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High Frame-Rate Television

M Armstrong, D Flynn, M Hammond, S Jolly, R Salmon

BRITISH BROADCASTING CORPORATION

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Abstract

The frame and field rates that have been used for television since the 1930s cause problems for motion portrayal, which are increasingly evident on the large, high-resolution television displays that are now common. In this paper we report on a programme of experimental work that successfully demonstrated the advantages of higher frame rate capture and display as a means of improving the quality of television systems of all spatial resolutions. We identify additional benefits from the use of high frame-rate capture for the production of programmes to be viewed using conventional televisions. We suggest ways to mitigate some of the production and distribution issues that high frame-rate television implies.

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1 Introduction

The frame rates used for film and television have been fixed for the best part of a century. A belief has arisen (eg Ferguson and Schultz (1)) that the frame rates chosen are close to an upper limit, and that little improvement can be expected from an increase. In this paper we will challenge this view, reporting on some experimental work that shows that the use of higher frame rates for capture, storage, transmission and display offers clear advantages at the resolutions associated with SD and HDTV. We will also explain why the frame rates currently in use will increasingly limit the quality of television pictures if the size of displays and/or the resolution of television systems continue to grow.

2 Historical Overview

2.1 Origin of Frame Rates

In the days of silent cinema, frame rates were not standardised, and projectionists were advised to vary the speed according to the subject matter portrayed. Operators were said to “render” a film similar to a musician rendering a piece of music (Richardson (2)). With the development of sound-on-film processes in the 1920s, film speeds and hence frame rates standardised at the now ubiquitous 24 fps. To avoid visible flicker, a double or treble-bladed shutter was used to display each image two or three times in quick succession. A downside of this technique is that moving objects being tracked by the eye appear as two or three overlapping images or appear to jump backwards and forwards along their line of motion: an effect also known as “film judder” (Roberts (3)).

The 30-line opto-mechanical television system developed by Baird and the BBC in the late 1920s and early 1930s ran at 12.5fps (Baird (4)). After broadcast trials against an improved 240-line (progressive-scan) Baird system, the interlaced Marconi-EMI television system (now known as “405-line”) was adopted by the BBC in 1937. These systems were described contemporaneously as "high-definition television". The Marconi-EMI system and all subsequent TV standards have used a field rate that is the same as the mains frequency (50Hz in Europe).

The reasons given contemporaneously (BBC (5)) for synchronising the frame rate of television to the mains frequency were to avoid "beating" against the 100Hz brightness fluctuation in AC-driven studio lights and the 50Hz fluctuation induced by poor ripple-suppression in the HT generation circuitry of early CRT televisions (Engstrom (6)). The 60Hz mains frequency used in the USA similarly led to a 60Hz field rate in their television systems (Kell et al (7)). In addition, these rates are slightly above the 40Hz minimum that was found necessary to avoid visible flicker in the displayed image on contemporary television screens (6).

At that time, it was considered sufficient (Zworykin and Morton (8)) for the frame rate to be high enough merely to exceed the threshold for “apparent motion” – the boundary above which a sequence of recorded images appear to the eye as containing moving objects rather than being a succession of still photographs. Priority was not given to the elimination of motion artefacts such as smearing and jerkiness. Contemporary tube cameras suffered from image retention, which may have limited the benefits of a higher rate anyway.

A final benefit of choosing a field rate equal to the mains frequency is simple interoperability with cinematic film recording. In 50Hz countries, since the speed difference between 24fps and 25fps

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