

# The Potential of More Liquid Views in Word Processors

Frode Hegland, ID: 29018757

## **Abstract 3**

## **Introduction 4**

Aim of the project 4

The Liquid View Host Word Processor : Author 4

## **Systems of Visual Thinking 5**

Analogue 5

Digital 6

## **Towards High Performance Visual Thought Augmentation 13**

Interaction Space 14

## **The Research Domain : Scholarly Writing 15**

## **Current Constraints on Scholarly Document Discourse 16**

PDF – WYSIAYG 16

Leslie Lamport's Tex 17

Scholarly Text Tools 17

## **Innovation Opportunities 21**

Boundaries and Constraints 21

Legacy 21

Specific Innovation Opportunities 21

## **Work Done So Far 22**

Before the PhD 22

For the PhD 22

## **The Research Question 25**

Q1 : Supporting Authors & Readers 25

Q2 : Visual Elements & Interactions 25

## **Plan & Timeline 26**

9th of December 2018 26

Change is Coming 26

Continuous Research Outputs 26

Cost 27

Levels of User Testing 27

Further Horizons 27

# Abstract

This report describes a proposal for a research project aimed at helping improve scholarly communication by investigating the opportunities of extending the traditional word processing views from linear columns into more liquid, free-form ‘spatial hypertext’ views where the user can think much more visually, giving the user other perspectives on their work, achieve both faster and deeper insights.

This proposal is for such a ‘Liquid View’ to be embedded in a word processor, which for this research purpose I have created (Author), but which is generalisable for other word processors. A foundational component of the research is that the user can instantly switch between the traditional word processor view and the Liquid View, by performing a quick and cognitively insignificant switching action (such as a macOS ‘gesture’), rather than providing the functionality in a different application with cognitively heavy round-trips *and just as easily* and quickly switch back to the traditional word processing view.

The result of the switching interaction will result in the collapse of the word processing view in a manner whereby the body text becomes hidden and only the ‘Headings’ are visible. The Headings now become ‘Nodes’ in a free-form interactive space, the nature of which will be determined through design and testing, being the primary aspect of this research project.

I have mocked-up a walkthrough here: <https://www.youtube.com/watch?v=InMcFp7zMNE>

To support the research I have looked at the history and presently available systems of visual thinking, both techniques and software, to inform how early visual thinking in general and hypertext thinking specifically can benefit from implementations on powerful modern personal computers and tablets – profiting from the cognitive benefits of pen use (Weel, 2017) – and how to possibly extend such systems, as well as start dialog with notable people in the field to gather deeper insights.

This report closes with a set of research questions for the project and a proposed research plan to answer them.

---

## Document Notes

*Please note that this document is longer than a regular 9 Month Report due to the extended timeframe of its development and that **an Author version of this document is available, complete with interactive citations at <https://www.dropbox.com/s/z0egpqiyx7g14qt/The%20Potential%20of%20more%20Liquid%20Views%20in%20Word%20Processors.zip?dl=0>***

# Introduction

## Aim of the project

The aim of the Liquid View project is to examine opportunities to improve scholarly communication through novel uses of free-form text editing to augment visual thinking within a traditional word processing environment, both for the individual author and for author-reader communication as powered by modern networked computer systems, in effect asking how far we can extend our cognition:

Human-extended machine cognition is a specific form of artificial intelligence in which the casually-active physical vehicles of machine-based cognitive states and processes include one or more human agents. Human-extended machine cognition is thus the idea that human agents can serve as part of the physical fabric that realizes the cognitive capabilities of a machine-based system. This idea is important, not just because of its impact on current philosophical debates about the extended character of human cognition, but also because it helps to focus scientific attention on the potential role of the human social environment in realizing novel forms of artificial intelligence.

*Smart, 2017*

## The Liquid View Host Word Processor : Author

In order to supply a traditional word processing environment built on current technologies, I have conceived of, designed, funded prototyped, restarted three times, developed to completion and released a word processor for macOS (and soon iOS) called ‘Author’, named in tribute to Doug Engelbart’s ‘Augment’, which will host the Liquid View. This is a crucial infrastructure for the Liquid View since it must be a part of a word processor, otherwise it will be in danger of being just another mind-map type application. The Liquid View is a flexible text view and not a general information view, since I believe that the history of text has not been written and the future of text has only just started, and the potential of interactive text lies largely untapped.

...writing does more than express meaning or knowledge; it makes meaning and knowledge. Despite common injunctions – “Think before you speak” or “Choose your words carefully” – we rarely assemble language in our heads before we speak or write. Certainly, most written texts do not emerge fully formed; they are crafted, composed, and unfold through a process of transforming ideas into language.

*Paré, 2009*

# Systems of Visual Thinking

Inspirations for visual thinking using Liquid View can be drawn from several established practices:

## Analogue

### Mind Mapping

The great prophet of Mind Maps Tony Buzan refers to the brain as a Branching Association Machine (Buzan, 1996) which mind mapping can tap into. Mind Maps are very specific visual representations with a central topic/premise/start at the centre of a visualisation, branching out. The user is free to choose how and where to add branches but they all have to come from one centre, which does not fit the Liquid View model, which is more freeform.

### Concept Mapping

Concept Maps are diagrams which depicts suggested relationships between concepts, with a strong focus on graphical frames and arrows to indicate directional relationships (Cañas, 2011).

### Post-It® Notes

David Straker's book on Rapid Problem Solving with Post-It® Notes (Straker, 1997) provides an analog experience of moving piece of information around in order to solve problems. Note that his use case is problems solving, which is close to writing an academic paper, but not exactly the same. His key principles are Chunking, Problem Patterns, Guiding Decisions and The FOG Factor. The Guiding Decisions set of principles is very much focused on problem solving, with categories of Objectives, Criteria, Questions and Constraints which are not directly applicable to Liquid Views.

Liquid View Design Notes: The FOG Factor notion of putting an F on Notes which are Factual, O on Notes which are Opinions and G on Notes which are Guesses can inform a visual tagging system for Nodes and lines.

### KJ-Ho

KJ-Ho is a method invented by the Japanese ethnologist, Jiro Kawakita, developed as a result of having difficulties in interpreting ethnographic data in Nepal (Scupin, 1997) and should be possible to do in the Liquid View, giving us one clear starting scenario. This method puts unstructured information on a subject matter of interest into order through alternating divergent and convergent thinking steps. (Kunifuji, 2013). Jiro explained the process in his

paper (Kawakita, 1991), where I have inserted basic arrows to indicate possible use in the Liquid View:

- **Label Making** is the process of writing down everything relevant on index cards.
- **Label Grouping** is the process of grouping the cards according to relevancy.
- **Group Naming** to name the groups of cards.
- **Spatial Arrangement** to arrange the Groups into useful arrangements.
- **Relationship Settings** to use links to indicate the relationships between the objects/nodes, where the shapes of the links convey the nature of the relationship:
  - Cause and effect: One is a predecessor or a cause of another —>
  - Interdependence: Objects are dependent on each other <—>
  - Correlation: Both objects relate to one another in some way —
  - Contradiction: Objects are conflicting to each other >—<
- **Verbal or written explanation.** The last step is to explain the chart clearly which other visual thinking systems neglect

Liquid View Design Notes: Giving arrow designs meaning is interesting and I think a way to teach the user what the different designs mean would be to the interaction to make lines from one node to another be through dragging one node onto another and have drop zones reveal options for what links should be made, including the ones above and the ones I have added below, with both textual description and visual.

memex

The last great analog system before the world was digitised was Vannevar Bush's memex, which provided a theoretical means to tie items together (Bush, 1945). Although his design did not include visualising the items nor their connections, his tying together of items were foundational. "*Whether implicit or explicit, static or dynamic, links offer a way of defining relationships in information and there are many ways of achieving this goal*" (Hall, 1999). The Liquid View system provides visual and semantic ways to tie nodes together, as well as supporting hypertext links in the associated word processor view.

## Digital

With electronic systems the potential to make the filing and retrieval more flexible resulted in a profusion of systems (Cole, 1982) with different conceptual structures. The promise of taking the physical meaning of filing ([www.etymonline.com](http://www.etymonline.com)), which originally meant to hang a document on a string, into the virtual dimension of cyberspace where any attribute of the document can be used to weave a web of documents in a network of text, all terms which originated with some aspect of weaving, is still ripe for development. The opportunities of digital capture/storage retrieval, knowledge work and publication are in their absolute infancies though there are some shimmers of light from the developments over the past half century or so, illuminating possible ways ahead.

Historically there have been separate issues dealing with information inside a document and the connections which explicitly ‘Extends’ away from a document, such as links and citations. We nevertheless have to divide our information into chunks in the same way that a photograph will always have a perspective and a frame – the scene itself is boundless – in order to enforce order on the information and to imbue it with a human perspective. The historical narrative that follows was originally written split into in-document and inter-document but it became clear that while the distinction is present, in a digital environment it becomes increasingly blurred.

## Deep Intercomparisons

Ted Nelson writes about the importance of supporting deep intercomparisons, referring to the problem as the Indeterminate Boundaries of Writing, where information is necessarily discarded to create the frame of a document. He further elaborates:

I have always thought of links as an extension of literature. Their structure would extend the footnote, the parenthetical note, the citation, the marginal note, the parallel element (marginal gloss or caption)– the ways text has always tried to break free.

*Nelson, 2002*

His notions of the importance of connections, as described through his wonder as a five year old in his grandparents boat and expressed in work such as the ZigZag visualisation system and his epic Xanadu visual connections, is a huge influence on Liquid View and my work in general. In 1960 he asked: “How can we improve on paper?” to which he outlined his criteria in his autobiography Possiplex (Nelson, 2011), users must be able to:

- **Underline anything** (not just within one application)
- **Put sticky notes son anything** (not just within one application)
- **Annotate anything**
- **Make visible connections** between parts of any documents, in any formats
- **Re-use and combine content** from all formats retaining connections to their sources
- **Bind pages together with visible connection-lines**
- **And much more**

## Augmenting Human Intellect

I have written much on my friend and mentor Doug Engelbart and his work, but what is relevant to highlight in terms of the Liquid View is his enthusiasm for ViewSpecs, of which he was not able to implement as many as he would have liked to, such as colour coding text based on subject matter and fading based on word novelty, and his enthusiasm for interactive text, or Symbol Interaction as he preferred to call it.

I honestly think that you are the first person I know that is expressing the kind of appreciation for the special role which IT can (no, will) play in reshaping the way we can symbolize basic concepts to elevate further the power that conditioned humans can derive from their genetic sensory, perceptual and cognitive capabilities.

*Engelbart, 2003*

## Still Flowing : Spatial Hypertext

30 years ago Jay David Bolter and Michael Joyce in collaboration with John Smith introduce Storyspace (Joyce), at the fabled Hypertext '87 conference – a seminal moment in the history of hypertext, since it was the first large international conference devoted to the field. Storyspace was, and still is, a hypertext authoring environment for serious interactive fiction.

David Bolter's dream had been to "*not merely to move a paragraph from page 265 to page 7 but to do so almost endlessly. I wanted, quite simply, to write a novel that would change in successive readings and to make those changing versions according to the connections that I had for some time naturally discovered in the process of writing and that I wanted my readers to share*" (Barnet, 2014), as quoted by Belinda Barnet. The collaboration between Joyce, a writer and Bolter, a classics professor with computer science training, was focused around storytelling and associative thinking. In Storyspace introduce the two primitives of interactive fiction; episodes and decision points, which they also call links, which can be conditional based on past behaviour of the reader (initially this included a string match where the reader had to answer a question before a link would unlock and a requirement that the reader have visited/visited specific other links, or a combination thereof), which are available in two modes, one for the reader (equivalent to Author's Read mode) and one for the author (Author's Edit mode). The authoring is done within a visual editor which they call the 'structural' editor, where the author can see a graphic or diagrammatic view of the hypertext work.

The implications for the Liquid View is primarily that this is the start of what would come to be called 'spatial hypertext' and the concept of navigation restricted by an author based on reader behaviour. It also illuminates some of the unique opportunities of digital writing through they cite the work of Jorge Luis Borges as a non-digital precursor, particularly his work *Ficciones* (Borges, 1942). Their analysis of hypertext writing also introduces guided writing, where the same 'story' can be told at different levels depending on the narrator,

something which can be employed to author documents for different audiences, such as specialists in a field or those not familiar with the specific field being discussed. The systems influence of interactive games (though less so than the linked lists in Fortran), can also be useful for Liquid View, as discussed with Jun Murai.

Cathy Marshall and Frank Shipman introduce the term 'Spatial Hypertext' at Hypertext 92, though it is hard to pin down exactly who coined the term, even when talking with the people who were there. Mark Bernstein elaborates in a private email to the author: *It might have been coined by someone else at Xerox PARC in the Aquanet era — Trigg or Halasz or Coombs might be barely possible — but Cathy used it in her HT92 talk in Milano and that's where I first heard it.*

Their paper points out how spatial hypertext is a graphical overview of a hypertext network, showing nodes with lines representing links though the nodes can also be represented without links and the “*nodes may appear in different contexts through multiple references to the same underlying content*” (Marshall, 1994). Frank M. Shipman further writes that “*Spatial hypertext emerged from the graphical presentation of traditional hypertexts as maps*” (Shipman, 1999) in order to help the user maintain context and understand paths.

In 1990 Eastgate takes over development of Storyspace under the stewardship of Mark Bernstein, who explains the transition in a private email: *Eastgate's a hypertext developer and publisher. In 1989, we were interested in publishing afternoon, and Storyspace needed a publisher. Our own system, Hypergate, was clearly in trouble because it was based on the wrong platform — a FORTH dialect called Neon.* Eastgate is a hypertext developer and publisher who were interested in publishing 'afternoon' by Michael Joyce and Storyspace needed a publisher. Their own system, Hypergate, was not viable because it was based on the wrong platform, a FORTH dialect called Neon.

According to Mark Bernstein, 'Spatial Hypertext' (Bernstein, 2011) rests on the perspective that information itself has inherent structure and that making this structure visible will augment our ability to understand and use the information. The interactive nature of hypertext allows the user to generate maps of structures and relationships on the fly. Mark Bernstein is one of the few who have been actually developing and delivering hypertext systems which are in use, most prominent of which is Tinderbox which my colleague Mark Andersson has been a long time user of technical support for and who is helping me better understand the system. Core to the discussion is Mark's assertion that spatial hypertext is difficult to explain and to share because we have so little vocabulary with which to discuss it (Bernstein, 2011).

Spatial Hypertext concepts will be increasingly relevant to the Liquid View as I continue to build it: “*To fuzzily relate two items, they are simply placed near to each other, but maybe not quite as near as to a third object*” (Haller, 2011). This allows for so-called constructive ambiguity (Marshall, 1999) and is an intuitive way to deal with vague relations and orders, something which is inherent to the proposition of Liquid Views. Where spatial hypertext is not completely relevant to Liquid Views however, is in the structure of the linking, where the author sets parameters for what connections are available under what circumstances. The

Liquid View is not an authoring tool for hypertext fiction, it is a view of a free-form set of nodes/headings which will be primarily presented as a structured, linear text.

### Spatial Hypertext Elements

In addition to the nodes and links of the Hypertext workspace, Mark Bernstein also refers to what he calls ‘adornments (forum.eastgate.com)’ which includes ‘separators’.

### gIBIS

Jeff Conklin, who joined us at the Future of Text (www.youtube.com), developed gIBIS, a ‘graphical Issue Based Information System’ to support conversation among stakeholders (Conklin, 1988), featuring a rich visual language for capturing and manipulating argumentation which can inspire design of a visual language for the Liquid View, in a more stringent direction than KJ-Ho or Post-It Notes.

### Neptune

Neptune, (an evocatively liquid name), developed by Tektronix Laboratories, applied hypertext to the CAD domain and called maps ‘Graph Browsers (Schwartz, 1986)’ which highlights the environment it was built for.

### HES > FRESS (File Retrieval and Editing System)

FRESS (Dam, 1976) was built by Any Van Dam at Brown University in collaboration with Ted Nelson (which was not to last), one of the very earliest hypertext systems, using a light-pen and is said to feature the first Undo command (www.derosé.net). FRESS featured two types of ‘links’: tags and jumps. Tags were links to information such as references or footnotes, while jumps were links that could take the user through many separate but related documents, using Doug’s parlance of the action of clicking on a link.

For the Liquid View, their notion of tags is relevant as a position of how to deal with non-external, non-visible, relevant information which the user should be able to call upon.

### Intermedia

Intermedia, built at the Institute for Research in Information and Scholarship (IRIS) at Brown University was an early hypertext system (1984), developed specifically to support teaching and learning. The concept of link ‘anchors’ grew out of the project which went on to become the famous “a href” tags in the HTML, from a realisation the team had that application development will be most fruitful when the community at large embraces object oriented building blocks and frameworks, a vision we still yearn for today. The project was part funded by Apple Computer (Drucker, 1988) so there would have been understandable optimism that this would come about.

## NoteCards

NoteCards (Halasz), was built at XEROX PARC in the mid 1980s, a hypertext-based personal knowledge base system with inspirations of Doug Engelbart's Augment though being network based rather than using Doug's hierarchy structure. The purpose of NoteCards was to support Idea Processing using a digital version of small index cards as nodes which can accept mixed media content, connected using (only) typed links. The process supported is similar to the KJ-Ho method and also simple Post-It Notes, as well as concept and mind mapping, though in a computational environment. A downside of their implementation on the available software and hardware systems of the time though was that strategic planning was required, it was not flexible enough to adapt from rough ideas into structures. The flexibility of the cards also presented planning problems since users were not sure how to segment their initial ideas.

## In the Beginning Was The Light : Macintosh

I have strong memories of the first time I saw a Macintosh, late in the evening at a friend of my parent's home in London and which simply awed me in that dark office with that bright and crisp and clear screen. As Steven Levy wrote: Someone flicked the machine on, and I knew right away: it would change the world (Levy, 1994). The issue was that the original Mac, elegant though it was, was not designed for handling more than a few documents and I was concerned that we'd have the same issue with Liquid Views. If we look at only nodes then it's not such a problem, with mind maps having only 31 nodes on average (Langer, 2011), however, since Liquid Views are not free-standing spaces – they are constituted of headings in a word processing document, with scientific papers as a metric being 3,000 to 10,000 words (Lauri, 2009) – it's worth noting that any body text can impact the constructed Liquid View, through visualised Find etc. so the user can potentially get blinded by the amount bright light of overwhelming amounts of nodes and other entities on the screen and the user will need specific tools to deal with the amount of nodes present.

## Sunglasses : Recent Efforts in Tackling Visual Information Complexity

There have been many specific techniques invented over the years to help the user deal with such large amounts of data visually. A primary tool is information filtering (Dumais, 1992) through various means, including restricting hierarchical levels, programmatic (Engelbart, 1984) and by contexts and analysis.

The complimentary side of filtering is the question of what each nodes shows, which can be abstract information such as size relating to the relative number of words in a given section/heading/node or icon previews showing the body text they represent, such as has been done for visualising web pages in the Data Mountain Project (Dantzich, 1998) for example.

A further dimension of the filtering/icon perspective is the users attention and here the Fisheye Technique (Brown, 1994) allows the user interactively choose what area of the view to show in high detail and larger size, in contrast with the rest of the view which remains

small and remains on the screen primarily for context, is a optionally useful interaction for the Liquid Views. The ‘space’ of information can be shown literally (interesting use of the word, I hope you agree), using a landscape metaphor (Chalmers, 1993) to visualise hierarchies or abstracted pyramidal places (Pichler, 1998).

Where Ted Nelson’s visualisations can be thought of as being 2 ½ Dimensional (2 dimensional document objects in 3D space), three Dimensional Views have been also been around since the last millennium (Greenhalgh, 1999) and are inspirational in the rich ways they present interrelationships between documents but in all the techniques surveyed there is a significant visual overhead associated with the elements of the scene which renders it three dimensional to the human eye, whether skeuomorphic, such as the WebForager and the WebBook (York, 1996), or highly abstracted like Natto (Matsushita, 1997). More recent examples of what was called data visualisation, a term which become popular after 1984 (books.google.com) and the more recent term data analytics (books.google.com) reveal a democratisation of looking at highly visual data in order to gain insights. These visualisations and techniques are primarily aimed at Big Data (Davenport, 2015) and as such are not completely pertinent to my work.

In terms of getting a better grip of virtual documents in virtual ‘folders’, the “*Alias*” (Wong, 1991) was an early means through which a user could choose to have a document listed by more than one criteria, specifically by creating an alias and putting the alias in a different folder which, when the user clicks on, will jump to open the original document.

User studies at Apple Computer (Wong, 1992) in the early 90s showed how people quite naturally organised their information in piles: *we found that users like to group items spatially and often prefer to deal with information by creating physical piles of paper, rather than immediately categorizing it into specific folders. Computer users are confronted with large amounts of information, but currently are only provided with a hierarchical filing system for managing it.* This resulted in the first representations known of piles in a computer system, after a conceptual implementation in the Business System (Webb, 1981). Their design recommendations were illustrated with icons which showed ‘screenshots’ of actual documents (what I referred to as being Glanceable (Hegland, 1999)).

For deep future perspectives, I had a private conversation with Jun Murai in Tokyo he asked how manga might help with the richness and immediacy of the text space and after considerable back and forth we moved into the area of computer games and AI deep learning to consider how groups of nodes could be analysed for body content, screen context and more, to produce various visual and interactive behaviours, such as jitteriness should the information they contain be incongruous, relaxed if richly linked and so on. Far-out perspectives, but provocative enough to maybe be useful at some point.

# Towards High Performance Visual Thought Augmentation

It is my background as a visual artist which compels me to work on this project, having started out at the Chelsea School of Art and ending up as a teacher at London College of Communication. It is my gut feeling that text can be much more richly visual which I am investigating in this project.

We perceive about 12 million bits/second (10 million from vision, 1 million from touch, and the rest scattered among the other senses). 16 bits per second is the bandwidth of consciousness. - Symbols are the Trojan horses by which we smuggle bits into our consciousness.

*Norretranders, 1999*

The premise of the Liquid View is that high level thinking, which happens largely in the prefrontal cortex (McNaughton, 2012) can be better served by using the brain's powerful visual spatial processing abilities (Palij, 1982) in a richly visual presentation rather than shoe-horning the visual processing to decode rectangular layouts of uniform dark text on light backgrounds, going far beyond the confines which 'sophisticated' typography have constructed for us: The very first time an ancestor noticed that animal tracks were left by animals, we were exposed to symbolic records, where the symbol of the track referred directly to the animal which left it (Everett, 2017). The evolution of visually recorded symbols started with such a simple insight ('sight') and both evolved and devolved into the minimalist symbolic notion of the words prevalent in the static PDF documents of current academic communication.

The principal virtue of the visual medium is that of representing shapes in two-dimensional and three-dimensional space, as compared with the one dimensional sequence of verbal language. This polydimensional space not only yields good thought models of physical objects or events, it also represents isomorphically the dimensions needed for theoretical reasoning.

*Arnheim, 2004*

## Interaction Space

### High Level

- **Curiosity Support.** The major focus is to help the user see and think in what I call a ‘curiosity space’, where the primary support is not for general moving around of entities but explicitly to support the author’s curiosity, with a focus on epistemic curiosity (Clark, 2010) (through flexible re-orientations of current knowledge) and specific curiosity (through implicit linking etc.), in order for the author to generate better understanding of what the text says and what it does not say, so that the author can subsequently clearly communicate any findings.

### Specific Actions

To support the high level goals, the process is built around the power of visual processing to support cognition and thus includes:

- **Allowing for Groupings/Spatial Organisation** of entities through freeform direct manipulation (Shneiderman, 1993) and programatic layouts (North, 2009) to employ the power of preattentive vision (Julesz, 1981) and the interactions of elementary perceptual tasks (McGill, 1984) to free up higher level cognition grounded in our inherent sense of space (Herskovits, 1997).
- **Connections/Associations/Processes/Relationships** between entities through the use of connecting lines, also through manual and programatic means. I am building a Glossary (see the Appendix) to research and explore the differences between these terms and how they relate to relationships and the way we can increase our cognitive fluidity (Mithen, 1998). The lines drawn in the Liquid View are not the same as links, though links can also be visualised.
- **Filtering** (Mukherjea, 1999) to choose what to see/hide.
- **Semantic Network visualisations** (Zhuge, 2012) can theoretically be employed, based on the body text the nodes refer to.
- **Processes**, similar to Connections but with the use of directional lines/arrows, as well.
- **What might be missing from their work.** This is in support of the important to surface what is already known (Ausubel, 1968).

The system furthermore needs to enable the means through which to use it:

- **Interactivity** is the novel addition to visualisation which computers can supply (Filipcak, 1996), allowing for interrogation of any textual entity and relationship to support specific curiosity. My ‘Liquid’ Philosophy, as developed in dialog with Doug Engelbart and Sarah Walton, puts interactivity at the centre, as the foundation of information, with potentially profound implications (Zhuge, 2009)

## Communication

The resulting views become diagrams when they can be employed by others to understand the work of the author. This was an insight brought about by my advisor Les Carr in an email regarding an earlier version of this document when he wrote in an email to the author: “Your mind maps are tools to help you. But they won’t help me recreate your thoughts”.

- **Diagrams** can be used for thinking but are designed for communicating to someone else, or yourself in the future not to think for yourself at a moment and will require additional visual supports such as comments, additional graphic elements such as frames and guides.

## The Research Domain : Scholarly Writing

The Liquid View is designed primarily to support curiosity while authoring scholarly texts and must therefore fit in the scholarly writing process. It can be said that the goal of scholarly writing are to increase the useful body of knowledge of a field and to further the academic author’s career, both of which need to be kept in mind when designing writing systems. Once the author has chosen a research topic, the scholarly publishing is a process of in the rough sequence of:

- **Primary and Secondary Research/Literature Review** providing an analytical overview of the significant literature published on the topic (Jensen) (consisting of the activities of finding, deep and skim reading & annotating academic documents) which impacts Liquid View design by highlighting the connected nature of the text,
- **Thinking**: Grouping, Sequencing, and Documenting Information and Writing an Outline (Wisconsin, 2017) and going back to perform more research, which are core Liquid View actions
- **Writing & Editing** and finally
- Making the work public by **Publishing** with Liquid Views intact

# Current Constraints on Scholarly Document Discourse

## PDF – WYSIAYG

PDFs, or ‘Portable Digital Format’ started out with a very clear mission, code named “Camelot.”

This project’s goal is to solve a fundamental problem that confronts today’s companies. The problem is concerned with our ability to communicate visual material between different computer applications and systems.... What industries badly need is a universal way to communicate documents across a wide variety of machine configurations, operating systems and communication networks. These documents should be viewable on any display and should be printable on any modern printers. If this problem can be solved, then the fundamental way people work will change.

*Warnock*

The result was a huge success and PDFs do an admirable job of encapsulating documents from any software in a format which can be printed out with WYSIWYG expectations.

The problem is that this retards the documents usefulness in a fully digital environment by dictating that the readability is preserved for print but constrained in the digital environment, as Doug Engelbart pointed out when he said the name should not be WYSIWYG but WYSIAYG - What You See Is All You Get (Markoff, 2007), somewhat putting a damper on early dreams of h-journals (hypermedia journals) rather than e-journals (electronic journals) (Treloar, 1999).

Whereas PDFs serve the documentation process of companies well, they are particularly unsuitable as a scholarly medium is because the scholarly process relies heavily on literature reviews yet the documents published for literature reviews are digital only in the very basic sense of being in a document the computer can read. There are no useful standards or tools for marking up PDFs and later browsing or searching the markup. Documents do not have uniform meta-data with even the basics such as the document name, publication date or even the name of the author and many academic PDFs do not feature the date of publication in the document itself.

I have therefore looked into creating a PDF Reader ([www.liquid.info](http://www.liquid.info)) to allow me to annotate text and then later search or browser based on what text is annotated and then Copy the text as Citation revealed how messy PDF formats are and how the fetish academic journals and institutions have for ‘camera-ready art’ is retarding real innovation of how to better author and read the documents – open data should also apply to document formats. This will not be built but the functionality will make its way into Author. With the computer able to store and process a myriad of data types the academic document should keep up. Instead of publishing ‘frozen’ documents the document could change to be more of a

framework or container, where new aspects of the work and new data can be incorporated. *“It is time for the research article to move beyond the now-obsolete print model and truly embrace the freedom that online publication gives us, moving towards living documents, with a single article for a single piece of research.”* (Shanahan).

A competitor to PDF is ePub, however it failed to achieve primacy in the jump away from paper, partly because it is not as easy to author in as PDF (Ferrara, 2017) so maybe it’s time to stop fighting PDFs and start turning them into Trojan horses for rich content, which is why I am working on the Rich PDF format, as described in ‘Work Done’, instead of trying to present entirely new formats (Shanahan, 2015)

## Leslie Lamport’s Tex

LaTeX is a document preparation system used widely in academia, since it can accurately show scientific notation and outputs as typesetting instructions. It could be beneficial to support LaTeX inside a word processor view for specific notations however.

## Scholarly Text Tools

### Readers

Specialist Reader applications focus on the reading process as distinct from the writing or editing process. Author features a Reading Mode since the act of reading does not always require the same toolset and functionality. This section focuses on PDF reader since that is the commonly used publication document format used in academia and other fields. PDF is a ‘rendered’ format so there is very little a specific app can do with the appearance of the document, such as re-flow text and change colours, type size and so on.

### macOS

- **The iBooks application** on macOS simply sends any PDF to Preview for reading: **The Preview application** gives the user minimal reading functionality, including a left slide-out menu which can display an interactive table of contents (which I have never seen as text in a PDF document, only as screenshots, even though Preview supports it) and the ability to see Highlighted and Annotated Text, which does not work consistently but which is a useful addition.

### iOS

- All the PDF Readers I have used (**Adobe Acrobat Reader, PDF Reader & Editor, and Mendeley**) lack the ability to highlight text and then search or list the document’s or documents’ highlighted text, something I will either build an app to do or we will allow Author to import PDF documents.

- **ePub format readers, such as Apple’s iBooks** provides some more functionality for the visual presentation of the document, including font, font size and colour but not means to change the view in any deeper way, such as showing only sentences based on specific criteria – even a search is presented in a separate view.
- **LiquidText** by Craig Tashman presents a more future oriented solution. He developed a reader app for iPad as his PhD thesis and produced a very powerful and liquid solution for people to actively read complex text (Tashman, 2011), such as legal documents. He presented LiquidText at The Future of Text: <https://youtu.be/kf7Z1uDB5el?t=1041> Note that his use of Liquid has no relation to any of my work.
- **Apple’s Pages** no longer supports an Outline view at all which is worth noting.
- **Microsoft Word** is a word processor focused on writing but which is often used to read in. It features an integrated outliner which structures the document based on styles, where ‘Headings’ is a style telling the system that assigned items should appear in the outline view, using a similar logic to how it works in Author. A minor difference in implementation is that in Word the user can click on a sentence and then click on the heading level but in Author the user needs to select the whole sentence before assigning a heading level. We might change the behaviour in Author to support this method as well. Once Headings have been assigned the user can choose to click into an Outline view where everything in the document is visible (though not very pleasantly designed it has to be said) and the user can now click on a pop-up menu to specify how deep in the outline to view. The user can further change the levels of the headings through tab and shift-tab. The keyboard shortcut to toggle to Outline view is: Ctrl-Alt-O
- **Literature & Latte Scrivener** has an outliner style which treats the sections as cards, in a layout where the sections are listed on the left and a synopsis on the right: <https://www.youtube.com/watch?v=Ql39ZsM1oc8> The paradigm for structure control is very different from Author’s in that it becomes a separate workspace for doing batch changes and seeing different versions of the available information – it is not simply another view of the word processor document.
- **RedleX Mellel** simply presents the outline of the document in a persistent column on the left of the document to provide access to jumping around the document, similar to what Preview does with PDF documents.

#### Text Diagramming Tools

Author’s Liquid View is not a concept map, mind map or an affinity diagram since the layout is completely free and arbitrary for the user but can accommodate coded views, hence the new name ‘Liquid View’. These are some of the most popular and useful tools in general use today which comes close:

#### macOS

- **Scapple from Literature & Latte** is a major inspiration for Liquid View and is introduced very well on their site: “*Scapple is an easy-to-use tool for getting ideas down as quickly as possible and making connections between them. It isn’t exactly mind-mapping software—it’s more like a freeform text editor that allows you to make notes*

anywhere on the page and to connect them using straight dotted lines or arrows. If you've ever scribbled down ideas all over a piece of paper and drawn lines between related thoughts, then you already know what Scapple does." (Blount, 2017)

- **Omni Graffle** is a popular macOS application for graphs and charts and has grown to be very fully featured over the years. It is very different from in that it is applicable for so many different uses and hence has a heavier visual and feature interface.
- **The Brain** bills itself as the ultimate digital memory and provides powerful mind mapping tools which are concerned with many types of information and uses and is constrained/organised by connecting lines.
- **iMapping** is a PhD project by Dr. Heiko Haller: "*iMapping is a visual tool that helps knowledge workers manage large amounts of information in a clear and structured way. Topics, projects and fields of work can be visually structured in depth, without ever losing overview. iMaps are virtual pin-boards that provide visual space for your notes, files and ideas, so that every little thing has its place and is found without effort.*" (Haller, 2016)
- **DebateGraph** by my friend and Future of Text contributor David Price and Peter Baldwin provides a rich and powerful way to visualise related information, with the aim of providing new ways to see the information in order to make changes. The visual design is quite different from the Liquid View but I expect useful dialog between myself and David on many related matters.
- There have been many attempts over the last half a century, to build interactive diagramming tools to support curiosity, including Apple's **OpenDoc** and Alan Kay's **Squeak**. These innovations come from deep thought but they lack integration into current workflows and are thus not mainstream.

## iOS

All the systems I have reviewed ([www.educatorstechnology.com](http://www.educatorstechnology.com)) on iOS are hierarchical based and not free-form enough for comparisons to Liquid Views with the exception of Mindscope ([www.mindscopeapp.com](http://www.mindscopeapp.com)) which offers freeform layouts and introduces a novel way of nesting pages/views as internal links.

### Issues arising from using Scapple to Simulate Liquid View

The first issue is one of size. This was created on a large display but the target user group uses significantly smaller screens. An issue then becomes how to best zoom in and out while also having a mechanism for deterring how deep or shallow in the hierarchy to reveal. Here the sub-headings under 'View' are visible: Expanded View: <https://www.dropbox.com/s/f16qjzs86y555ek/expanded-view.png?dl=0> The visual design will also need to be revised, with better magnetism for where the lines should spring from the headings/nodes and how the lines should be visualised. In this example only a sub-set of the headings in this document were turned into nodes so the user should be able to easily and elegantly choose what should be used. Furthermore the black notes on the sides of the view are not in this document so I need to design an interaction and system for handling such notes. Further design notes are in the appendix of this document.

Liquid View is a mind map/concept map/non-linear layout component of the word processor Author, and as such have competition in both areas. In terms of how Author compares to all of these competitive offerings, it does not attempt to compete with Word since Word is much more general and has a much bigger development budget.

As of the day of writing this section, late July 2017, Scrivener by Literature & Latte (developed by Kevin in Cornwall) which is a specialist story and novel authoring tool is number 5 in the macOS App Store in the Productivity category and iA Writer (by Oliver in Zurich), a minimalist word processor, is number 5, both of whom are people I know from their involvement with The Future of Text Symposium. Number 7 is a word processor called Word Writer by Xia Hongjun in China. ByWord by Metaclassy is not on the current top list but is the original visual inspiration for Author. These word processors are all focused on providing a simple and elegant writing environment but do not provide many advanced features such as what Author provides.

There are several academic word processors worth noting, most of which are web based, with features more towards the traditional layout style of academic documents. Author does not yet compete directly against these, but their feature set and approach is worth noting. Rather than compete against these, I would rather like to build a community for all of us, primarily through The Future of Text Symposium and agreeing on document formats, such as the Rich PDF proposal. These academic word processors are all web based:

- **Authorea** is “where more than 65,000 researchers in fields from Astronomy to Zoology write their documents online. These researchers work in the top labs, universities, and private companies in the world. The best way to write research documents.” The developers planned to join us at The Future of Text but were unable to, so I expect them to join us in the future.
- **Editoria**<sup>TM</sup> is a “web-based open source, end-to-end, authoring, editing and workflow tool that presses and library publishers can leverage to create modern, format-flexible, standards compliant, book-length works. Funded by the Mellon Foundation, Editoria<sup>TM</sup> is a project of the University of California Press and the California Digital Library.” It does not appear to be live yet.
- **Idyll** is “a tool that makes it easier to author interactive narratives for the web. The goal of the project is to provide a friendly markup language — and an associated toolchain — that can be used to create dynamic, text-driven web pages.”
- **Leanpub** is a “powerful platform for serious authors. This platform is the combination of two things: a publishing workflow and a storefront. Leanpub is more than the sum of its parts, however – by combining a simple, elegant writing and publishing workflow with a store focused on selling in-progress ebooks, it’s something different. Leanpub is a magical typewriter for authors: just write in plain text, and to publish your ebook, just click a button. (You can click a Preview button first if you want!) Once you’ve clicked the Publish button, anyone in the world can instantly buy your ebook from Leanpub, and read

it on their computer, tablet, phone or ebook reader. Whenever you want to distribute an update to all your readers, just click the Publish button again. It really is that easy.” This service is not strictly academic, but relevant nevertheless.

These tools all constrain our intellect primarily by neglecting to exploit the new opportunities afforded by the digital media.

## Innovation Opportunities

### Boundaries and Constraints

The future of text and text thinking spaces will be determined by many constraints from the legacy of the technological, cultural and biological world as it is today, but is unlikely to ever become a system able to convey a natural, spoken language in full (Olson, 2016), though this is not what writing was invented for in the first place (Harari, 2015) and a Liquid View will possibly fulfil different roles than linear reading has or visual thinking separated from word processing text.

*“Writing was ‘inventable’ because our visual system has inherited just enough plasticity from its evolution to become a reader’s brain”* (Dehaene, 2010), and the same neuronal recycling will enable future developments in how visual media can extend our minds.

### Legacy

Change is expensive in different ways and the costs need to be mitigated. The simplest way to reduce the cognitive cost of change is to change as little as possible, only making innovation where it is really of benefit. Hence Author and the Liquid Views must adhere to Macintosh standard interactions and user expectation whenever possible.

### Specific Innovation Opportunities

Opportunities for future document are rich and varied since our species favours novelty as much as what might be ‘objectively’ seen as correct (Brandt, 2017) and will but the visual attributes of the physical media’s attributes provide inspirations for how to categorise and browse texts, including length, format, colour or typeface (Lansdale, 1988) in order to enhance cue enrichment (Stroud, 1987).

# Work Done So Far

## Before the PhD

The relevant work which will be brought to bear on the value of Liquid Views has long sought to feed the intellectual ‘spark-point’ of curiosity, whether lit by something someone is reading or simply from a thought, and to enable the user to instantly act – without conscious effort for a really liquid-smooth interaction – to satisfy or further feed the curiosity.

### System Wide Scratch Area Concept

The earliest aspects of curiosity-related work was through a desktop workspace idea called the System Wide Scratch Area as posted on my early site liquid.org back in 1997. Back then I wrote in the introduction:

Working in a computer information environment should be as easy and flexible as writing on a piece of liquid paper. You should have complete freedom to write, access information, move it around any way you want to- free of the linearity of word processors. You should be free of always having to think of files and folders, free to cut your information up into little chunks and shuffle them around to your hearts content. I believe we can move towards this freedom without having to completely abandon our current GUI interfaces.

*Hegland, 1997*

### Liquid

Liquid is the name of my macOS text utility which works in all macOS applications through the Services (developer.apple.com) system. Originally released in 2012 it has been commercially difficult since it’s hard to explain the functionality to someone without showing them, which is why it is now considered an aspect of Author. The basic notion is that it allows for ‘implicit’ links for all text in macOS, to search any search engine, look up in any references, as well as translate, convert, publish and more: <http://www.liquid.info/liquid.html>

## For the PhD

### Author

The full name of my macOS word processor is ‘Liquid | Author’ since I don’t ‘own’ that name in the Mac App Store, but I do own it in the iOS App Store so there it will simply be called ‘Author’. Author will continue development alongside the Liquid View which Author hosts, but it is the Liquid View which is the major focus for my PhD work. Author is implemented as a native macOS application with a clean visual interface and use of keyboard commands and gestures.

The origin of the name is as an homage to Doug Engelbart's 'Augment' system. He was my mentor and great inspiration and on his passing in 2013 it did not take me many months to decide to start something larger than I could complete, but at least it would be something I could start. After many failed attempts with various developers around the world, I have now released a full and stable version with the collaboration of Jacob Hazelgrove, and, as of end of 2017, Author is available in the macOS App Store: Liquid | Author (itunes.apple.com, 2017).

## Implementation Notes

From Jacob Hazelgrove, coder of Author, via Skype text: "We switched to a far more flexible, efficient, faster, and safer file format. The underlying text core is now implemented as a Foundation level framework (which is almost completely shared among all Apple platforms) which can be shared with iOS, making porting and maintaining both versions much easier going forward. The new format is a package based format with a separation of document attributes from the actual content, allowing us to easily add new features while maintaining support with older versions of the app almost as an afterthought. The text storage is not longer being hacked to facilitate things like collapsing. In earlier versions when collapsing, the collapsed text was attached as attributes to the header it was collapsing into, greatly limiting the flexibility. The old format used a CoreData SQLite store. An example of inefficiencies of the old format is that the old format would store the document window frame. Resizing the window would "dirty" the document, requiring a save, and potential network activity if stored in iCloud Drive or Dropbox. Plus, the window frame doesn't make sense as part of the format on any other platform. This is better addressed using state restoration <https://developer.apple.com/macos/human-interface-guidelines/app-architecture/restoring-state/>"

## Specific Innovations Related to My PhD

- **Outline** The ability to instantly toggle between word processing view and Outline view though pinching on the trackpad, a gesture which leads the way to the Liquid View, and embedded citations, including abstracts and the ability to cite YouTube videos and have them play in Author from the moment cited.
- **Find** Cmd-f in Author if the user has selected text results in an instant re-ordering of the document to only show sentences with the selected text. Click on a sentence to jump to that sentence in the document or click in the margin or ESC to return to regular view.
- **Video Citations** Author can play cited YouTube video inside the Author document, from the specified moment in the video.
- **About Document** Author allows the user to use a two finger horizontal swipe gesture to flip the document around to see the information about the document and author which will be used to cite the current document. This is in support of Chris Gutteridge's concept of Intermodal freight transport (blog.soton.ac.uk) to support better document findability and linkability and is implemented in this way to make the document feel like a more tangible document.

Author introduction video: [https://www.youtube.com/watch?v=Bhbhi-FNx70&list=PLYx4DnFWaXV\\_y6wsQDnV74Shq1Tm0jve7](https://www.youtube.com/watch?v=Bhbhi-FNx70&list=PLYx4DnFWaXV_y6wsQDnV74Shq1Tm0jve7)

## Rich PDF

The issues with PDF have been brought up time (Nielsen, 2003) and time (Lohman, 2014) and time (Connell, 2015) and time (Ertl) and time (Freeman, 2017) again but breaking out of legacy information sharing formats is a real challenge. This is why I have proposed the Rich PDF (Hegland, 2017) system where publishing from a word processor produces a clean PDF document which also has a full version of the original document compressed as a hidden attachment, which the receiver can access if opening it in the same program as the document was authored, and an XML version for generally compatible systems, but it can also be opened in a regular PDF reader.

## Document Web, not Server Web

I am also working on working along the idea of reverting back to addressability by object not location, as before the web where you would search for a copy of a journal by its name and issue number, rather than the location you left it and where it might no longer be. The idea here is to publish from Author a document which has a unique ID appended at the point of publication from the Author software (time and date) so that someone may cite this document and if it does not show up at the expect server a web search can provide a list of available alternatives (of which spoofing becomes an issue, but no more or less than faking a printed journal), protecting against link rot.

## Liquid View

The Liquid View will be developed for macOS and iOS simultaneously in order to best exploit the interaction possibilities presented by each platform.

- The design outline completed so far is available online [sftp://liquid.info/home/lili/public\\_html/Liquid%20View%20Description%20.pdf](sftp://liquid.info/home/lili/public_html/Liquid%20View%20Description%20.pdf)
- Issues with line design: <http://wordpress.liquid.info/lines-designs/>
- Interaction options on ctrl-click: <http://wordpress.liquid.info/ctrl-click-on-headings-in-liquid-view-early/>
- Wider design issues: <http://wordpress.liquid.info/design-issues/>

## Web/Blog

I am working on making high resolution addressing work in Wordpress blogs, initially through posting using Liquid but potentially also as a Wordpress plugin. This is as an extension of the work I did with Doug (web.archive.org).

# The Research Question

## Q1 : Supporting Authors & Readers

How can a highly visual and interactive view of an author's word processing document, of nodes (from headings) lines and other visual elements augment the author and readers interaction with the knowledge in the document?

How can such a system augment the **author's**:

- A) Understanding of the knowledge the author has already provided
- B) Further development (research, writing and editing) of the document
- C) Add citations quickly and accurately to increase the credibility of the arguments
- D) Presentation of the document when published

How can such a system augment the **reader's**:

- A) Ability to skim the document for salient points
- B) Actively read for deep, critical understanding
- C) Verify citations

## Q2 : Visual Elements & Interactions

A) In order to provide the desired augmentation, what should the **Nodes** represent?

Clarification will be needed to determine what the nodes should represent:

- Should they be only headings from the word processing view?
- Should they also a new type glossary item (maybe to be called 'Glodes' (glossary nodes) to support the equivalent of code-reuse programmers employ?
- Should they represent external sources on the web or external sources in the users system?
- Can the FRESS notion of tags for non-visible, non-linked content, such as comments be useful?
- How should they be visually represented?

B) What will be the characteristics of the visual **Lines** on the screen?

- Will they only be aids to the author?
- Will they be useful for the reader?
- Will they somehow be reflected in the word processing view as a type of link?

- Should they also represent extensions away from the document, through citations and links?
- How should they be visually represented?

C) What **Interactions** should be possible?

- How can the reveal and hiding of nodes and lines best occur?
- How can filtering best occur?
- How can manual and programatic layouts best occur?
- What further interaction opportunities can be useful?

## Plan & Timeline

Author for macOS will be completed for end of 2017 (with the iOS version following closely behind), and I will then be in a position to start testing design concepts for Liquid Views both for desktop and laptop interaction as well as for large and small tablet in order to draw out the best interactions for each platform, as outlined in this map: <https://www.dropbox.com/s/86x2jl5o6yl37y6/Screen%20Shot%202017-09-19%20at%2014.19.34.png?dl=0>

9th of December 2018

I aim to have a working version of Liquid Views in Author for the 50th anniversary of Doug Engelbart's demo, which will be celebrated in California on the 9th of December 2018. I am running a small group hosted at doug-50.info who are working to implement some of Doug Engelbart's inventions which are currently not in widespread use (doug-50.info) and I feel that rich, liquid ViewSpecs, as demonstrated in the Liquid View, can be a powerful demo.

## Change is Coming

I expect the system will change as I implement it and better understand what it is like to work in it, which is why I am keen to get started. "*The thing about technological visions is they change; in particular, they change as they are being built into artefacts*" (Barnet, 2014).

## Continuous Research Outputs

I will continue to publish findings on my active blog: <http://wordpress.liquid.info> where I am also building an Interactive Text Glossary (wordpress.liquid.info) to feed a possible future glossary element in Author/Liquid Views.

## Cost

I am not a programmer and never will be, I am not clever enough. I will continue to stay on the users side of the man-machine equation, and that requires that I pay someone to do this work. The project will cost something along the scale of 5-10,000 US dollars a month (\$60,000 - \$120,000 a year), depending on what I will be able to afford, with either part time or full time development time with my current, US based developer Jacob Hazelgrove.

## Levels of User Testing

User testing will be performed online and in person with users completely unaware of any aspects of Author or the Liquid View, as well users who have been introduced to the system with training materials. The tests will be for subjective feedback and objective metrics of users ability to answer multiple choice questions about material provided.

## Further Horizons

Further horizons can see the Liquid View concept extended into VR or larger physical spaces to further exploit embodied cognition (Kirsh, 2013). The system can use deep learning over time to learn about the users work habits and provide insights based on them.

## References

*Please also note that the 'References' section was generated using Author, as was this document and as such is still under development with issues to be resolved and that this is a core part of my research project.*

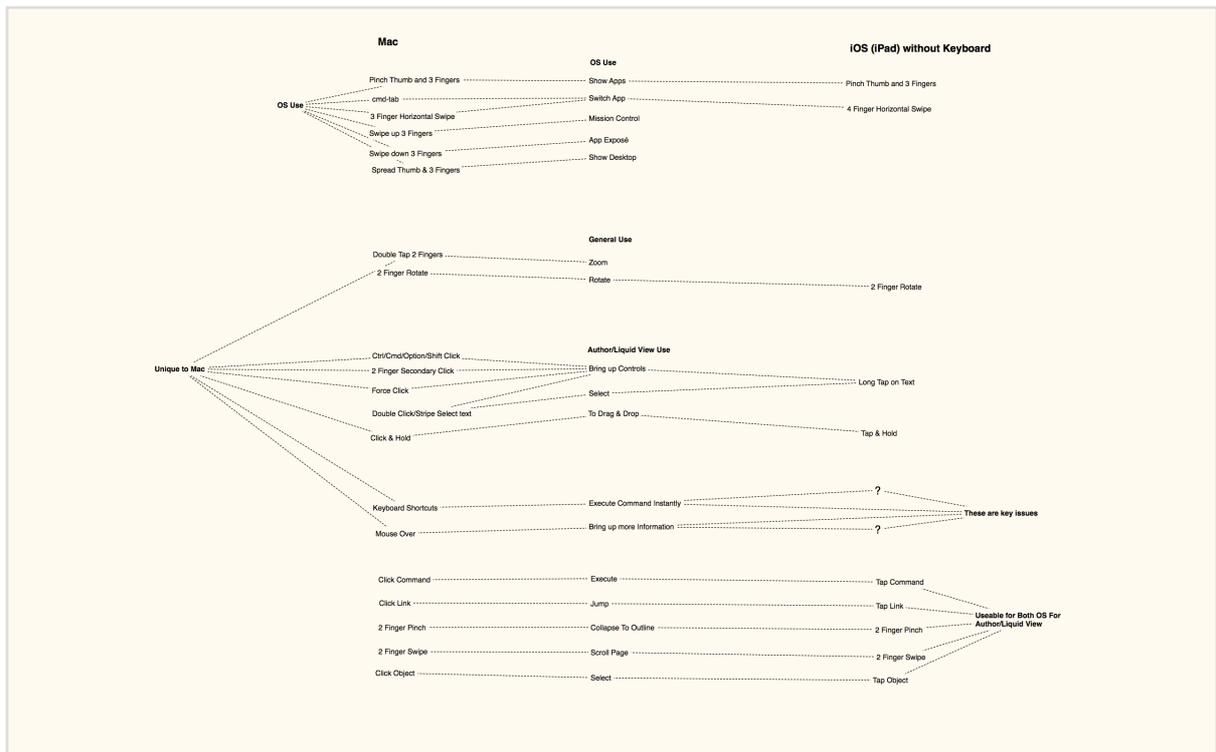
1. (2017). Available at <https://itunes.apple.com/app/liquid-author/id951792010?ls=1&mt=12>. [Accessed 02 11 2017].
2. Available at <http://wordpress.liquid.info/category/glossary-entry/>. [Accessed 20 11 2017].
3. Available at <http://www.derose.net/steve/writings/whitepapers/fress.html>. [Accessed 21 11 2017].
4. Available at <http://blog.soton.ac.uk/webteam/2017/11/12/50-years-since-the-mother-of-all-demos/>. [Accessed 17 11 2017].
5. Available at <http://doug-50.info/what-is-missing-from-dougs-work-in-todays-world/>. [Accessed 17 11 2017].
6. Available at <https://web.archive.org/web/20151023200210/http://community.cim3.net/cgi-bin/wiki.pl?PurpleNumbers#nidABB>. [Accessed 20 11 2017].
7. Available at <https://developer.apple.com/library/content/documentation/UserExperience/Conceptual/OSXHIGuidelines/Services.html>. [Accessed 16 11 2017].
8. Available at <http://www.liquid.info/reader.html>. [Accessed 02 11 2017].
9. Available at <https://www.youtube.com/watch?v=1sCfM6lOnWM&t=27s&list=PLYx4DnFWaXV8tT5j3yVzh3XXunyQqXUfP&index=7>. [Accessed 18 11 2017].
10. Available at <http://www.educatorstechnology.com/2012/11/the-top-9-mindmapping-and-brainstorming.html>. [Accessed 20 11 2017].
11. Available at <http://forum.eastgate.com/t/tripping-over-the-line-best-practices-with-separators/961/16>. [Accessed 20 11 2017].
12. Available at <https://www.etymonline.com/word/file>. [Accessed 16 11 2017].
13. Available at <http://www.mindscopeapp.com/index.html>. [Accessed 20 11 2017].
14. Available at [https://books.google.com/ngrams/graph?content=data+analytics&year\\_start=1800&year\\_end=2000&corpus=15&smoothing=3&share=&direct\\_url=t1%3B%2Cdata%20analytics%3B%2Cc0](https://books.google.com/ngrams/graph?content=data+analytics&year_start=1800&year_end=2000&corpus=15&smoothing=3&share=&direct_url=t1%3B%2Cdata%20analytics%3B%2Cc0). [Accessed 18 11 2017].
15. Available at [https://books.google.com/ngrams/graph?content=data+visualisation&year\\_start=1800&year\\_end=2000&corpus=15&smoothing=3&share=&direct\\_url=t1%3B%2Cdata%20visualisation%3B%2Cc0](https://books.google.com/ngrams/graph?content=data+visualisation&year_start=1800&year_end=2000&corpus=15&smoothing=3&share=&direct_url=t1%3B%2Cdata%20visualisation%3B%2Cc0). [Accessed 18 11 2017].
16. Arnheim, R. (2004). *Visual Thinking*. University of California Press.
17. Ausubel, D. (1968). *Educational Psychology, A Cognitive View*. Holt McDougal.

18. Barnet, B. (2014). *Memory Machines: The Evolution of Hypertext (Anthem Scholarship in the Digital Age)*. Anthem Press.
19. Barnet, B. (2014). *Memory Machines: The Evolution of Hypertext (Anthem Scholarship in the Digital Age)*. Anthem Press.
20. Bernstein, M. (2011). *Can We Talk about Spatial Hypertext?*.
21. Bernstein, M. (2011). *Can We Talk about Spatial Hypertext?*.
22. Blount, K. (2017). *Scapple*. Available at <https://www.literatureandlatte.com/scapple.php>. [Accessed 30 09 2017].
23. Borges, J. (1942). *Ficciones*. Grove Press.
24. Brandt, D. (2017). *The Runaway Species: How human creativity remakes the world*. Catapult.
25. Brown, M. (1994). *Graphical Fisheye Views*.
26. Bush, V. (1945). *As We May Think*. Available at <https://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/>. [Accessed 16 11 2017].
27. Buzan, T. (1996). *The Mind Map Book: How to Use Radiant Thinking to Maximize Your Brain's Untapped Potential*. Plume.
28. Cañas, B. (2011). *Applied Concept Mapping: Capturing, Analyzing, and Organizing Knowledge*. CRC Press.
29. Chalmers, M. (1993). *Using a Landscape Metaphor to Represent a Corpus of Documents*.
30. Clark, A. (2010). *Supersizing the Mind: Embodiment, Action, and Cognitive Extension (Philosophy of Mind)*. Oxford University Press.
31. Cole, D. (1982). *Human Aspects of Office Filing: Implications for the Electronic Office*.
32. Conklin, M. (1988). *gIBIS: a hypertext tool for exploratory policy discussion*. CSCW '88 Proceedings of the 1988 ACM conference on Computer-supported cooperative work.
33. Connell, D. (2015). *Your data deserve better than a PDF*. Available at <https://www.urban.org/urban-wire/your-data-deserve-better-pdf>. [Accessed 29 10 2015].
34. Dam, C. (1976). *Final Report: An Experiment in Computer-Based Education Using Hypertext*.
35. Dantzich, G. (1998). *Data Mountain: Using Spatial Memory for Document Management*. ACM.
36. Davenport, T. (2015). *5 Essential Principles for Understanding Analytics*. Available at <https://hbr.org/2015/10/5-essential-principles-for-understanding-analytics>. [Accessed 18 11 2017].
37. Dehaene, S. (2010). *Reading in the Brain: The New Science of How We Read*. Penguin Books.
38. Drucker, N. (1988). *Intermedia: The concept and the construction of a seamless information environment*. IEEE.
39. Dumais, P. (1992). *Personalised Information Delivery: An Analysis of Information Filtering Methods*.
40. Engelbart, D. (1984). *Authorship Provisions In Augment*.

41. Engelbart, D. (2003). *Private email to the author*.
42. Ertl, A. *What is the PDF format good for*. Available at <https://www.complang.tuwien.ac.at/anton/why-not-pdf.html>. [Accessed 29 10 2017].
43. Everett, D. (2017). *How Language Began: The Story of Humanity's Greatest Invention*. Liveright.
44. Ferrara, D. (2017). *EPUB versus PDF: The Pros and Cons for E-Publishing*. Available at <https://www.thoughtco.com/epub-vs-pdf-3467286>. [Accessed 18 11 2017].
45. Filipczak, B. (1996). *Engaged! The Nature of Computer Interactivity*.
46. Freeman, J. (2017). Available at <https://overcast.fm/+OFMaEXgU>. [Accessed 29 10 2017].
47. Greenhalgh, S. (1999). *Three Dimensional Visualization of the World Wide Web*.
48. Halasz, R. *NoteCards in a Nutshell*.
49. Hall, P. (1999). *The Significance of Linking*.
50. Haller, H. (2016). *What is iMapping?*. Available at <http://www.imapping.info/what-is-imapping/>. [Accessed 28 09 2017].
51. Haller, H. (2011). *User Interfaces for Personal Knowledge Management with Semantic Technologies*.
52. Harari, Y. (2015). *Sapiens: A Brief History of Humankind*. Harper.
53. Hegland, F. (1999). *Glanceable*. Available at <http://web.archive.org/web/19990427145218/http://www.liquid.org:80/articles.html>. [Accessed 16 11 2017].
54. Hegland, F. (1997). *System Wide Scratch Space*. Available at [https://web.archive.org/web/19970415031315fw\\_/http://www.liquid.org:80/syswscri.html](https://web.archive.org/web/19970415031315fw_/http://www.liquid.org:80/syswscri.html). [Accessed 17 11 2017].
55. Hegland, F. (2017). *Making PDF Great Again*. Available at <http://wordpress.liquid.info/making-pdf-great-again/>. [Accessed 01 11 2017].
56. Herskovits, A. (1997). *Language, Spatial Cognition, and Vision*. Springer, Dordrecht.
57. Jensen, D. Available at <https://www.academiccoachingandwriting.org/dissertation-doctor/resources/writing-a-literature-review>. [Accessed 29 10 2017].
58. Joyce, J. *Hypertext and creative writing*. ACM.
59. Julesz, B. (1981). *A Theory of Preattentive Texture Discrimination Based on First-Order Statistics of Textons*.
60. Kawakita, J. (1991). *The Original KJ Method*. Kawakita Research Institute.
61. Kirsh, D. (2013). *Embodied Cognition and the Magical Future of Interaction Design*.
62. Kunifujii, S. (2013). *A Japanese problem solving approach: the KJ-Ho method*. Proceedings of KICSS'2013.
63. Langer, J. (2011). *An Exploratory Analysis of Mind Maps*.
64. Lansdale, M. (1988). *The Psychology of Personal Information Management*.
65. Lauri, B. (2009). *Scientific journal publishing: yearly volume and open access availability*. Available at <http://www.informationr.net/ir/14-1/paper391.html>. [Accessed 18 11 2017].

66. Levy, S. (1994). *INSANELY GREAT: The Life and Times of Macintosh, the Computer that Changed Everything*. Viking Adult.
67. Lohman, T. (2014). *Time to break up with PDFs?*. Available at <http://www.accessiq.org/news/news/2014/05/time-to-break-up-with-pdfs>. [Accessed 29 10 2014].
68. Markoff, J. (2007). *The Real History of WYSIWYG*. Available at [https://bits.blogs.nytimes.com/2007/10/18/the-real-history-of-wysiwyg/?\\_r=0](https://bits.blogs.nytimes.com/2007/10/18/the-real-history-of-wysiwyg/?_r=0). [Accessed 01 11 2017].
69. Marshall, F. (1999). *Spatial hypertext: An alternative to navigational and semantic links*.
70. Marshall, F. (1994). *Spatial Hypertext*.
71. Matsushita, H. (1997). *WWW visualization giving meanings to interactive manipulations*.
72. McGill, W. (1984). *Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods*.
73. McNaughton, D. (2012). *The Role of Medial Prefrontal Cortex in Memory and Decision Making*.
74. Mithen, S. (1998). *The Prehistory Of The Mind*. Weidenfeld & Nicolson.
75. Mukherjea, S. (1999). *Information Visualization for Hypermedia Systems*.
76. Nelson, T. (2002). *Philosophy of Hypertext*. Keio University.
77. Nelson, T. (2011). *Possiplex*. Mindful Press.
78. Nielsen, J. (2003). *PDF: Unfit for Human Consumption*. Available at <https://www.nngroup.com/articles/pdf-unfit-for-human-consumption/>. [Accessed 29 10 2003].
79. Norretranders, T. (1999). *The User Illusion: Cutting Consciousness Down to Size (Penguin Press Science)*. Penguin Books.
80. North, T. (2009). *A Comparison of User-Generated and Automatic Graph Layouts*. IEEE.
81. Olson, D. (2016). *The Mind on Paper: Reading, Consciousness and Rationality*. Cambridge University Press.
82. Pali, M. (1982). *Principles of Spatial Problem Solving*. American Psychological Association.
83. Paré, A. (2009). *Writing Matters: back to the future with rhetoric*. Available at <https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0ahUKewiu85y77qnXAhUNCewKHTGuCfUQFggwMAE&url=https%3A%2F%2Fwww.edcan.ca%2Fwp-content%2Fuploads%2FEdCan-2009-v49-n4-Par%25C3%25A9.pdf&usg=AOvVaw0ErhwYXBxwXEsbTIBQwUVq>. [Accessed 06 11 2017].
84. Pichler, K. (1998). *Information Pyramids : A New Approach to Visualising Large Hierarchies*.
85. Schwartz, N. (1986). *Neptune: a hypertext system for CAD applications*. ACM.
86. Scupin, R. (1997). *The KJ Method: A Technique for Analyzing Data Derived from Japanese Ethnology*. Available at <http://sfaajournals.net/doi/10.17730/humo.56.2.x335923511444655?code=apan-site>. [Accessed 29 09 2017].
87. Shanahan, D. (2015). *A living document: reincarnating the research article*.
88. Shanahan, D. *A living document: reincarnating the research article*.
89. Shipman, F. (1999). *Spatial Hypertext: An Alternative to Navigational and Semantic Links*.

90. Shneiderman, B. (1993). *Sparks of Innovation in Human-Computer Interaction*. Intellect Ltd.
91. Smart, P. (2017). *Human-Extended Machine Cognition*.
92. Straker, D. (1997). *Rapid Problem Solving with Post-It Notes*. Da Capo Press.
93. Stroud, W. (1987). *Comparing Word and Icons as Cue Enrichers in an Information Retrieval Task*.
94. Tashman, C. (2011). *LiquidText: A Flexible, Multitouch Environment to Support Active Reading*.
95. Treloar, A. (1999). *Applying Hypertext and Hypermedia to Scholarly Journals Enables Both Product and Process Innovation*. Available at [http://cs.brown.edu/memex/ACM\\_HypertextTestbed/papers/4.html](http://cs.brown.edu/memex/ACM_HypertextTestbed/papers/4.html). [Accessed 18 11 2017].
96. Warnock, J. *The Camelot Project*. Available at [https://web.archive.org/web/20090304134754/http://www.planetpdf.com/planetpdf/pdfs/warnock\\_camelot.pdf](https://web.archive.org/web/20090304134754/http://www.planetpdf.com/planetpdf/pdfs/warnock_camelot.pdf). [Accessed 29 10 2009].
97. Webb, P. (1981). *BUSINESS - an end-user oriented application development language*.
98. Weel, A. (2017). *Only Three Fingers Write, but the Whole Brain Works: A High-Density EEG Study Showing Advantages of Drawing Over Typing for Learning*. Available at <https://www.frontiersin.org/articles/10.3389/fpsyg.2017.00706/full>. [Accessed 20 11 2017].
99. Wisconsin, U. (2017). *Writing a Research Paper*. Available at <https://writing.wisc.edu/Handbook/PlanResearchPaper.html>. [Accessed 01 11 2017].
100. Wong, R. (1992). *A 'Pile' Metaphor for Supporting Casual Organization of Information*. CHI 92.
101. Wong, R. (1991). *Inside Macintosh, Vol. 6*. Addison-Wesley.
102. York, S. (1996). *The WebBook and the Web Forager: An Information Workspace for the World-Wide Web*.
103. Zhuge, H. (2012). *The Knowledge Grid: Toward Cyber- Physical Society*. Available at <http://www.knowledgegrid.net/~H.Zhuge/data/SLN.pdf>. [Accessed 17 11 2017].
104. Zhuge, H. (2012). *The Knowledge Grid: Toward Cyber- Physical Society*. Available at <http://www.knowledgegrid.net/~H.Zhuge/data/SLN.pdf>. [Accessed 17 11 2017].
105. Zhuge, H. (2009). *Interactive semantics*. Elsevier.



mock-up of the Liquid View showing three columns with connecting lines and comments to the left and right