Using 3D Modeling Tools and Applications to Create a Virtual Teaching Collection of Archaic Pottery Shards

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ABSTRACT – The instruction of courses in Native American cultures is supported by extensive use of physical collections of ceramic pottery shards. These shards are generally collected as surface finds, catalogued, and then placed on reserve at the institution’s research library. This fixed locus is a detriment to efforts to migrate those courses to distance education delivery via the Internet. By creating a representative 3D model of the pottery shard and capturing surface details as a raster image an appropriate virtual teaching collection could be created. This paper will describe in detail a procedure for creating 3D models of pottery shards as well as methods of display that support distance education.

I. Introduction

Anthropology courses that focus on Native American cultures utilize fragments of ceramic pottery, typically shards, to gain insight into the daily lives of individuals of that culture. Ceramic vessels were commonly used for cooking and storage of food as well as transportation of water. Analyses of the materials used by the potter are diagnostic of the level of technology achieved by the culture. These ceramic vessels were typically decorated with textures and graphics which served as a form of personal expression to identify the owner and as a means of deity worship. Classification of materials used to construct the vessel, called tempering, is frequently used as an indication of the regional ecology and the existence of trade routes.

The study of archaic society, which pre-date written history, can be readily achieved by an analysis of artifacts left behind by its members. Ceramic pottery shards offer an ideal means to support this method of inquiry due to the inherent durability of their materials. An instructor teaching a course in Native American cultures would make a collection of pottery shards available to students for study. This collection most likely is comprised of catalogued surface finds. The method of collection includes recording data pertinent to location, date and cultural association.

II. Modeling Process

Individual ceramic shards were retrieved from the physical teaching collection and then carefully mounted onto a fixture for digitizing. The fixture is constructed from common opaque rigid plastic with a smooth polished top surface and an arrangement of non-skid pads attached to the bottom surface. In the lower left corner of the top surface, three small countersinks were milled using CNC equipment. The three countersinks form a pair of orthographic reference axes that are used to orient the digitizing equipment to the fixture surface. The sample artifact is positioned in the first quadrant of the Cartesian coordinate system established by the reference axes. Low-tack adhesive putty is used to anchor the artifact to the digitizing fixture. The fixture is then anchored to a work surface, such as a desk or lab bench, using the same putty. It is crucial that neither the
artifact nor the fixture be displaced during the digitizing process. The exact placement of the mounting putty will vary for the placement of the artifact; however the putty should be placed on opposite sides of opposing corners to mount the fixture to the work surface. It is important to form a rigid connection between the artifact and the fixture plate to prevent movement and cushion the piece.

Figure 1. Detail of mounting technique.

Once the artifact has been properly mounted the process of modeling can move into a new phase. A surface model needs to be created and there are several modeling packages available that will suffice. Rhinoceros 3D, offered by McNeel Associates, is an appropriate choice of modeling applications and the built-in support of digitizing equipment makes this method of data collection simple to calibrate and intuitive with a minimal amount of practice. Once the digitizer equipment is calibrated, the procedure is to use an interpolated spline tool to create three data sets which will be used to create the 3D model: a boundary curve, a cross sectional profile, and a sweep curve. The method can be described as moving the tip of the digitizer through a series of points along the surface of the artifact and clicking a foot switch to select that discrete 3D point as a control point for a NURBS curve.

Figure 2. Digitizing a point on the surface.

The number of collected points is directly proportional to the complexity of the finished model. In order to create a representative model of the artifact this complexity must be sufficient to replicate features such as chips and cracks along the boundary edge as well as contour variations across the top of the artifact. Too much complexity on the other hand will strain the resources of the intended downstream application and therefore should be avoided. The correct balance between a representative model and an overly complex model is a matter of practice and cannot be easily described. The boundary edge is the most critical in terms of creating a representative model.
Creating the cross section profile and sweep curves is a simple process of digitizing an open NURBS curves across the maxima of the artifact in the y-axis direction and creating a 3-point circle in the x-axis direction.

Using the cross section profile and the sweep curve, a one-rail swept surface can be created that will model a domain that form the basis for the finished model. Surface complexity is again an issue and sufficient results are often achieved using software default settings. Once the swept surface is created, it is critical to verify that the boundary curve does not extend beyond that surface. This inspection is simplified by projecting the boundary curve onto the swept surface.

The boundary curve is used as a feature to trim the unwanted portion of the swept surface and the result is a surface model of the top of the artifact. In most cases, the surface model can be extruded in a linear fashion to the thickness of the artifact. This thickness dimension is readily ascertained using standard methods of metrology.
In cases where the top and bottom surfaces are radically different the inner surface will have to be digitized using this same procedure. The procedure for this case is beyond the intent of this paper and will require a significant amount of effort in aligning the top and bottom swept surfaces prior to trimming with the boundary curve.

### III. Rendering Process

At this point that the part can be imported into digital rendering software to receive a raster image bitmapped texture. The importation will require a conversion from the NURBS surfaces created in the modeling application into polygon mesh networks. Polygon mesh networks are required for the standard shading algorithms found in rendering software. 3DS MAX 6, offered by discreet, is an appropriate choice of rendering applications. The raster image is simply an image taken by a digital camera while the artifact remains mounted in the fixture plate. Standard room lighting will suffice in most cases and the use of a flash should be avoided due to the close proximity between the camera and the object. The digital image can be stored in JPEG format with a minimum of compression; however a loss-less format such TIFF is preferred. It is crucial that the camera have a sufficient depth of field setting to maintain focus on curved surfaces and that the camera be positioned perpendicular to the fixture plate. These criteria will reduce distortion in the resultant image that will apparent to the viewer. Using an image editing application, the texture detail of the artifact can be separated from the rest of the image and placed within a ‘clean’ background.

![Figure 7. The surface trimmed and extruded.](image)

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![Figure 8. The surface texture image](image)

The next step is to map the image onto the polygon mesh object in the rendering software. The mapping parameters will require some adjustment in the UVW cropping and placement settings. This is a necessary compromise between model geometry and the planar nature of the bitmap image. Should the image and the model not align perfectly then you will have to make slight adjustments to achieve complete coverage. Once the bitmapped texture is in place, the complete model is ready for export into interactive multimedia software.

### IV. Interactive Multimedia

The goal of this project was to create interactive content for display in a web browser interface. In recent years, advances in Internet technology have emphasized
the increase in bandwidth and throughput necessary to support multimedia content on the web. Beginning with audio and then video streaming, Internet technology has progressed to the point where immersive environments are routinely supported by a growing community of online gaming. Specifically, online gaming that connects a personal computer to a file server which feeds a steady stream of video and audio data that constitutes a persistent, immersive world for the gaming experience. It is this gaming technology that is at the core of this project. Instead of an environment that is comprised of swords and sorcery, the environment contains a representative 3D model of a Native American artifact and that artifact can be manipulated using a computer mouse. Anark Studio, offered by Anark, is an interactive application that is based upon game technology and supports content creation with a minimal amount of scripting. The procedure for creating the content for the web is as simple as importing the model, with the textures, placing the model within an environment (simple black background), and assigning event behaviors. In the prototype I created, the model will tumble and rotate as the viewer clicks and moves the mouse. The installation of a content ‘player’ is required for both versions of the commonly used Internet browser and this player is offered free of charge from the software vendor.

V. Future directions

This paper described the processes used to create a prototypical delivery mechanism for a virtual teaching collection of ceramic pottery shards to support distant education in Native American culture studies. Initial reaction from colleagues teaching these courses has been favorable. In the near term work will continue to build the diversity of the teaching collection and emphasis will shift to the creation of tabular data to complete individual pages. One concern associated with this method of model creation is the need to probe the surface of the artifact with the hardened steel tip of the digitizer arm. Without meticulous care, the probe tip could damage the surface by scratching or chipping off bits of pigment and glaze. This drawback is more serious for complete pieces that could have exceptional collector value as works of art than for mundane collections of fragments. The logical next step is to explore non-contact scanning of the artifacts to gain both the polygon mesh and texture image simultaneously. The ShapeCAM suite, by Eyetronics, is an example of readily available technology that will serve this purpose. Additionally, non-contact scanning will allow data collection in situ. The collection of usable data for a virtual teaching collection without disturbing the artifact hold great appeal for archaeologists.

VI. References