

## **2.5 Taxonomies of Information Visualisation Techniques**

According to Skupin (2002), the research and development efforts in IV have matured to a point at which the provision of meaningful taxonomies of the various techniques should be a necessary step towards the creation of a coherent theoretical framework on which further progress will depend.

Currently, only a couple of taxonomies have been developed by information visualisation specialists (Shneiderman, 1992, Chi, 2000, North, 1996, Reed & Heller, 1997). These are all generic taxonomies for information visualisation and none of them are specifically focused on digital libraries. In this Information Visualisation study, we propose a taxonomy by combining the taxonomies developed by the domain experts and in particular, we especially focus on the JISC Information Environment. This Information Visualisation taxonomy for digital libraries (Table 5), is aimed at designers and developers within JISC to provide an overview of how existing information visualisation tools and techniques could be implemented into the design for the JISC Information Environment.

Table 1: Taxonomy of Information Visualization User-Interfaces by DataType (North, 1996)

Data Type	Tools/Technique	Institute (and URL where available)
<b>Temporal (i.e. Timelines, histories)</b>	LifeLines	HCIL, University of Maryland
	LifeStreams	Yale, <a href="http://www.cs.yale.edu/homes/freeman/lifestreams.html">http://www.cs.yale.edu/homes/freeman/lifestreams.html</a>
	MMVIS: Temporal Dynamic Queries	U Michigan: Hibino, <a href="http://www.acm.org/sigchi/chi96/proceedings/demos/Hibino/sh2txt.htm">http://www.acm.org/sigchi/chi96/proceedings/demos/Hibino/sh2txt.htm</a>
	Perspective Wall	Xerox
	VideoStreamer	MIT, <a href="http://www.lightmoves.net/">http://www.lightmoves.net/</a>
<b>1-Dimensional</b>	Document Lens	Xerox, <a href="http://people.cs.vt.edu/~north/infviz/1">http://people.cs.vt.edu/~north/infviz/1</a>
	Fractal Views	UEC-Japan: Koike, <a href="http://citeseer.nj.nec.com/cache/papers/cs/3285/http:zSzzSzwww.vogue.is.uec.ac.jpzSzpaperszSzt0is95.pdf/fractal-views-a-fractal.pdf">http://citeseer.nj.nec.com/cache/papers/cs/3285/http:zSzzSzwww.vogue.is.uec.ac.jpzSzpaperszSzt0is95.pdf/fractal-views-a-fractal.pdf</a>
	SeeSoft	Lucent/Bell Labs <a href="http://www.cc.gatech.edu/computing/classes/cs7390_98_winter/reports/realsys/seesoft.html">http://www.cc.gatech.edu/computing/classes/cs7390_98_winter/reports/realsys/seesoft.html</a>
	Tilebars	Xerox, <a href="http://elib.cs.berkeley.edu/tilebars/about.htm">http://elib.cs.berkeley.edu/tilebars/about.htm</a>
	WebBook	Xerox, <a href="http://www2.parc.com/istl/groups/uir/pubs/items/UIR-1996-14-Card-CHI96-WebForager.pdf">http://www2.parc.com/istl/groups/uir/pubs/items/UIR-1996-14-Card-CHI96-WebForager.pdf</a>
<b>2-Dimensional</b>	ArcView	ESPI, <a href="http://www.esri.com/">http://www.esri.com/</a>
	Fisheye/Distortion views	Fairchild
	Group Kit	Calgary, <a href="http://www.groupkit.org/">http://www.groupkit.org/</a>
	Information Mural	GVU-Georgia Tech, <a href="http://www.cc.gatech.edu/gvu/softviz/infviz/information_mural.html">http://www.cc.gatech.edu/gvu/softviz/infviz/information_mural.html</a>
	Pad++	HCIL (University of Maryland College Park), UCSD, <a href="http://www.cs.umd.edu/hcil/pad++/">http://www.cs.umd.edu/hcil/pad++/</a>

	Powers of Ten	<a href="http://www.designlab.ukans.edu/pwr_of_ten.html">http://www.designlab.ukans.edu/pwr_of_ten.html</a>
<b>3-Dimensional</b>	The Neighbourhood Viewer	Minnesota
	Visible Human Explorer (VHE)	HCIL-Maryland, <a href="http://www.cs.umd.edu/hcil/visible-human/vhe.shtml">http://www.cs.umd.edu/hcil/visible-human/vhe.shtml</a>
	Volvis	SUNY-SB, <a href="http://www.cs.sunysb.edu/~vislab/volvis_home.html">http://www.cs.sunysb.edu/~vislab/volvis_home.html</a>
	Voxelman	IMDM-Hamburg, <a href="http://www.uke.uni-hamburg.de/zentren/experimentelle_medizin/informatik/index.en.html">http://www.uke.uni-hamburg.de/zentren/experimentelle_medizin/informatik/index.en.html</a>
<b>Multi-dimensional</b>	Filter-Flow	HCIL, University of Maryland
	Dynamic Queries, Query Previews (HomeFinder, FilmFinder, EOSDIS)	HCIL, University of Maryland
	Influence/Attribute Explorer	Imperial College
	LinkWinds	JPL –NASA
	Magic Lens	Xerox
	Parallel Co-ordinates	Alfred Inselberg
	Selective Dynamic Manipulation	CMU
	Spotfire	IVEE Development
	TableLens	Xerox
	Visage	CMU
	VisDB	Munich
	Worlds Within Worlds	Feiner
	Xgobi	AT&T Labs, Bellcore
<b>Hierarchical (i.e. Trees)</b>	Cone/Cam-Trees	Xerox
	Elastic Windows	HCIL
	Fractal Views	UEC
	Hyperbolic Trees	Xerox
	Info Cube	Sony
	TreeBrowser (Dynamic Queries)	HCIL
	TreeMap/WinSurfer	HCIL
	WebSpace	U Minnesota
<b>Network (i.e. Graphs)</b>	Butterfly Citation Browser	Xerox
	Fisheye	<a href="http://www.csi.uottawa.ca/ordal/papers/sander/node25.html">http://www.csi.uottawa.ca/ordal/papers/sander/node25.html</a>

	Galaxy of News	MIT
	Graphic History Browser	GVU-GaTech
	IGD (Interactive Graphical Documents)	Columbia:Feiner
	Intermedia	Brown
	Multi-Trees	Furnas
	Navigational View Builder	GVU-Gatech
	NETMAP	ALTA Analytics, Inc., <a href="http://www.altanalytics.com/">http://www.altanalytics.com/</a>
	RMM	Isakowitz <a href="http://jmis.bentley.edu/rmm/What_is_RMM.html">http://jmis.bentley.edu/rmm/What_is_RMM.html</a>
	SemNet	Bellcore
	Themescape/SPIRE	PNL <a href="http://www.pnl.gov/infoviz/index.html">http://www.pnl.gov/infoviz/index.html</a>
<b>WorkSpaces</b>	CASCADE	Pittsburgh <a href="http://www2.sis.pitt.edu/~cascade/">http://www2.sis.pitt.edu/~cascade/</a>
	Information Visualizer/3D Rooms/Web Forager	Xerox
	Pad++	New Mexico
	Personal Role Managers	HCIL

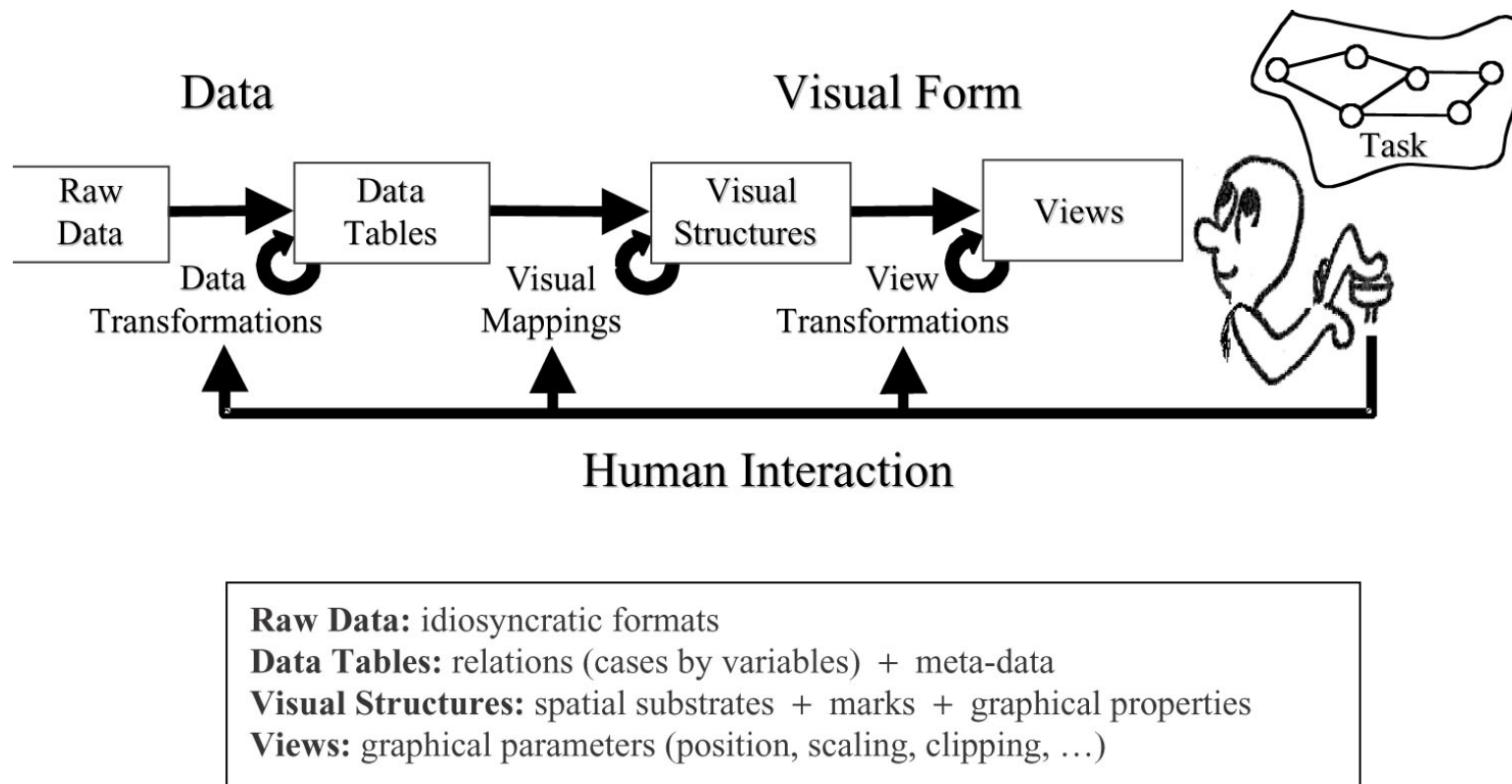


Figure 1: Reference model for visualization (Card et al., 1999).

From Figure 33, Card et al (1999) suggested that visualisation can be described as the mapping of data to visual form that supports human interaction in a workspace for visual sense making. And that the components of the reference visualisation model are shown in Figure 33. Specific techniques are also

included in Table 2. The specific techniques for Data Tables are a list of common data types that have well-known Data Tables. Tasks are operations that a user may want to do with the visualisation.

Table 2: Summary of specific visualisation techniques with reference to the Reference model for Visualisation (Card et al, 1999)

<b>DATA TABLES</b>	<b>VISUAL STRUCTURES</b>	<b>VIEWS</b>	<b>HUMAN INTERACTION</b>	<b>TASKS</b>	<b>LEVEL</b>
Cases	Spatial Substrate	Location Probes	Data Tables	Forage of Data	Infosphere
Variables	Marks	Viewpoint Controls	Visual Structures	Problem Solving	Workspace
Values	Graphical properties	Distortion	Views	Search for Schema	Visual Knowledge Tools
Metadata				Instantiate Schema	Visual Objects
				Author, Decide or Act	

**Specific Techniques**

Spatial (Scientific)	Position: NOQ	Brushing	Dynamic Queries	Overview	Delete
Geographic	Marks: PLAV	Zooming	Direct Manipulation	Zoom	Reorder
Documents	Properties: Connection, Enclosure, Retinal, Time	Overview + Detail	Magic Lens	Filter	Cluster
Time	Axes:	Focus + Context		Details-on-Demand	Class
Database	Composition			Browse	Promote
Hierarchies	Alignment			Search	Average
Networks	Folding			Read Fact	Abstract
World Wide Web	Recursion			Read Comparison	Instantiate
	Overloading			Read Pattern	Extract
				Manipulate	Compose
				Create	Organize



<p><b>II. Composed Visual Structures</b></p>	<p>Single Axis Composition <math>[XY^n]</math></p> <p>Double Axis Composition <math>[(XY)^n]</math></p> <p>Recursive Composition 2D in 2D <math>[(XY)^{XY}]</math></p> <p>Marks in 2D <math>[(XY)^R]</math></p> <p>3D in 3D <math>[(XYZ)^{XYZ}]</math></p>	<p>Permutation matrices Parallel coordinates</p> <p>Graphs</p> <p>Scatterplot matrices Prosection matrices Hierarchical axes</p> <p>Stick figures Colour icons Shape coding Keim spirals</p> <p>Worlds within worlds</p>
<p><b>III. Interactive Visual Structures</b></p>	<p>Dynamic queries Magic Lens Overview + detail Linking and brushing Extraction and comparison Attribute explorer</p>	
<p><b>IV. Focus + Context Attention-Reactive Visual Abstraction</b></p>	<p>Data-based Methods</p> <p>View-based Methods</p>	<p>Filtering Selective aggregation</p> <p>Micro-macro readings Highlighting Visual transfer functions Perspective distortion Alternate geometries</p>

Table 4: Information Visualisation Taxonomy for Digital Libraries (For JISC Information Environment)

Data Type	Tools/Techniques	Examples of when the techniques can be used	Data Type Applications
<b>1 – Dimensional</b>	<ul style="list-style-type: none"> <li>▪ Document Lens [Robertson, 1993]</li> <li>▪ SeeSoft [Eick, 1992]</li> <li>▪ Tilebars [Hearst, 1995]</li> <li>▪ WebBook [Card, 1996]</li> <li>▪ Value Bars [Chimera, 1992]</li> </ul>	<ul style="list-style-type: none"> <li>▪ Traversing long lists in changeable sort orders.</li> <li>▪ Viewing summary data about many ordered items, possibly to find important specific elements.</li> <li>▪ Filtering out unwanted items.</li> </ul>	Linear data type: textual documents, program source code, and alphabetical lists of names organised in sequential manner
<b>2-Dimensional</b>	<ul style="list-style-type: none"> <li>▪ ArcView [esri.com]</li> <li>▪ Fisheye/Distortion views [Sarkar, 1992]</li> <li>▪ Group Kit [Roseman, 1992]</li> <li>▪ Information Mural [Jerding, 1995]</li> <li>▪ Pad++ [Bederson, 1995]</li> <li>▪ Pagemaker [</li> <li>▪ LifeLines [Plaisant, 1996]</li> <li>▪ TileBars [Hearst, 1995]</li> <li>▪ MapQuest [MapQuest.com]</li> </ul>	<ul style="list-style-type: none"> <li>▪ Geographic Mapping</li> <li>▪ Chip Design</li> <li>▪ Semantic zooming</li> <li>▪ Tracking system</li> <li>▪ Newspaper Layout</li> <li>▪ Photo and Image Browsing</li> </ul>	Planar or map data include geographic maps, floor plans, newspaper layouts.
<b>3-Dimensional</b>	<ul style="list-style-type: none"> <li>▪ The Neighbourhood Explorer [Apperley &amp; Spence, 1999]</li> <li>▪ Visible Human Explorer [North, 1996]</li> </ul>	<ul style="list-style-type: none"> <li>▪ Containment issues.</li> <li>▪ Position (Up, Down, Inside, Outside) queries.</li> </ul>	CAD, real-world objects such as molecules, medical images, and architecture.

<p><b>Temporal (i.e. timelines, histories etc)</b></p>	<ul style="list-style-type: none"> <li>▪ LifeLines [Plaisant, 1996]</li> <li>▪ LifeStreams [Freeman, 1996]</li> <li>▪ Perspective Wall [Mackinlay, 1991]</li> </ul>	<ul style="list-style-type: none"> <li>▪ Viewing events or data in sequence and/or varying the order of those events or data.</li> <li>▪ Manipulating hypothetical planning of personal or corporate activities.</li> <li>▪ Viewing and creating historical overviews of events or data.</li> <li>▪ Finding temporal inconsistencies and/or undesirable relationships in events or data.</li> </ul>	<p>Medical Records, project management, video data editing, animation composing, date Spiral</p>
<p><b>Multi-dimensional</b></p>	<ul style="list-style-type: none"> <li>▪ Filter-Flow (Young &amp; Shneiderman, 1993)</li> <li>▪ Dynamic Queries, Query Previews (HomeFinder [Ahlberg &amp; Shneiderman, 1994], FilmFinder [Vinit &amp; Shneiderman, 1994], EOSDIS[Plaisant et al, 1997])</li> <li>▪ Influence/Attribute Explorer [Tweedie et al, 1994]</li> <li>▪ LinkWinds [Jacobson, 1994]</li> <li>▪ Magic Lens [Bier et al, 1993]</li> <li>▪ Parallel Co-ordinates [Inselberg, 1995]</li> <li>▪ Selective Dynamic Manipulation (SDM)</li> <li>▪ Spotfire [spotfire.com]</li> <li>▪ TableLens [Rao &amp; Card, 1995]</li> <li>▪ Visage [Roth et al, 1996]</li> <li>▪ VisDB [Keim, 1995]</li> <li>▪ VIBE [Olsen et al, 1993]</li> <li>▪ Worlds Within Worlds [Feiner, 1990]</li> <li>▪ Xgobi/ArcView [Symanzik, 2000]</li> </ul>	<ul style="list-style-type: none"> <li>▪ Understand or get an overview of the whole or a part of the n-dimensional data. For example, finding patterns, relationships, clusters, gaps, and outliers of the data.</li> <li>▪ Find a specific item in the data. For example, zooming, filtering and selecting a group or a single item from the data.</li> </ul>	<p>Relational and statistical databases.</p>

<p><b>Hierarchical (i.e. Trees)</b></p>	<ul style="list-style-type: none"> <li>▪ Cone/Cam-Trees [Lamping &amp; Rao, 1996]</li> <li>▪ Elastic Windows [Kandogan, 1997]</li> <li>▪ Hyperbolic Trees [Inxight.com]</li> <li>▪ TreeMap/WinSurfer [Shneiderman, 1991]</li> <li>▪ WebSpace [Chi, 1994]</li> <li>▪ WebTOC [Nation, 1997]</li> </ul>	<ul style="list-style-type: none"> <li>▪ Obtain global relationships and structure from the entire hierarchy.</li> <li>▪ Find the most recent common ancestor between two nodes.</li> <li>▪ Find the path to a particular node from the root of the hierarchy.</li> <li>▪ Find clusters, duplicates, relationships, and inheritance properties from the structure of the hierarchy.</li> <li>▪ Discovering attributes (especially the size) of nodes or entire subtrees.</li> </ul>	<p>Hierarchies or tree structures: collections of items with each item having a link to one parent item (except the root). E.g. Indented outlines, file managers in computer directories, sales data, business decision-making</p>
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<b>Network (i.e. Graphs)</b>	<ul style="list-style-type: none"> <li>▪ Butterfly Citation Browser [Mackinlay, 1995]</li> <li>▪ Fisheye</li> <li>▪ Intermedia</li> <li>▪ Multi-Trees</li> <li>▪ NetViz</li> <li>▪ Netmap</li> <li>▪ RMM</li> <li>▪ SeeNet</li> <li>▪ Themescape</li> </ul>	<ul style="list-style-type: none"> <li>▪ Network Management: allow the user to view as much of the a network as possible in one view so that resources decisions can be made</li> <li>▪ Traffic Management: relate traffic from different to nodes to identify any traffic patterns</li> <li>▪ Program Performance: display a graph of a program to find any bottlenecks or incorrect data flows.</li> <li>▪ Graph Editing: Change the layout of nodes of a graph so that the network is easier to comprehend.</li> <li>▪ Relate: enable the user to find relationship among the nodes in a diagram.</li> <li>▪ Shortest/Cheapest path: find interesting paths in a graph.</li> </ul>	<p>Relationships that cannot be easily captured with a tree structure will be useful to have items linked to an arbitrary number of other items.</p>
<b>WorkSpaces</b>	<ul style="list-style-type: none"> <li>▪ Personal Role Managers [Shneiderman94]</li> <li>▪ Information Visualise/3D Rooms/Web Forager</li> <li>▪ Pad++ [Bederson94]</li> <li>▪ Elastic Windows [Kandogan96]</li> <li>▪ Workspace</li> </ul>	<ul style="list-style-type: none"> <li>▪ Enable users to view and interact with computer screen layouts in a more efficient manner.</li> <li>▪ Allow geographically dispersed users to collaborate and interact concurrently.</li> <li>▪ Synthesise information, expertise, and results to create high quality solutions.</li> <li>▪ Organise, interact, and search task related information efficiently.</li> <li>▪ Allow rapid access and restructuring for task information.</li> </ul>	

Table 5: Information Visualisation Taxonomy for Digital Libraries by task.

(Base from Shneiderman, 1996, A Task by Data Type Taxonomy for Information Visualisation, HCIL, University of Maryland)

<b>Tasks</b>	<b>Description</b>	<b>Tools/Techniques that are applicable</b>
<b>Overview</b>	Gain an overview of the entire collection	<ul style="list-style-type: none"> <li>▪ Fisheye strategy</li> <li>▪ Fisheye distortion</li> <li>▪ Context plus focus</li> <li>▪ Navigation tools to pan or scroll</li> </ul>
<b>Zoom</b>	Zoom in on items of interest	<ul style="list-style-type: none"> <li>▪ Starfield displays</li> </ul>
<b>Filter</b>	Filter out uninteresting items	<ul style="list-style-type: none"> <li>▪ Dynamic Queries</li> <li>▪ Sliders, buttons</li> <li>▪ Control widgets</li> </ul>
<b>Details-on-demand</b>	Select an item or group and get details when needed	<ul style="list-style-type: none"> <li>▪ HTML text to links to further information (e.g. Spotfire)</li> </ul>
<b>Relate</b>	View relationships among items	<ul style="list-style-type: none"> <li>▪ Alphaslides (e.g. FilmFinder)</li> <li>▪ Select and highlight items with similar attributes (e.g. SDM),</li> <li>▪ click on an item and see related attributes (e.g. LifeLines),</li> <li>▪ Influence Explorer</li> <li>▪ Table Lens</li> </ul>
<b>History</b>	Keep a history of actions to support undo, replay, and progressive refinement	<ul style="list-style-type: none"> <li>▪ Allow retrace by preserving the sequence of searches so that they can be combined or refined.</li> </ul>
<b>Extract</b>	Allow extraction of sub-collections and of the query parameters	<ul style="list-style-type: none"> <li>▪ Drag and drop selection into the next application window (e.g. Visage)</li> </ul>