Virtual studio technology
An overview of the possible applications in television programme production

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As the resources available for television production become fewer and fewer, public broadcasters are looking towards virtual studio technology to satisfy the need for increased productivity with reduced costs.

This article provides a brief introduction to virtual studio technology. The two main systems are discussed – sensor-based systems and those which use image analysis – and then the Author points out the advantages and limitations of the technology. He concludes by challenging the programme makers and, in particular, the graphics designers to grasp the extremely versatile opportunities offered by these new techniques.

1. Introduction

In recent years, the public broadcasters in Europe have been forced to restructure their programme production comprehensively. In the face of fewer and fewer resources, this change – which is still going on – is essential to their survival in the highly-competitive and increasingly-fragmented video market. Pressure is growing to produce more and more programming in a shorter time and for less and less money. So, in order to meet these changing demands, the efficiency and productivity in programme production must be increased.

Two factors which are contributing towards this end are the rapid growth in the digitization of production equipment, and the increasing use of information and computer technology in broadcasting organizations. And this is where virtual studio technology comes into play. The general hope is that it can satisfy the need for higher productivity at a lower cost.

Original language: English
Manuscript received 27/6/96.

But what exactly is virtual studio technology and how does it affect programme production in television?

2. Chroma-key technology

For many years, blue-screen or chroma-key technology has been an essential part of daily television production. The presenter in the studio is recorded in front of a blue screen by the so-called foreground camera. The background – either a video image from a VTR or an image created by a graphics designer at a computer workstation – is mixed in to take the place of the blue screen in the foreground recording.

Camera movement in the studio, as well as zooming, panning and tilting, are not possible with this technology. This significant limitation to image composing is a result of spatially unlinked foreground and background pictures that are superimposed on only one plane by the image combiner. If a later alteration were to be made to the picture segment, the spatial reference would be lost and the foreground-to-background perspectives would no longer be correct.

To overcome these disadvantages of conventional blue-screen technology, a spatial locking of the foreground and the background is needed. This is achieved by determining exactly all the positional parameters of the recording camera, including the lens setting parameters. This is the only way to lock the background perspective with the foreground perspective and to adjust for movements of the recording camera.

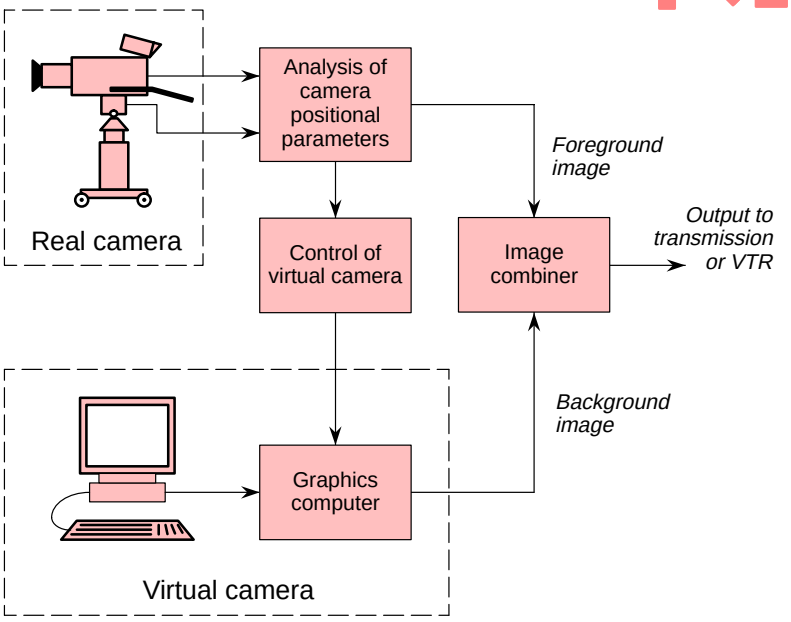

Figure 1
Simplified principle of television programme production in a virtual studio.

3. Types of virtual studio

In the simplified block diagram shown in *Fig. 1*, the principle of TV programme production in a virtual studio is shown. The presenter – who is acting in a nearly-empty, mostly U- or L-shaped blue box – is recorded by the physical or "real" foreground camera. However, the background images (decorations, props, scenery etc) – mostly in 3-D – are computer-generated in advance (i.e. they are prerendered) by the graphics designer and mixed in during the transmission or recording. This aspect of synthetic image production is referred to as *virtual* and consequently the image recording system is called *virtual camera*.

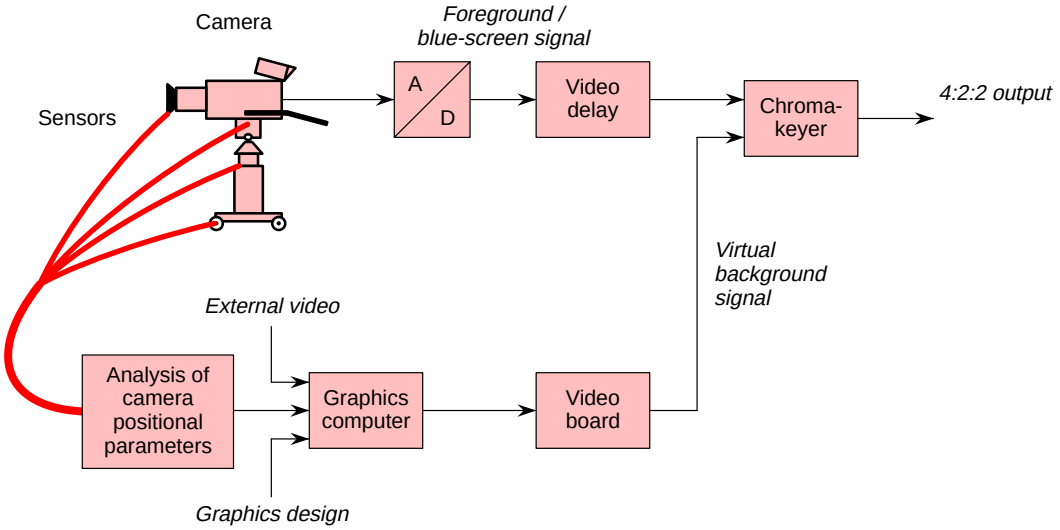

Figure 2
Virtual studio technology – sensor-based system.

In contrast to conventional blue-screen technology, both cameras – the real and the virtual one – are permanently interlocked in the case of virtual studio technology. To achieve this, the positional parameters of the real camera need to be determined. These are:

– the coordinates x, y, z within the blue-screen set;

– data on tilts, pans, and possibly rolls of the camera;

– the focal distance and focal setting of the camera lens.

All these positional parameters of the real camera are then analyzed in the computer and the control of the virtual background image is accomplished in relation to the foreground image. In the final stage, the foreground image (with the actors and real props) and the computer-generated background image are seamlessly combined in the chroma-keyer and the output image is either transmitted or recorded on tape.

With live transmissions or pre-recorded programmes, however, it is a prerequisite that the tracking and image mixing in the chroma-keyer are in real time, i.e. at a rate of 50 frames per second. At present, only a supercomputer such as the Silicon Graphics *Onyx* can achieve this but the situation may change in the near future. As a result of this procedure, the real camera can move freely in the studio and the image segment may be altered without losing the illusion of the 3-D studio set.

For the continuous determination of the camera positional parameters, two alternative procedures are in general use: sensor-based systems and systems which use image analysis to recognise special patterns (such as stripes) or markers (e.g. dots).

Figure 3
View of a virtual studio environment at Sendezentrum Munich (SZM) which uses sensory-based cameras for regular programme production.
(Photo: Kabel 1).

3.1. Sensor-based systems

With the sensor-based process, the orientation and positioning of the real camera in the studio space, as well as the lens setting, are determined by precise electro-mechanical sensoring devices on the camera *(Figs. 2 and 3)*. Depending on the practical application, this generally tripod-based method may limit the camera in its range of movement. Exact position and movement of the camera may also be determined by measuring the distance via laser, ultrasound, infra-red or any other signalling devices.

3.2. Systems which use image analysis

A system which uses image analysis to recognise patterns/markers seems to be a very elegant and probably more promising approach for the future *(Fig. 4)*. Either special patterns on the blue screen (e.g. stripes in different colours or of different brightness – see *Fig. 5*), or reference markers on real objects and on the blue wall and floor, are used to calculate the position and focal angle of the recording camera.

No additional sensors are required in this case. The camera has complete freedom of movement within the blue space and even handheld cameras may be used. Furthermore, no modifications are needed to the camera equipment to switch the studio back to conventional recording methods with real sets. Up to now, however, little experience has been gained in the use of this method for TV programme production.

4. Advantages of virtual sets

As a significant technical effort is needed to produce programmes using a virtual studio, of course the question arises: what are the benefits of virtual studio technology and what advantages does it really bring to TV programme production?

One thing is for certain: the preparatory work and also the flow of production in the virtual studio will be quite different from those for current television productions. Scenery, decorations and even props in future will be generated more and more in the form of computer graphics, using computer-aided-design (CAD) techniques. The term *synthetic set* is already in use.

Since set designs no longer have to be built with physical hardware but in software, greater free-

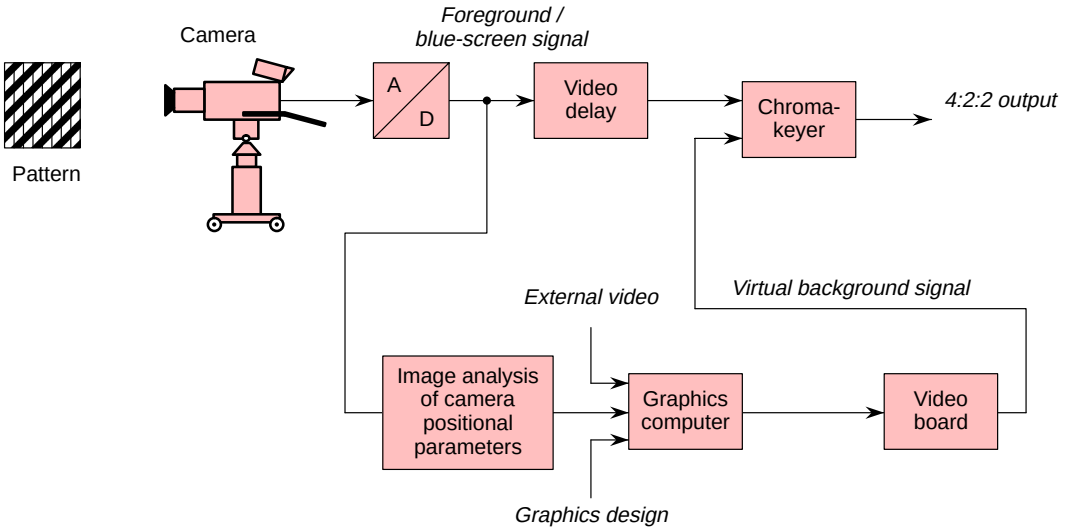

Figure 4
Virtual studio technology – pattern-regognition system.

dom may be taken with artistic expression. Sets which previously could never have been built – for reasons of complexity or size – can now be realized graphically. Apart from the savings made in the materials and time when building such sets, cost savings also result in the area of transportation and storage of sets and props. One could even imagine that, in the near future, sets and props may be exchanged between broadcasters via the data highway!

By expanding the "flat" blue-screen technology to include a third dimension, various possibilities for spatial picture composition, via today's CAD software, can now come into effect. Compared to conventional production techniques, the virtual studio also leaves more freedom. For example:

– set lighting, including shadows, can be simulated on the computer and altered at will;

– it is very easy to modify quickly the structures, colours and textures in the computer-generated image;

– scenery can be rebuilt by pushing a button;

– small studios can be made to appear larger.

By using a virtual set, a more intensive use of existing studios can be made; there is the possibility that they can provide for multiple use, both conventional and virtual.

The experience of a number of broadcasters and production houses shows, however, that virtual studio technology is not yet suited equally well for all types of programme production. On the one hand, great advantages can be realized by using it in the production of news, regular magazines, games shows, sports, music and children's programming, commercials and election coverage. On the other hand, more complex productions with complicated sets and props are very difficult to make in a virtual studio, especially in real time and in front of a large audience. One notable success in making a very complex programme of this type was the broadcast of the *1996 Eurovision Song Contest* from Norway in May (see the article beginning on *page 7*).

5. Limitations of virtual sets

Now that the initial euphoria over potential applications of virtual studio technology has settled down a bit, the user is becoming increasingly aware of the limitations that need to be considered in the practical application of this technology for television programme production. Experience with professional productions has revealed a few problems to be solved:

Figure 5
View of a virtual studio environment, using an Orad (Israel) pattern-recognition system, installed at WDR in Cologne for test trials *(Photo: H. Graf)*.

– the orientation of the presenter or actor in the blue space;

– the wearing of blue clothing (e.g. denim jeans, etc.);

– careful keying to avoid noisy edges;

– the currently-applied flat or soft lighting with troughs;

– the maintenance of real shadows of the actor, on the virtual floor and wall, and on artificial objects;

– the unnatural depth perception of the sharply-focused foreground and the background images (when there is a close-up of the presenter, the background image has to be defocused to enhance the depth of field realism);

– automatic Z-keying;

– the processing times which cause a relative delay, of several frames in some cases, between the real foreground pictures and the sound, and the virtual background scene.

Up until now, an enormously powerful computer has been necessary for *each* camera system, for the imaging and tracking of the background in real time. (It is hoped that, in the near future, a single less-specialized computer will be able to handle *several* camera systems). Without a very powerful computer, unnatural artifacts – e.g. jerky effects – are evident in the case of more complex sets, and during quick camera movements.

Virtual studio technology is still rather expensive, not only in terms of hardware and software purchase, but also in terms of equipment maintenance and the training and continued education of the operating personnel. The latter is especially important. We have already learned how vital it is to produce a virtuoso application in animation effects, since they can quickly become stale when they are repeated daily.

Synthetic sets and props can be generated nowadays so effectively that they can barely be distinguished from the real world anymore; the boundaries between reality and illusion are growing increasingly hazy. Consequently, animations and virtual sets ought to be used sparingly, responsibly and preferably only when they can be recognized readily as such by the viewer. Otherwise, the credibility of the programme may suffer.

6. Conclusions

Up to now, rather costly capital investments have been required by broadcasting organizations for the installation of virtual studio technology. This expenditure can only be justified if the virtual studio offers, in the long term, potential added value and benefits over conventional programme production.

In the case of the broadcaster, this means:

– cost and time savings;

– better studio efficiency;

– realization of new ideas for the scenery.

The viewer must also see the benefits, for example:

– improved representation of information;

– increased entertainment;

– enhanced realism.

The recent NAB exhibition in Los Angeles showed that various fully-operating commercial systems are now available for the production of television programmes in the virtual studio. It is thus up to the programme makers and, in particular, the graphics designers to grasp the extraordinarily versatile opportunities which these new techniques offer them for their creative work, and to use their skills and powers of imagination for the greater benefit of television programmes.

Max Rotthaler *graduated in Telecommunications Engineering at the Technical University of Munich and has been with the IRT – the Research and Development Institute of the German Public Broadcasters – since 1963. He has worked in various fields such as film technology in relation to television requirements, telecine, colorimetry and lens performance.*

Mr. Rotthaler was closely involved with the activities of EBU Working Party G; for several years he was Chairman of Subgroup G3 (which dealt with film in television) and of Specialist Group G/Lenses. In 1987, he received the Phil Berkeley Award from the BKSTS and the Agfa Gevaert Gold Medal from the SMPTE. Quite recently, he became involved in the IRT project on virtual studio technology for television programme production.

At present, Mr. Rotthaler is head of the IRT section "TV production technology" and in this capacity he is also a member of the EBU Production Management Committee (PMC).