Proposal main texts for "Digital TV Standards Convertor"

1 What is the historical significance of the work (its technological, scientific, or social importance)? If personal names are included in citation, include justification here. (see section 6 of Milestone Guidelines)

For international transmission of TV programs such as sporting events, especially those between regions with different TV standards, such as between Europe and Japan, telecommunications carriers or broadcasters perform TV standards conversion.

TV standards conversion has been performed since international TV transmission began more than half a century ago[1]. In the SDTV (standard TV) era, the number of lines that made up one screen (frame) and the number of frames per second (frame rate) were converted. HDTV and 4K no longer require conversion of the number of lines, but the frame rate difference still remains and conversion is still necessary(Fig.1).

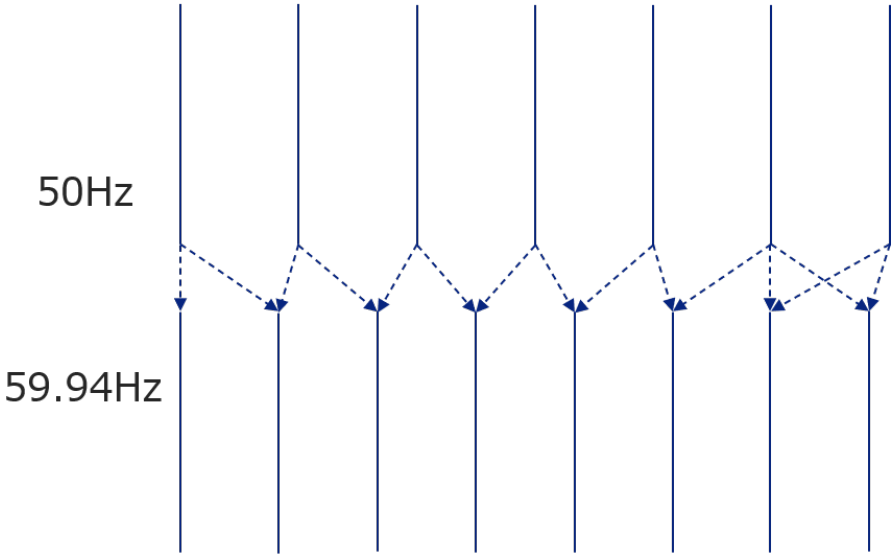

Figure 1: Frame rate conversion from 50Hz to 59.94Hz.

In the early days of TV standards conversion, a photoelectric conversion device was used in the receiver side country, in which the transmitted video signal was projected on a CRT and re-captured by a camera of the domestic standard. Its image quality was poor, because blur was large due to the re-capturing. Subsequently, an all-electronic device using a quartz ultrasonic delay line was newly developed[2], but it was still analog and had the following two major issues. (1) The size was huge (room capacity more than several tens of square meters) and it required high maintenance costs due to the unstability of quartz ultrasonic delay lines. (2) Although the

image quality degradation (reduction in resolution) was improved compared to the photoelectric type, it was still significant because of the intra-field conversion.

Regarding (2), due to memory limitations, the lines after conversion were obtained by weighted addition from only two lines in the same field before conversion (lines from multiple fields could not be used). This caused the problem of insufficient preservation of vertical resolution, resulting in blurring. This was an especially important issue in Japan, where sharp image quality tends to be preferred.

The historic significance of the achievement

Meanwhile, semiconductor memory technology was rapidly developing as the technological background at the time. KDD, the Japanese major international telecommunication operator at that time, was quick to recognize this trend and succeeded in developing a digital standards convertor that simultaneously solved the above two issues, i.e., the equipment size and the picture quality, and was *the first in the world to introduce it commercially*[3].

Specifically, the use of semiconductor memory instead of quartz ultrasonic delay lines has enabled digitalization and miniaturization (the size of the equipment was about 1.5 racks). Furthermore, adaptive image processing (utilizing frame memory in addition to line memory) based on still/moving judgment was introduced and used to convert the number of lines between 625 and 525, resulting in conversion with minimal reduction in resolution. In addition, the use of semiconductor memory has made the equipment more stable and the adjustment work easy. These factors made it possible to achieve the world's first commercial introduction of this technology.

The ways the achievement was a significant advance rather than an incremental improvement of existing technology

By going from analog to digital, we have achieved the following.

(1) Significant size reduction

(2) Unparalleled improvement in image quality through superior signal processing

(3) Opening up of possibilities for more advanced signal processing afterward

The following is how to suppress resolution reduction in detail (the second item above). Still/moving judgments (judging for each pixel whether it belongs to the still or moving part) are made, and for the still area, inter-field line interpolation is performed using the lines of two adjacent fields to suppress resolution reduction. In the case of interlaced video, which was the globally adopted method for TV broadcasting at the time, the vertical line positions of two consecutive fields are different, so in the case of a still picture, the two fields are considered to be a single still picture and line interpolation is performed to minimize the resolution reduction. On the other hand, for the moving area, intra-field line interpolation using line memory is performed in the previous and the next fields, respectively, and the final result is obtained by their weighted addition according to the field interpolation ratio(Fig.2).

The rapid invention and implementation of a method that not only employs digital frame memory but also takes full advantage of its capabilities has led to the realization of this sophisticated equipment.

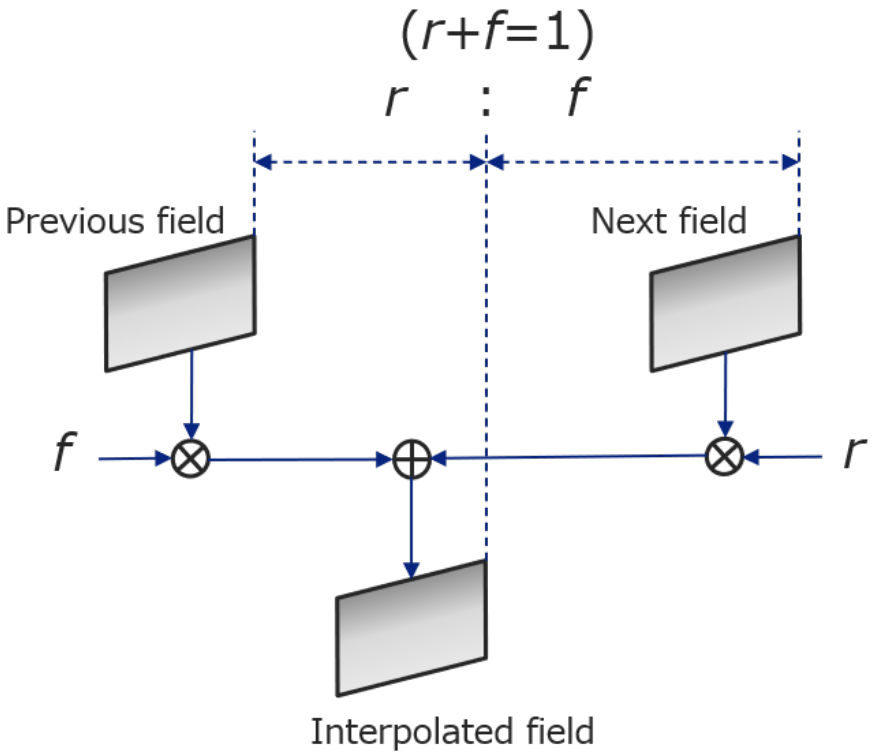

Figure 2: Field interpolation; weighted addition of previous and next fields after intrafield line interpolation.

Its importance to the evolution of electrical and computer engineering and science

The realization of the digital TV standards convertor has dramatically improved picture quality, whereas previously we had no choice but to accept images with significant picture quality degradation such as blurring, etc. In addition, the smaller size has made it possible to increase the number of simultaneous relays because of space saving. Thus, the commercial success of the digital convertor led to the significant evolution of digital TV transmission and brought international TV relay closer to the people.

Further, this digitalization has laid the foundation for applying sophisticated image processing technology which has developed rapidly since then, leading to its further development. One of the major advances was the introduction of motion-compensated frame-rate conversion in the late 1980s, and as improvements were made, we can now enjoy international TV programs with picture quality that is almost the same as that of local programs.

Its importance to regional/national/international development

Its benefits to humanity

Since TV standards convertors are mandatory in transmission between countries that use different TV standards, its development can be said to be the history of international TV transmission itself. It has contributed greatly to interconnecting people around the world by providing live coverage of international sporting events such as the Olympics and the World Championships, as well as major news broadcasts.

2 What obstacles (technical, political, geographic) needed to be overcome?

In the past, analog delay lines (crystal ultrasonic delay lines) were used, which were huge even for a single line delay and difficult to adjust. In addition, image quality was poor (low resolution) because temporal correlation could not be used during conversion due to memory limitations. To solve these problems, in addition to the advent of semiconductor memory, it was necessary to invent the revolutionary idea of adaptive line interpolation based on still/moving judgment. Such advanced adaptive processing could not be achieved by analog processing, but was realized only by digitization.

3 What features set this work apart from similar achievements?

(1) This work rapidly adopted semiconductor memory, which had just appeared at the time, which led to the miniaturization of the equipment.

(2) This work invented and introduced a groundbreaking method that used the miniaturized memory to judge still/moving for each part of the image, adaptively changing processing between still and moving parts of the image, and suppressed resolution degradation in still areas that are particularly noticeable to the human eye.

(3) This work laid the foundation for the development of subsequent TV standards conversion technology.

References

[1] "Milestones:First Transpacific Reception of a Television (TV) Signal via Satellite, 1963," https://ethw.org/Milestones:
First_Transpacific_Reception_of_a_Television_(TV)_Signal_via_Satellite,_1963, Accessed 2023-12-26.

[2] E. R. Rout and R. E. Davies, "Electronic standards conversion for transatlantic color television," *J.SMPTE*, vol. 77, no. 1, pp. 12–16, 1968.

[3] K. Kinuhata, H. Sasaki, H. Yamamoto, and K. Amano, "Digital standards converter by adaptive intra-frame line interpolation," *IEEE Trans.*, vol. COM-26, no. 10, pp. 1413–1420, Oct. 1978.