Virtual studios – the BBC's experience

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When a broadcaster is faced with any new technology there is initially a period of uncertainty. Is it just an engineering toy, or will it radically alter the production process? Such is the dilemma over virtual studios.

The Author describes the facets of virtual studio production which the BBC has found hardest to adapt and get right, and puts forward some ideas on where improvements could be made by the developers of such systems.

1. What is a virtual studio?

The term *virtual studio* is perhaps a little misleading, as one of the items you do require is a studio space. *Virtual sets* is a better term for the production technique whereby a real studio set of wood and steel is replaced by a set that is either computer-generated or is a video image.

In order to do this requires two key elements:

– the action must be incorporated into the background image;

– the background image must match the foreground action in real time.

Simple! Unfortunately not.

The first element currently requires the use of chromakey, and the second one needs a real-time tracking device attached to the camera, which in turn is linked to a background generation device.

So having defined a virtual set, what do you need to set one up?

This depends upon your requirements. There are three basic systems:

– pre-rendered images off a disk store (used for static or pre-programmed moves);

– 2D;

– 3D.

The first option is not a true virtual set as it is the background that controls the camera movements, not the foreground action. For static sets such as news, this can be very effective.

Let us start with 2D because it is possible to expand from there to 3D.

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All the 2D systems use some form of video framestore, linked to a camera. A portion of the original image is displayed as the background. 2D is fine if you do not wish to move the camera position (i.e. crab, track or crane). Pan, tilt and zoom account for about 90% of all moving shots and hence this technique is certainly acceptable for a lot of programmes. 2D systems are generally easier to use, and integrate more easily into existing facilities. Systems of this type are the BBC/Radamec Virtual Scenario, the For-A Virtual Studio set and the Photron "Pseudio".

All the 3D systems use a powerful computer to generate the background image in real time (at 50 or 60 fields per second). There is a larger choice of suppliers here, and most will link to any tracking system. Vendors include; Accom ELSET, Discrete Logic Vapour, RT-SET Larus and Otus, ORAD Cyberset E, Brainstorm Estudio, Evans & Sutherland Mindset, Triavset Reality Tracking.

You will also need a studio space equipped with a chromakey cyclorama, ideally a digital video infrastructure, and a lot of patience.

2. Virtual Studios in use

The BBC has been using virtual studios for two years, both its own 2D system and the Accom ELSET system. Our experience has led to the following comments about the production process using virtual sets. To start with, here are a few simple rules for the production team:

Towards everyday use?

Virtual sets are no longer a novelty. The European *Mona Lisa* project was launched in 1992 and has since flourished, giving rise to increasing experimentation. Several major TV programmes (national elections in various countries and even the Eurovision Song Contest), as well as high-rating magazines (sports programmes), have given us the opportunity to test the capacity of such sets on the screen.

However, we should not presume that all development problems have been solved, and that the hardware on the market is ready for use and actually offers a plug & play facility; far from it. In the accompanying article, the Author – Mr Danny Popkin – outlines some of the more desirable developments that are needed to ensure the future success of virtual set technology. The article is based on a presentation Mr Popkin gave at a seminar on virtual sets, held recently at the International Academy of Broadcasting in Montreux. Alongside that particular presentation, it is interesting to have a quick look at some other information given during the seminar, starting with the procedures on which future virtual studio technology will be based.

So far, two procedures – one based on the use of sensors fixed to the camera, the other based on pattern recognition applied to the video signal – have shared the emerging market between them and have appeared ready to fight it out. An objective look at their respective disadvantages has led specialists instead to expect a peace treaty to be negotiated. For example, pattern recognition cannot deal with extreme close-ups while the difficulty in calibrating the sensors makes them awkward to use. Combining the two systems in the same studio makes it possible to compensate for the weak points of either system.

A third procedure is now on the horizon: infrared detectors that allow the movements of actors, cameras or stage set elements to be followed precisely. According to Orad (Israel), this technique enables precise depth-keying down to pixel level, making it possible, for example, to attach a virtual object to a physical one.

Helping out the presenters on the real set is starting to become the focus of attention, as their job is made much easier when they know where they are positioned in the virtual set. In one product, it is a spotlight on the stage which indicates the movement of the virtual set, while being invisible in the image on the screen. In another product, this position is shown using an image projected on the ground, but also invisible through the camera.

Other information at the seminar related to the application of current techniques.

Combining these procedures, which each compensate for the technical shortfalls of the others, is obviously not the most cost-effective way of equipping a studio. This realization appears to have been the incentive that set off the mushrooming of production and service companies. Some studios, which have been fitted out with all the latest virtual-set technology, provide services for several broadcasters; the profitability of these studios is guaranteed, thanks to having a variety of customers and a variety of uses.

Manufacturers, in the meantime, continue to extend and improve the range of equipment available on the market. In a recent product from Silicon Graphics (the Octane system), the bus architecture has been replaced by crossbar architecture: processing is faster, even at the bottom of the product range. The same is true of the software programs, which now exist in abundance. But where should one start? The BBC solution enables beginners to get going with a 2D system, running on a top-of-the-range PC. Ideally what studios need is the possibility to work gradually up to more complex, more expensive systems. European research programmes (MIRAGE, MAGIC) are based on a range of software being designed with this well-ordered progression in mind and, in addition, they take into account the needs of small and medium budgets. Unfortunately, these research projects were not able to respond to the invitation to address the seminar.

Perhaps we'll see them there next year?

Jean-Jacques Peters

– work closely with set designers;

– plan all shots well in advance, do not try to make them up as you go along;

– involve the lighting director as early as possible;

– Use mannequins etc. in the virtual set to calculate distances, heights and angles;

– make sure there is enough room for the lighting (leave a minimum space of 1.5 metres from the chromakey walls);

– establish keylight directions and angles that can be reproduced in the studio;

– print out the positions of the camera, artists, etc. on a studio floorplan;

– mark the floor as appropriate for each shot;

– be prepared for the process to take twice as long as you expect.

This is all basic stuff, but all too easily forgotten.

Virtual studios are basically just another technique available to productions; they are not a universal panacea for television production. The following sections describe areas which we found hardest to adapt and get right for our productions, and where we would like to see improvements.

2.1. Planning

The first, and by far the most important, aspect of planning to use a virtual studio is to have a clear picture of what you want to achieve.

No virtual system can cope with a last-minute change of mind any better than a real set can. The models take as long to design as a real set does; the time saved is in construction and transport. The designer and the lighting director need to communicate and decide on the set lighting during the design process, since this forms part of the final render. There is little point in rendering a set with huge dramatic shadows, if the lighting director cannot achieve the same effect on the talent.

One of the major benefits of not building the set in reality is that a virtual set can be considerably larger than the studio space required for the action. However for the correct perspectives to be maintained, the area of action in the virtual set and the area of action in the studio need to be the same. (It is not acceptable to use a DVE to reduce the acting area to fit within a virtual set if the actor has to move.)

The use of computer-based planning tools will become essential to allow the creative team to be able to view and discuss the set, without building a real one. In the longer term, immersive VR would be a very good way of allowing a director access to the set in order to plan the camera shots.

2.2. Chromakeying

The next major hurdle to overcome is the chromakeying. For those who venture into virtual sets for the first time, it can be a shock to discover how long it takes to get an acceptable result.

A benefit of virtual studios is that the resultant combined image is available to record straight onto tape. As with any process involving a keying colour, the keyed area needs to be evenly lit. This will always conflict with the lighting directors ideal way of lighting the talent. Ideally you should use as large an area of chromakey colour as possible to allow the artist to stand as far away as possible from the background. If the artist needs to walk four metres then there needs to be four metres of chromakey colour plus another 20% to allow for shoot-off.

While the technology for chromakey has improved over the years, there is still the basic problem of having to remove an unwanted colour from the foreground. A system is required that does not require the foreground artist lighting to illuminate the key colour as well. Whatever system is devised must also have little or no processing delay.

2.3. Camera positioning

Whether using a 2D or 3D system, the camera positioning is critical to the resultant images. In a 2D virtual studio, the backgrounds have to be prepared with an approximate camera position in mind. However, as the system has been specifically designed for use with manual cameras, the foreground and background registration can easily be adjusted.

With a 3D system rendering in real time, the camera position needs to be fed to the computer very accurately, so that the rendered view exactly matches the camera's view. This tends to mean that small adjustments to the registration are difficult to make. All of the current tracking systems have limitations that prevent total freedom for the cameraman, and the artist.

None of the current camera tracking systems fit easily within a large multi-purpose studio, or allow enough creative freedom to match their asking price. Every system, whether optical or mechanical, has drawbacks and it may be that a

mixture of the two is what is required for the final solution.

Ideally a hand-held camera with a 20:1 zoom lens needs to be able to roam freely around a semi-circular area of about 800 square metres. Focus should not affect the tracking or how the camera is mounted.

2.4. Computational power

With 2D systems there is no limit to the set complexity, except how long the designer wants to wait while a render is being done; as the input to the system is a video picture, it can be a television image of the real thing.

With 3D sets, the computer has to render the image by drawing the surfaces and covering them with shading or texture (just like wallpapering a room). More realism requires more surfaces, which in turn reduces the maximum frame-rate.

Current limitations mean that images rendered at 50 independent fields-per-second are either fairly simple models with complex texture maps, or more complex models with simple shading.

Adding the lighting effects and anti-aliasing, lens artifacts and proper interpolation also consume processing power. The next generation of supercomputers will still not achieve photo-realistic sets in real time: trying to make computer companies understand video pictures is rather like swimming in treacle.

It is certain that processing power will increase dramatically over the years, but the production demands will always be ahead of what can be achieved.

2.5. User interface

Virtual set systems need to be operated within the existing skills base of the broadcaster. The user interfaces need to be intuitive and should not require specialized computer programming skills. The director needs to be able to chose the desired shots with exactly the same freedom as when using a real set. Elements within a set should not be fixed, or limited in resolution by the textures. Video inputs need to be at full frame-rate and should not slow the frame-rate down.

Hierarchical animation should be preserved and it should be easy to edit.

A common file format between the various model creation, lighting and rendering packages is required.

2.6. Depth

In order that an actor can roam freely around the virtual environment, he needs to be able to pass around objects without the need to change manually the foreground priorities. A reliable automatic system which is capable of dealing with multiple actors is required. This needs to link to a depth map from the 3D model, and the camera focus position and aperture. The actors should not have to wear any form of transmitters.

2.7. Defocusing

Although real-time defocusing can be achieved by the virtual systems currently offered by the software developers, it is not the same as the defocus through a camera lens. It either has to be pre-calculated and then used as a texture, or has to be rendered in real time which is computationally expensive and can only approximate to what a lens would do to a picture.

The BBC's solution was to develop some custom hardware to approximate the defocusing of a lens. It is the first-ever solution to offer pixel-by-pixel defocusing of a TV image.

2.8. Cost

The cost of these systems is still undoubtably a major issue with most broadcasters. While 2D is far cheaper than 3D, the cost is still considerable.

Typically computer hardware has a very short life before the next generation becomes available. As virtual studio is a very leading-edge technology, it is also expensive with little or no upgrade path available. For a studio to recover its costs, it needs to be used for many hours a day. If it is dedicated to only chromakey work, the relevant programmes must share the resource which, unfortunately, is not what producers like to do.

Specialist staff, with higher skills, also push up the price.

A number of systems are becoming available which allow camera movements to be captured, and provide a low-quality background in the studio which then renders the fully-detailed background, frame by frame.

This method has the benefit that you can use cheaper computers, and hence reduce the capital costs, but the downside is that post-production costs will be greater.

3. Conclusions

No-one can force producers to use virtual sets. Quite a number have shown interest in it but many are worried by the current costs of modelling and the relative inflexibility that the tech nology imposes. The commissioning process in the United Kingdom works very much against producers trying out new ideas on programmes with long runs (i.e. 26 or more programmes). Also, it is very hard to raise enough money to cover fully the costs of pilot productions.

Experience, the falling cost of technology and the development of new off-line production tools will help to solve these problems. Although the power of super-fast graphics computers will undoubtedly continue to grow, the development of true 3D virtual studios will be held back until the day when realistic sets can be run on much lower-cost computers. This is a great shame, as this exciting new technology needs to be used, nurtured and experimented with to obtain the best results.

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Figure 1
Examples of BBC programmes produced using their 2D virtual studio system.

***Mr Danny Popkin** joined the BBC in 1977 as a camera operator at Television Centre, London, working on the full range of television programmes. In 1983, he became a special-effects supervisor and during this period worked on a number of award-winning programmes including Dr Who, the widely-known science fiction series.*

In 1987, Mr Popkin joined – as Technical Producer – the BBC/IEE Faraday Lecture tour which visited many towns and cities around the UK. He returned to studio work as a lighting director in 1990 and then joined the BBC's studio technical development group in 1992. Since then, he has been involved in the specification of the BBC's first digital vision studio and its first Omnibus control system, and in the introduction of the BBC's first widescreen studio.

In 1995, Danny Popkin became the project manager for the launch of the BBC's virtual studio project. He is also currently involved in the installation of new transmission areas for BBC digital television, due for completion in August of this year, and will be involved in some important BBC announcements to be made at the forthcoming IBC in Amsterdam.