The space synthesizer of Helsinki University of Technology

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ARCHITECTURAL SPACE SYNTHESIZER - The last link of a CAAD system

The time for spherical projection has come.

Computer technology and CAD are about to change radically the thousands of years of tradition of the architect's work. We are leaving behind the old method of drawing by hand, replacing the pencil with a stylus for pointing elements of mathematical models of projects. We are changing over from two dimensional to three dimensional design.

Decisive for the architect to achieve a successful outcome has always been and will always be the visualisation of the project right from its early stages. There is a trend in our time and a risk in the new technology of fragmenting our work and making it more abstract.

The new technology is based on the old one and in the beginning its user still has the habits of the old. Therefore the visualisation in present CAD systems and three dimensional design is based on the old plan projections; axonometrics and perspectives.

However, there is an essentially better way which happens also to be natural to the new technology and simple to realize using it. This is the spherical projection.

Why is spherical projection better?

when considering our environment from the point of view of projective geometries, all its components can be divided into objects, planes and envelopes. Geometrically these are in fact all the same thing. The position of the projection centre is decisive for which of these it will be transformed into. We see the same house as a mass, wall ox room depending of where we stand in relation to it.

In a plan projection we can only project objects and plans, whereas the spherical projection is universal; in addition to these, envelopes can also be projected on it.
From the point of view of environmental psychology, the built environment appears for us mostly as envelopes. With spherical projection we get a grasp of these.

In addition to having in static spherical projection a tool for perceiving envelopes, it opens up unique possibilities when it is made dynamic.

The dimension of depth is translated for us in a static picture through the edges and gradient of texture of the faces of the object. In addition to this in a dynamic spherical projection the depth is transmitted through motion parallax. In this perceiving situation it actually compensates for the binocular parallax to communicate depth. A condition for this is, however, a picture which fills up almost the entire visual field.

We thus look at the picture of the environment represented by a dynamic spherical projection in exactly the same way as those living creatures which in their visual field do not have a binocular area - for instance birds - but which despite this, with the help of motion parallax, can see their environment excellently in three dimensions - and quite successfully navigate among the branches in the woods.

When the dynamic spherical projection also keeps its coordinates constant, we have a tool with which to perceive, already in the designing phase, large series of spaces and evaluate for instance the orientation possibilities in these.

(The spherical projection may have its applications in many other fields such as planning, landscaping, traffic planning, environmental psychology, environmental control or geophysics. In astronomy it already has, as we know, its uses.)

How can it be applied using the present technology?

It is quite understandable that the spherical projection has not become everyman's tool yet. The building of the sphere itself is quite a demanding technical procedure. The geometrical construction of the projection on it is an awkward task. The picture should further be transported, stored and later be available when needed. With a developable surface (like a perspective drawing) all this is much easier.

In the age of CAD it is, however, simple to make use of a spherical projection.

The picture graphics and graphic functions of present CAD systems are carried out for the spherical projection in the same way as for others. In principle our new projection is connected as a part of the system alongside the axonometric and perspective projections. Besides, it is considerably simpler to calculate and more economical in the computer graphics program just because of the above mentioned universality.

Typical of this simplicity is the fact that it is only necessary to give as initial value the projection center.

Therefore it is easy to connect the spherical projection as part of all present CAD systems with three dimensional modeling. What is needed is the projection calculating part within the host's graphic programs and a new set of hardware - the space synthesizer.

The hardware of the space synthesizer consists of the sphere itself, a projector and a picture control unit. The sphere which forms the projection surface, is most conveniently set up as a geodesic dome. A suitable projector is for instance a light valve projector commonly used in flight simulators. Its resolution should be at least the same as the resolution of the picture of the host CAD systems. 4096 x 4096 line picture suits the synthesizer well. We can also get along with 1024 x 1024 lines because in this case the point for instance on a 3,5 meter diameter sphere will be 6,5 mm, which is still small enough for line drawings. A fish-eye of 2200 picture angle is suitable as the objective of the projector.

The picture control unit is situated inside the sphere making possible interactive handling of the picture. A suitable device for this is a small, hand held microcomputer with a little flat screen. The picture is handled from its keyboard.

Since the pictures of existing CAD systems are not yet dynamic enough for really live presentation, the synthesizer with dynamic picture needs its own picture processor. The speed needed is achieved for instance by a fast disc memory which is prepacked with single pictures or by an efficient vector processor which calculates the projection direct from the three dimensional model of the host system. In the latter case the picture control can be made interactive directly from the sphere if there is a joystick in the keyboard.

The whole projector, which is situated in the middle of the best perceiving area, can be completely eliminated by constructing the geodesic dome of triangular flat screen elements.

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In 1976 when the construction of the space synthesizer was begun in the Institute of Architectural Research, CAD systems were not available. At the Institute a system of its own was specially made for the space synthesizer. With the aid of this, a three dimensional model was made on the digitizer from plans and sections of the design. It was generated by pointing the edges, arches, continuous curves or elements made up of these. In one operation the type of element can be changed from one model to another. The creation of the model can be monitored in the form of an axonometric or perspective projection on the screen. In practice there are no limits to the size of the model.

Completed models are generally stored in the data store of the computer. They have included for example, a theatre, an opera house auditorium, a pedestrian precinct, an old district of the city under a partial preservation order and other similar subjects.

When the architectural model is ready, we move from the digitizer and the graphics display screen to the sphere itself. Here the model is summoned up by means of a small microcomputer that can be held on the lap. On its keyboard a suitable vantage point is chosen. The position of this can be verified on the small screen of the micro. The point can be chosen anywhere in the model, inside or outside. For example in the model of the auditorium of the opera, one can move from one row of seats to another and check the visibility of the stage as well as the spatial properties of the auditorium full of people. Or the effects of the size of buildings on the character of a residential area can be evaluated in various alternative models.

The computer program itself for our space synthesizer system was also prepared within the Institute of Architectural Research. The programming language is Fortran and it has been successfully run on a Univac 1108 and AS 8000 computers generally at a speed of 2400 bauds. In the construction of the model, a Tektronix display and digitizer were used. The graphics terminal and picture processor specifically for our space synthesizer were assembled in the applied electronics laboratory of the

University of Technology and our laser projector in the laboratory of material physics.

The display is of the raster-scan type with a resolution of 1024 x 1024 lines and a picture frequency of 25 Hz. A commercially available fish-eye lens of 220° with a focal distance of 8 mm and an aperture of f/2.8 is connected to the projector. The geodesic dome is constructed of triangular elements of two different sizes. These are isosceles triangles, both of which have a base of 685 mm, one has its other two sides 595 mm long and the other has sides of 700 mm. The diameter of the sphere so formed is 3.4 meters and its internal surface is lined with pearl screen material with an angle of reflection of 20 + 20 degrees.

Our space synthesizer has functioned well and lived up to the expectations of its performance as a whole. The resolution of our laser projector has not entirely fulfilled our objectives due to the modulator used.

At present we are taking a big leap in the development of our system; the realisation of the dynamic picture. our present graphics terminal, its picture processor and the projector have been planned with this in mind. We are establishing the production of projections for a 32 bit processor which calculates projections in real time according to data flow principle, which will permit interactive picture control in our space synthesizer.

After that we can look forward to an era when our entire built environment will be continuously mathematically modeled in three dimensions, just as in the present geodesic mapping systems. Then it will be possible to carry out all steps affecting our environment initially on the model and with the space synthesizer to evaluate the effects.

Reference:

Jyrki Paasi: A method for perceiving architectural spaces in laboratory conditions.
Otaniemi 1978
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