Automated Classification of Stone Projectile Points in a Neural Network

E.S. Lohse

IdahoMuseum of Natural History, IdahoStateUniversity

Lohserne@isu.edu

C. Schou

Technology Innovation Center, Idaho State University

Schou@mentor.net

R. Schlader

Technology Innovation Center, Idaho State University

Schlrobe@isu.edu

D. Sammons

College of Education, Idaho State University

Sammdott@isu.edu

Abstract: We have built a working prototype for online classification of stone projectile points in a neural network. The initial application involves specimens drawn from the North American Pacific Northwest cultural area. The computing system environment for hardware is designed for I386 architecture. Software is coded in VB.net and C# for the DLLs. The current database design is not software specific; however, it requires a robust relational database server. The auto-classification system consists of three stages. Stage 1 is the classification system, with software that allows users to submit images of artifacts or actual specimens that are digitized by lab staff. Stage 1 generates projectile point classifications with specimens assigned to recognized types and is a .NET standalone application. Stage 2 consists of release of a typological descriptive report to system users, including a full image inventory of submitted and classified specimens with attached statistical probabilities of type assignment. Stage 3 is a web-based application hosted on the Technology Innovation Center system that serves as the educational system for public access and study. This paper presents the practical difficulties and successes encountered in automating stone projectile point classification in a neural network, which offers potential for development of a creative, thinking classification system and a rich, accessible, secure reference database.

Key words: neural networks, online classification, databases

Neural Networks and Archaeological Classification

Through training, this neural network (SIGGI-AACS) can replicate the actions of archaeological experts in identifying types. SIGGI implements a projectile point classification system developed by Lohse (1985) for the Columbia Plateau region of western North America. Samples to date include over three thousand specimens divided into eighteen basic types that have clear temporal and spatial significance.

SIGGI is unique in the archaeological community. Experiments with AI systems have been largely confined to rule-based forced classifications. Use of a sophisticated neural network that is trainable and capable of making novel intelligent decisions is a new and important approach to archaeological classification.

SIGGI-AACS is a working a prototype for online classification of stone projectile points in a neural network. Our initial application uses specimens drawn from the North American Pacific Northwest cultural area as exemplars but the system is extensible. The current database design is not software specific and was initially implemented using Microsoft Access. The autoclassification system consists of three interrelated stages. Stage 1 (in preparation) is the classification system, with software that allows users to submit images of artifacts or actual specimens that are digitized by lab staff. This stage generates projectile point classifications with specimens assigned to recognized types and is a .NET standalone application. Stage 2 (in planning and development) consists of release of a typological descriptive report to system users, including a full image inventory of submitted and classified specimens with attached statistical probabilities of type assignment. Stage 3 (in planning and development) is a web-based application hosted on the ISUTechnologyInformationCenter system that serves as the educational venue for public access and study.

SIGGI functions as a virtual analyst that, given some basic rules and concepts, is trained by introduction of new data sets. To improve its accuracy, SIGGI must be exposed to new and amplifying data fields. SIGGI is capable of accurately applying extant projectile point typologies; however, SIGGI can also identify outliers or unique data sets and suggest that these represent new types or that previous analysis identifying types needs modification within new explicit data ranges.

As with any student, we must be certain that the data we ask SIGGI to analyze is authenticated, and that we gather samples that are clearly representative of defined research populations. Because SIGGI learns by mimicking experts' decisions, behaviors, and explicit rules, and then creates new decision frameworks integral to the compilation of new data, SIGGI eventually may generate insights into decisions made by human analysts or by prehistoric makers.

The principle barrier to training SIGGI is the retrieval of collections that we can argue were produced at a specific point in time by cooperating social actors. A primary assumption in archaeological typologies is that the knappers or makers of the stone projectile points were operating within a very well defined cultural template or model that laid out clear expectations regarding what a particular projectile point form should look like. This working assumption, of course, is borne out in the clear temporal and spatial separation of populations of projectile points. Essential for training our virtual analyst is retrieval of sample populations that as nearly as possible represent these real time actors in the past.

For example, SIGGI needs projectile point samples found in large numbers on a single site, within a specific layer, in association with cultural features representing clear prehistoric human activity, and bracketed by good reliable radiocarbon dates. These samples supply our virtual analyst with numerous points made to a prehistoric standard, and reveal expected ranges of statistical variation in basic variables of form. This allows SIGGI to make intelligent decisions on where to draw lines demarcating the distinctive types of projectile points. SIGGI's ability to handle explicitly multiple variables in a multidimensional statistical environment promises insights into clarification and refinement of chronologies of prehistoric projectile point types, a result of considerable interest to the practicing archaeologist.

Archaeological Auto-Classification System Working as Virtual Analyst

The AACS Project initially focuses on obtaining authentic data to fill our database. By "authentic data," we mean information about projectile points from well-dated stratigraphic contexts. This allows us to produce a "clean" data set that reproduces exactly the classification published by Lohse (1985). Data collected are stored in an image database with attached descriptive fields.

SIGGI is in a sense, Lohse's virtual brain. Since SIGGI represents the thinking of only one archaeologist, we plan to go out into the general archaeological community to collect information about artifacts that help us to go beyond Lohse's original typology. At this point, we have demonstrated that SIGGI can "think" like Lohse. We want to expand and have SIGGI interact with other researchers' ideas, i.e. bring SIGGI an education from the larger community. This reflective activity is one of the more important aspects of the project. We know that certain kinds of things may be classified in innumerable ways; however, we need to identify WHY they should be classified in a certain way. By observing SIGGI make classifications, we improve our knowledge of why we make classifications the way we do.

Feeding SIGI:

SIGG

I's brain is an artificial neural network (ANN). An ANN is composed of a series of artificial neurons, or nodes, which are connected by a series of edges that possess an attribute known as a weight. The artificial neuron produced reflects the structure of a biological neuron (Buckland 2002). (Figure 1: An Artificial Neuron, modified from Buckland 2002: Figure 7.2; Figure 2: A Biological Neuron, modified from Buckland 2002: Figure 7.1).

Like a biological brain, the ANN is composed of the intelligent combination of artificial neurons and weights. A typical ANN consists of three layers: an input layer, a hidden layer, and an output layer. The input layer consists of a set of data items that the ANN acts upon. The output layer is the set of valid responses that the ANN produces. Our input layer consists of information pulled from an image of a projectile point, while the output layer consists of the information set and classification of that point. The hidden layer is simply an intermediate stage in the actual analysis where the data is manipulated.

(Figure 3: Diagram of Network).

Weights are set values used by the ANN to modify the inputs. The key to having an intelligent ANN is identifying proper combination of weights. Combination requires a two step process. The first step has each artificial neuron performing a summation of all the inputs modified by the weight of the path that the specific input took to reach the neuron. This summed value enters the second step or activation function.

The activation function is a mathematical equation that evaluates the summed value of the inputs to the neuron and decides whether the neuron will "Fire." The activation function calculates the value passed to the next stage of the process. Typically, there are two types of activation functions: a step function and a sigmoid function.

Step Function

The step function based percepton was one of the early attempts at developing neural networks. Researchers assumed that since the activation function of real neurons was a step function the neural net should do the same. The step function compares the summed inputs to a stored "activation value." If the sum is greater than or equal to the activation value, the neuron will pass a "1" through its outputs; otherwise it will pass a "0," which is effectively not firing.

Sigmoid Function

The sigmoid activation function, on the other hand, uses an equation to produce a value within a given range of values, rather than an all-or-nothing approach like the step function. An example of a typical sigmoid function is:

where *e* is a mathematical constant, *a* is the sum of the inputs to the neuron, and *p* is a number that controls the shape of the curve, which is typically "1." The function generates a value between "0" and "1." If the value of *p* is increased the system approaches a step function.

Once the activation of one layer is complete, the next layer performs the same calculations until the data reaches the output layer. In the output layer, the neurons pass the final values back to the program, and the process ends. These raw values may be further modified or may be used as they are, depending on what the ANN is directed to perform. In our case, we take the values; pass them through a normalization or softmax function, which produces a normalized distribution across the domain of the outputs.

This function takes the form of

$$Output =$$

This identifies a set of variables and establishes a set of statistical probabilities. The output of the ANN is the probability of inclusion in each projectile point type, rather than simply a set of activations of neurons.

Establishing the weights within the ANN is "training the network." There are two ways to train the ANN: supervised and unsupervised.

Unsupervised Training:

A typical unsupervised training utilizes another type of artificial intelligence system to monitor the values being generated by the training process. This other AI refines the training values so that the "correct" outputs are generated from the input set (Buckland 2002).

Back Propagation:

Another method of training an ANN, supervised training. We selected this method since it required implementing only one AI algorithm. A typical supervised training runs feedback from a set of pre-defined inputs that modifies the weights by a set value that is fed back into the network in reverse or back propagation (Buckland 2002). SIGGI uses supervised training and back propagation, like any elementary school student.

Back propagation feeds the data set through the network and calculates the error between the expected values and the actual values returned from the ANN. The error value is then fed through a set of equations at each layer in the network. The equation for that layer then modifies the weights that feed into each layer so that the next time that set of inputs is fed into the ANN, the ANN is more likely to produce the desired values. This process fits a line to the data set so that a predictive model is generated. In essence, the ANN is conducting a discriminant analysis.

The Process

Images are the input data. The steps the image undergoes are as follows:

1. Load an image.
2. Convert the image to a grayscale image.
3. Produce a black and white bitmap of the grayscale image.
4. Find the background of the image.
5. Smooth the image to remove edge distortions.
6. Generate a rough set of outlines.
7. Find the largest object in the image.
8. Remove all outlines on the image but the outline of the largest object.

The outline is input to the tokenizer, which produces a set of tokens from the outline. Tokens are generated by starting at the center top of the outline and reducing the outline to a series of line segments. The line segments are then converted from a set of pairs of end points into a distance and direction from the start point of each pair to the endpoint of that pair. These distances and directions are packaged into a vector, and these vectors are the tokens for input to the ANN. This abstraction of the outline preserves enough of the variation in the object that the original outline is still discernable.

(Figure 4: Generation of Inputs for SIGGI).

The accuracy of the system is dependant on the number of tokens generated. We sought to use a minimum number of tokens, such as the eighteen line segments generated for the original discriminant analysis in Lohse (1985). That number of tokens was not sufficient for full description of form. For the final version of the software, we determined that 100 tokens provide sufficient resolution to separate the different types.

SIGGI's Memory: The Database

The accuracy of identification and subsequent classification provided by SIGGI depends on large knowledge base. The SIGGI database performs several functions that influence both the performance of SIGGI and sharing of data among researches in diverse disciplines and locations. At a minimum, the requirements are that it be able to (1) store images; (2) store locations, (3) store characteristics, (4) store provenience and (5) keep private things private.

Beyond these five basic functions, SIGGI also allows for improved research collaboration. Currently, each researcher has his own island of information. Using the underlying SIGGI-AACS research database, many researchers can maintain information about many collections on-line. Each researcher may maintain complete ownership of access to his own material. This allows research bridges to be built while maintaining the unique identity of each research collection. When fully implemented, the system can maintain collections of many types and provide neural network analytic services where appropriate.

(Figure 5: Multiple Users).

SIGGI relies on a relational database. A relational database system is an application of mathematical set theory to the problem organizing data. In a relational database, data are collected into tables. When properly implemented, no duplicate data elements exist, that SIGGI must update. Related pieces of data are grouped together in a single data structure; relationships can be defined between these structures and records.

A table represents some class of objects that are important to SIGGI. For example, SIGGI has with a table for objects, another table for locations, another for images, and another for access. Each table is composed of columns (attributes) and rows (tuples). Each column represents some attribute of the object represented by the table. For example, an Objects table would have columns for attributes such as size, weight, material, identification number, current location, etc. Each row represents an instance of the object represented by the table. For example, one row in the Object table represents the object that has identification number (ID) 10116. This ID can link together data for original location and the access information.

TYPE	CULTURALPHASE	TIMEUNIT
TypeID	ID	ID
TypeNAME	Name	FromDate
TypePhase	Description	ToDate
TypeRegion	TimeUnit	AbsoluteDate
TypeShape	Deleted	AbsoluteRange

TypeOutline Deleted LastModified	Date Created LastModified	Deleted LastModified

Table 1: Sample Database Tables.

The tables are linked using the keys among the tables. All the relationships are then managed using the rules described later. (Figure 6: Prototype File Structure).

Information Assurance

In North America, there are government requirements that require that certain data contained in an archeological database be protected from disclosure. The principle used to keep private things private is Information Assurance. Information assurance is more than just security. It is a complex blend of confidentiality, availability, and integrity.

Confidentiality is "the assurance that information is not disclosed to unauthorized persons, processes or devices" (Maconachy and Schou 2001). The application of this security service implies information labeling and need-to-know imperatives are aspects of the system security policy.

Availability is the timely, reliable access to services for authorized users. Often, this service is viewed as a function, which is not entirely security, related. Availability is a function of information system operations such as back-up power, spare data channels, off site capabilities, and continuous signal (Maconachy and Schou 2001). Should the SIGGI system be unavailable when researchers or other users need to use it, its utility is minimized.

Integrity is "the quality of an information system reflecting logical correctness and reliability of an operating system; the logical completeness of the hardware and software implementing the protection mechanisms; and the consistency of the data structures and occurrence of the stored data" (Maconachy and Schou 2001). If we are to rely on SIGGI-AACS, the data contained in it and used in the identification process must be of the highest integrity. (Figure 7: Information Assurance Components).

Identification and Authentication:

In order to assure the information in the system, one must control access to the system using a two-step process. The first of these is Identification. This establishes who the user is (user name) and the second is authentication, which proves to the system that you are who you represent yourself to be. Authentication is based on something you have, something you are or something you know. This type of security discretionary access control (DAC) provides minimal assurance of the information in a system.

In addition, the system will use mandatory access control (MAC) systems implemented in the system. Using MAC, one ensures that the data can be (1) created only by authorized individuals; (2) modified only by authorized individuals; and (3) accessed only by authorized individuals. Access to the access controls is only through the operating system's reference monitor.

Data Ownership:

Each participant will be able to establish the access rights to each table in the database. For example, the data can be designated as research, private and public. With in each of these general categories, the owner will be able to allow access to universities, industry, government, Native Americans, and educational institutions. For example, the owner could give one individual access to fields designated as research if and only if they were also Native American and part of an academic institution.

SIGGI Can Work With Others: User Interfaces

A crucial aspect of the SIGGI-AACS project is how users will access and input information. Internet access for users has already been determined to be the most expedient method for acquiring and disseminating data about the projectile points in the database. However, the exact look, feel, and mechanics of that web site have not been determined. A preliminary web page has been developed and serves the current purposes of the AACS programmers and designers. The next part of the design will require interfaces for specific user groups. (Figure 8: Sample User Interface).

The SIGGI-AACS project has provisionally identified four major user groups: government agencies, researchers, Native Americans, and the general public. While some of the functions will be common to all four groups, some groups have very specific interests and agenda for the information contained in the AACS.

Government Agencies:

A primary user of the AACS will be federal and state land-management agencies (e.g., USDA Forest Service, USDI Bureau of Land Management, and National Park Service). Agency users certainly will be interested in the automated typology made possible by SIGGI's neural network. Three major tasks will be associated with these government agencies:

1. The agencies will request that SIGGI-AACS analyze projectile points recovered during mitigation projects or held in their collections, and assign those points to the appropriate types.
2. The agencies will request that SIGGI-AACS store data about the projectile points which the agencies hold or have recovered, and that this data be stored securely and not released to unauthorized users.
3. The agencies will request that SIGGI-AACS produce summative information about the temporal and spatial distribution of the points and point types in the AACS database.

For Task 1, the web site must contain appropriate interfaces to allow the agency (or a SIGGI-AACS staff member) to enter an image of the projectile point for automatic type assignment. This site must allow the user to progress through the different stages of image acquisition, manipulation, and analysis. At each point in this image manipulation process, the user must be able to check the image and authorize its movement to the next stage. Once the image is entered, SIGGI analyzes it and returns the appropriate typological assignment. At the same time (and out of the user's view), SIGGI encodes the relevant data points (size and shape indicators), and file the data points, image, and typological, locational, and temporal information into the SIGGI-AACS database.

For Task 2, the agency user must be able to access information which is already in the database and for which that agency has statutory responsibility. In this case, the web site must provide an interface by which the government agency can request images, specimen or inventory numbers, counts, chronologies, charts, graphs, or maps displaying information about specific projectile points.

For Task 3, the web site must provide interfaces by which the government agency can request similar, but summative, information for projectile points not within their statutory responsibility. For example, in Task 2, a federal agency could get a detailed map showing exact locations of Type X projectile points on that agency's land; in Task 3, the federal agency could get a generalized map showing the distribution boundaries of all points of Type X within the Columbia Plateau.

Researchers:

The second user group accessing SIGGI-AACS will be academic or contracting archaeologists. These users will also be interested in the automatic typology made possible by SIGGI's neural network, but will also need to be able to access information from the database for specific projectile points, including images but possibility excluding locational data. Four major tasks will be associated with archaeological researchers.

1. Researchers will request that SIGGI-AACS analyze projectile points recovered during research or contract excavations and surveys, and assign those points to the appropriate types.
2. Researchers will request that SIGGI-AACS store data about the projectile points which they have recovered, and that this data be stored securely and not released to unauthorized users.
3. Researchers will request that SIGGI-AACS produce summative information about the temporal and spatial distribution of the points and point types in the AACS database.
4. Researchers will request that SIGGI-AACS provide images and descriptive information about specific projectile points from the database.

For Tasks 1-3, the web interface will be the same as that set for government agencies. These interfaces must allow the user to submit images of projectile points for processing into SIGGI's neural network, allow the user to access the data for those projectile points, and allow the user to request maps, charts, graphs, and summative data about projectile point types.

For Task 4, the interface must also allow the user to request information about specific projectile point (s). For example, a researcher may request images of points from the type site or of a recent find. Providing this type of specific information to archaeologists advances the resolution of study, adding chronology, spatial distribution, functional studies, or symbolic studies. However, locational information would be excepted: academic or contract archaeologists cannot be given exact locations for artifacts without permission from the federal, state, or tribal landowner.

Native American Tribes.

A third user group consists of recognized Native American tribes and First Nations in the United States and Canada. On the Columbia Plateau alone, there are 19 recognized tribal groups (Walker 1998). Native American tribes have a unique interest in the types and distribution of projectile points. SIGGI-AACS, with its chronological and spatial data, may have profound implications regarding cultural affinity issues, and tribes may be interested in this information for both heritage and legal reasons. Tribes may be able to use the data stored in SIGGI-AACS to argue for traditional use of land or rivers not currently within the tribes' legally recognized authority. In addition, the tribes may wish to use the projectile point database as a mechanism for storing cultural heritage information and to provide that information in educational contexts (tribal museums, schools, etc). Finally, Native American tribes will have an interest in the security of the database, that the locations of these projectile points (which might imply the existence of a protected archaeological site) be kept confidential. Federal law requires that locations of archaeological sites which are on federal or state lands, or which have been discovered through federally- or state-funded projects, not be made available to the general public. Given these concerns, we envision the following tasks required by Native American users.

1. Native American tribes will request that SIGGI-AACS analyze projectile points recovered through tribal projects, and assign those points to the appropriate types.
2. Native American tribes will request that SIIGI-AACS store data about the projectile points recovered through tribal projects, and that this data be stored securely and not released to unauthorized users.
3. Native American tribes will request that SIGGI-AACS produce summative information about the temporal and spatial distribution of the points and point types in the AACS database.
4. Native American tribes may request that SIGGI-AACS provide images and descriptive information about specific projectile points from the database.
5. Native American tribes will request that SIGGI-AACS not release locational or other sensitive information about the projectile points in the database.

Incorporating the interests of Native American tribal users need not necessarily require any additional interfaces on the web site beyond those already described. However, additional text or a different screen design to address specific tribal concerns may be appropriate.

General Public:

The fourth major user envisioned for AACS are members of the public who will seek out the site for personal information or formal education. These users will ask such questions as, "I found a point. What type is it?" "Where are these points found?" and "How old is it?" Such users may also be interested in images of projectiles in the database, perhaps to compare with a point in their own possession or to copy into a school report. AACS must also be prepared to provide these users with access to real data about projectile point measurements, material, and other non-locational information. These users will make the following demands on the AACS:

1. Educational users will request summative spatial and temporal information about projectile points in a given cultural area.
2. Educational users will want to download quality images of type specimens.
3. Educational users will want to be able to type projectile points in their possession or that they have seen, but without subscribing to the AACS service.
4. Educational users will want to access statistical information about projectile points for class exercises and research projects.

As with the Native American users, the web interface for the general public will not require major modifications from the original. However, the web page design may need modification to be more user-friendly and less intimidating while at the same time providing the knowledgeable user access to real information. The web page design will seek to minimize jargon and utilize multiple modes of access (menus, icons, and hypertext). Table 2 shows the classes of users and type of access they will have to the contents of the AACS database and the overall SIGGI-AACS process. Based on the type of functions shown in Table 2, users will be able to request information in several forms.

User Type	Type Assignment	Store & Return Information	Summative Chronological	Summative Spatial	Images	Education Links
Government	X	X	X	X	X	
Researcher	X	X	X	X	X	
Native American	X	X	X	X	X	X
Public			X	X	X	X

Table 2. Defined User Groups Aligned with Probable AACS Functions

Conclusions

To improve, SIGGI must experience new and amplifying data sets. SIGGI is capable of accurately applying extant projectile point typologies, but SIGGI can also change prior classifications given new population samples that change data ranges. SIGGI can also identify outliers or unique data sets and suggest that these represent new types or that prior types need modification within new explicit data ranges. As with any student, we must be certain that the data we ask SIGGI to analyze is authenticated, and that we gather samples that are clearly representative of defined research populations.

Federal and State agencies, university researchers and contracting professionals, and Native Americans are interested in having SIGGI produce standard, explicit, defensible type assignments that can be used in basic descriptive archaeological research and reporting. But SIGGI is capable of far more, and anthropologists, educators and psychologists, will observe SIGGI making decisions as part of basic research into understanding how human actors think as part of problem-solving in the manufacture of items to solve practical restraints. Researchers interested in unraveling the evolutionary changes in the human mind over the course of human evolution will find SIGGI of merit.

SIGGI's work will prove valuable in

1. exploring the statistical validity of stone projectile point types and
2. examining the logical decision making structures of analysts. Neural networks are unique in that they will learn, making new decisions and distinctions based on inclusion of new data.

The principle hurdle in training SIGGI at this juncture is to assess its abilities in archaeological classification by comparing its decision-making to that of archaeological experts. We have assessed SIGGI's ability to mirror accurately the classification system of Lohse (1985) as quite high. We would now like to expose SIGGI to an intense workshop environment with other recognized experts in the Columbia Plateau archaeological community. We need to assess SIGGI's work in a peer-reviewed environment, just as we would any other real time archaeological analyst.

Our agent is trained to accurately reflect the thinking of archaeological typologists. SIGGI produces

(1) valid types in an automated online environment,
(2) a confidential validated database that preserves information as images and as text fields, and
(3) provides insights into how analysts think.

Since SIGGI learns, analysis of how SIGGI makes decisions and manipulates data can lead to new insights regarding redefinition of types and definition of new types, and may well revise how archaeologists consider doing typology. Input of the archaeologists interacting with SIGGI will be instantly included in the data being considered and will be reflected in types assigned and their evaluation. SIGGI will be able to correspond with these archaeological consultants in real time, responding to their inquiries and helping to enhance the operation of their own classification systems. Insights and contributions will be immediate and compelling.

This project operates on multiple levels, from development of an explicit statistically based online classification system with attached database, to use of an electronic or virtual agent to augment archaeological training in classification, to observation of an artificial agent to study the character and effectiveness of archaeological thinking. Anthropologists and archaeologists are beginning to join cognitive psychologists and learning theorists in the use of artificial intelligence systems to explore human thought and behavior (e.g., Baylor 2002; Conte and Castelfranchi 1995; Cumming 1998; Doran various; Epstein and Axtell 1996; Gonzalez and DesJardins 2002; Russell and Norvig 1995; Woolridge and Jennings 1998; Woolridge, Muller and Tambe 1996).

Although others have used neural networks and primitive perceptons, SIGGI is an innovative approach in archaeological classification. SIGGI is extensible, and in the future, can be adapted to identifying stone projectile points across the North American continent or elsewhere in the world. As a shape recognition system, SIGGI can to classify or organize any image data that can be rendered in a digital environment. A central key issue at this point is authenticating SIGGI's efforts within the archaeological community. The workshop proposed here offers that peer review and allows intensive, expanded training for SIGGI. We hope to develop an explicit curriculum and protocol that will continue to be adapted to making the SIGGI-AACS system extensible.

There are several obvious productive spin-offs from this research. Training of an online neural classification system capable of accurately identifying stone projectile points to accepted types with attached statistical probabilities of group membership (SIGGI in this sense constitutes a highly interactive user interface sitting atop a secure database); Creation of a typology workshop bringing together prominent archaeologists from the Columbia Plateau cultural area (SIGGI here is the virtual student and teacher for workshop participants).

Further development of an artificial intelligence system that can be observed making analytical decisions under a range of accepted archaeological classificatory frameworks.

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A team of collaborators with very different areas of expertise has developed this project. Dr. Skip Lohse, Professor, Department of Anthropology, Idaho State University, and Curator of Anthropology, Idaho Museum of Natural History, has developed an accepted, explicit classification system for the Columbia Plateau, and working with Dr. Corey Schou has spearheaded development of SIGGI-AACS (Lohse, Schlader and Schou 2003; Lohse, Schou, Schlader and Sammons 2003). Dr. Schou, Professor and Associate Dean of the College of Business, IdahoStateUniversity, and director of the Center for Decision Support and the Simplot Decision Support Center (SDSC) and the National Information Assurance Training and Education Center (NIATEC), has applied his considerable computer resources to making SIGGI a workable prototype.

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Figures

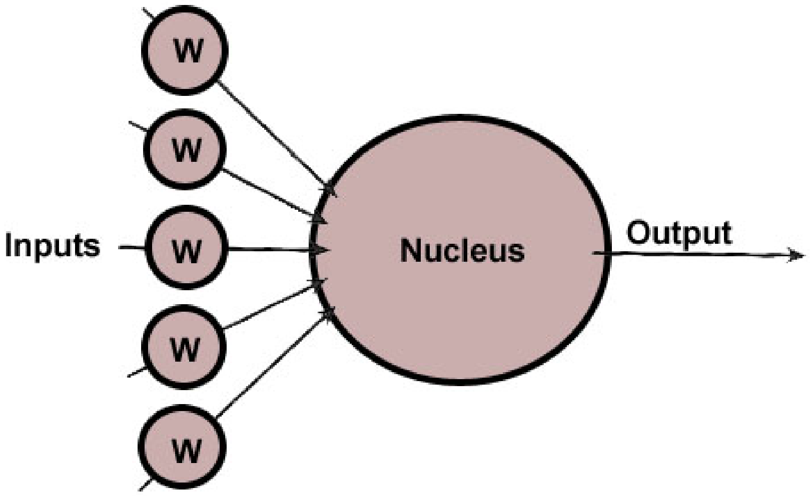

Figure 1 . Artificial Neuron (modified from Buckland 2002: Fig. 7.2) >>back

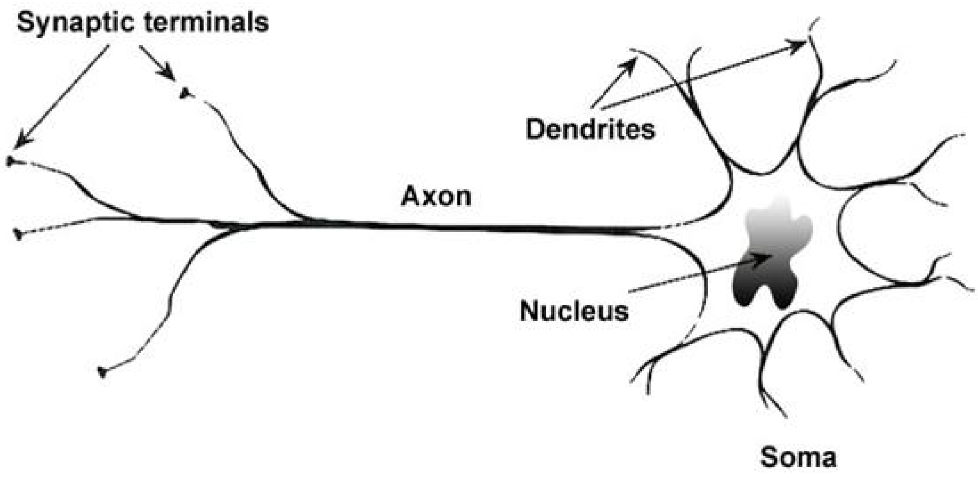

Figure 2 . Biological Neuron (modified from Buckland 2002: Fig. 7.1) >>back

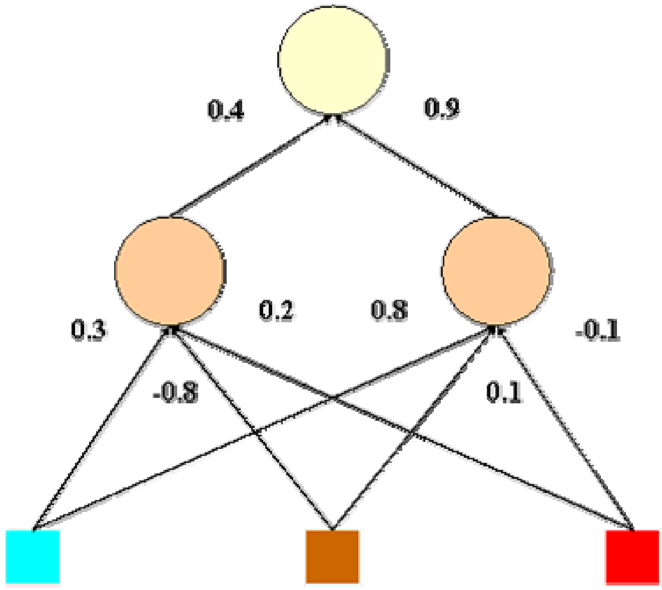

Figure 3 . Diagram of a Network >>back

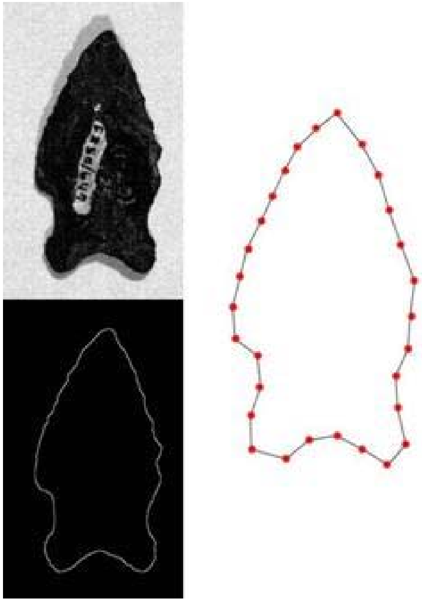

Figure 4 .Generation of Inputs for SIGGI. >>back

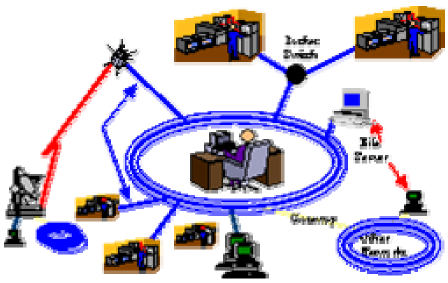

Figure 5 .Multiple Users. >>back

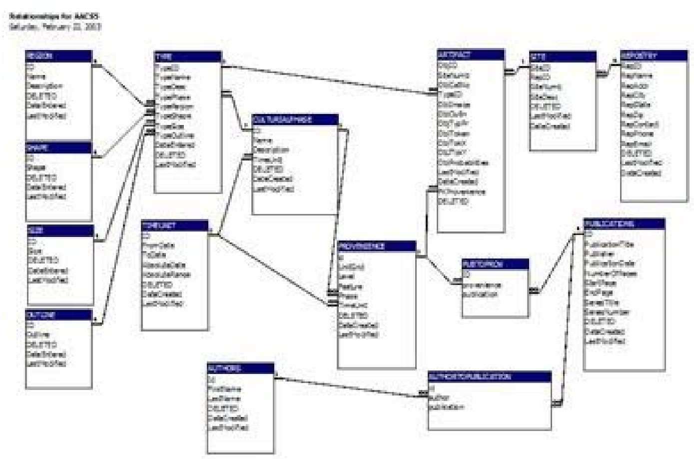

Figure 6 . Prototype File Structure >>back

Figure 7 . Information Assurance Components >>back

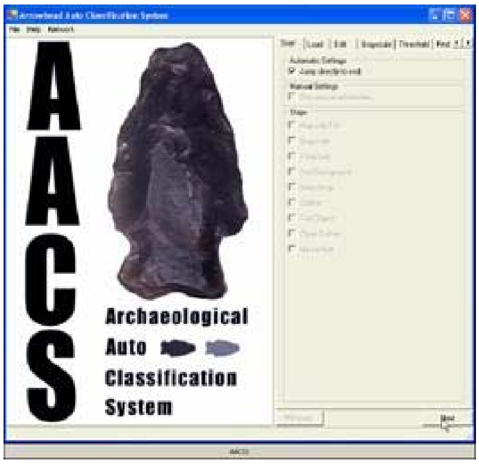

Figure 8 .Sample User Interface >>back