategy of Using the Different Scanning Formats

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Abstract

The purpose of this recommendation is to update the *Recommendation on Scanning Formats* formulated by the RACE Image Communication Project Line 4 in January 1994. This update takes into account the studies performed in WP2 within the framework of the *Scanning Formats Extension*. This paper also discusses the strategy to follow in order to adopt a progressive format for the coding of digital television.

The work performed within the framework of the RACE 2110 HAMLET Extension on Scanning Formats, leads to the following statements :

1. Interlaced format has been chosen in the early years of television considering it was one of the most interesting solution to achieve compression with regard to the available technology [1].

2. The improved quality of today's television sources and displays make the viewers less tolerant of the defects of the interlaced format (i.e. *interline flicker*, *line crawling* and *field aliasing*), especially for large displays, close viewing distance and high brightness levels [1].

3. Besides the typical interlaced defects, interlaced sources further suffer from a loss of vertical definition, deliberately introduced in order to reduce interline flicker [1].

4. With the change from analog to digital television, drastic changes will occur in our television system. These changes may be seen as a unique opportunity to change formats, implying only minor costs compared to the overall budget involved in such operation [1].

5. Leaving space for the future, it could be envisaged as a wise step not to degrade the image quality at the very beginning of the television process (i.e. inside the camera), chosing a lossy scanning format [1].

6. The choice of a scanning format needs to be done with care in order to avoid backward and lateral compatibility problems that would become difficult to overcome in the future [1].

7. Compared to interlace, progressive-scan signals are more suitable for digital compression in terms of high correlation for vertical and temporal directions, motion estimation and compensation [1].

8. Progressive scanning cameras suffer from a substantial signal-to-noise ratio loss due to the increased scanning velocity. However it can be observed how the technological gap between interlaced and progressive is reduced passing from tube to CCD technology. A specific design of a CCD video camera for progressive scanning allows to increase significantly its performances with a cost comparable to that of interlaced [1].

9. Progressive *frame-transfer* CCD cameras allow to shot frames like a photograph and thus improves the display of still pictures taken from sequences that suffer from fast motion [1].

10. A progressive format offers the compatibility with computer graphics, multimedia applications and film production [1].

11. A progressive scanning format makes most signal processing operations easier than interlaced scanning, but since the system has to work with a doubled clock frequency and higher memory requirement in some cases, attention must be paid to the real complexity [1] :

    - *Filtering.* Vertical is intrinsically more effective for a signal sampled on a progressive grid, in terms of both complexity and final results.
    - *Multi-resolution - HDTV/TV Scalability.* Since interlaced performs poorly in terms of separation of the vertical frequencies, an intermediate progressive conversion is often considered even for interlaced-to-interlaced spatial scalability .
    - *Frame Rate Conversions.* Besides the 50/59.94/60Hz conversions (European/Japanese/American standards) which can be performed by handling interlaced fields only (to the detriment of some jerkiness), other conversions like 50/100Hz (improved domestic video displays) or 50/72Hz (compatibility with the computer world) require the use of a deinterlacer in order to offer a satisfactory quality.
    - *Slow-motion.* In order to avoid undesirable jerky motion effects specific to the simple field repetition, efficient slow motion algorithms are all based on high-quality deinterlacers.
    - *Still Picture.* Unlike a progressive format, still pictures taken from interlaced sources requires the use of motion compensation in order to avoid the loss of definition that occurs when performing still field display.
    - *Aspect Ration Conversion.* Digital television will probably start in 16/9, so the problem of compatibility with 4/3 material is real. The required resampling reverts principally to a filtering problem (see above).
    - *Chroma-keying.* Digital chroma-keying is intended to replace the historical analog blue component-based process. Within the research currently under development, progressive material is considered.

12. Besides the cathodic ray tube that takes benefit from the use of an interlaced format, new promising technologies like *Active Matrix LCD*, *Digital Micromirror Device* and *Plasma Display Panel* require a progressive input format [1].

13. With the advent of digital television, the uselessness of interlaced scanning will raise since digital coding offers many other ways to save bandwidth. Moreover, the use of a progressive format improves the subjective quality of the decoded sequences compared to an interlaced coding scheme. This result holds even in case of interlaced displaying of the progressive decoded sequence. [1, 3].

14. Moving towards a progressive transmission scheme will require *progressive-to-interlaced* (low-cost) and *interlaced-to-progressive* (high-cost) conversions in order to manage present studio and consumer environments. Economical considerations will force the market to use low-cost conversions at the consumer side. Fortunately, if a progressive transmission scheme is adopted, only a progressive-to-interlaced conversion must be carried at this side in order to ensure the compatibility with old interlaced displays. This conversion can easily be integrated in the digital decoder that will be purchased if an analog interlaced display is used to decode digital broadcast services.
    Interlaced studios will have to make use of a high-cost deinterlacer. Besides removing the interlaced artifacts, this deinterlacer is supposed to improve the digital coding of interlaced sources [3]. However, this result holds for high-quality deinterlacers only and has to be achieved by the use of a finely tuned motion estimation and compensation. Also, field aliasing has to be handled properly. The *general sampling theory* offers such requirements. A deinterlaced based on such technique has been described in [2].

15. Work carried in WP2, comparing CCIR 601 interlace with a 50Hz-progressive scanning format, showed that [3]:
    - *if an all progressive chain is compared to an all interlaced one* (same bit-rate), progressive is generally preferred to interlaced mainly due to the display;
    - *if interlaced display is used*, progressive transmission improves the picture quality if progressive sources are used. The degree of improvement is linked to the complexity of the source material (higher the complexity, bigger the improvement). Conclusions are not as clear when dealing with interlaced sources since the results depend on the quality of the deinterlacer and the contents of the source sequence. In general, similar results are performed (but at higher cost for progressive since the prior deinterlacing operation and the doubled clock speed).

16. 50Hz-Progressive transmission leads to more stable bit-rate control and offers a more homogeneous picture quality [3].

As a conclusion, when considering the same bit-rate, an all progressive broadcasting chain (from the source capture to the final display) is preferable to an all interlaced one, except for the increased hardware performance since twice the number of pixels have to be scanned. A progressive chain offers an improved picture quality, a more homogeneous transmission quality and the compatibility with multimedia applications (computer, film, digital processing,...). However, a progressive coding can not be seen as an efficient way to improve the quality of the decoded sequence, as long as interlaced displays are concerned, but can be used as an intermediate step towards a fully progressive television implementation without loss of performance compared to the existing interlaced format. Moreover, the choice of a progressive scanning format for the future digital television should not be regarded as an efficient way to improve quality but as a wise step towards multimedia and computer compatibility.

For such reasons, a progressive format has already been considered for the introduction of the new digital television services in the U.S. and Japan. In a European context, the adoption of a progressive scanning format will have to cope with the decision of the DVB group, which expressed itself in favour of the MP@ML MPEG2 coding scheme. Just as it is, MP@ML does not allow the coding of 50Hz-progressive sequences. However, this limitation only comes from the definition of the MP@ML itself which was decided to restrict the *pixel* rate below that needed by a 50Hz-progressive format. From a practical point of view, this problem is meaningless since the 50Hz-progressive format may be coded using the same *bit* rate as interlaced at same or improved visual quality. In other words, it would have been more judicious defining the MP@ML to include the 50Hz-progressive format. On the contrary, the 50Hz-progressive format has been classified with other high-cost formats that require a more complex high-1440 level-compliant decoder (MP@H-14). As proposed by the RACE Image Communication Project Line, this syntax problem can be solved by defining an intermediate MPEG2 level compatible with the 50Hz-progressive format. However, this demand could take a long time before being considered by the MPEG2 authorities. Moreover, the moderate improvements offered by a progressive transmission scheme are not eager to boost alone such a demand. As it is difficult to propose a new profile, it is suggested to cope with existing ones (MP@ML or professional 4/2/2) with either lower picture size or frame rate for the progressive format. In these cases simulations are required to evaluate the impact of using different spatial or temporal resolution, but results from the Grand Alliance are promising.

Finally note that a 25Hz-progressive scanning format is already compatible with the MP@ML considered by the DVB group. Thus, it is proposed to use this format for the encoding of films (24Hz-progressive), which represent an important source of motion picture material for future television apart from video-camera sources. Hence, the choice will be given to the display to keep the progressive source or convert it into interlace, depending on the quality to be offered to the consumer.

References

[1] S. Pigeon and P. Guillotel, "Advantages and Drawbacks of Interlaced and Progressive Scanning Formats", *CEC RACE/HAMLET Deliverable n° R2110/ WP2/DS/R/004/b1*, June 1995.

[2] S. Pigeon and al., "Specification of a Generic Format Converter", *CEC RACE/HAMLET Deliverable n° R2110/WP2/DS/S/006/b1*, September 1995.

[3] P. Guillotel and S. Pigeon, "Coding Efficiency Comparisons of both Interlaced and Progressive Scanning Formats", *CEC RACE/HAMLET Deliverable n° R2110/WP2/DS/S/012/b1*, December 1995.