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# InnotiveBrowser

## *A real-time digital content display software using VR technology*

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Abstract: This paper explains the results of a collaborative research project between Multimedia University (Malaysia) and Innotive Corporation (Korea) to manage, design a multimedia archiving system and visualising knowledge for the students or the users in the Faculty of Creative Multimedia, Multimedia University. This research introduces InnotiveBrowser technology, a high performance multimedia display software that enhances the ability of user to search and discover digital content. The unique result of this method is that the images to be viewed are not limited to available RAM, instead the content utilises the available storage directly from the disk (hard drives). In other words, the larger the size of the hard disk, the greater the number of content information can be stored and displayed. This system is employed with Virtual Reality (VR) techniques particularly imparting viewing technology (pixel-on-demand) and navigation strategy to increase the viewing speed of multimedia information in real-time over the Internet, broadband and even via PDA platforms. This research hopes to set the benchmark for multimedia archiving system that can be applied in other CAD, CAAD or most of the design or production-based teaching and learning environment. The early findings of this research have been patented and this paper will demonstrate the research ideas and explain how we implement and customise the technology and content development in the Faculty of Creative Multimedia, Multimedia University.

# 1. INTRODUCTION

Advances in imaging and computing technology are creating an explosion of data in image form. The ability to quickly analyse this information however is limited by the inefficiencies in image display imposed by current technology. A method for rapid access and display of large image sets would considerably improve analysis and conceptualisation of information contained within the images. According to Donelan (2003), power now lies in knowing which data is important, and even more, having the ability to manipulate data so that your information rises to the top, drawing people's attention away from competing content. Similar to this, Rafi and Karboulonis (2003) explain that in the new knowledge economy**,** assets and intellectual properties are expected to play an increasingly dominant role in establishing both valuation and value creation capabilities in such enterprises.

## 1.1 Case Studies

There are a lot of evidences in small and large enterprises that have benefited from the right management of knowledge asset. Companies like the British Aerospace (BAE) decided that the company's growth depended on knowledge and know-how when they got the job of creating a Virtual University (Heisig et. al, 2001). Autonomy technologies (*www.autonomy.com*) were developed to provide users with relevant and timely information especially when considering the company's geographical spread (Rafi and Karboulonis, 2003). Phillips (2004) from BAE System says that it is worth noting that Autonomy's products bring order to information chaos, but in an economic and user-responsive way. Similar to this, with the help from IBM, the National Geographic Society recently posted 10,000 of its 10 million photographs for sale on its new Web site, *www.ngimages.com* (Donelan, 2003). According to his report, the collection is scheduled to grow by thousands of images in a year. While having this online with a high quality of images, the process is too costly as it requires the time of human experts primarily in terms of searching speed, hardware cost and maintaining the database. For a small-scale knowledge management practice, Canto's Cumulus (*www.canto.com*) is an off the shelf program that is often used for Web Publishing and many others. It provides simultaneous multiple cataloguing while displaying a catalogue in the background.

In the context of teaching and learning, keeping and managing content assets are becoming more complex particularly when the numbers of information are increasing and the need for effective usage becomes more apparent. Among the pioneers of this are a collection of a text-based standalone PDF-files of Cumulative Index of CAD (CUMINCAD – *http://cumincad.scix.net*) developed by Martens and Turk (2003), who started in 1998. It basically keeps account of more than 3000 records of publications while supporting free access and knowledge dissemination of all major CAAD related publications (i.e. ACADIA, CAADRIA, eCAADe, SiGraDi and CAAD Futures).

However, dealing with multimedia-based knowledge is more complex. The image review process is often time-consuming and tedious due to the lack of fast random access memory (RAM) where displayed multimedia images normally reside within the computer. The option of using additional memory is expensive and alleviates only part of the problem. In this research we relate digital asset management (*www.marketingpilot.com*) to the concept of knowledge management (Rafi and Karboulonis, 2003; Kluge et. al., 2001) where it concerns the identification, encapsulation, and redeployment of knowledge at the workshop, operational, and designer level. They further argue that support tools need to be developed and deployed to assist in the search for knowledge, its visualisation and effective navigation in an effort to reduce the number of redundant searches.

## 1.2 Related Work

The Faculty of Creative Multimedia, a design school at the Multimedia University in Cyberjaya Malaysia, has been operating for nearly eight years. Though still considered new compared to other leading design schools, it has pioneered in using new media as a means of expression in design within this region of the world. The faculty is currently conducting 4 major areas of specialisation in the Bachelors of Multimedia Honours Degree. These areas are Bachelors of Multimedia (Hons) in Digital Media, Media Innovation, Interface Design, and Film and Animation.

Courses are project-based, allowing them to explore their imagination and to innovate, using new media deliveries. Students are required to acquire skills liken to professionals while at the same time possess the understanding of the processes involved in the design process. Like most design-based courses, classes are centred on projects, exercises and submissions. Through the use of student-centred teaching methodology combined with technology, students are able to think and develop their own design approach using technology-based tools that will guide them throughout their design career.

The following briefly explains the learning outcomes for each undergraduate degree that will be used as a consideration in designing an integrated archiving system and efficient browsing technique mainly for student and staff references:

**Foundation Years:**

In the 2-year of foundation students will be exposed to creativity through the principles and elements of design. Amongst the key learning outcomes are understanding of design process, problem solving, drawing as one of the communication tools, thinking skills towards a design-process, and design appreciation and perception towards objects. They will express these ideas through drawing, sketches, writing and photography. The learning experience is not limited to manual (analogue) but also covers expression and exploration through interactive multimedia, graphic software and 3D tools. More importantly, the students understand the limitations as well as the advantages of both the analogue and digital tools to produce good content design.

**Digital Media Degree:**

Students in Digital Media majoring are required to equip themselves with new media skills through integrating, exploring and presenting design ideas in an interactive manner highlighting areas of interactive design, e-learning content or experimental arts. Student will learn how people interact and communicate through multimedia platforms such as Hybrid CD, web-based design, Games, Multimedia Installation, and Courseware Design.

**Interface Design Degree:**

In the Interface Design Degree students are required to fully understand the interface between human and product that carries content (e.g. Electronic and Communication Products). Students will be also be exposed to good and bad products in which they have to 'reverse-engineered' through a discussion and documentation of the idea, process and possibilities of solution using the new technology. Rapid prototyping, sketches, simulation, and CAD modelling are some of the tools used to explore, understand, and represent the design ideas.

**Film and Animation Degree:**

The Film and Animation course contributes the learning outcomes using 3D animation as the vehicle for creativity. Students will be exposed to film screenings, pre-production, production and post-production design stages together with adaptation of film language and principles of animation. This includes the design of drawing viewer's attention, giving life to animation, managing and selecting animation or moving images. The area of specialisation and design exploration will be more on Character Animation, Visual Effect and Motion Graphic.

**Media Innovation Degree:**

Media Innovation Degree focuses on design creativity through the art of persuasion. While giving the basic advertising and marketing principles, student will develop skills in designing and selecting new media that has a strong ability to position the product or issue for the user either to buy, understand, aware, engage the brand or highlight certain value. Student will realise that this is mostly depending of the critical understanding of the target audience, people's perception and current design demand. Some of the main design explorations are Third Generation (3G) Content, Dynamic Web Sites, and Electronic Billboard.

These different degree outputs show that the Faculty requires a robust and effective information management system that can integrate, archive and access this information data whenever required. This will provide the faculty with a means of archiving and researching digital content needed to improve the efficiency and the quality of teaching and learning. With the ever expanding student faculty and their digital projects as well as the offering of new degrees, the need for a digital content management database becomes more crucial.

## 2. ISSUES IN ARCHIVING CONTENT FOR CREATIVE MULTIMEDIA

In this research, we check-listed several key issues that we used as the considerations in designing and implementing the archiving (knowledge) system for the Faculty of Creative Multimedia. The overall goal is to make users of such systems more effective in their information management and communication tasks where learning times are reduced, knowledge is retained, and personal satisfaction and performance are increased thus benefiting the enterprise (Rafi and Karboulonis, 2003).

**Cross-media and platform.** The nature of the current multimedia degrees demands a digital asset management system to allow multimedia content to be used, exchanged and explored effectively when using the Internet, TV Broadcasting, and preparing for exhibition, presentation, teaching and learning. It is also important to embed these activities in various platforms such as allowing the content to run on desktop computers, PDAs, set-top boxes and Internet. The nature of the courses requires the student to understand, explore and develop such content using different platform for the right time and context.

Unlike conventional design degrees, this faculty is trapped with huge numbers of different media submission (i.e. analogue and digital) simultaneously. The difficulties are becoming more burgeoned to manage and make available these media submissions to the existing classes online (i.e. Multimedia Learning System- MMLS). This system has been employed for the last 5 years with a compilation of course notes, assignment samples, step-by-step tutorials to name a few for the students to access over the Intranet and Internet at their own pace and any time anywhere.

Archiving and storing these submissions have become more overwhelming with the increasing number of students being recruited into this faculty. We are currently facing an average more than 3000 collection of knowledge information from various classes and majoring per year. These submissions often involves design sketches, storyboarding, ‘animatics’ (i.e. pre-animation), flow-charts, scripts, web-based reports, physical and virtual models, just to name a few. As such we require an integrated system that could standardised the information to organise the material so that it can be efficiently managed, used, shared and hopefully sold.

**Searching Techniques.** Current technology of digital asset management can be divided in 3 categories which often overlaps primarily differ based on the functions. The most common type of search facility is a text-based (Rafi and Karboulonis, 2003; Donelan, 2003) organisation. An example of this might be question papers, online journals, and newspaper archives. User can search based on category, author, date and year of the articles. The second category involves digital imagery to a greater degree (Donelan, 2003). In the context of Faculty of Creative Multimedia, the collection of student and staff works of still photography, illustration, sketches and graphic stocks are made available for student references and the university to print out for advertisement purposes through different media platforms.

The third type of asset management includes animation, digital visual effect, audio, rendering techniques, 3D models files and to name a few. Students, staff and researchers frequently need this kind of search system not only for references but most importantly to developed and revised on the specific project in parallel with a group of numerous parties, researchers and professionals. We found it is very difficult to handle conventional digital asset management that requires digital files (e.g. PDF) to be individually downloaded to view information. Such system is slow in terms of accessing the information as well as when cross-referencing and random-access is required. We consider current search engines to be analytical, methodical, serial technologies suited to the activity of the left hemisphere of the brain where shapes and patterns that would tap in the right hemisphere have generally been neglected (Rafi and Karboulonis, 2003)

**Technology.** In the context of teaching and learning, keeping and managing content assets are becoming more complex as claimed by Tuncer (2001) particularly when the numbers of information is increasing and for effective used are concerned. In fact, the image review process is often time-consuming and tedious due to the lack of fast random access memory (RAM) where displayed multimedia images normally reside. The option of using additional memory is expensive and alleviates only part of the problem. According to Rafi and Karboulonis (2003), the most common approaches include cone trees and tree structures as well as new alternatives such as networked structures, hyperbolic views, trajectories and feature maps. All these concepts show marked diversity and tend to be used, depending on the type of data and user requirements (Chen, 1999).

**Database-Centred.** Design-based content activities were developed under myriad parties and processes. Digital artists develop their ideas through storyboards and sketches. Animators will incorporate motion from the modellers together with the texture and lighting artists to bring 3D into life. The fact that this project requires a non-linear development process definitely needs a centralised-database system that allow certain level of flexibility, systematic files organisation and efficient access. As Scheidt CEO of NXN Software (Donelan, 2003) says, they want their data in a central place, they want control over who can see the files, and they want a version control system that allows users to go back to earlier versions of files if modifications don’t work. We found that students have difficulties in handling normally group projects where collaboration taken place in the process of learning and exploring design ideas. Our current system requires improvement in handling centralised content information to ensure cross-referencing and process recording in particular can be managed effectively.

## 3. HANDLING AND VISUALISING KNOWLEDGE

Technology advances enable and encourage practitioners and students to make the design process more information intensive and to exchange this information effectively with other participants in the process (Tuncer et. al, 2001). Tuncer further highlights the design complexities (i.e. design presentation and project documentation facilities) by raising questions on how to organise large amounts of information and how to relate the information entities within the organisation, in order to facilitate efficient retrievals of this information. Undirected graphs were chosen to represent the stored knowledge and its relationships despite the challenges they pose

(Rafi and Karboulonis, 2003). Eades (1984) suggests undirected graphs for handling drawing documents through spring-embedder model and follows two aesthetic criteria namely uniform edge lengths and symmetry. This popular algorithm is further developed by Kamada and Kawai (1989), Frutcherman and Reingold (1991), and Davidson and Harel (1996).

In this research, we suggest an InnotiveBrowser technology, a system that is being developed by a joint collaboration between Innotive Corporation (Korea) and Multimedia University (Malaysia), in Innotive Research Lab. Several plug-ins are being developed based on the issues raised earlier in Section 2, primarily to support and suggest a strategy for the Faculty student and staff members in handling and visualising past, present and future (mostly R&D) knowledge (content). This research is necessitated by our recognition that current asset management systems are limited mainly to support text-based search and do not provide flexible cross platform support.

## 3.1 Design Considerations

In this research, one of our main focuses is to ensure that a clear integration of knowledge information can be achieved as what Kluge's et. al. (2001) categorises as explicit knowledge (knowledge that can be structured and documented) and tacit knowledge (knowledge linked to human senses and experience) which are heavily inter-linked in any knowledge relationships. Similar to Tuncer's (2001) research, she propose that the best way to handle complexity in architectural information is to advocate a complex information structure that enables views unbounded by the original abstractions. Thus the accumulation and storing of information coupled with an ability to create, effectively visualise and identify relationships between these items of information is considered a vital part in the success of a knowledge management software system, regardless of the of the industry that it serves (Rafi and Karboulonis, 2003).

The goal of the prototype system is to provide an automated intelligent interface that could respond to users' request for information according to the specific requirement of the topic, design, concepts, techniques and design processes. It was required that the system could:

- accommodate different types of users
- allow the user to easily browse content with fast and flexible navigation system
- provide an effective knowledge management system,
- provide an easy to update knowledge base
- provide a tool of dissemination of knowledge

- support domain and language independency

InnotiveBrowser Technology provides much improvement to access and visually search database from conventional technology. InnotiveBrowser Technology's two main characteristics are Dynamic Visual Retrieval and Compound Content. Dynamic Visual Retrieval is a feature that enables the search of content through visual comparison of entire index search results by eyes (i.e. visuals). In fact this feature not only offers 'text-based' result (i.e. like most conventional system) when searching information, instead reveals the 'visual-based' categorisation for user to recognise the information by zooming in and out or panning of contents. This means that users searching for 3D models with a rectangular form as the key design component will have display of dynamic visual samples, instead of having to interpret a long list of text descriptions or individually linked thumbnails which is time consuming. For users that access using Internet or Networks, the data transferred between archiving system and client is minimised through partial access streaming service for easy navigation on entire screen regardless of data size and number of contents.

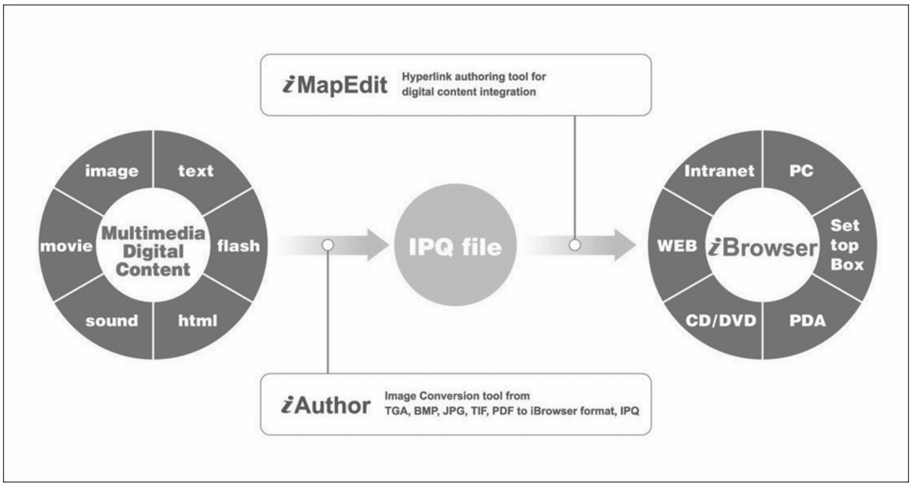


*Figure 1.* The workflow of the Authoring tools

When dealing with HTML users, they often face difficulties of having to open many windows to view many types of media or formats. Compound Content technology enables simple and easy creation of new content through creating links between the contents created in conversion process. It enables browsing of different types of contents as one compounded content through integration of different types of contents such as Image, Flash, MP3, multimedia contents (such as movies) and web-based contents in cross platforms and media. The online version of InnotiveBrowser consists of three main components; namely, Authoring Tool, Client Browser and Streaming Server. The Authoring Tool known as the IPQconverter (I-Author) converts documents and images into InnotiveBrowser's IPQ files and stores them in a database. A link editor (I-MapEdit) is then used to overlay multimedia content into the IPQ files. A collection of IPQ files may be hyper-linked in much the same way as a set of web pages. The difference is that an IPQ document is far more powerful as for publishing multimedia content. (Figure 1).

The main functions of the Authoring tools are as follows:

1. Content Authoring: Supports most of image formats including JPG, GIF, TIF, PNG, TGA, and PDF
2. Compound Content Authoring: Supports content integration of various objects such as Image, Audio, Video, HTML Links into one compound content.
3. Movie Frame Extraction: Extraction of frames in time or frame units from movies to provide faster and better movie content search method than direct movie service.
4. Watermarking

Client Browser is an end-user application. It allows the users to access IPQ content on a file system locally or retrieve content from streaming image and/or media servers on the Internet. The browser may display pages of content in a single mosaic, where the pages are laid out in a regular grid. This allows the user to see all pages at once. To access any one page randomly, the user simply picks a page and zooms in to read the content. However, the pages may also be displayed in a more traditional book-like format. In the e-book form, the user will traverse the pages sequentially by flipping forward or backward. To retain the advantage of random access, the browser can display a visual page index. This is a hybrid between a table of contents and a standard text-based index. It is a thumbnail mosaic of all pages in the document. When the user selects a thumbnail, the browser displays the desired page in e-book form.

Streaming Server is a multi-thread streaming server written in JAVA. It transmits multimedia contents requested the client browser over the Internet or Intranet. The key functions of the Streaming Server are:

1. Partial Access: Increase in system response time by the reduction of transmission data quantity through transmitting part of data needed to display contents on the Screen
2. Multi-thread: Rapid and accurate process of requests from multiple clients
3. Request Queuing: Provision of optimised response speed through

inserting of requests from multiple clients into queue, and management of each clients with multi-thread

InnotiveBrowser also provides an intuitive user interface that enables the users to search and browse in the form of dynamic content displays. Using a Virtual Worlds image manipulation concept (i.e. pixel-on-demand), users can approach the content within one window (or screen) by walking-through wall of vast numbers of multimedia or image contents with visual navigation. This browser allows:

1. Offline, Online Browser: Enables the local viewing of contents requested
2. IE Plug-In: Enables the user to access multimedia archiving system without installation of separate program in user's client
3. Special Effect: Various special effects including 2D/3D flipping
4. Instance zoom-in/zoom-out: Immediate zoom-in and zoom-out of contents within current window without opening new window (figure 2)
5. Dynamic Mosaic View: Displays contents through ordering the contents in table mosaic way

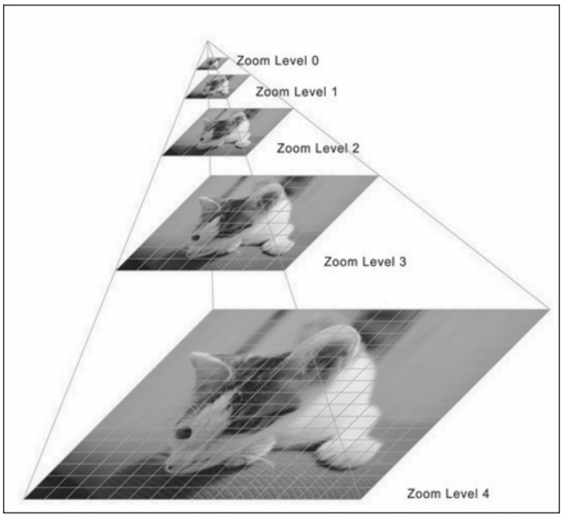


*Figure 2.* The concept of pixel-on-demand through fast zooming

Much investment must be made in order to construct effective content search system. However, with implementation of InnotiveBrowser system, one can construct equally effective search system at a much cheaper cost. InnotiveBrowser enables the high speed browsing of the content even at lower server and client system specification. Independent benchmarking tests show that InnotiveBrowser can increase the image search and browsing speed up to 65 times from conventional system (Innotive, 2002). The following tables compare InnotiveBrowser's performance with other image viewers for small and large content sizes. When the content size is beyond the RAM capacity of the test workstations, InnotiveBrowser's performance remains unchanged while other viewers fail to display the test documents. For example, InnotiveBrowser only requires 0.5 seconds compare to 87.28 seconds of loading time in other web-browsers when loading an 84.2 MB satellite image of North America (Innotive, 2002). The performance difference is even more pronounced during animation tests. The InnotiveBrowser can display hundreds of frames of GOES satellite images at 10,000 x 10,000 pixels in real-time while zooming in and out. This feat is impossible for viewers that load entire images into RAM before display (table 1, table 2 and table 3).

*Table 1*. Local file benchmarking test Data 1; Windows Bitmap file (4961x3508 pixels) 49.7MB vs. the same size IPQ file.

| | **InnotiveBrowser** | **MS Windows Picture Viewer** | **Irfan View** | **ACD See** |
|---|---|---|---|---|
| First screen | 3 seconds | 2 seconds | 2 seconds | 2 seconds |
| Scrolling or panning | No delay (<1 second) | No delay (<1 second) | No delay (<1 second) | No delay (<1 second) |
| Zoom in or out | No delay (<1 second) | No delay (<1 second) | No delay (<1 second) | No delay (<1 second) |
| RAM usage (while display actual size) | 18MB | 110MB | 52MB | 56MB |

*Table 2.* Local file benchmarking test Data 2: JPEG file (30000x20000 pixels) 24.6 MB vs. The same size IPQ file.

| | **InnotiveBrowser** | **MS Windows Picture Viewer** | **Irfan View** | **ACD See** |
|---|---|---|---|---|
| First screen | 3 seconds | 6 seconds. Cannot view at actual size | Cannot open | Cannot open |
| Scrolling or panning | No delay (<1 second) | 1 - 20 seconds. The more zooming in, the slower the scrolling | Cannot operate due to large file | Cannot operate due to large file |
| Zoom in/out | No delay (<1 second) | No delay (<1 second) – or hang if | Cannot operate due to large file | Cannot operate due to large file |
| RAM usage (while displaying actual size) | 32MB | The more zooming in, the more memory is consumed | Cannot operate due to large file | Cannot operate due to large file |

InnotiveBrowser's unique multi-layer mosaic also provides an effective visual approach for data search. A typical query on the Internet may return over a hundred results. The user has to spend a lot of time to examine each result in turn. InnotiveBrowser's approach is do display the entire result set on the same screen. The user can scan the screen to quickly identify the likely matches. Unlike conventional form of browsing where a user will have many separate display windows. (figure 3).

*Table 3.* Network benchmarking test data: Windows Bitmap file (4961x3508 pixels) 49.7MB on an Internet web server vs. the same size IPQ file on IPQ streaming server using http mode (Maximum http download speed is 120KB per second).

| | **InnotiveBrowser** | **Others** |
|---|---|---|
| First screen | 4 seconds | >9 minutes. Download the whole file then open it locally. |
| Scrolling/panning | 1 - 4 seconds | Can only be viewed locally |
| Zoom in/out | 1- 4 seconds (without cache)<br>No delay (<1 second) (with cache) | Can only be viewed locally |

Note: All data for Table 1, 2, and 3 are tested on CPU: AMD Athlon (m) 2200+ 1.8GHz; Hard Disk: IDE7200rpm; RAM: 512M and Operating System: Windows XP

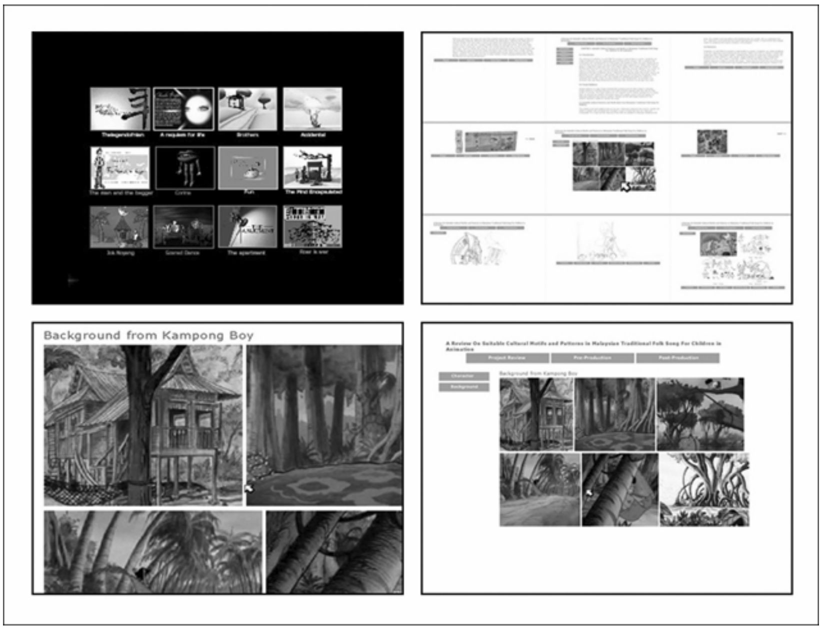


*Figure 3*. Clockwise from top left picture, display of student animation works at various zoom levels using VR and games techniques.

# 4. CONCLUSIONS AND FUTURE RESEARCH

This research has presented an original concept of the first design phase for the development of a universal and flexible tool by adopting games and VR technology concept to manage and visualise knowledge for the use of multimedia content as well as conventional design information. It has also discussed the issues leading to a chosen design approach, a greater value of the system, and an automatic performance based on the user interaction. The system is designed with the value of effective viewing strategies (robust zooming technology), searching mechanisms (e.g. graphical-base), cross media and platforms (e.g. Internet, PDA and set-top boxes) to reduce the complexity of the navigation and thus increases the speed of information acquisition. Its dynamic database-driven technology allows the user to add, edit, store and access information without a broken links at cheaper cost of investment (i.e. not RAM dependent). As design is becoming more complex, architectural design, urban planning, CAD, CAAD and other design-related industries could easily benefit this system as these industries are changing, adopting and merging with the new and emerging tools (e.g. multimedia, virtual reality and Internet) in the design explorations and outputs.

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