Abstract

People used to illustrate our ideas by hand and now we use machines. But we still can’t search through all the world’s drawings and ideas by proportion, aesthetic, and a list of measurements and space requirements. Suppose there was a new way to communicate with our machines that would allow design and other subtle relationships to be measured, compared and perceived using the design intent and viewers interpretations themselves as descriptions? In the future, using a system like this will eventually create so many designs, interpretations, patterns and spaces to choose from the questions become: how would design be perceived within these virtual spaces; and how might our aesthetics change due to this new dialogue with machines?
INTRODUCTION

Since the time of the alchemists people have been going through a long period of reduction and specialization, however, the relatively recent development of advanced networks and complex dynamic data stores may be causing the pendulum to swing back the other way. Beginning in the 1920s with the development of atomic theory and impressionist painting, we slowly began looking at the relationship between the pieces and the overall. In the 1950’s between the effect Abstract Expressionism had on abstract art and Logical Empiricism had on theoretical science, seeing and understanding the process has become more important as well. Today we are witnessing a similar change trying to develop the best way to express and explore new linkages and new questions beginning to emerge between the specialized disciplines we have been developing over long periods of time.

Even with all of the recent, dramatic progress in design and image making, automated experimentation, record and time keeping, and international research communication, we are still not REALLY able to discuss advanced questions over shared networks yet. The author believes this is due to an overdependence on natural language and terminology over image, measurement, context and interpretation or “use”. This snag in progress may also be caused by the use of equal, practically interchangeable data components geared for machine processing rather than the fluid, variable human imagination and investigation process, which may be caused by an overdependence on electrical pulses. Digital information is held in discrete countable units yet our ideas and progress across all fields seem to be more continuous. This paper, and the collaborative project to follow, asks this question: How can we articulate and capture what is overall and continuous between these discrete units, in other words, how do we “Digitize the Non-Digital”?

“God does not care about our mathematical difficulties. He integrates empirically.” Albert Einstein
“Take advantage of the accidents.” Chuck Close

VISUALIZATION OF CONTEXT DRIVEN TOPOLOGIES

Design is purposeful, perceiving design therefore implies perceiving a purpose, or reason for the design. Most designs, for example a set of architectural drawings, typically allow a view of both overalls and details. Art and scientific discovery both seem to be able to show only one or the other and still convey meaning. When people use machines to look through the abstract or unfamiliar to create or discover new ideas, how will we be able to detect designs that are purposeful versus what “just happens” simply because this arrangement seems useful, appealing, or just appears to be authentic because it has been in the data store for a long time? The example below shows an overall and detailed view of a simple material - gravel.


Is one of these views is “Better”? more purposeful or “Designed”? That depends on the viewer’s preference and how that relates to the intention of the designer. Capturing the understanding between viewer and designer is an age-old problem that has been both complicated and simplified with the added requirement of “showing” “describing” and “explaining” design intent to shared systems and machines. Design intent, and what the viewer perceives versus what the designer imagined, are both facing unprecedented challenges being constrained to “fit” within standards, that of course are necessary and
truly required, but do not allow each design to be recorded, explored, and modeled\(^4\) in its own way whether this “way” reflects the intention of the designer, or the preferences and quality assurances of the viewer.

Many shared systems, for example Dublin Core metadata\(^5\), rely almost exclusively on text without providing adequate or realistic mechanisms for translation, variation in cultural interpretation, or change in word meaning over time. Therefore, the question starts to become, exactly what is being shared across these systems? How modified and constrained are the vast majority of ideas and designs we are exposed to when they are filtered through shared systems as discrete, countable units rather than continuous overalls?

“Context Driven Topologies” is a new concept proposing that design intent and an evolving series of viewers interpretations, evaluations and knowledge based questions can be used to develop limitless overalls, themes, mathematical patterns, quality controls, expressions, techniques and other unique characteristics that eventually let designs “make their own metadata” as they evolve and are understood over time.

![Fig. 2 Measuring the Continuous Flow of Ideas](image)

**THE STEPS OF A MATHEMATICAL PROCESS**

Data arrangements, context and complex time dependant shared collections are mapped, organized, and identified using mathematically based “knowledge patterns” to place designs, ideas and interpretations into the context of a continuous stream of designs, interpretations and new ideas. A second, opposite and related set of “display patterns” are used to search, extract, transform and simplify each data arrangement to be displayed light and sound, or digital units able to be displayed as light or sound, as preferred or specified by each person or research group interpreting each knowledge object and research thread in the future.

“Light and Sound” could mean writing in any natural language, images, music, drawings, flow and complex sequences, and any other data arrangement that is able to be displayed on a backlit screen with speakers similar to current computers; or projected image sequences with high quality ‘surround sound’ similar to films in current theaters; high dimensional ideas similar to current scientific visualizations; recreated environments similar to current virtual reality caves; layered imagery similar to current holograms; and any other display and interpretation technique people are able to dream up in the future to present through machines connected to a network.

The lifespan of each topology is generally much longer than that of a person, research group, operating system, software, device or machine. Progressively improving networks and machines are combined with people’s evolving knowledge, awareness and abilities to question meaning in data to change and develop these patterns over time, the feedback between these patterns is what is used to streamline shared data stores. Context Driven Topologies are constructed and measured for both logical and temporal reasons.
They reside in a boundless abstract cloud, also called a “stateless space” accessible to any number of users. Mathematically perfect copies of each pattern and object are handed down from generation to generation.

This process and these patterns are perceived and used in the following states: as scale free configurations connecting and placing data components in data arrangements [Fig. 3]; as symbols that map the placement of each component in each configuration as part of each components description [Fig. 4]; a self-referring history of these placements in a continuous sequence [Fig. 5] and as multidimensional waveforms [Fig. 6] used to distribute, streamline and consolidate these patterns and forms over time [Fig. 7]. Context Driven Topologies remain mathematically the same and recognizable regardless of whether they are being used in the configuration, symbol or waveform state.

**Figure 3. (left) A Context Driven Topology as an underlying structure.**

Step 1: The written content in a set of specifications is used to show a set of information as pages, sections, and paragraphs in “rows” and “stacks”.

Step 2: Because page breaks are not relevant, this unintended grouping is removed and simplified to show only the paragraphs.

Step 3: Context and references between paragraphs are indicated by a series of arcs.

Step 4: Typically the connection arcs in this system are arranged to correspond to the “tightness” or “looseness” of each connection, however, this particular topology is arranged to show a set of linear connections (the pages, paragraphs, and references in this order). In the future, this topology could be used to show this content in this order (pages 1 to 117) or in a different view to show tighter to looser connections, the density of the most connections , or which ever way the viewer wishes to evaluate and interpret this information.

Context Driven Topologies as an underlying structure are scale free because they are constructed, scaled to fit and arranged to reflect what they are “holding together”. For example, a statistician may be analyzing data in 492 dimensions, graphs in 2 dimensions, and explaining these together with text and equations in a paper, this will generate one kind of topology. An artist generates a series of pencil drawings, they are scanned carefully, each piece is only 2 physical dimensions but the digital information is high resolution and very dense so this generates another kind of topology. Generally, the viewer only sees their information in a collage and does not see the underlying structure.

During the time people are creating, associating, reviewing, selecting and describing groups of information - for example looking at images, reading text, constructing complex drawings and visualizations, downloading music etc. - virtual connections are being generated and continuously updated “underneath” these groups of information in both individual and networked machines to map these connections. These virtual connections are used to build temporary bridges between data of any type in any number of dimensions. They allow connections that may not exist in real life or are able to exist in real machines yet.

The time and sequence these bridges are built show how designs and ideas have been built. These connections form a conceptual map and mathematical pattern that can range from very simple to intricately detailed and complex. The form and dimensions of these connections are able to vary tremendously because they are not tied to current concepts of machine topologies, nodes and hierarchies.

The skeleton structure of a Context Driven Topology is based on arcs rather than straight lines. Some arcs may have such a large radius that they appear to be a straight line, but however slight, there is always a curve. An arc’s radius varies according to the ‘looseness’ or ‘tightness’ of the connection between data.
components. There are no corners between arcs, what may appear as a corner is actually a precise rotation in the way the arcs meet. Aligning and measuring these radii and rotations is one of the fastest ways for machines to compare data and data relationships very generally. These same arcs can scale when the same components are used in another context in another structure [Fig. 8]

The topologies are used to indicate the context, or placement of designs and ideas in relationship to each other over time. Unless a particular form is needed or regularly used for a reason, the default is a spiral or seashell. This will force information with tight connective arcs to be on top and looser connections to fall to the background. It will also allow shortcuts across similar kinds of connections in zones, yet information will still be captured together in one continuous form.

When users have drawn conclusions about their information the underlying connections stop evolving and become “set” into unchanging symbols. Each topology appears to be ’simplified’ or ‘compressed’ into a map showing each component in the context of the new hierarchy. Context Driven Topologies as they are used in the symbolic character, or mapping state, never change. The mathematical machine comparison of these symbolic characters is used to trace the historical context of each data component and its placement within data arrangements as people have extracted, referenced and reinterpreted them over time.

Figure 4. (right)  A Context Driven Topology ‘compressed’ into a symbol inside each component descriptions, used as a map within each topology

Step 1: An area of concentration, in this case paragraph 8.2, is identified and isolated.

Step 2: Placement within the hierarchy is indicated by a dot.

Step 3: The topology itself, including a self-referring emphasis on this placement is embedded into the mathematical description (in this case just the paragraph number 8.2) as a permanent, embedded part of the description of this set of content (in this case a string of words in this order). In the future, this history of this component will always show how it has been placed in the context of this configuration. If this exact component, (all of the words in this context and paragraph described by the number 8.2) are used in a different document or assigned a different context in this document, this will create another, linked, topology.

When conclusions are more obvious and the data relationships more cohesive, the Context Driven Topology responds by becoming tighter and more balanced. The “edges” change to reflect the ‘status’ of changing data relationships and interpretations. Each topology takes on its own machine derived description to reflect the essential properties of this particular topology. It is unlikely people will understand the machine derived descriptions without the underlying forms.

Streamlining these extractions and links over time will provide machines with “something to measure” that reflects and compares the way people think. Streamlining similar boundaries, descriptions, placements, contexts and topologies on different levels by aligning these symbols in high dimensions will help people to draw new conclusions from complex data collections we could not understand without machines.

The most important and useful aspect of Context Driven Topologies is the ability for both people and machines to recognize, and be able to compare, both very general and very detailed knowledge relationships by identifying proportions and densities at the more simple, abstract level of the topologies before ‘reading’ the entire description of each component.

Context Driven Topologies in the symbol, or mapping, state are subsequently simplified and mathematically compacted even further to fit within each component description as if they were a character in the description. Each map indicates each component placement, proximity and priority in the hierarchy as a whole in a special, self-referring way as an “inside-out” view of the topology itself. The same component often has different meanings in different contexts / different topologies. Each component is a record of each topology, each topology is a record of each component. This relationship
and this history of placement understood through the symbols allows people to trace knowledge and association going in one direction, and helps machines to learn better placements in the future. These self-referring relationships and back and forth between knowledge components (or data) and hierarchies (or data arrangements) are the actions and decisions by people that form mathematical “knowledge patterns”.

**Figure 5. (below)** the self-referring relationship between a Context Driven Topology [Fig. 3] and a component [Fig. 4] location is shown on three levels

It can be such an extraordinary challenge simply understanding certain kinds of data or data arrangements clearly enough to form sensible groups and arrangements, that placing components in a hierarchy to draw conclusions is something that has to wait. Sometimes, very meaningful information that could lead to increased knowledge and understanding is hidden deep inside and we do not know how to recognize it. Before it is possible for either people or machines to derive new knowledge from this kind of complex data and data arrangements, the proposed arrangements and boundaries themselves may need more discussion and review to be understood, even if they are completely correct. Therefore, Context Driven Topologies evolve over time to reflect changes in historical comprehension. One of their primary uses is to ‘fill in the blanks’ ‘bridge the gap’ and otherwise help people to streamline and compare records of what we understand with what we do not understand.

Through this continued back and forth dialogue at the changing boundary between what people understand and machines can show us will eventually lead to sets of data arrangements and techniques that are difficult to get to work together and therefore kept separately will start to be compressed into tiny little records tucked inside more simplified arrangements that DO work. All of these embedded, small slightly incorrect records and techniques can be evaluated by machines together over time which may simplify our records.

Topologies in the symbol state are used to trace histories of previous context and associations originating deep in the background to gently “push”, precisely align and lock the relative proportion or sequence of data and data arrangements into suggested groups.

Lastly, When Context Driven Topologies are distributed to be shared as knowledge for interpretation by others, the arcs inside appear to ‘stretch out’ or ‘expand’ and transform into continuous multidimensional waveform to be distributed and compared in a purer form. As illustrated below, the compacted topologies ‘unfold’ to become a continuous irregular series of waves. Each arc is connected to the next arc by changing orientation from the end of one arc to the beginning of the next.

**Figure 6. (above) A Context Driven Topology expanding into a multidimensional waveform**
The process of this transformation does not place or arrange the arcs, and therefore high dimensional waveforms, in a flat plane. The rotations vary according to both the direct relationship between adjacent arcs, and as a series of periodicities down the continuous length. Variations represent dimensions, time, density, frequency and other factors that are important to each design and interpretation. The continuous series of arcs in a multi-dimensional waveform may be open or closed in a loop, but each Context Driven Topology is one continuous whole. The topologies are typically more effective and recognizable if they are closed to allow a circular path through the entire topology rather than starting or stopping at a beginning or end. It is hard to understand the dimensions these topologies are able to be in.

Context Driven Topologies are graceful and continuous like music. They have a special annotation system that could be learned by anyone. Each person and research group has certain topologies they prefer over others for any number of reasons, but to machines they are all just measurements.

Figure 7. (above) Context Driven Topologies in a group with other topologies.

Context Driven Topologies remain mathematically the same in any state to machines at all times regardless of each arrangement is being interpreted and used by people. When a Context Driven Topology is in the form of a spiral or seashell, it is more convenient to make the transformations between the connective shape, symbol and waveform uses.

Portions of the configurations, symbols and waveforms can be overlapped and combined in this simplified, abstract form before the original information itself is retrieved and interpreted. For example, if only tight connections are acceptable, only this specific radius or range is recognized. The states which topologies are typically in will say something about how the information is used, the value it has and what it means. For example, topologies used in a library will typically stay in the symbol phase [Fig. 4], a theorist will typically rearrange the structures [Fig. 3], an analyst will compare waveforms [Fig. 7] and see where pathways contained within the history of symbols [Fig. 4] and configurations leads [Fig. 3].

Context Driven Topologies are user defined pathways in and out of the stateless space or boundless abstract cloud [Fig. 1] that are given by the mathematical relationships between the symbol/map use, the connective/changeable state, and the simpler/expanded waveform state. New patterns generated by comparing these topologies and uses is recognized by either people or machines for different reasons, machines may be able to compile and consolidate the topologies in groups we may not have put together or broken apart yet but will never “know” if they make any sense until we review them. People will not know what machines are consolidating in the background until we look for it this particular way, otherwise it is a structure, a symbol, or a waveform we are using for our own knowledge, investigations and expressions.

THE DESIGN AND DECISION MAKING PROCESS

The flow, or pace, of these changes to the topologies and the patterned space around them directly corresponds to the pace of changes in designs and comprehension idea by idea, relationship by relationship. Over time, these histories, contexts and placement will help people to understand data and data arrangements that are harder to configure or draw conclusions from. It will also give us a new way to
recognize design and purpose as a holistic, evolving, interrelated process that may be expressed through any number of computer programs, networks, knowledge domains, natural languages and cultures.

Context Driven Topologies, including the history and knowledge they contain, are distinguished from each other in a dialogue and decision process between people and advanced networks of machines over long periods of time. These distinctions are directly related to the nature and interpretation of the information itself, the way the user is looking, the similar examples each user or research group provides, knowledge describing the information, the era which the information originated and the era the knowledge is being re-interpreted. For example, a teenager downloading music may input slang words that disappear over time; a mathematician may input very precise equations that have not been examined for 142 years and also unexpectedly retrieve all the arguments from the original era as well; a mechanical engineer inputs a flow sequence and accidentally retrieves similar flow sequences that illustrate about shopping trends. Through a knowledge based interactive process where people provide machines realign, twist, turn and manipulate groups of topologies and components [Figures 8 and 9] using with similar examples, in similar dimensions, with similar pacing or evolution, until eventually, non-relevant information is weeded out and the arrangement is the designer decides is the best way to represent their idea to others.

Various interpretations and objects appear to scale by implying adjustable boundaries to permit associations that may not have been possible either in real life or machines that exist when the association is discovered in a person or research groups imagination. The invention provides an easier, better way for these objects to virtually merge or be broken into individual components because these objects are not required to function in real life or real machines. All boundaries are scale free to machines. Each boundary is “stretched or squeezed” to fit in hierarchies and levels constructed by people until a meaningful context is assigned and a conclusion is drawn. methods for scaling data as objects and relationships will also lead to better ways for the topologies between advanced networks of machines to scale.

During the time people are manipulating, selecting and determining the priorities and adjacencies of data components and groups in the new configuration, machines never “see” these arrangements as people do - in a hierarchy where portions of the background are completely blocked by the foreground - machines always process the whole group of techniques in the current arrangement as if they were one technique by borrowing from the background, updating with current techniques on the network, and folding this set of techniques over to consolidate, mix, simplify and weed out algorithm by algorithm until machines can establish their own pattern defining simpler ways to do the calculations and simplifications that eventually get this group of techniques to work together.

The only way people can check this work is to see how it compares to other calculations and simplifications that are known to be correct. The vast majority of topologies use the same technique throughout and it is not an issue. Machines keep techniques separated and just ‘pretend’ to run them together at the same time to temporarily show the images, words, drawings and ideas people are would like to see together at the same time for reasons machines can’t understand and people are not able to describe together in a new way yet. Diverse, potentially incompatible techniques only appear to be combined when they are compressed and captured together in a topology. Each data compression and technique consolidation may need to leave sets of techniques separated until they can be simplified, streamlined and consolidated over longer periods of time. These separations could be compared to natural languages and cultures, people can still communicate and share common interests even if we do not speak one shared natural language, each culture’s ideas and personality is expressed best in their own language, the same might be true for machines, how would people know?
It is ‘cleanest’ or ‘easiest’ for machines to search, identify, compare and retrieve groups of Context Driven Topologies with each other when they are in the multi-dimensional wave form state in the stateless space [Fig. 1] because this is where the topologies are most pure and machines are able to rearrange them in ways we may not understand. These operations are transparent to users, the more knowledge they have to specify the information they seek, the more direct the connection is to the original design intent.

Generally, these configurations, histories and patterns are treated as objects in spaces where both the object and the space around it have meaning.

Ideal objects, spaces, proportions, densities and other measurements are able to be regularly observed by all people when they observe nature, art, music, design and mathematics. Sharing information using the Context Driven Topology system will lead to a new politics of data description and presentation and, more importantly, a new aesthetic for what is perceived as designed, balanced, or purposeful.

Advanced networks of machines use mathematical processes to help us understand, maintain, organize and simplify dynamic shared data stores by translating these actions, groups and relationships into an automatic language that is a new application for Graph Theory; Knot Theory Topology; Algebra, Group Theory, Combinatorics, Fourier Analysis, and various interrelationships between these fields that is most clearly captured through mathematics but understood through words, sounds, and images and other modes.

**PROPOSED METHOD**

These mathematical processes will be tested and prototyped through an upcoming project entitled “The Visualization of Context Driven Topologies – Digitizing the Non-Digital” using these steps:

A group of theorist/mathematicians individually present a visual and mathematical talk to a group of artists describing their work, the mathematics they use, and the images they create (for example visualizations, graphs and diagrams). Aesthetics and relationships between the theorists’ talks are interpreted differently by each artist (1). Their unique interpretations are manifest through an art object, performance, media or layered, digital system (2). The collaboration overall will generate a series of technical papers and other writings across several domains (3), one complete publication or book (4), a changing internet presence (5), two art exhibitions (6), and sets/series of discussions (7) - a limitless series of panel discussions, a structured series of lectures, and simple questions from kids. All of these words will be translated into an ‘occurrence’ model (8) of ten natural languages to supplement the mathematical and aesthetic connections. Each participant will produce at least one paper (9) describing and illustrating the connections they see among this group of ideas. Both of the exhibitions and all of the discussion topics will be modeled as a set of ideas that have originated at the same time through the same series of theorist talks (10). See www.contextdriventopologies.org for more information.

The steps of these mathematical processes are intended to result in a limitless collection of knowledge patterns, designs and ideas seen as objects with patterned spaces around them. Each patterned space is caused by mapping both the era which the object was created and the series of eras which this object has been subsequently interpreted. The creation of new patterns, new memory forms and a shared memory space will evaluate, simplify and streamline the geometry of these knowledge relationships over time.
which will improve the quality and understandability of data in dynamic shared collections by recognizing a new relationship between process, pieces and overall.

The intention is to change the communication mode between people and machines by looking at the process of going from piece to overall as indicated by the arrows in the image below. This process will develop more precise descriptions, categories, drawings and other records that can be interpreted, discussed, changed and used over long periods of time; to make all types of patterns and spaces easier to perceive and discuss for a variety of reasons; and to improve design deliverables and international, constantly updating discussions and collaborations. The system described process and methodology to begin looking through large scale museum and library digitization projects, automated scientific experiments, specialized databases, internet accessible publishing and other complex shared information. It is also an automatic system to improve the quality of data in dynamic shared data stores. It will train the shared information and memory space to prefer threads of knowledge that have been thoroughly reviewed and discussed to give these data arrangements a greater chance of persisting because they might be true, regardless of the fact neither people nor our current machines may be capable of fully understanding yet.

CONCLUSIONS

There is something internal that happens when design is perceived, it is a different part of our brain where words are not useful. If we can develop a system to communicate with our machines at this level - our designs, mathematics, studies, investigations and curiosities will all have opportunities for advancement we could never have imagined before.

REFERENCES

2 Suresh Konda Software (1992) Shared Memory in Design: A Unifying Theme for Research and Practice

Key Words
Patterns, Mapping, Visualization, Proportion, Heuristics, Abstraction, Simplification, Aesthetics, Interpretation, Historical Comprehension, Modularity, Dynamic Protocols, Complex Data Stores

Background on the Author

Deborah MacPherson is an independent curator who organizes museum content and collections by selecting, categorizing, numbering, indexing, describing and presenting objects in meaningful hierarchies to tell cultural, scientific and historical stories through spaces, objects, voices, projection geometries and immersive environments that simulate a feeling of “being there”. This idea and proposed system was prompted in 2001 researching thermodynamics for Shanghai Scienceland in China and a variety of which projects included constantly updating architectures, environments and spaces, interactives, artifacts, stories, programs and complex scopes of work documented by the author through matrices, CSI specifications, photographs and CAD drawings. This project and group of participants has been brought together over the past three years (by the author) and became cohesive approximately three months ago.

See www.contextdriventopologies.org for more information on the project participants
See www.accuracyandaesthetics.com for a small portfolio