VRSolar:
A Web-based Architectural Tool for Understanding Solar Movement

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1. INTRODUCTION AND CONCEPT

Knowledge of the sun and its movement relative to the earth is important for architects and essential for the design of climatically responsive and energy saving buildings. While solar movement can be found from solar tables and sun charts available in architectural science books or from computer modeling programs, these books and programs are either not convenient or are time consuming both to access and to understand.

Our development of a Web based tool to support teaching solar movement was inspired by combining a belief that understanding solar movement is an often under-emphasized crucial issue in architecture with a belief that the Web can provide a widely accessible, powerful method for teaching architecture students.

The Web is a widely available resource for students, instructors, and professionals. Recent advances in Web technologies make it highly suitable for the development of interactive tools that can take advantage of the platform independent and location independent range of resources that the Web can access.

As a case study of these advantages, a Web based prototypical teaching tool called VRSolar was developed to teach solar concepts to students and to serve as a convenient tool for information on the sun's location at any point and time.

2. AIMS OF VRSOLAR

VRSolar is designed to calculate the position of the sun at a particular day and time and to help users understand the sun's movement over time. Using the language VRML (Virtual Reality Modeling Language) as a basis for making primitive three-dimensional computer models, the tool is able to display accurately modeled shadows with the sun in position, so that users can see how much of their particular site would be in sun on a particular day. The capabilities of VRSolar are the following:

Generating the position of the sun for a particular place, date, and time as shown in Fig. 1.

Doing window shading calculations

Plotting the sun positions in the form of Mazria's cylindrical sun chart.[1]

Inputting the site and the surrounding buildings via a built-in elementary geometry defining program written in JavaScript.

Generating the information as a VRML world file for view from any direction/angle and walk through the site.

Allowing for the animation of solar position and path.

Permitting the users to input their own models in the solar VRML thus generated, so that the site can be viewed with the users' built form.

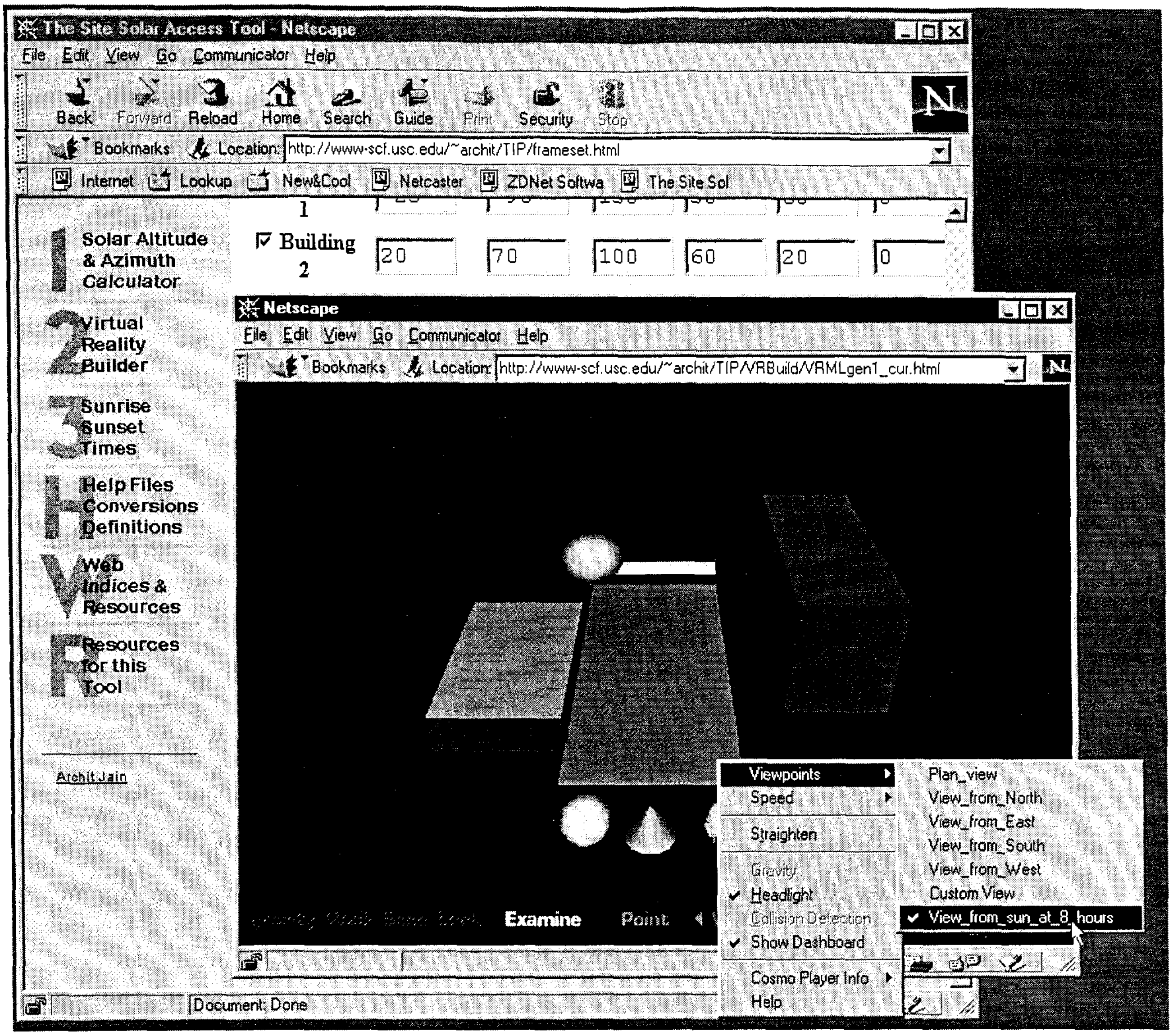
Allowing the solar model to be imported to other systems by using the AutoCAD DXF standard.

Providing on-line support through the built-in help file, which includes the glossary, conversion tables, and links to other Web resources.

3. BACKGROUND

Instances where universities are using online versions of course contents, with search capabilities, indexing, online discussion forums, and on-the-fly-generation of Web content are becoming increasingly common. At the University of Southern California, online courses on Oral Pathology and Communications and Art show the possibilities of Web based teaching.[2] The Oral Pathology pages feature interactive searching for terms, an automated self-exam to study for State Board Examinations, and an online dictionary. In the Communication pages, comparative study and extensive cross-referencing make self-study easier.

The Web is also being used for instructional support material on courses related to architecture. A notable example is the use of "enhanced, annotated and manipulated" digital images on the Web to teach structural concepts.[3] Others have used the Web as a community resource, where the students and the teachers can discuss projects and get feedback.[4] From the University of Colorado, the PHIDIAS II system aims at using VRML and Java on the Web as the front end for collaboration by distributed design teams, working together on a PHIDIAS hyperCAD system.[5] The Architectonics Studio at the University of Oregon uses Java in creating tools for



Location: http://www-scf.usc.edu/~archit/TIP/frameset.html

☑ Building 2 | 20 | 70 | 100 | 60 | 20 | 0

Location: http://www-scf.usc.edu/~archit/TIP/VRBuild/VRMLgen1_cur.html

✓ View_from_sun_at_8_hours

Document: Done

The Site Solar Access Tool - Netscape
File Edit View Go Communicator Help
Back Forward Reload Home Search Guide Print Security Stop
Bookmarks
Internet Lookup New&Cool Netcaster ZDNet Softwa The Site Sol
1 Solar Altitude & Azimuth Calculator
2 Virtual Reality Builder
3 Sunrise Sunset Times
H Help Files Conversions Definitions
W Web Indices & Resources
R Resources for this Tool
Archit Jain
Netscape
File Edit View Go Communicator Help
Bookmarks
Examine
Point
Viewpoints
Speed
Straighten
Gravity
✓ Headlight
Collision Detection
✓ Show Dashboard
Cosmo Player Info
Help
Plan_view
View_from_North
View_from_East
View_from_South
View_from_West
Custom View

Fig. 1. A screen capture of VRSolar running on a Windows PC. The VRML view is the perspective view from the sun at 8:00 am on July 26, for the user defined geometry.

teaching structural concepts. Developed at the University of Oregon by Prof. Dr. Chris H. Luebkeman with Eric Ngai and Elton Ng, this teaching tool features Java Applets that can be run over the Web for teaching structural concepts such as loading of pencil towers.[6]

However, there have not been instances where simple programming and Web resources have been put to use in creating a teaching and simulation aid. VRSolar does just that. Of the many categories in which teaching tools may be classified, VRSolar can be partially described as a "learning by fixed example" type and partly as a "simulation" type of tool. VRSolar provides both examples so that the students can learn about the evolution of the idea and the various terms associated with it, and it also helps the users to simulate their own site and get results specific to that site.

4. USING HTML AND VRML IN VRSOLAR

VRSolar has no specific hardware requirements. As long as a Web browser runs on the system the tool will function. Faster machines are advantageous for improved VRML scene rendering.

The two pieces of software that VRSolar requires are a standard HTML browser, capable of interpreting JavaScript, such as Netscape 3.0, and a VRML 2.0 browser, (usually as a plug-in to an HTML browser) such as Cosmo Player from Silicon Graphics.[7,8,9,10] JavaScript runs in the Web browser and dynamically generates new HTML and VRML pages based on user interaction. The HTML pages are displayed in the browser itself and for the VRML pages, the [HTML] browser calls in the VRML browser, which displays the three-dimensional scene.

VRML was developed with a idea of making the Web a three-dimensional "world," a second type of Web, where one can move from place to place and not from page to page, completing the metaphor of going from site to site. With VRML, it is possible to define the geometry of a place and allow users to navigate in a three-dimensional space in addition to retaining hyperlinks. "Avatars" or "virtual agents" make it possible to move and communicate in virtual space.

VRML and its development is relatively new. The first draft of VRML was specified in July of 1995 and VRML 2.0 or Moving Worlds was specified as early as August 1996. VRML, like other Web-based technologies is still in transition, though it has achieved many new capabilities in the 2.0 version."

In practice, VRML is a text based language, where objects are defined as geometries in this modeling language. As an example, the following code describes a red box of dimension 7x5x2 meters in VRML 2.0 and the resulting image is shown in Fig. 2.

```
#VRML V2.0 utf8
 Transform {
   center 0 -0.5 0
   translation 0 0.5 0
   children Shape {
     appearance Appearance (
       material Material {
       ambientIntensity 0.1
       diffuseColor 1 0 0
       }
     }
     geometry Box {
       size 7 5 2
     }
   }
}
```

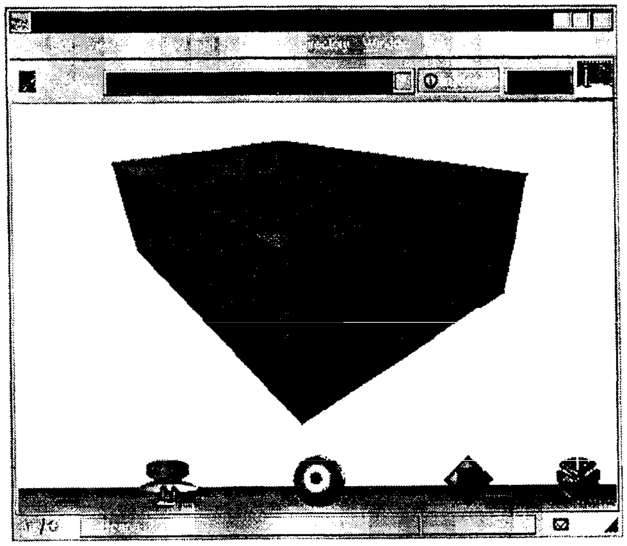


Fig. 2. View using the Netscape browser showing the box defined by the above geometry.

Once the page is viewed through a Web browser, the user is free to walk around the geometry and view it from any angle. The viewer also has the opportunity to view the model from predefined view points, that may have been specified in the VRML geometry and hear sounds coming on nodes within the VRML world.

The program uses the Web browser as a base for programming in JavaScript. JavaScript, developed by Netscape, is a script based language, simple and flexible.'? JavaScript is compiled at runtime and executed by the Web Browser itself. It descends in spirit from a line of smaller, dynamically typed languages like HyperTalk and dBASE. These scripting languages offer programming tools to a much wider audience becauseof their syntax, specialized built-in functionality, and minimal requirements for object creation. In an HTML page, the JavaScript is embedded as code. The coding is fairly straightforward.

5. DEVELOPMENT PROCESS

VRSolar was developed to run on the Web. Its development involved no high-end CGI-bin programming, nor did it involve the use of any expensive authoring programs. Tools like VRSolar can be developed by anyone who has access to post Web pages. A benefit of using JavaScript for programming is that Web access is not constantly needed. JavaScript is a client-side language. Therefore JavaScript is interpreted by the Web browser and not by the server, where the pages resides. Once the page is read by the local computer, there is no more communication taking place with the Web server. All further calculations occur directly on the local machine.

JavaScript for VRSolar was first keyed into a text editor along with the HTML. When these pages are opened by the Web browser, the Web browser itself works as the debugger, and the corrections to JavaScript can be made. No other programming packages are needed.

Once the pages for VRSolar were tried and tested on the computer where they were being written (network access is not required), the pages were uploaded to the Web pages from where they can become universally accessible. The only special care that needed to be taken for VRSolar was to add the MIME type for the VRML .wrl files on the server as x-world/x-vrml. This ensures that the browsers recognize the VRML file being opened and bring up the proper VRML plug-in.

6. FEATURES OF THE PROGRAM

The tree of present and anticipated future functions of VRSolar is shown in Fig. **3.**

VRSolar is comprised of two main sections, the Solar Calculator and the VRML Builder. The Solar Calculator calculates the position of the sun as defined by location, date, and time values provided by the user. The VRML Builder combines the resultant solar location with the geometry that the user supplies and dynamically generates a VRML scene that has both the building geometry and the solar geometry. In addition to the two main sections, the other components are

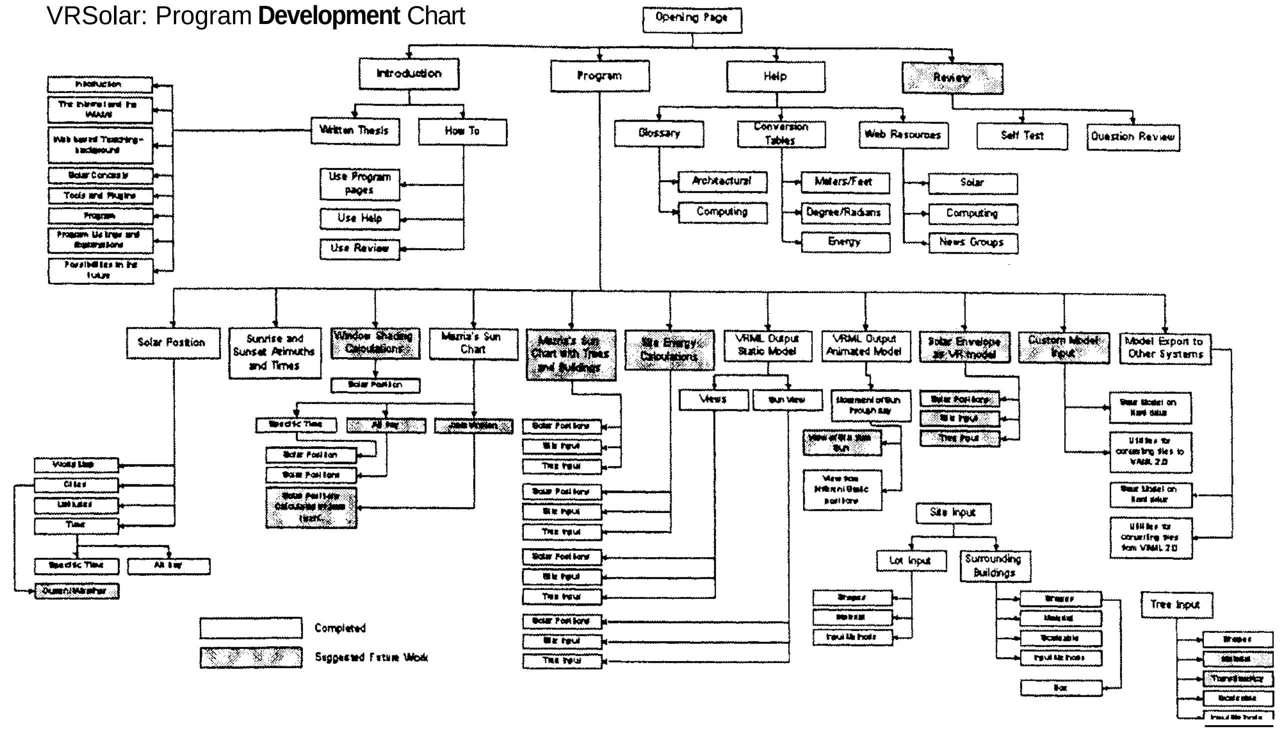


Fig. 3. Tree of capabilities and expected functions

the help and resource files.

On opening, VRSolar accesses the page that checks for the browsers that the user is currently using and informs the users about the requirements for the program and the software needed to run it. The user can also download the needed software off the Web through the links that point to HTML and VRML browsers and other utilities.

The main page is written in simple HTML so that even the most basic browser like the Netscape 1.1 or Mosaic, or even text based browsers can read the page.

After the users have acquired any needed software, they can proceed to the program itself. On opening the next page, theembedded JavaScript automatically checks for the HTML and VRML browser on the local system, and informs the user whether the versions are acceptable. This page also causes VRSolar to be the top page, in case it was accessed from within a frame in a browser.

The program's primary interface consists of the menu bar to the left, the help files on the bottom and the main screen on the right as shown in Fig. 4. Context sensitive help is available at all instances by running the mouse over the headings.It is also possible to turn off the help feature to both reduce distractions and improve the performance of slower computers.

7. SOLAR CALCULATOR

The Solar Calculator is used to calculate the position of the sun at a given time and location. The location of the site can be chosen by city name from the drop down menus, or if a particular city is not listed, the latitude can be entered numerically. It is also possible to choose a rough approximation of the location by clicking on the graphical world map shown in Fig. 5.

The user chooses the date and time desired for the calculation from the drop down menus provided. From the date, time and location provided, VRSolar uses JavaScript to calculate the Julian Day and the Declination for the day and the Hour Angle with the Altitude and the Azimuth for the sun. It displays these results in the form of the table shown in Fig. 9 which can be printed from within the browser.

Fig. 7 shows the optional cylindrical plot of the diurnal solar motion that can be displayed to the monitor or printed.

8. THE VRML BUILDER

Once the location of the site has been described, and the solar positions calculated, the VRML Builder guides the users to input the geometry of their own site and buildings into the program and view how the sun moves with respect to the structures. The chief aim of VRSolar is to help users decide what areas of their site are in shade and which are in sun. VRSolar has the capability of letting the users input their sites plus any adjacent buildings and trees.

The users can select the units in which they want to work. The distance units can be chosen from feet, meters, inches or millimeters. For angles, the units can be degrees or radians. By convention, the units for distance for VRML files is meters, therefore in the VRSolar generated VRML files, all the units are in meters. Also by convention, all the angles are in radians.

VRSolar accepts both rectangular and irregular sites. For simple rectangular sites, the length and the width of the site

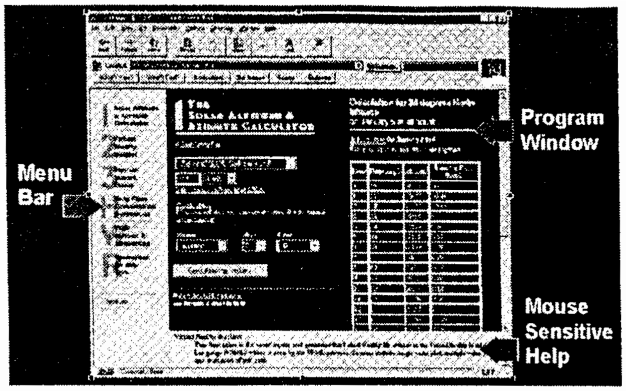


Fig. 4. Layout ofVRSolar

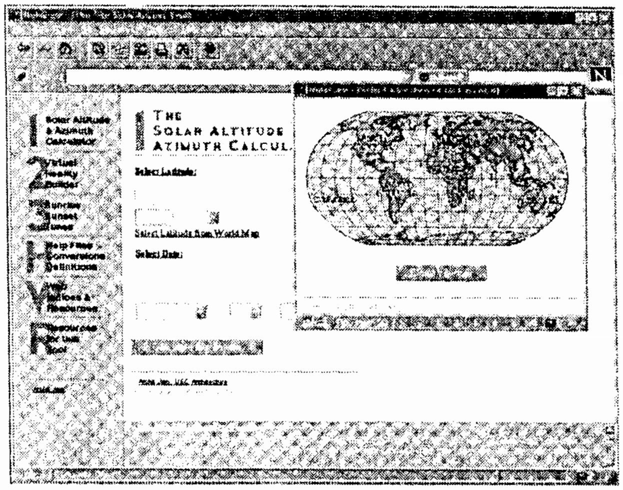

The Solar Altitude & Azimuth Calcul.
Select Latitude:
Select Latitude from World Map
Select Date:

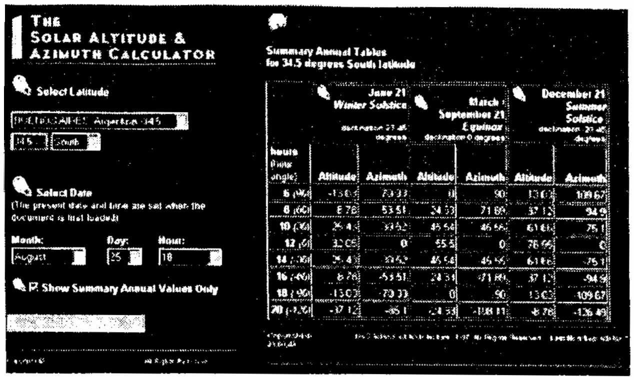
Fig. 5. Choosing location from drop down menu or world map.

can be entered. The orientation ofthe site can be specified as angular units if the site is not along the cardinal directions. For non rectangular sites, the VRSolar allows users to have up to a seven sided site, which may be entered as coordinates.

For the prototype version, VRSolar allows for only three differentgeneric tree shapes. Users can decide the number of trees, the location and the height and width of each tree. Transparency ofthe trees is intended as a feature in the next version ofthe program.

Buildings adjacent to the site can be input into VRSolar with the x and y coordinates ofthe center point and the length, width and height dimensions. Currently, VRSolar only allows rectangular shapes, but these can be combined to create more complex geometries. Different colors chosen for these buildings can identify them in the generated VRML scene.

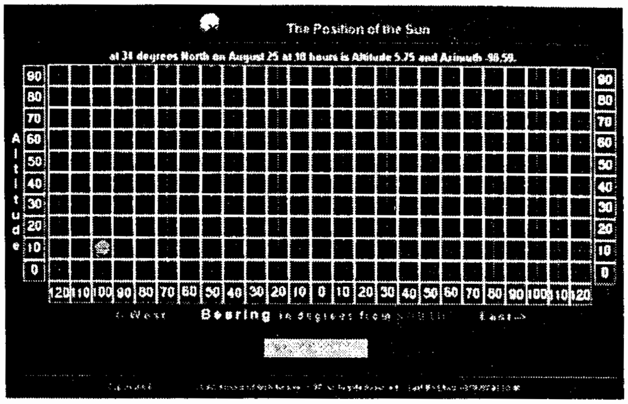
By defaultVRSolar generates five viewpoints. One from each cardinal axis and another fromthe top. The user is given an option to enter a sixth viewpoint from a custom point. These viewpoints are available to the user through theVRML browser interface. Users have the option of changing the default viewpoints and creating custom views, which would be more specific to that particular site.


The Solar Altitude & Azimuth Calculator
Select Latitude
BUENOS AIRES, Argentina 34.5
34.5
South
Select Date
(The present date and time are set when the document is first loaded)
Month:
August
Day:
25
Hour:
18
☑ Show Summary Annual Values Only

Summary Annual Tables
for 34.5 degrees South latitude

	June 21 Winter Solstice declination 23.45 degrees		March 21 September 21 Equinox declination 0 degrees		December 21 Summer Solstice declination -23.45 degrees	
hours (hour angle)	Altitude	Azimuth	Altitude	Azimuth	Altitude	Azimuth
6 (90)	-15.03	70.33	0	90	15.03	109.67
8 (60)	8.76	53.51	24.33	71.89	37.12	94.9
10 (30)	25.43	30.52	45.54	46.56	61.66	75.1
12 (0)	32.05	0	55.5	0	78.96	0
14 (-30)	25.43	-30.52	45.54	-46.56	61.66	-75.1
16 (-60)	8.76	-53.51	24.33	-71.89	37.12	-94.9
18 (-90)	-15.03	-70.33	0	90	15.03	-109.67
20 (-120)	-37.12	-85.1	-24.33	-108.11	-8.76	-126.49

Fig.6. Annual Summary *results fromthe solar calculator for Buenos Aires, Argentina.*


The Position of the Sun

at 31 degrees North on August 25 at 18 hours is Altitude 5.75 and Azimuth -98.59.

Fig. 7. Sun chart generated for a single day and hour.

9. HELP FILES

The help files include glossaries, conversion tables, and links to filesthat users may need. The glossary provides definitions to commonly used terms in computing along with the help for the program itself. The program includes built in metric/ *standard conversion tables for distance, angle, and thermal calculations. These pages are provided as start up look up for resources on the Web which may be useful for the users of VRSolar. These links are categorized under the following headings:*

Associations and Organizations
Product Information and Specifications
Energy, Sustainability, and Automation
Schools and Departments
Directories and other Resource Guides
Discussion Groups

10. THE PROGRAMMING MODEL

VRSolar uses JavaScript *to perform all its calculations.*

10.1 Solar Calculator

The Solar Calculator uses standard formulae to calculate the solar altitude and azimuth." When the Solar Calculator has calculated the values for the azimuth and altitude, the program dynamically writes the new HTML page to the other frame in the window which shows the calculated result. The MIME type for this new page is set as text/html and therefore the page is displayed as formatted HTML within the browser. The HTML for this generated page is within the JavaScript of the program which concatenates the text strings and writes the new page.

10.2 VR Builder

The VR Builder, using the same algorithm as the Solar Calculator, assembles the VRML file based on the user input. VRML files are also text files. JavaScript can therefore, simply write out the generated text to another newly created browser window on-the-fly. Since the MIME type for this new window is x-world/x-vrml, the VRML browser for seeing the generated VRML comes up automatically.

Prototypes for the usable shapes are defined in the program. These prototypes are included in the VRML file if the user has used that particular shape. In addition to the prototypes, references to it are also included, specifying the parameters that the user has selected.

Consider an example of two user-specified rectangular buildings. JavaScript automatically inserts the rectangular building prototype in the generated VRML file that looks like:

```
PROTO rectBuilding [
field SFVec3f buildingTranslation 0 0 0
field SFRotation buildingRotation 0 0 0 0
field SFVec3f buildingScale 1 1 1
field SFColor buildingColor 1 0 0
] {
  DEF rectangularBuilding Transform (
  translation IS buildingTranslation
  rotation IS buildingRotation
  scale IS buildingScale
  children Transform {
    center 0 -0.5 0
    translation 0 0.5 0
    children Shape (
      appearance Appearance {
        material Material {
        ambientIntensity 0.1
        diffuseColor IS buildingColor
        shininess 0.2
        }
      }
      geometry Box {
      size 1 1 1
      }
    }
  }
  }
}
```

The geometry of the rectangular building is now defined as a prototype object called rectBuilding in the VRML file. In the prototype the first four lines are the fields for the translation, rotation, scale and color of the buildings, which are the user defined variables.

Once the prototype has been defined, two buildings can be described as:

```
rectBuilding {
  buildingTranslation -7.62 0 -27.432
  buildingScale 39.624 18.288 15.24
  buildingRotation 0 1 0 0
  buildingColor 1 0 0
}

rectBuilding {
  buildingTranslation 6.096 0 21.336
  buildingScale 30.48 6.096 18.288
  buildingRotation 0 1 0 0
  buildingColor 0.66 0.489909 0.12528
}
```

This method is far more efficient for producing VRML files with previously specified geometry. The size of files created by this program is vastly smaller than those generated by modeling programs.

Viewpoints are generated by utilizing the positions of the sun calculated in the Solar Calculator. Rotations about the x and z axes are required to view the site correctly from the position of the sun. VRML describes rotations in the format x y z rotation, where x, y and z are numbers between 0 and 1, which define the percentage of each axis along which rotation is occurring, and rot is the rotation value in radians. This format of rotation could be calculated by a program written in C, but integrating it into VRSolar would not only mean converting the program into JavaScript, but also increasing the file size tremendously.[14]

This problem is resolved by applying two rotations, one after the other, to the viewpoint positions, creating a not so elegant but effective resolution.

VRSolar uses JavaScript to write out animations within the VRML 2.0 specifications. These animations use the position of the sun calculated earlier and relate it based on mouse clicks. JavaScript can be used for animations with VRML now, but this is only supported in the newest version of the Cosmo Player.

10.3 Saving Files

The VRML files generated from within the program can be saved onto the user's computer by generating the VRML as a text file, cutting and pasting it in a text editor, and saving it with ".wrl" as the suffix. For security reasons, JavaScript does not write directly to the local disk automatically.

10.4 JavaScript Limitations

Working with a language such as JavaScript does have its limitations. JavaScript works on a model referred to as the "sandbox effect" and is unable to make any system calls. The browser is the sandbox within which JavaScript can act. It cannot do anything outside the browser window. This is an intentional characteristic that helps to avoid writing Web pages directly onto the users hard drive. For VRSolar, this means that the program by itself would not be able to save files on the users local drive. The computation within the program occurs in RAM (and in the cache) of the computer. The resultant pages are held in the memory buffer and in the cache of the browser, and are not permanently recorded.

This limitation requires a workaround for saving the files onto the users local drive. Another complication is that JavaScript cannot pass variables from one page to the next. This means that all the values that the users provided to the Solar Calculator are not available to the VRML Builder. Therefore another workaround was required, and as shown in figure 13, the side menu bar actually acts as a buffer storage to hold the values and pass it to the VRML Builder. This part of the menu bar is not accessible to the user, due to the frame restrictions applied in the HTML.

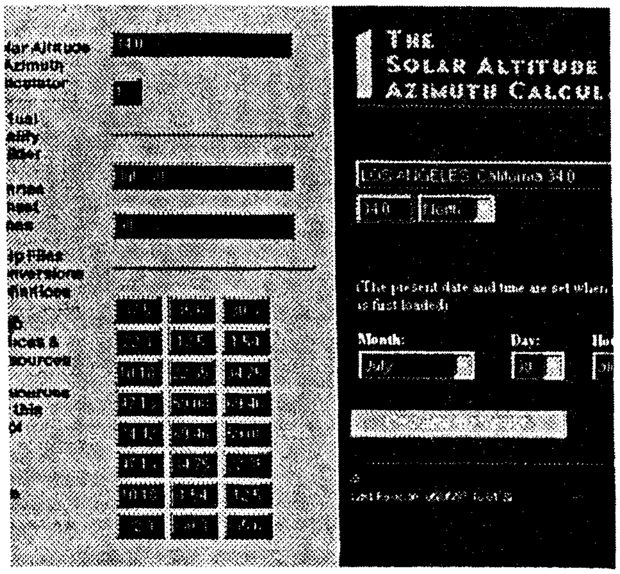
11. ADVANTAGES AND DISADVANTAGES OF VRSOLAR[15]

The VRSolar system has many advantages. It can be updated and made accessible easily and immediately. Once the files have been changed on the server, all the programs change automatically. Students can proceed at their own pace, and work from anywhere, at home or in school. Extensive hard-copy printing is not required. The pages can be linked to external sources of information. Teaching material could have many levels of detail, each at a separate level, that could be accessed by students in any sequence. With the aid of a projection device, the pages can be used to support lectures or hands-on lab sessions. The pages can be used by prospective students to assess course or to prepare for it and provides a broad audience for student work

There are also disadvantages of the VRSolar system. Because the material on the Web is public, it can easily by copied and used by others with no credit given to the original author. Password protection and limitation of use to certain servers can limit this problem, but not prevent it completely. The pages are open to inspection, comparison, assessment, and criticism from anyone (colleagues, administrators, etc.). Students may get lost in a maze of external references. Preparation of the course material and programs can be very time-consuming. Web based teaching presumes basic computer literacy on student's part. Currently, a limitation of tools like VRSolar is that the programs and languages that the tools are based on are still under development. Since the standards are continuing to evolve, the tools may not perform equally well on all platforms and under all browsers. This results in a requirement to frequently update the program.

12. CONCLUSION

VRSolar demonstrates that the World Wide Web can be used for the development of architectural teaching tools that are interactive and platform independent. Improvements in both hardware and software are allowing faster access, which encourages use of the Web. Visual tools can be developed with the interaction between languages like JavaScript and VRML.



THE SOLAR ALTITUDE AZIMUTH CALCUL

LOS ANGELES California 34.0

(The present date and time are set when is first loaded.)

Month: July

Day:

Fig. 8. The secret section of the menu bar, not visible to users, passes values between frames.

VRSolar, even in its present basic form, has value. As a teaching tool, the program can help students to understand the notion of solar movement easily, remember concepts, and get online study for architectural science courses. It provides access for students to use in their calculations, without the effort of searching for books and solar charts. Solar charts which can be printed can help students work on their simulation models aided by this tool.

For studio projects, it could be used as a quick and simple method of determining solar access to sites for initial design. The geometric model data from VRSolar can then be transported into other software.

In an architect's office, VRSolar could be used a handy tool to calculate solar altitudes and azimuths and sun charts. It could be run over an Intranet too, where the tool would work faster.

JavaScript is not difficult to learn and can be used for writing small architectural tools in the future. VRML has great potential to be used not only for converting three-dimensional models to Web viewable walk-throughs, but for real-time dynamic generation of three-dimensional spaces.

While the capabilities of the VRSolar program are currently limited, the method appears promising.

ACKNOWLEDGEMENTS

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REFERENCES

[1] E. Mazria, *The Passive Solar Energy Book* (Emmaus, PA: Rodale Press, 1979), pp.302-322. Chapter 4, Solar Concepts. The Cylindrical Sun Chart is a vertical projection of the sun's path as seen from the earth.

[2] The Oral Pathology web page can be found at http://www.usc.edu/hsc/dental/opath and the Communications and Art page is at http://www.usc.edu/dept/annenberg/anscl0O/

[3] K. Martini, "Digital Imaging and the Web in Teaching Structures: A Rigorous Visual Approach," *ACADIA 1996 Proceedings: Design Computation, Collaboration, Reasoning and Pedagogy* (Tucson, ACADIA), pp. 215-225, http://urban.arch.virginia.EDU/~km6e/tti/tti-summary/.

[4] An example is the Computational Composition by Rob Woodbury at the University of Adelaide. http:l/www.arch.adelaide.edu.au/df/.

[5] R. W. Knapp, and R. McCall, "PHIDIAS 11-In support of Collaborative Design," *ACADIA 1996 Proceedings: Design Computation, Collaboration, Reasoning and Pedagogy,* (Tucson, ACADIA): 147-154, http://phidias.colorado.edu/phidias.

[6] http://darkwing.uoregon.edu/~struct/.

[7] HTML, the HyperText Markup Language, is the *lingua franca* of the Web.

[8] http://www.netscape.com. JavaScript, because of differences in interpretation, does not work well with the current versions of Microsoft Internet Explorer. However, it is fully supported in the coming version 4.0

For a list of VRML browsers available for various platforms refer http://www.sdsc.edu/vrml/cgi-bin/display.cgi?category=Browsers+and+Plug-ins&

[10] http:llcosmo.sgi.comi

[11] For a general discussion on VRML, refer VRML Frequently Asked Questions (Jan Hardenbergh) at http://vag.vrml.org/VRML_FAQ.html.

[12] http://home.netscape.com/eng/mozilla/3.0/handbook/javascript/

[13] K. Kensek, "Work In Progress: Solar Envelopes and Solar Zoning," *ACADIA Quarterly,* 14(2) (1995). The lisp program called CalcSolar, designed to generate solar envelopes in AutoCAD, provided the final versions of the formulae. The formulae were taken from books on Solar Design, mainly *CBRI, Climatological* (Meerut, India : Sarita Prakashan. 1969) and *Solar Data for India,* and S. V. Szokolay, *Thermal Design of Buildings,* (Red Hill, ACT, Australia: RAIA Education Division, 1987)

[14] orient.c written by Stephen Chenney prompts for a from vector, an at vector, and an up vector, then calculates the orientation required to align the default VRML camera with the given camera. The code is available from ftp://ftp.cs.su.oz.au/stephen/vrml/orient.c

[15] Though the advantages of the Web are generally known, this section has been derived mainly from http://www.wayne.edu/wtt/wtt.html and from http://seaccd.sccd.ctc.edu/~jkent/ntcforum/index.htm. For a general discussion on Web based teaching and related topics refer http://www.csv.warwick.ac.uk/alt-E/alt-C95/papers.html.