The Development of 3D Polygon Type Interactive Interface Design Prototype

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Summary
This paper proposes the development of 3D interactive interface prototype using basic shape of built and distributed by origin shape, direction, and texture mapping. The partial interactive interface of a polygon object is placed on polygon surface, which make interaction interface 2D based shape such as square, circle, and closing free-curve with harmless texture mapping. To building dynamic interaction interface, animation is required with several possible types for final interactive media format although most decent 3D application support various animation control function using key, skeleton, and blend shape. The final output is interaction interface prototype for web and multimedia interactive CD-ROM which has customized freeform polygon component interactive interface dealing with texture mapping. A designer for 3D interaction interface requires balance between design ability and technology limitation. This prototype shows how complicated 3D polygon object is implemented as basic 2D shape for 3D interactive interface.

Key words:
Polygon, face, Interaction, Interface

1. Introduction

Currently most interactive media is based on 2D design. It depends on not because of useful interactive interface design but the today's multimedia technology. In addition, common computer related hardware products are designed for 2D interactive interface. Indeed, 3D software and hardware could be attached with 2D based computer products, which can be the main issue that it is difficult to produce a 3D related computer product. However, the need of appropriate 3D contents on 2D based computer should be developed.

In the mean time, the primary purpose of decent 3D computer graphics is to produce a 2D image from an object which may be a real or existing object or it may exist only as a computer description. The extremely important usage of 3D computer graphics is where the act of creation of the object model and the visualization are intertwined. This must occur interactive 3D applications where a designer uses the visualization to assist the act of creating object[1]. Most object descriptions are approximate in the scene that they describe the geometry or shape of the object only to the extent that inputting this description to a renderer produces an image of acceptable quality. It is most common 3D computer graphics purpose to be existed until now. With combining or joining with interaction in final output, the final procedure or general purpose of 3D computer graphics must be changed or added in some part.

In the part of multimedia, especially medium of interactive interface between the human and the computer can be thought to exist in "direct" and "indirect" paths. The direct paths is physical or involve the transfer of signal in the form of light, sound or mechanical energy between human and the computer. A primary difference that should be noted between architectural or engineering design and multimedia design is the performance of the product[2]. A building or other structure is generally intended to remain essentially unmodified for a long time. Most software is subjected to major maintenance and modifications throughout its useful life. This difference has both profound and practical implications during the design process. Interactive interface design is design for human and the computer interactivity. This type of design includes many significant considerations derived from a number of different disciplines such as communication science, computer science, and computer graphic art etc. Most 2D based interactive interface design on Multimedia requires 2D based physical design theories such as making a magazine, poster, and book. 3D based interactive interface design may needs another approach against 2D based interaction interface design. It is mostly similar to produce film and video work in the physical world.

The aspects of making prototype 3D interactive interface are to be considered above both elements, and needs negotiation above two different genre in computer graphics. Mocking a modeling, texturing and mapping, and adapting interactive interface design should be the main focus in this study and research. In addition, the management with 2D hardware for 3D interaction interface and physical interactive function are to be mentioned.

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2. 3D Interactive Interface Perception

2.1. 3D object perception in 3D virtual environment

With our two eyes, we see the world in 3-Dimensions. Each eye receives a slightly different view of the world and visual system fuses these into one 3-Dimensional stereo view. The difference in the two images is called *binocular disparity*[3]. The simplest way to see this is to look somewhere in environment where you are located now, and alternately switch between your two eyes, with at any moment one open and the other closed. Notice the image shifts horizontally from left to right and back again, demonstrating the disparity. Notice also that the disparity is much greater for nearer objects than it is for objects further away.

3D virtual space could not be existed on the general 2D support output devices such as a monitor and LCD. But, there some trick or technology is applied for 3D virtual environment. Most 3D application uses linear perspective for index where 3D objects are located comparing 2D grid function. Linear perspective can make 3D visual illusion for a viewer on the computer. Another elements for making 3D virtual space are shadow, shading, lighting and texture gradient which actually are 3D visual illusion. Contrary 2D images on the computer, 3D computer generated object is affected by light which is also applied in physical world. The light source in 3D virtual environment can be generated color which is calculated by digital data. Light source on the computer also can produce shadow and shading. It is a bit differs from physical environment does, but it is easy to create and control light in most 3D application. Fig.1. shows a 3D object with grid, shading, lighting, and texture in 3D virtual environment.

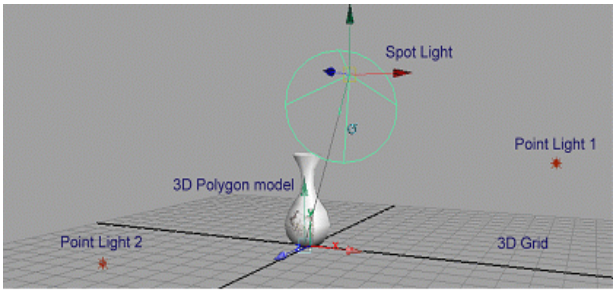

Fig.1 grid, shading, lighting, and texture in the 3Dvirtual environment

2.2 Interactive perception in 3D virtual environment

There are interactions between a user and the computer. Interaction is one of main elements to populate the computer. Interaction on the computer occurs when a user uses the computer to expedite communication. The main purpose of interaction on the computer is communication not with the computer but through the computer. The user exchanges information the way of using interaction thorough the computer during sharing information with variable purpose. To interact between the computer and the user requires input function, and the computer should respond about input. The interface, the place which occurred interaction on the computer is function that the human and the computer communication that is designed to enable interactivity has many features in common with interpersonal communication, but also has some distinct differences. *Marcus* makes it clear that he believes that a form of communication is taking place between the computer and its user via the user interface. Marcus explains that the user interface must achieve effective communication of

Metaphors : Fundamental terms, images, and concepts that are easily recognized, understood, and remembered.
Mental Model : Appropriate organization and representation of data. function, work tasks/activities, and roles
Navigation of model : Movement among data, function, work tasks/activities, and roles depicted in the model that provide speedy access and facilitate comprehension
Looks : Appearance characteristics that efficiently convey information to the user in an appealing manner
Feel : Interaction techniques that operate efficiently and provide an appealing perceptual experience
Predictability : From the user's point of view, does the program interface behave in a predictable manner that is in agreement with what the design planned?
Consistency : Does the program interface respond consistently to the user's behavior, giving the same results for the same input each time?
Progression : Does the program interface advance at an appropriate pace from simplicity to complexity, never requiring more complexity than necessary or than the user is ready to handle?
Natural Constraints : Does the program interface anticipate and correct potential user errors by gently constraining the interaction so as to preclude mistake?
Visibility : Does the program interface display all of the necessary elements so that the user can easily find, identify, and use them without undue search or uncertainty as to their purpose or how they function?
Transparency : Does the program interface recede into the back ground to become almost invisible, thereby permitting the user to concentrate on the content of the production rather than the details of the interface?
Feedback : Does the program interface provide immediate and clear feedback or results in response to a user's input?
Modes of operation : Does the program interface facilitate the three main modes of interaction with

the program : 1) commanding or telling the program to do something, such as look up a word 2) manipulating an object or element being displayed or otherwise presented, such as rotating an object on the screen to view it from other perspective 3) recording or inputting information or data, such as adding a new entry to a bibliography?
Pace : Does the program interface enable the user to control the speed at which the user progresses through the program, navigating under the user's preferred timetable?
Appropriateness : Does the program interface contain the flexibility to meet the needs of different users, allowing it to be tailored or modified to adapt to the abilities and limitations f the current users?[2]

2.3 The current technology

Internet with 3D is delivering 3D contents over the world wide network. One of internet 3D, Web3D is a general term used to describe protocols, languages, file format, and other technologies that are used to deliver true, interactive 3D content over the World Wide Web. Web3D is a group of standard technologies. There are many internet 3D formats are developed with various hardware and software support for instance:

1) VRML(Virtual Reality Modeling Language)
- VRML1.0, VRML97, VRML2.0
- Extensible 3D(X3D, VRML-NG)
- Java3D : Java3D is an Interpreted 3D content development language, and a 3D extension to the popular Java programming language.
- MPEG4/BIFS
- MPEG-4 : MPEG-4 is a global media solution that supports audio, video, texture, 2D, and 3D content. BIFS (Binary Format for Scenes) is a complete framework for encoding scene data in MPEG-4. BIFS allows MPEG-4 media to be mixed with 2D and 3D content.

2) Shockwave3D : Macromedia Director Movie format is shockwave, which is the tool of choice for legions of Web and multimedia developers[4].

3. 3D Interactive Interface Prototype

3.1 Building a basic 3D polygon modeling

A 3D object is represented by mesh of polygonal facet. In general case, 3D object possess curved surfaces and the facets are an approximation to such a surface. Polygons may contain a vertex count that emerges from the technology used to create the model, or a designer may constrain all polygons to be triangles, rectangle, and customized freeform. Polygonal representations are ubiquitous in computer graphics. There are two reason for this that creating polygonal objects is straightforward and visually effective algorithms exist to produce shaded versions of represented in this way. Polygon meshes are strictly a machine representation rather than the convenient user representations are often function in this capacity for other representation. A polygonal object is convenient to order polygon component into a simple hierarchical structure. Polygons are grouped into surfaces and surfaces are grouped into an object.

Fig.2 a cylinder posses three surfaces: a planar top and bottom surfaces together with a curved surface. The reason for this grouping is that a designer must distinguish between those edges that are part of the approximation edges between adjacent rectangles in the curved surface approximation to the cylinder. The way in which these are subsequently treated by the rendering process is different. Polygon is the component type of building a 3D object. Looking at conceptual hierarchy of polygon type 3D object in Fig.2, the smallest or the last component of 3D polygon type object is vertex, edge is the shortest connection line between vertex. At least 3 vertex and 3 edges are possible to make facet, which could be a polygon object.

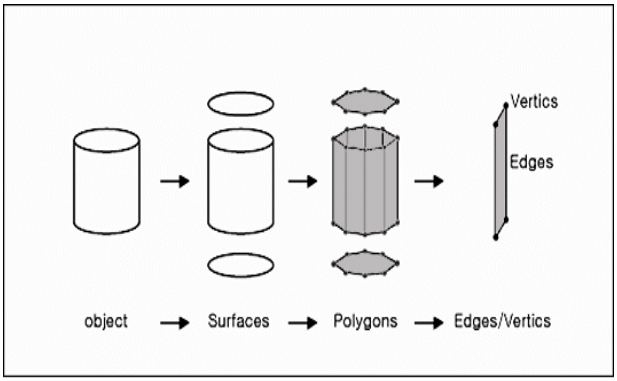

Fig. 2 Representation of an object as a mesh of Polygon.

For building 3D polygon interactive interface or putting interactive interface on the 3D polygon facet, the basic shape polygon object such as sphere type, cube type, cylinder type, and freeform type. In addition, each polygon object two different component shape; one is triangular shape and the other is rectangular shape. Fig.3 shows basic polygon object such as cube type, sphere and cylinder type, and freeform type with 2 types of different shape.

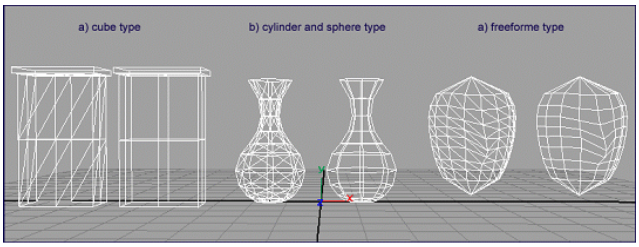

Fig. 3 Basic Polygon Objects with 2 different shapes

3.2 Texture Mapping

To complete 3D object for interactive digital media, there needs texture mapping. For mapping textures of a 3D polygon object, there are many ways to perform. The choice of a particular method depends mainly on time constraints and the quality of the image required. The most common ways of mapping texture are ways: 2D texture map on to the surface and 3D texture map on to the surface. Mapping a 2D texture map onto the surface of an object then projecting the object into screen space is a 2D to 2D transformation, and can thus be viewed as an image wrapping operation. The most common way to do this is to inverse map for each pixel. However, for reason, that will shortly become clear, specifying this overall transformation is not straightforward and a designer consider initially that texture space into the 3D space of the object, and via the projective transform into 2D screen space[2].

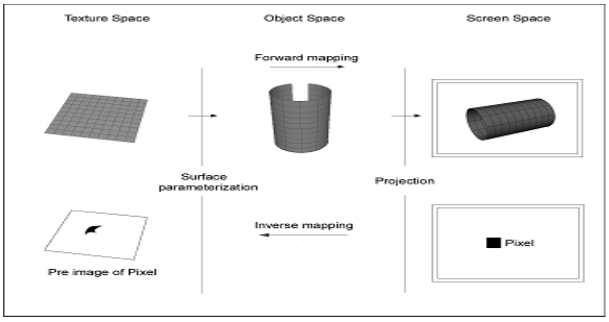

Fig. 4 2D Texture Mapping Procedure

There are two main problems 2D texture mapping. The first is 2D texture mapping based on a surface coordinate system can produce large variations in the compression of the texture that reflect a corresponding variation in the curvature of the surface. The other is that attempting to continuously texture map the surface of an object possessing a non trivial topology can quickly become very awkward. 3D texture mapping neatly circumvents these problems since the only information required to assign a point a texture value is its position in space. 3D polygon models in Fig.4 use customized 2D file textures thus 3D texture mapping technique would not use in this prototype.

Freeform type model actually uses projection texture mapping, which is convert to 2D normal texture file with 3D application. For exporting interactive 3D polygon model, a designer needs basic and clear polygon models with normal 2D texture. Fig.5 shows each two basic polygon model with 2D normal texture mapping.

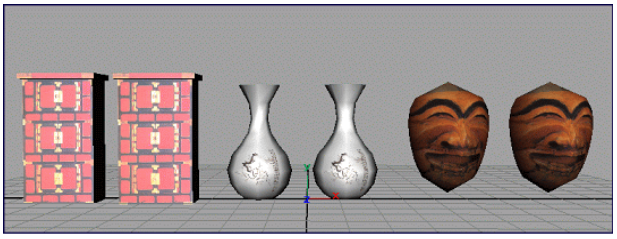

Fig. 5 2D normal mapping with 2 different types of Polygon models

3.3 Adding interaction with high vividness

Vividness, especially 3D virtual environment is also the part of telepresence. In general, depth, as a part of vividness is related to the amount of information used to generate a particular element in an interactive product. In common technology, depth is a measure of the quality of that element. An 2D image that uses 8-bit color will have less depth than one using 16-bit color, and amount of data in 2D space is less than one in 3D space. Multimedia computers are limited in the number of human senses with which they can interface, the depth of media employed is even more important in determining the level of interactivity that is possible. However, there is a significant tradeoff between depth and the size and speed of data files. The more depth will make the system slower. [5]

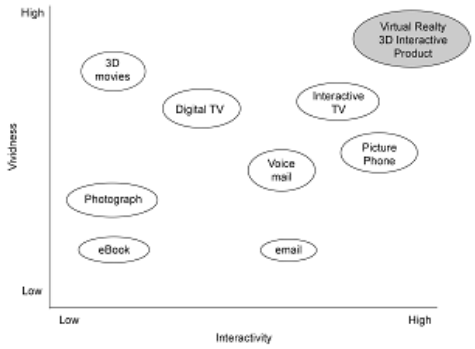

Fig. 6 Vividness and Interactivity for 3D Interactive Products

Dark areas in Fig.7 show where put the interaction on the cube type polygon. To add interaction on a cube type polygon facet, rectangular type polygon facet is not fit in the interaction interface area. Box or square type polygon shape is adapted for box style interaction interface. However, it definitely customized the location where exact interaction takes place. Fig.7 b) shows that texture is vertically extended because of incorrect vertex modification of the polygon object.

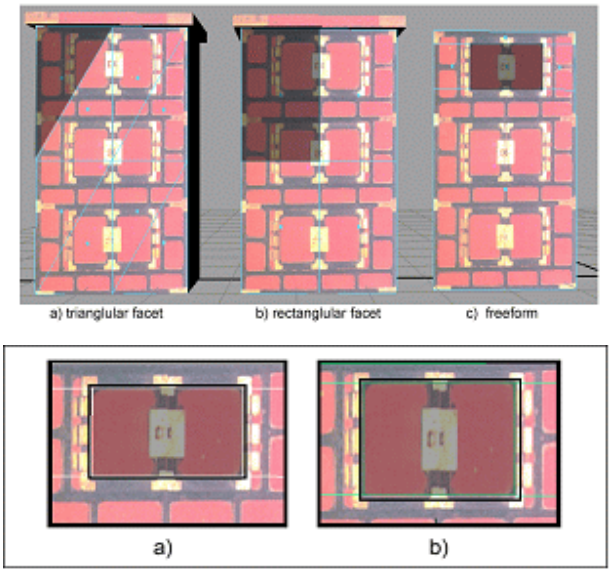

Fig. 7 Adding Interaction on Cube type face.

Sphere type polygon facet faced a problem, which related triangular facet direction. Fig.8 a) shows black area where we can see the facet direction from upper-right to lower-left. It is automatically produced on a rectangular shape polygon object. Fig.8 b) has looks adaptive for interactive interface area, but Fig.8 c) has more effective interaction area. It mostly depends on the interaction interface area shape.

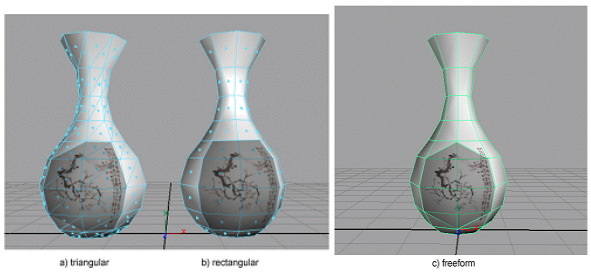

Fig. 8 Adding Interaction on sphere type face.

Freeform type polygon facet could not fit in above two types. It is free curved interaction interface area. Fig.9 a) and b) show black area in which the interface interaction area does not fit at all. Fig.9 c) is the proper interaction interface area with customized modification.

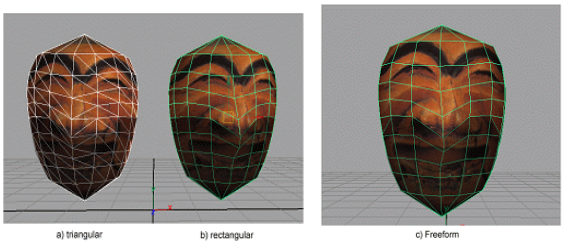

Fig.9 Adding Interaction on freeform type face.

3.4 Interaction with 3D Animation

3D computer animation can be categorized by mix of type and nature of the objects that are going to be animated and the programming technique used to achieve the animation. There are 5 types of computer animation such as Rigid body simulation, Articulated structure animation, Dynamic animation, Particle animation, and Behavior animation. The best way of comparing animation on the 3D computer graphics approaches is through the level of motion control implemented in the system, in other words the critical issue of high level versus low level motion control. Rigid body animation is self-explanatory and is the easiest and most unique form. It means using a standard renderer and moving objects and the view point around. Articulated structures are 3D models that simulate quadrupeds and bipeds. Such models can range from simple stick figures up to attempts that simulate animals and human being complete with a skin and clothes surface representation. Dynamic animation means using physical laws to simulate the motion. The motivation here is that these laws should produce more realistic motion than that which can be achieved manually. Behavior animation is modeling the behavior of objects[6].

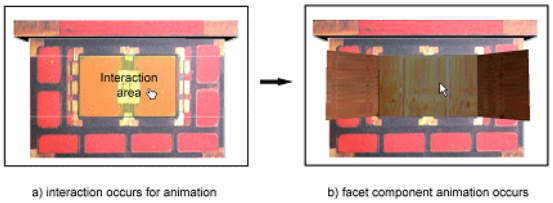

Fig.10 Adding Animation on cube type object

Fig.10, cube type polygon model has square interaction interface area which has normal key animation using most 3D application. When the user navigates and clicks interaction area on virtual space, the mouse cursor changes arrow to finger shape, and polygon facet animates, as doors are open widely. Animated polygon facets should divided by 2 areas and each polygon facet axis plays a role as a hinge. The door's opening takes 10 frames setting keys at time slider.

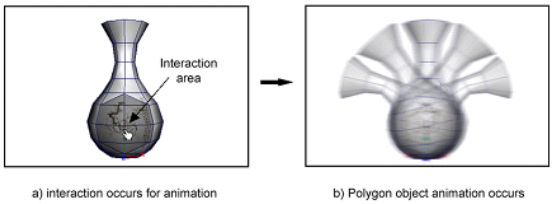

Fig.11 Adding Animation on sphere type object.

Fig.11, sphere and cylinder type polygon model has circle type interaction interface area. Contrary to cube type polygon object, the user's view area is smaller than actual interaction interface area, which is possible to see entire object. Sphere and cylinder type polygon model has skeleton animation with vertical lattice. When the user clicks interaction interface area, a whole object shakes left and right direction. Skeleton animation also uses key animation. Setting keys like key animation on time slider, the skeleton can be controlled wherever direction. Skeleton animation is easy to control 3D character animation with hierarchy.

In Fig.12, freeform type polygon model has free curved interaction interface area with Blend shape animation. In order to do Blend shape animation, two same modelings are required. Fig.12 a) is the original Polygon modeling, and Fig.12 b) is modified Polygon modeling from Fig.5-3 a).

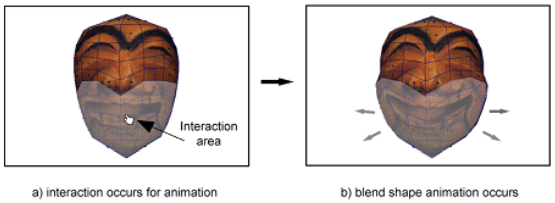

Fig.12 Adding Animation on freeform type object

3.5 Publish for Internet Product

For publishing a final out, 2 types of digital media are considered that the user is easy to approach for its using. Shockwave 3D format has easy of publishing 3D to the multimedia and web comparing VRML, Java3D, and X3D. It also allows a multimedia 3D designer to develop a wide spectrum of 3D productions, ranging from simple text handling to interactive product demonstrations to complete immersive game environments. Using Shockwave player, the users can view 3D interactive product on the CD-ROM, DVD, and web. Shockwave 3D format is automatically detected the capabilities of the user's system and adjust playback demands accordingly. The desktop computer with 3D hardware acceleration brings the user's view with the hi-quality 3D contents, but the user can successfully use shockwave 3D movies on most both Macintosh or Windows hardware platforms[7].

Fig.13 is published prototype on the web browser using Shockwave 3D format. Left of each three polygon object groups shows a object which is not adapted interaction, right 3D objects are after transformation. The polygon inbetween is not shown, because the interaction and animation are based on time passing. The user can see the only one picture per frame. Internet format 3D interactive interface has more compression to final output. There are two major processing to be a final output such as 3D application and publishing application. During each processing, for converting supporting 3D file formats, it is compressed, and for the best internet streaming; time saving, final output should be compressed. To keep hi-visual quality, before compression processing, the original texture file should be keep in the best quality with hi-resolution

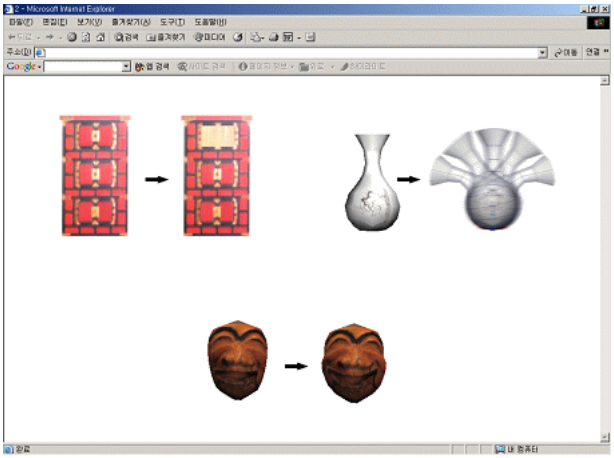

Fig.13 publish final output for the Internet

Fig.14 is published CD-ROM type using macromedia director projector format. Contrary to much compressed shockwave 3D format for internet, macromedia director projector type is less compressed. Data streaming on CD-ROM is better than it on internet.

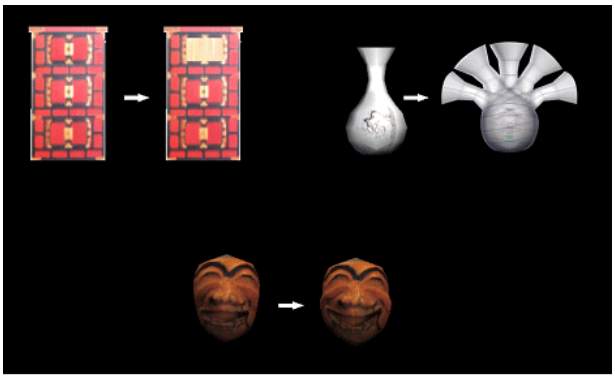

Fig.14 publish final output for CD-ROM

4. Conclusion

The development of partial 3D polygon interactive interface prototype shows the benefits managing digital information, although the balance is needed between 3D interface design and decent 2D computer technology.
The implementation of interactive interface design using partial 3D polygon facet is possible to remedy time consuming and time waste looking for widespread information. In 3D virtual space with Z-depth or Z-axis, the designer can store more information in one page than 2D space. In addition, partial interactive interface design can make several interactive interfaces in a object. With additional interactive control function such as dolly, zoom, and pan, the user can control the 3D information with less click numbers. Even, 3D interactive interface design, similar to physical object can be easily understood to control complicated information. To communicate complicated information between digital contents and the user, the current 2D interactive interface design considered the arrangement of information in order to make easily understand information for the user. However, 3D interactive interface can be designed for the same physical object with virtual Z-Depth. In addition, with applying photo-realistic texture, the user is familiar to control 3D contents as same as does in physical world. Moreover, partial 3D interactive interface can easily apply animation. Animation on digital contents can play a role to explain the property of the data object. With animation, the user can easily understand and accept the property of contents.

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