THE UNIVERSITY OF MICHIGAN VISIBLE HUMAN PROJECT (UMVHP)
QUARTERLY PROGRESS REPORT: Y2Q3

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U-M NGIVH PHASE TWO CONTRACT

Y2Q3 REPORT, KNOWLEDGE ENGINEERING TEAM

September 25, 2001

ACCOMPLISHMENTS OF THE QUARTER JUST ENDED

The principal accomplishments of the quarter just ended were as follows.

1. Completion of the EWSH surface display module

An interim version of EWSH3.2.8 has been released for use within the project, as demonstrated at the quarterly meeting earlier this month. The new version incorporates full functionality for surfaces within the EWSH object environment. Multiple surfaces can be rendered in different colors in the left (3D) window, where they interact with the three reference coordinate planes, with the moving sectioning plane, and with one another under full user point-of-view control. Any combination of surfaces can be active in this display. Simultaneously in the righthand (section) window, the same surfaces appear as they are sectioned by the section plane. The section of a surface by the EWSH sectioning engine is a discretely sampled polygon that moves precisely under the usual user or filmstrip positioning control already applying to the volume section; the result in either control mode is to render one or more contours tracking one or more moving edges within the moving RGB section window. Furthermore, in that window a surface may appear simultaneously in two different coordinate systems, one native and one warped by a thin-plate spline driven by a landmark configuration observed in two different forms. In this way, a surface model can be migrated from one form to another, and the adequacy of its fit to color gradients inspected.

2. A second filmstrip style: the ridge curve

Filmstrips supplied during previous quarters of this grant have been in the style referred to in the original contract proposal as "curve tracing," sequences of the centerline of the pencil of sections which follows the middle of a generalized tube in Eve. During the Y2Q3 quarter we established EWSH's capabilities with respect to a second filmstrip style, the "ridge curve." A ridge curve is the integral trajectory of the lesser principal curvature directions of a surface at the

submanifold of local extrema of the complementary greater principal curvature. In EWSH, such a curve is initialized by aligning the principal axes of the surface's Dupin indicatrix (the outline in paratangential section, close to an ellipse or hyperbola) with the horizontal crosshair, then translating within the corresponding normal section until the curve lies atop the sharp vertex that characterizes the curves. The curve is thereafter traced by stepping along the long axis of the indicatrix by a convenient increment and repeating this alignment strategy. A demonstration filmstrip has been constructed that follows Eve's mandibular border from the mental symphysis up to left the condylar head, a boundary that is particularly easy to see in the raw images. A more realistic test of this mode, tracing the bottom of the pouch of Douglas, is set for the next quarter of the contract.

3. Preliminary ascertainment of one landmark set for application testbeds

In collaboration with Deborah Walker of the UIT component of this grant, we have located the standard five landmarks of obstetrical pelvimetry (posterior symphysis, coccyx, left and right ischial spines, sacral promontory) on Eve. Landmark location was helped greatly by reference to the existing surface models, but none of the five points actually lay on any of the currently available surfaces. An adjustment of the surface mesh facility (PSC) is envisioned where discrete landmark points and selected curves will constrain surface meshes to include them.

4. Loading of another specimen into EWSH

We have successfully loaded a second specimen into EWSH, the female pelvis Lucy2.0 from Stanford. The image volume was resampled to 16 megabytes of RGB, which fits into the main memory of our workstations and thus does not require a server implementation. Experiments with the warping module of EWSH (see para. 1 above) indicated that the precision of this Lucy2.0 volume is insufficient to drive an accurate specification of corresponding landmark points between it and Eve, the data resource on which the surfaces will be compiled. Further experiments with Lucy2.0, including the warping of Eve's pelvic surfaces onto Lucy2.0 will thus await restoration of the full in-plane precision of this data set, which will require its own server implementation parallel to that of Eve.

PLANS FOR QUARTERS Y2Q4 and Y3Q1

1. EVALUATION

Completion of the surface rendering facility this quarter, along with the filmstrip traverse (Y2Q1), makes EWSH relevant, at last, to the actual context of anatomical education. In a few weeks we will begin the long-awaited interaction between our group and the Anatomy Testbed Evaluation Team. To this end, as reviewed under the UIT quarterly report in this document, we have (1) selected a specific pedagogic unit of the M1 gross anatomy course for complementation, namely, the Urinary Bladder, (2) selected a short list of Curve Traverse features that EWSH will be expected to supply complementing the text and table presentations of the existing syllabus, and (3) sketched a desktop protocol by which the student can navigate among the different software products pertinent to this task, specifically, the Pittsburgh Volume Browser (PSC), the Lexical Database, and the Edgewarp Animated Viewer. Separately, we are preparing an additional unit, obstetrical pelvimetry, based on Eve's pelvic landmarks and pelvic bony surfaces, to test with groups studying obstetrics and obstetrical nursing.

2. LABELS

Before the end of Y2Q4 we expect to release a version of EWSH that handles labels for filmstrips. This implementation, which is substantially independent of other efforts elsewhere in the project that apply to the PSC and the Ade JAVA browsers, will emphasize the dynamics of the label as the filmstrip player proceeds through a pre-edited sequence of frames, along with corresponding tools for the higher-level EWSH user who is creating that sequence. By the annual meeting we expect to have an assortment of these augmented filmstrips available for critique by Prof. Smith and the other members of the UIT team. Information about labels will be incorporated in the same savefile that currently serves to set the geometry of the filmstrip, and the labels will be created and edited in an extension of the EWSH dialog box that currently supports editing of filmstrip geometry.

3. A COMMON SAVEFILE FORMAT

Likewise during the next quarter, we will freeze the EWSH savefile format in a slightly extended version that specifies full window contents on both sides. The extensions, which are minor, include the active surface list (contents of the surface dialog box), the left-side view geometry, and the label manager that will

work with filmstrips. The PSC group has agreed to work within this same format, writing out appropriate fields when screen states are to be transferred between browsers and ignoring any fields that are pertinent to EWSH but not to the PSC domain.

4. TOWARD EWSH3.3

In our last quarterly report, we listed five directions of EWSH development that are most pressing at this point in the contract. Of these five, incorporation of surface traverses by ridge curve has been prototyped, as noted above, and expedited invocation has been incorporated in the evaluation testbeds combining EWSH with the PSC browser and currently slated for rollout early in October.

i. Over the coming quarter, PSC will begin serving chads in compressed form. The EWSH kernel will be modified to accept these in either lossy or lossless versions, with appropriate user control. Image quality with compression appears undetectably altered, and we expect this to be the normal setting for everything except final "filmstrip production" runs. The net effect of compression will be to speed up the tie with the server by a substantial factor and thus to permit a classroom of students on wireless laptops to browse Eve over the same server bandwidth presently required for the single user.

ii. One general goal of this project is the incorporation of additional generalized spectra in Eve's "volume" beyond the familiar three eight-bit channels of color. Production of a 48-bit data resource that adds MR and CT contents to RGB is dealt with elsewhere in this progress report. A second augmentation, currently prototyped by a subordinate server at PSC, would provide a lookup capability linking every single voxel of Eve to one or more of thousands of associated text strings. The geometric preimages of these lexical entries will in some cases be regions of voxels and in other cases two-dimensional surfaces, one-dimensional curves, or discrete points. Entries that are themselves dynamically renderable (curves or surfaces) will be linked to the corresponding Edgewarp filmstrips. Back in the Edgewarp windows, a subset of these links may be active in the geometry windows in the form of abbreviations that serve analogously to labels in textbook illustrations (but move with the geometry); by this means the user can pass, for instance, from an interesting-looking chunk of tissue in a section to the database entry for the structure sectioned there and immediately, through another invocation of Edgewarp, to a filmstrip for the pedagogically more relevant view of this same novel structure. EWSH3.3.x will

incorporate user control of the byte(s) intended for display from these or similar multispectral resources and activation of the hot links when appropriate.

iii. Now that EWSH renders surfaces well, it is appropriate to proceed with the design and testing of modified widget sets for nonexpert users. In the coming quarter a group led by A. Ade will be exploring such simplified GUI's, which will probably combine the minimal functionality of the filmstrip player for sequences with the subset of main EWSH buttons sharing the functionality of the PSC browser's navigation dialog box (motion of the sectioning plane). A future release of EWSH will involve flexible initialization of the GUI at the time of program activation.

UIT/ANATOMY/NURSING TEAMS

YEAR2 QUARTER3 REPORT

Anatomy

Hand segmentation of the thorax and addition of detail to the pelvic structures continues. For the thorax and pelvis, certain minute features (e.g., the intercostal vessels and nerves, gluteal / uterine vessels) may require placement via a combination of surface generation from landmark points and curves and artist renderings. This schema is presently being explored.

Nursing

Development of a module for nursing students with deployment expected in December has begun. This will be ob/gyn centered. Use of standard pelvimetry landmark descriptions will be emphasized.

UIT

Goal: Creation of Visible Human Anatomical Map Kiosk
Current status: In process. Elements of the kiosk have proven challenging in terms of time and effort.

The software to support the Kiosk will consist of these elements: a www server, a www browser, a database of labels and the query interface to that db, the PSC Volume Browser (PSCVB), and the "glue-ware" necessary to hold this all together. Placement of the Edgewarp browser into the kiosk format will occur when it is ported to Mac OS X and/or Windows. Streaming video of Edgewarp 'filmstrips" will be available in the database to emulate its presence.

The various flows of control will be:

1) standard www browsing (links on the www browser fetch pages on the www browser)
2) "standard" vh browsing through the PSCVB interactive interface
3) label query in the PSVB: The user clicks on a point in the VH and gets a display of the related label (with a "context" set earlier that determines the "language" of the label)
3) links on the www browser activate scripts in the www server that send "position" information to the PSCVB (and a HTML page back to the www browser)
4) links on the www browser activate scripts in the www server that send "model display requests" to the PSCVB

There is a long-range plan to perform all the communication between the browser(s) and the www server through a standard "save file" format. This will not be available in time for the October kiosk rollout. PSC is setting up a "rapid prototype" approach that will use the same type of interface (a channel to glue-ware) describing the "language" for the "position" type requests, and "model display requests". This new feature is described below.

Model Display Requests (Request to activate model parts)

The set of models is organized to relate to some portion of the set of structural labels in the database, and each model in the set of models has a unique ID that is permanent and persistent (a "primary key"). We would like the ability to make requests to the PSCVB in the form:

show/hide model <id>

If the model corresponding to <id> is loaded it will be activated accordingly. The software on the www server is responsible for "knowing" what models are loaded and which models to turn on in the case that the "object" being viewed is composed of multiple models (that is, the script making the requests understands the point of view, the structural relations of the models, and the necessary grouping for objects, like the pelvic structures, that will consist of a grouping of multiple models).

The Challenges: One of the PSC programmers' availability was discovered to have been reduced to 50%. This directly impacted development of the necessary language to institute a dialogue between the Anatomical Index and the PSC Volume Browser. In addition, the kiosk required AppleScripting, development of html, graphic design, and trouble-shooting on the Mac OS X platform. Survey questions and log access results (Note: log access results are required from the database server, the PSC Browser server, the model server, and the web server) are being discussed within the Educational group of the UIT.

All work is on-going. By early October, testing will begin on the middleware necessary for dialogue between the Anatomical Index and the PSCVB. The beta site consisting of html and static images have been posted to http://141.214.52.178/kiosk/index.html.

Testing has shown good stability of the previous version of the PSCVB in conjunction with the Internet browser, Explorer. Additional tests are being conducted with the beta browser, iCab, which provides a pre-packaged kiosk mode. Use of AppleScripting is intended to prevent movement outside of the kiosk environment, and necessary modifications to the kiosk Macintosh should be in place by mid-October.

PITTSBURGH SUPERCOMPUTING CENTER
VISIBLE HUMAN SUBCONTRACT STATUS REPORT
YEAR 2, QUARTER 3

1) Description of progress towards completion of quarterly milestones & deliverables:

The largest effort during this quarter has been the continuation of mesh model building, development of the PSC Volume Browser (PSCVB), and improvements to server facilities and networking.

Mesh construction has continued and now covers all of the pelvic regions that have been marked up as manual guide contours. Most of these objects have been enhanced by additional computed segmentation but there are still some areas where this is difficult. The pancreas, for example, does not yield to current techniques and has to be manually contoured. Additional modifications to the mesh construction process have reduced, and in most cases eliminated, the artifacts that were seen in regions of sharp curvature. Existing guide contours are being reprocessed with the new techniques to build improved accuracy surfaces models.

The same volume identification data used to produce mesh models has also been used to produce a voxel identity server. This service translates 3D coordinate positions into an identifying number coresponding to the segmented volume. In most cases this is a direct mapping to the name of the smallest enclosing object. The anatomy database, being constructed at Michigan, provides the actual name of the object in either of the supported naming systems based on the object id number. In some cases there are several object names or portions of object which need to be identified. In those situations the anatomy database is being extended to resolve the names by using an intermediate virtual object.

The Beta testing release of the Insight Segmentation and Registration Toolkit (ITK) was provided by Bill Lorensen's group during the final weeks of the quarter. We are currently running the various test sets to determine which components will be useful for improving the quality of our results, streamlining workflow or which can be directly integrated into user accessible tools such as the PSC Browser. It is too early to have any substantial results in this determination but it is clear that the toolkit is extensive and complex so it will take several months to properly evaluate.

Extension of the PSCVB has been driven by feedback from the anatomy markup users, the UIT members and support needed by the overall system development plan. Improvements were made to the segmentation tools to allow more rapid manual markup for guiding surface mesh construction. A number of features have been added or modified to support the planned student user evaluation tests being organized by the UIT team and operated from a Macintosh G3 user kiosk at Michigan. Some of these changes provide for display of colored model surfaces, access to the anatomy database at Michigan and display of object labels with pointer lines. Additional hooks have been implemented to allow external programs to reset the browser state and remotely control its operation. These same hooks are being extended to provide a collaborative teaching mode which will be functioning during the next quarter. Additional improvements will replace the current widget control set with a new menu driven interface to eliminate the separate floating control panels.

A great deal of further PSC work is in progress but not yet released for regular use. Some of this work is proceeding in synchrony with server development. This includes the capability for data set switching and support for gray scale data sets such as CT & MRI. We are implementing a server driven data set description format which uses the data set switching capability so that all of the data set characteristics are described external to the browsers with no remaining compiled-in parameters. This is currently working to the extent that we are able to switch between RGB and a reduced CT data set with no memory leaks that would eventually lead to a system lockup. Additional work is underway to provide this capacity with compressed data and particularly selectable compression levels.

Improvements to the various server codes and network connectivity have been continuing. The current system consists of four server programs to operate concurrently with user interface codes.

The primary volume server, vh.PSC.edu, continues to operate from the ES-40 at the PSC machine room and has been running nonstop without error for 145 days as of this writing. We will be rebooting that machine at a convenient time during the next few weeks to install the latest Web-100 auto tuning kernel. That kernel has been tested and installed on a number of other machines at PSC and elsewhere for the testing and debugging phase. Besides improved network behavior this kernel upgrade provides improved memory utilization in multiprocessor environments such as the ES-40. We have also adapted the volume server code to run on the new IA-64 architecture and have successfully

operated this code on a test machine at PSC. Further work is underway to run a version of the server on the 64 bit Sun UltraSparc. All of these are completely interchangeable in supporting both Edgewarp and PSCVB. We have also implemented and tested the initial version of a "hop server" which provides decompression for Edgewarp support until a stabilized decompression code can be directly compiled into the Edgewarp code.

The other three servers in the system are the anatomy database server at Michigan, the mesh model server at PSC and the voxel identity server also at PSC. Both the anatomy and mesh servers operate using http as the protocol. The voxel identity server, which translates xyz coordinates into object identification numbers, has to run at higher speeds and uses a custom streamlined protocol.

A number of the planned PSC network connectivity improvements associated with the TCS project have now been completed. As that machine moves from the initial test phase to regular use during the next 60 days the rest of the network upgrades will be finished. This may require one or two days of down time which will be scheduled to avoid any critical demos.

During the quarter PSC also supported and participated in several UMVH project demonstrations including the August Telemedicine Symposium at Michigan.

2) Problems encountered during this quarter:

Time conflicts between the long-term development goals and the short term demands of demonstrations and ongoing model building continue to be a problem. In many cases this results in labor intensive and repeated manual or semi automated short term solutions which delays the intended solution and streamlining of the task.
Use of the current public domain widget set continues to be a problem as it is now performing functions for which it was not well designed. There is a system lockup problem when running PSC VB on certain versions of Apple G4 based systems.

3) Resolution of problems:

We have discussed the time difficulties during the quarterly meeting and believe the overall project team now has a better appreciation of the problem and the need to maintain adequate time for proper development. The widget set problem is being addressed by development of replacement controls for PSC VB which will

be released during the coming quarter. We have borrowed a Mac G4 system to help us identify and fix the remaining problem in that environment.

4) Goals for the next quarter & action plan for their completion:

We will continue to work with UIT to tune the proper control interface to all components of the system and adapt to provide the best overall service. Some of this will be assisted by the planned collaboratory teaching interface and more extensive activity logs with detailed time stamps.

We plan to improve the volume server data build process so we can release additional data more quickly. This will also require improvements to the data set switching mechanisms and data set parameter description handling. In particular, users will be able to select at least 3 compression levels depending on their connectivity and intended use. The uncompressed service will be phased out and replaced by the lossless compression mode as the hop server becomes more compatible with Edgewarp. Additional support will be installed into PSC VB to support Edgewarp save file formats for uniform operation of the capabilities which are shared by both browsing programs.

Based on UIT results to date, we believe that student users tend to use the primary coordinate axis views most extensively during their early work and for position location and then use the arbitrary axis views for specific objects but not for a very long duration. This suggests improvements to optimize the primary plane views and we plan to take advantage of that during the next 2 quarters.

We will be completing all of the anticipated network upgrades at the PSC machine room and will be running at the maximum feasible rates by the end of the quarter.

Preliminary functions are being built for limited release of stereo and raycast viewing during the 3rd project year.

5) Next quarter needs:

The major need is better time balance between support of day-to-day requests and the long-term development of the intended system software.