Module: MSC MD (INTMMT)   **Seminar 4**

Video and Animation

Introduction

During this seminar we will investigate video and animation for multimedia. These two areas are responsible for the improved visual appeal and success of multimedia presentations. They have encouraged computer scientists to provide advanced tools capable of speeding the production process and network designers to provide vastly greater bandwidth to consumers. Both these areas are treated somewhat cavalierly by users. We expect them in presentations and because of the acuity of our visual senses we often criticise them unfairly. It is a mistake to take them for granted or to underestimate the time required for their production. The costs for professional work can be counted in millions of dollars.

We have two areas this seminar and both deserve a larger treatment. Expertise in these areas takes time and requires skills we cannot develop in a short module. Both concepts were, for many years, thought to rely on a phenomena known as persistence of vision (Herbert, n.d.) to create an illusion of motion. It has been shown that the after images ascribed to this effect do not occur until 50mseconds later and already the next frame will have been presented. What we do know from common experience is that if we present a sequence of images quickly enough our brain will combine them to produce a single motion sequence. All we have to do is change the content of each image slightly. Many technologies and standards have been developed to enable us to do just this. We will look at the most influential technologies and we will discuss the tools and techniques required to bring a successful video or animation clip into our multimedia presentation.

Video

Although we often ascribe the first video to John Logie Baird in 1926, it is more accurate to say his mechanical system was the first on the market. Like all items of advanced technology it came about as a synthesis of the work of others. His mechanical system would never have been a commercial success and it was the use of electronic systems based on cathode ray tube technologies that allowed our modern video industry to evolve into the mass market. Human vision will accept fifty images per second as a continuous event however most of us will notice some flicker. Experimentally some humans have detected flicker at rates

as high as 70 frames per second. As in so many aspects of the physical sciences flicker is a statistical phenomena and will vary from human to human. It is also dependent on the amount of light and the colours present. Early film was recorded at 16 frames per second and used a three bladed shutter to triple the number of 'frames'. This gave them an apparent rate of 48 frames per second. Film was standardised at 24 frames per second when soundtracks were first used and the shutter became a 'two bladed' device. For the moment let us assume we were to present our information at 30 frames per second using an interlaced system as we do in television (OK, for the experts amongst us that is an approximation ☺) then we would be presented with images at 6o frames per second but we would only need to send half the data. The amount of data we need to send is critical to our multimedia presentations particularly if we use the Internet. If we take a full screen image to be 640 x 480 pixels and we update this at 30 images a second we would need to transmit 640 x 480 x 30 bits per second for a monochrome image. When we use 24 bit colour we would need to transmit 221184000 bits of information per second just for the video! This bandwidth requirement is obviously beyond the consumer market. Fortunately it is not necessary. Since we can choose the rate at which frames are displayed on a computer we could reduce the frame rate to 15 Hz and still retain a passable motion video. Immediately we have reduced our bandwidth requirement by half. Suppose we reduce our colours to 8 bits and our picture size to one quarter screen? How much bandwidth would we need? Sometimes a reduction in screen size is not desirable e.g. when watching a movie and so we need compression techniques to further reduce the bandwidth. We will look at them later in the lecture. Let us now turn to the production process.

We use digital video in one of several forms depending upon the quality desired and the end use. Present day home cameras will allow storage on mini DV tape for later playback or connection to a computer. Some cameras allow direct storage to onboard memory as Mpeg files, e.g. the Canon MVX10i. This allows us to be our own film directors and to produce video content in our homes. There are some simple techniques to follow. Planning is all important. We will cover design issues in seminar 8 but for the moment a few tips. Start by creating a 'storyboard' showing key steps along the story line. A storyboard, in this case, should consist of simple images and descriptors describing the content of each shot. Do not think you must be a great artist. In this situation you are only convincing yourself. This will let you sort out timing and give you a sense of how large the file will be. Under each image and between each image you should establish a timeline which allows you to calculate the length and emphasis for each scene as well as the total time for the product. For most of us, using a hand held camera will require a tripod. It is better to keep the camera view constant if possible because the eye quickly spots jitter and constant shifting of viewpoint looks bad. Keep backgrounds simple for the web as this helps with compression. When filming close ups of people get them to wear plain clothing; stripes for example will cause aliasing at low image sizes. You need to have good lighting. For talking head shots e.g. like a newsreader, you will want to get rid of shadows

and to do this will require three lights; two in front and one behind the subject. One light will focus on the face, the second will flood the scene from the front and the third backlights the subject to make them stand out more and helps get rid of the shadows. Shadows are in effect cluttering of the image and will lead to artefacts being created during compression.

Traditional multimedia arrived on a CD and the high data rates needed could be easily achieved on modern computers. However network bandwidth has improved to the extent that we now expect more and more video content. One option would be to down load and store the files on the local machine then play them back later but there are times when we want near real time response. For example, perhaps we are watching a live web cast or an interactive lecture where an instant response is required or taking part tin a videoconference. This is where a technique known as streaming is used. Streamed video is kept on a server and downloaded in a just- in- time manner. This technique usually sets up a small buffer first to compensate for the vagaries of the network throughput rate but it is not noticeable. Effectively the stream is similar to a television broadcast however it is easier to protect from copying and offers much greater scope for materials licensing and interactive choices to be made available to the user.

Standards for Video and Broadcast

Video technologies continue to improve at a remarkable rate but this would not be possible without mutual cooperation between manufacturers. This cooperation takes the form of agreed standards; not only for the technology but also for the storage recording media and broadcasting of content. In this section we will introduce the most common standards.

Broadcasting for television uses three main analogue standards and many variants of the same. The first standard colour system used commercially (1953) was formulated by the National Standards Television Committee (NTSC) in the USA. It was the outcome of a national initiative to produce a single nationwide system for manufacturers to follow. Contrast this with the mobile phones where different standards were popularised in different areas leading to a slowdown in development and customer uptake in the USA. The other main broadcast systems are; Phase Alternating Line (PAL) introduced in the early sixties, which is used in Europe, Australia, the Middle East, Asia and Africa. Finally there is Sequential Couleur Avec Memoire (SECAM) from France which finds popularity in Eastern Europe and parts of the Middle East. The list of countries mentioned is only indicative and a full list is available at several locations on the web (Broadcast Anon). Pal is by far the most popular standard with some Eastern block countries moving over to it since the European Union expansion also some country run more than one standard particularly in the Middle East.

Television uses an interlaced display consisting of 2 fields. See Figure 1 in Lecture 2. Each field is transmitted and displayed in turn so that the flicker rate is

at the field rate, e.g. 60 Hz for NTSC and 50Hz for PAL. For each complete frame; 525 lines are transmitted in NTSC and 625 lines in PAL however nor all the lines are used for the image, (PAL uses only 576 lines per image and NTSC 487 lines), the rest are used for control and data such as Teletext. When using captured broadcast video, it is important to remember this and remove these non-video lines. (They contain information that will later be compressed at some cost to the size of the file whereas blank lines will reduce the compressed file size). These analogue broadcast standards use composite video, a system where luminance, colour and sound are 'mixed' on the same carrier signal. It is differences in the bandwidth allocation and central frequencies of associated sub-carriers, e.g., for sound, account for most of the differences between the standards and their variants.

The composite system uses only one cable to carry all the information but professional video is now either digital or component where the colour and luminance signals are separated. These signals start life as the red, green and blue signals from the cameras and are mathematically transformed to a composite system such as YIQ (NTSC) or YUV (PAL and SECAM). Why do this? Because the luminance signal is the same as the old black and white system and this allowed backwards compatibility.

No matter how we obtain the video it must eventually be sampled into a digital form. The standard for this is the CCIR 601. This system samples by using a chrominance signal and two colour difference signals. Then to reduce the size of the file produced fewer samples are taken of the colour difference signals. You may have seen the terms 4:2:2 or 4:1:1, these numbers are ratios referring to the number of samples taken for the chrominance and each colour difference signal. For 4:2:2 the data rate at eight bits per component is reduced to 166 Mbits per second.

We may have a digital version of our video but we need further compression and this has led to the DV and MPEG standards. The MPEG standards are produced by the ISO/IEC Motion Picture Expert Group and the most important one for the Internet of today is the MPEG4 standard used in streaming video. The basis of all the MPEG standards is the use of profiles and levels which define how the data stream is put together and what is contained in it. Your DVD video uses MPEG2 at main level and main profile. The list below briefly describes the key standards:

MPEG-1   1.4 Mbits/sec, 30 fps, window size 320x240 pixels. Used for storage of moving picture and audio on storage media (CD-ROM). Introduced 11/1992

MPEG-2   2 – 100 Mbits/sec, 60 fps, window size 720x576 pixels. Used for DVD, Digital TV. Introduced 11/1994

MPEG-4   Targeted at web, cellular phone, teleconferencing. Coding of natural and synthetic media objects for multimedia applications. Introduced

09/1998

MPEG-7   Multimedia content description for AV (Digital Audio and Video) material Introduced 08/2001

MPEG-21   Digital audio-visual framework: Integration of multimedia technologies (identification, copyright, protection, etc.) Introduced 11/2001

Rather than attempt to look at all the standards in a short seminar, we will examine MPEG4. There are excellent tutorials (MPEG Anon) on the Web some of which are produced by leading MPEG experts. Most are (as you would expect) derivative of the MPEG standard including these notes.

Given the use of profiles and levels some manufacturers have rushed to produce proprietary variants on the scheme notably Microsoft with Windows Media 9, however most manufacturers have supported the use of standard approaches. MPEG 4 is used by QuickTime and RealMedia and the DivX system for AVI's. The standard can support applications from mobile phones to full screen movies and from text to animation. As we will see many of the differences are in the compression / decompression stages and it is this that leads to the proliferation of Codec's for different stream types.
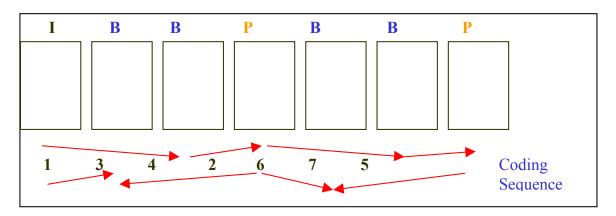
A video stream consists of bitmaps displayed sequentially as frames, therefore we could simply compress each frame (intra frame compression) but this is not enough. It is soon appreciated that each frame does not change much as we move from one to the next. The trick is to isolate the changed components and compress and send only these to describe the changes to the next frame. Then we can use initial key frames and motion descriptors for subsequent frames in our video stream. This differencing technique is called inter-frame compression. Let us take a closer look. Figure 1 shows a sequence of frames and we are going to replace them by different types of frames depending upon the type of compression

Figure 1. An uncompressed sequence of frames.

We will use one of four frame types: I-Frames,(Intra-coded frames), P-Frames (Predictive-coded frames), B-Frames (Bi-directional frames), D-Frames (DC-coded frames). The I-Frames are similar to key frames. These are full frames but compressed with a JPEG-like compression technique. They are compressed independently of previous or future frames. P-Frames record only the moving part of the clip and they do so using vector techniques based on the previous I or P frame. B-Frames use data from previous and future frames to describe how

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parts of the image are moving around. See figure 2. These have even less data than P-Frames. D-Frames code only the DC-coefficients. These allow for fast-forward and rewind and produce a very 'blocky' picture. Typically a block of data in an MPEG file will be in the format:

I B B P B B P B B P B B P B B B I etc.

I	B	B	P	B	B	P

1   3   4   2   6   7   5   Coding
                                                 Sequence

Figure 2 shows the sequence for coding typical frames.

Encoding an MPEG film is comparatively slow because the encoder must look at a whole sequence of frames at a time, analyse them and then encode them. However, playback can give full screen motion picture quality, similar to a VHS player. To improve decoding B-frames are often not used.

There are other codec's for video in systems such as QuickTime and Real Player but you should bear in mind that they all are optimised for certain circumstances. There is an art in selecting the correct codec for your production and then ensuring the user can use it.

The most popular streaming systems are Real Player (Real), Quick Time (Apple) and Media Player (Microsoft). Each of these companies offers streaming video servers, encoder and decoder of video and audio streaming as well as players and authoring packages. Microsoft supplies for its Windows system a freeware program named Producer by which Video and Audio streaming combined with synchronized PowerPoint slides can be easily created (see tools). All these sites contain samples of Video streaming.

Earlier we mentioned some techniques for making a quality production and it is important to realise that your production will only degrade as you process it. You cannot get back what was not there in the first place. Having said that you can use some post production and editing tricks to improve the presentation (or hide the faults). A simple example: Suppose you did not use a tripod and your picture is jittery, you can either re-shoot the scene or use a still frame instead.
Post production uses image processing techniques to enhance the individual images in some way. A typical use might be to change the light quality in a

scene. For example, you may wish for a brighter car headlight as the car turns towards the viewer. Rather than exhaustively re-shoot hoping to capture your ideal halo effect you can simply paint it on later. Special effects are often added at this stage.
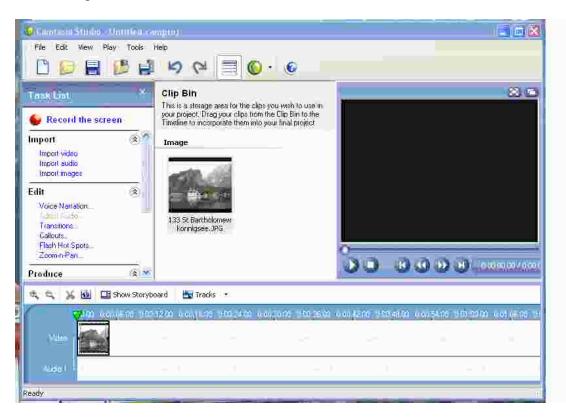

Figure 3 The Camtasia Studio editor. Note the timelines for audio and video along the bottom and the stage area in the centre.

When these stages are finished you can finally prepare your video for the Internet. Here decisions regarding the final size and choice of colour palette are made. We have already described some of the trade – offs in transmitted file sizes.

Some editing packages are Adobe Premier 6, After Effect 5 and for serious streaming media, The Digital Video Collection, which includes Premiere 6, Photoshop 6 and Illustrator 9. A simple freeware movie editor that is included with the Windows/XP system is Movie Maker. An unusual but useful editor is Camtasia studio that can handle video capture directly from the computer screen. See Figure 3

Animation

The second part of this week's seminar is concerned with animation.

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Animation is the creation of moving pictures which can bring an object to life. In many respects it is similar to video except we need to create the individual frames using media rather than taking a film of an object directly. Given that an animation needs to run at 24 frames per second (fps) we would have to produce 1440 drawings per minute. It is a very costly process! Before computers came along all the key ideas for animation production had been developed and it was left for the computer to automate them. Then came 3D graphics and artificial intelligence techniques and suddenly a whole new way of directing the animation was needed. We will start at the beginning with a short history.

Animation began in exactly the same way as video with Roget's ideas on 'Persistence of Vision'. Only two years later in 1826 John A Paris produced the commercial version of the Thaumatrope. Simply two images, one on each side of a disc which when rotated showed a composite picture. In 1888 Reynaud demonstrated the Theatre Optique which projected images painted on celluloid and was the beginning of animated stories. The first one was entitled 'Un bon bock' (A good beer). In 1908 the first film of drawings on paper was produced by Emile Cohl. The same inventor also made animations from paper cut outs to avoid re-drawing. In 1914, in the USA, animation was developing quickly. Earl Hurd patented the first use of 'cels'. These are transparent sheets each with a part of the drawing on. By overlaying a background image the motion could be generated more quickly. In 1920 Walt Disney was hired by the Kansas City Film Ad Company to produce cartoon advertisements and began his career in cartoons. Although many others had produced cartoons before him it was probably 'Steam Boat Willy', the first Mickey Mouse cartoon from 1928, that is the most famous. By the time of Snow White and the Seven Dwarfs' (the first feature length animation) in 1937 all the combinatorial tricks of mixing live action, stop action, and special effects had been introduced. It would take computers to make them seamless. Disney studios also contributed the animation guidelines, which are still used to day. John Lassiter who went on to lead Pixar films summarized these in a scientific paper. If you wish to create your own animation then you would do well to follow his guidelines: He defined principles for good animation. The key ones are listed below:

Squash and Stretch: This is used to define the rigidity and mass of an object. E.g. A soft object squashes more than a cannon ball
Timing: Space the actions to suit the object. E.g. Giants move more slowly
Anticipation: Preparation for action should build suspense
Staging: Making sure the intention is clear
Follow through and overlapping action is needed to ensure continuity e.g. The end of one scene is the beginning of the next
Straight ahead or Pose-to-Pose action describes your approach to the story creation. For good timing you need to use the latter.
Exaggeration: Improving on the basic motion
Secondary: Action The motion of an object due to another object
Appeal: The audience must enjoy the experience

For a full list read John Lassiter's paper (1987), or for Flash demonstrations of the principles see (Casady, n.d.)
If you can get these principles into your script then you are well on your way to a good animation.

There are several approaches we can use to create an animation today. Perhaps the simplest is the use of a frame grabber which is a modern 'cel' technique. We use a camera to film the source but instead of storing every frame we store only those we need as individual images. Later after processing we will put them together in an animated sequence. Of course, we could have done this with a scanner if the source was a set of pictures.

Amongst the early innovations from Disney studios was the use of production line techniques to produce his animated films. No longer did the main animators produce each frame but instead they produced what is still known as key frames.. The in-between frames were then completed by sub-ordinates. This 'in-betweening' is taken advantage of by modern computer graphics packages to automatically fill in the motion gaps between poses of 3D models. In – betweening may not be as straight forward as we think. It is not visually correct to generate a set of frames where acceleration is not taken into account. John Lassiter described the solution as 'slow-in and slow out'. Sometimes referred to as 'easing-in and easing-out'. We need to produce increasing increments in motion during the first few frames and similarly decrements at the end of the motion. Some packages allow for this in their tool sets. E.g. Flash. However complex motions require more control over acceleration and deceleration rates. These tools use a Bezier function to control the shape of the transitions in a manner similar to the way they control curves in drawing packages.

We will make many references to Macromedia and Flash during subsequent work as they are without doubt the leading tool sets for web animation creation however for complex and realistic 3D animations tools like 3D Studio Max, Maya and Lightwave are the specialist tools of choice. If you have not already tried it, GMax (see Tools in Tools of lecture 2) will give you a feel for these and it is a free download. If you have not already done so, you should download the 30 day trial version of flash now. It is easier to follow along if you can play at the same time.

We can implement animation on web pages using embedded video or Gif files but Shockwave Flash files (SWF) are the most popular. You should recall that Flash is a vector animation tool. Recent versions can do much more. It also has a scripting language which allows Flash movies to be interactive. They can respond to your inputs. You will meet this in a latter seminar. Flash is the authoring environment which produces movie files and these are stored as .fla files The SWF files are created for use in a variety of players and browser plug-ins by using the Export Movie command in Flash. This type of file can be

produced by other programmes such as Adobe Live Motion.

Animation packages use the concept of a timeline when building the animation. This was first used in video recording and editing suites for broadcast purposes although the concept goes back to early movies and the idea of a story board. They also use a 'stage' area in which the objects to be used are created or assembled. In this usage a timeline breaks the action into predetermined lengths of a given time which is determined by the fixed frame rate. An outcome of this organisation is that actions can be built into the timeline to occur at a particular frame number. A further refinement is to use multiple layers of timelines. This provides considerable freedom for compositing the image.

Flash uses the concept of objects to store all the components of the movie. Even bitmaps may be turned into vector objects by use of tools after putting the bitmap on the stage. This allows us to use symbols to describe instances of objects and then store them for later re-use. Complex animations can be built by developing keyframes and then tweening between them. Because of the concept of layers many complex motions can be built up by separating the affected parts or symbols onto different layers. Tweening can also be used for colours and morphing. Image morphing is an image processing technique used to compute a transformation from one image to another. The idea is to create a sequence of intermediate images that take you from the start image to the end image. If straightforward tweening between start and end is used the process will not look convincing however the intermediate images, if chosen correctly, will guide the tweening so that a more subtle transformation is obtained.

One of the great computer applications to come onto the desktop in recent years is 3D animation. The early computer animations were often sponsored or developed for the advertising industry and many new techniques made the transition from the research lab to the market through advertiser's desire for something new. 'Flying logos' were so common they became objects of fun for developers but without them development of the graphics algorithms needed would have slowed considerably.

We looked at 3D graphics in seminar 2 and it is a short step to producing an animated film. We first create our 3D graphical objects ands then decide how they are to move. Having set the scene up we render each position the object reaches at our chosen frame rate. Sounds Easy? ☺ Perhaps not. Let us take a closer look at some of the issues we face. We could create our animation from a low level using graphics libraries and a knowledge of programming. There are many libraries to choose from but the most common are OpenGl and DirectX. This is far too complex and time-consuming process for our purposes. Instead, we use a graphics package such as 3D studio Max and render directly to our chosen file format. This is often AVI, which is really a collection of Jpeg images, one for each frame.
The greatest difficulty for new comers to 3D graphics is the ability to work in 3D

whilst looking at a 2D screen and it takes a while to develop the necessary spatial awareness. Some people never can. The next difficulty is to make the motions convincing. There are over 200 degrees of freedom in the human body and similar numbers for animals. Getting each of these correct at the right time is beyond human abilities. (Stop motion experts do a good job but they do not have the 2D screen to contend with). A technique was developed to help animators get motions correct; it was Inverse Kinematics, IK. When we move our arms, we start by moving the upper arm, then the lower arm and so on adjusting as we go. With IK we decide where the end point of the motion is and the software makes the appropriate movements to arrive at the end point. This does not work where perverse motions are required. E.g. when you deliberately desire a funny walk. This is a low level of control acting on joints and we can expand our tools to improve control. The next level acts on whole limbs e.g. running and then interaction between humans (behavioural rules) and ultimately world motion control e.g. collision avoidance. To do this requires a certain amount of 'intelligence' on the part of the software and more and more artificial intelligence techniques are entering the tool sets of animators. One early example is the Boids of Reynolds, which were developed as examples of behavioural animation. Reynolds wanted to implement Flocking Behaviour and to do this he gave each bird its own set of rules. The Birds animate themselves by obeying the rules for the flock. They are Autonomous Agents and each has: Perceptual, Behavioural, and Motor Systems. Here are some possible rules; avoid static obstacles, avoid birds, eat food, leaving, wandering, escaping, flocking, maybe you can think of more. The result of these will be weighted to produce decisions that control motion. You can find this work (Reynolds 2001) on the web today and it is still being extended by enthusiasts.

The complexity of the animation tasks computers can handle has grown from initially helping with Cell generation, to early systems using keyframing, then physics based models and now behavioural animation. It is a complex world requiring considerable specialist knowledge and most of us will need to employ others to produce satisfactory work for our multimedia applications. In the multimedia world, we are adventurous and always trying new ideas and our final idea is bringing virtual reality, VR, to our presentations. In its traditional role as an immersive experience VR is beyond the capabilities of the current networks and home PC's. However, today the VR title is often applied to life-like flythroughs and non-immersive experiences where involvement is through a single screen. It is still the illusion of participation in an artificial environment as opposed to external observation yet technology prevents the illusion from being complete. Unfortunately for our limited bandwidths today virtual objects require properties not found in ordinary 3D graphics. Besides geometric and surface properties, they require dynamic properties, acoustic properties and physical boundaries which greatly increase the associated database size. Despite this the World Wide Web has a standard and some implementations of a language design for interactive VR worlds. This is VRML It is not an easy language to develop with and most designers would use other packages and then save the work as VRML.

You might like to look at some examples by downloading a browser extension called Cortona3D player. In order to see VRML in action install one of these extensions and search the web for files ending in .WRL. Clicking on these file will set the player in motion. For simple freeware VRML editors see the Tools section and for a good VRML tutorial see (Fernandes, n.d.). For a commercially oriented browser add-in you could try Blaxxun Contact 5.3. (see item 11 in the tools list).

We have finished the seminar on video and animation. As you must realise, it is a very large area to cover.

Links and References

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   http://www.chiariglione.org/mpeg/tutorials.htm
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Tools:
1. <u>Real Player and server are found at:</u>
   http://www.real.com
2. Quick Time is found at:
   http://www.apple.com/quicktime
3. Windows Media Player offerings are at:
   http://www.microsoft.com/windows/windowsmedia/download/default.asp
   and the Producer is at:
   http://office.microsoft.com/en-us/powerpoint/
4. Adobe Premier Pro
   http://www.adobe.com/products/premiere/main.html
5. Movie Maker can also be downloaded from:
6. http://www.microsoft.com/windowsxp/downloads/updates/moviemaker2.mspx
7. Flash and other adobe tools
   http://www.adobe.com/downloads/
8. Camtasia
   http://www.techsmith.com/
9. Corton3Da Viewer
   http://www.cortona3d.com/Products/Cortona-3D-Viewer.aspx

VRML editors:
10. gbVRML: http://www.garybeene.com/free/gbvrml.htm
    Render Soft VRML: http://pachome2.pacific.net.sg/~jupboo/
11. Blaxxun Contact 5.3:
    http://www.extremetech.com/article2/0,1697,2041419,00.asp
12. Springboard – a tool for creating 'storyboards'
    http://6sys.com