4D VISUALIZATION

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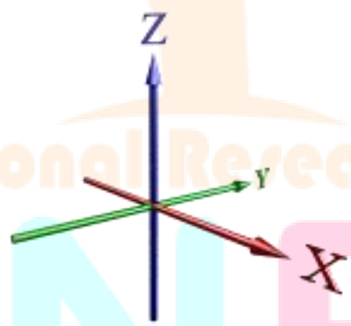
Abstract: The main concept of Visualization is to Visualize objects in biology and medicine extend across a vast range of scale, from individual molecules and cells through the varieties of tissue and interstitial interfaces to complete organs, organ systems, and bodyparts. The practice of medicine and study of biology have always relied on visualizations to study the relationship of anatomic structure to biologic function and to detect and treat disease and trauma that disturb or threaten normal life processes. Traditionally, these visualizations have been either direct, via surgery or biopsy, or indirect, requiring extensive mental reconstruction. The potential for revolutionary innovation in the practice of medicine and in biologic investigations lies in direct, fully immersive,real time multi-sensory fusion of real and virtual information data stream into online,real time visualizations available during actual clinical procedures or biological experiments. In the field of scientific visualization,the term "four dimensional visualization" usually refers to the process of rendering a three dimensional field of scalar values."4D" is shorthand for "four dimensional"- the fourth dimension being time. 4D visualization takes three-dimensional images and adds the element of time to the process. The revolutionary capabilities of new three-dimensional (3-D) and four dimensional (4-D) medical imaging modalities along with computer reconstruction and rendering of multidimensional medical and histologic volume image data, obviate the need for physical dissection or abstract assembly of anatomy and provide powerful new opportunities for medical diagnosis and treatment, as well as for biological investigations. In contrast to 3D imaging diagnostic processes, 4D allows doctor to visualize internal anatomy moving in real time. So physicians and sonographers can detect or rule out any number of issues, from vascular anomalies and genetic syndromes. Time will reveal the importance of 4d visualization as it grows with time.***Keywords—4D VISUALIZATION, advantages of 4D, 4D Techology, scope of 4D Visualization.***

Introduction:

Higher-Dimensional Space

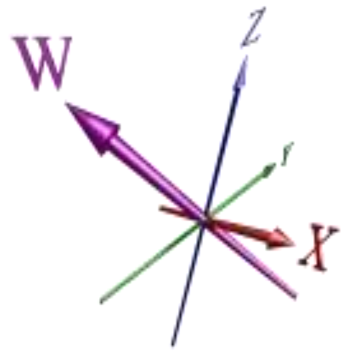
The world around us exists in 3-dimensional (3D) space. There are 3 pairs of cardinal directions: left and right, forward and backward, and up and down. All other directions are simply combinations of these fundamental directions. Mathematically, these pairs of directions correspond with three *coordinate axes,* which are conventionally labelled X, Y, and Z, respectively.



The arrows in the diagram indicate which directions are considered numerically positive and which are negative. By convention, right is positive X, left is negative X, forward is positive Y, backward is negative Y, and up is positive Z, and down is negative Z. We shall refer to these directions as +X, -X, +Y, -Y, +Z, and -Z, respectively. The point where the coordinate axes intersect is called the *origin*.

As far as we know, the space we inhabit consists of these 3 dimensions, and no more. We may think that space *has* to be 3-dimensional, that it can't possibly be anything else. Physically, this may be true, but mathematically, there is nothing special about the number 3 that makes it the only possible number of dimensions space can have. It is possible to have dimensions lower than 3: for example, 1D space consists of a single straight line stretching off to infinity at either end; and 2D space consists of a flat plane, extending in length and width indefinitely. However, nothing about geometry restricts us to 3 dimensions or less. It is quite possible—and mathematically straightforward—to deal with geometry in more than 3 spatial dimensions. In particular, we can have a 4th spatial dimension that lies perpendicular to all 3 of the familiar cardinal directions in our world. The space described by these 4 dimensions is called *4-dimensional space,* or *4D space* for short.

In a 4D world, there is another directional axis which is perpendicular to the X, Y, and Z axes. We shall label this axis *W,* and call the direction along this axis the *fourth direction*. This new axis also has positive and negative directions, which we shall refer to as +W and -W.



It is important to understand that the W-axis as depicted here is perpendicular to *all* of the other coordinate axes. We may be tempted to try to point in the direction of W, but this is impossible because we are confined to 3-dimensional space.

Concept Of 4D Visualization

In the field of scientific visualization, the term "four dimensional visualization" usually refers to the process of rendering a three dimensional field of scalar values. While this paradigm applies to many different data sets, there are also uses for visualizing data that correspond to actual four-dimensional structures. Four dimensional structures have typically been visualized via wire frame methods, but this process alone is usually insufficient for an intuitive understanding. The visualization of four dimensional objects is possible through wire frame methods with extended visualization cues, and through ray tracing methods. Both the methods employ true four-space viewing parameters and geometry.

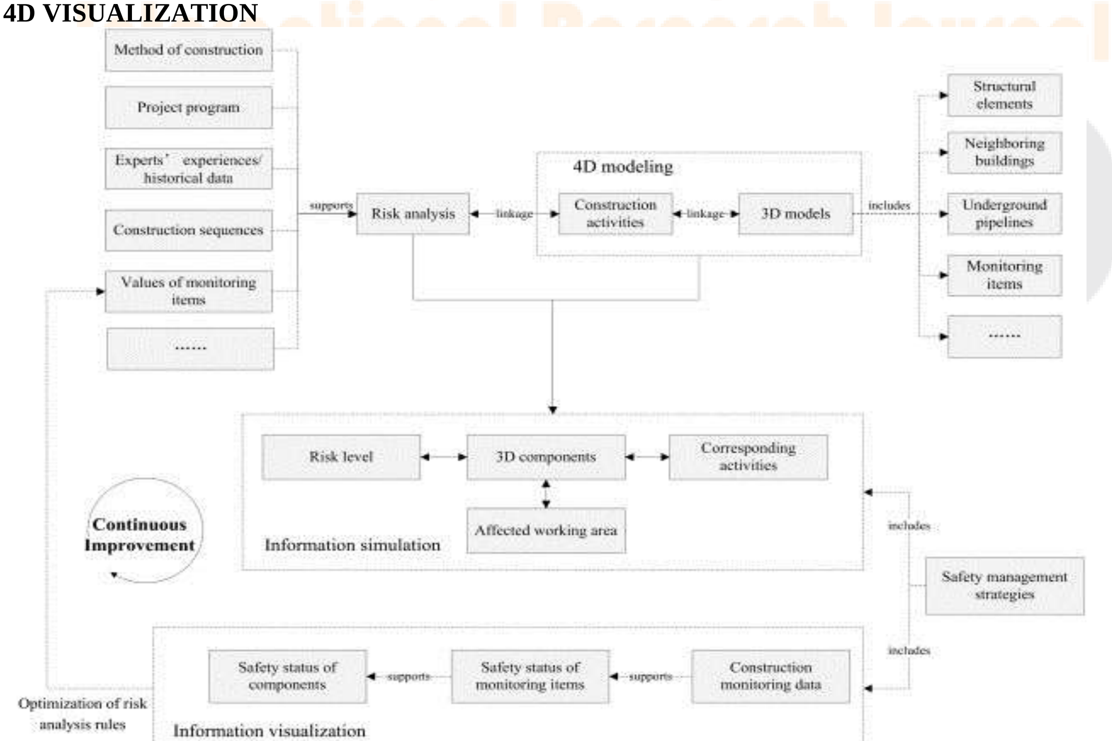
The ray tracing approach easily solves the hidden surface and shadowing problems of 4D objects, and yields an image in the form of a three-dimensional field of RGB values, which can be rendered with a variety of existing methods. The 4D ray tracer also supports true four-dimensional lighting, reflections and refractions. The display of four-dimensional data is usually accomplished by assigning three dimensions to location in three-space, and the remaining dimension to some scalar property at each three-dimensional location. This assignment is quite apt for a variety of four-dimensional data, such as tissue density in a region of a human body, pressure values in a volume of air, or temperature distribution throughout a mechanical object

4D Viewing Vectors and Viewing Frustum

Definition - 4D VISUALIZATION

4D Viewing Vectors and Viewing Frustum. The viewing-angle is **defined** as for three-dimensional viewing, and is used to size one side of the projection-parallelepiped; the other two sides are sized to fit the dimensions of the projection-parallelepiped.

Block Diagram of a 4D VISUALIZATION



How Can we Visualize 4 dimension

Best thing to do, to build up a good intuitive sense for this, is to first analyze what happens when we go from 0 to 1 dimension (point to line), from 1 dimension to 2 (line to square), and from 2 to 3 dimensions (square to cube).
Since we already have good intuition for these transitions, we can dissect what happens during these transitions, regarding boundaries, number of faces, volume, and extrapolate from there, towards the fourth dimension.

References:

- Wikipedia
- Techopedia
- www.elprocus.com

Conclusion:
In this article to Visualize objects in biology and medicine extend across a vast range of scale, from individual molecules and cells through the varieties of tissue and interstitial interfaces to complete organs, organ systems, and bodyparts. The practice of medicine and study of biology have always relied on visualizations to study the relationship of anatomic structure to biologic function and to detect and treat disease and trauma that disturb or threaten normal life processes.