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Paul A. Kirschner, Simon J. Buckingham Shum and Chad S. Carr (Eds)

Visualizing Argumentation

Software Tools for Collaborative and Educational Sense-Making

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in general, with traditions going back to the dialogues of the Greek philosophers. It is beyond the scope of this book to review this huge literature in any more detail than to provide a few key pointers to Speech Act theory (Searle, 1969), and argumentation theory (e.g. Perelman and Olbrechts-Tyteca, 1969; van Eemeren et al., 1983; Walton, 1996). Law is, arguably, the most argument-intensive profession of all, with greater resources than other professions to devote to analysing the structure of arguments, and extensive research into computer-support for teaching argumentation skills (e.g. Aleven and Ashley, 1994; Marshall, 1989; Bench-Capon, et al., 1998).

The human-centred technology research fields such as computer-supported co-operative work (CSCW), computer-mediated communication (CMC), and computer-supported collaborative learning (CSCL) have developed their own flavours of CSAV, in order to support the coordination of distributed organisational activity (Malone et al., 1987), the structuring of contributions to group support systems (Turoff et al., 1999), and the creation of conversations in which learning takes place (Andriessen et al., in press). The chapters in this book demonstrate how widely CSAV is attracting interest and finding applications.

1.2 Mapping the History of Argument Visualization

There are numerous ways to organise this review, but for simplicity, it steps through chronological history, uncovering roots of different sorts along the way. In some cases, it is known that one individual drew on another's work, while in others we are left to wonder what might have happened had the two met or read each other.

1.2.1 Charting Evidence in Legal Cases

In 1913, John Henry Wigmore proposed a *Chart Method* for analysing the mass of evidence presented in a legal case, in order to help the analyst reach a conclusion:

> Our object then, specifically, is in essence: *To perform the logical (or psychological) process of a conscious juxtaposition of detailed ideas for the purpose of producing rationally a single final idea. Hence, to the extent that the mind is unable to juxtapose consciously a larger number of ideas, each coherent group of detailed constituent ideas must be reduced in consciousness to a single idea; until the mind can consciously juxtapose them with due attention to each, so as to produce its single final idea.* (Wigmore, 1913, 2nd Edition 1931, p.109)

He sets out the "necessary conditions" for such an "apparatus", following what we would now recognise as requirements analysis and schema modelling for a visualization tool. For a given case, one must be able to express different types of evidence, relations between facts, represent and on demand see all the data, subsume subtrees, and distinguish between facts as alleged and facts as believed or disbelieved.

As a tool to comprehend a potentially large dataset:

> It must, finally, be compendious in *bulk*, but *not too complicated* in the variety of symbols. These limitations are set by the practical facts of legal work. Nevertheless, men's aptitudes for the use of such schemes vary greatly. Experience alone can tell us whether a particular scheme is usable by the generality of able students and practitioners who need or care to attack the problem. (p.110)

Wigmore was also clear that:

> …the scheme need *not* show us what our belief *ought* to be. It can hope to show only what our belief actually is, and *how* we have actually reached it. (p.110)

This echoes the difference of most CSAV tools from other classes of computer-supported argumentation that seek to evaluate argument or recommend conclusions based on a formal model of decision processes, or the meaning or relative weight of argument elements. Wigmore's scheme is a cognitive tool for reflection:

> Hence, though we may not be able to demonstrate that we *ought* to reach that belief or disbelief, we have at least the satisfaction of having taken every precaution to reach it rationally. Our moral duty was to approximate, so far as capable, our belief to the fact. We have performed that duty, to the limits of our present rational capacity. And the scheme or method, if it has enlarged that capacity, will have achieved something worthwhile. (p.111)

The final line encapsulates the motivation behind much CSAV work: to augment our intellectual ability in argument analysis and construction. The theme of "intellectual augmentation" resonates, of course, with the work of Engelbart, introduced shortly. Wigmore's Evidence Charts (Figure 1.1), showing how connections between *Testamonial Assertions and Circumstances* may lead to credible *Propositions*, continue to be used today in some law schools (see also Carr's work on legal argumentation mapping with hypertext technology: Chapter 4).

1.2.2 Trails of Ideas in the Memex

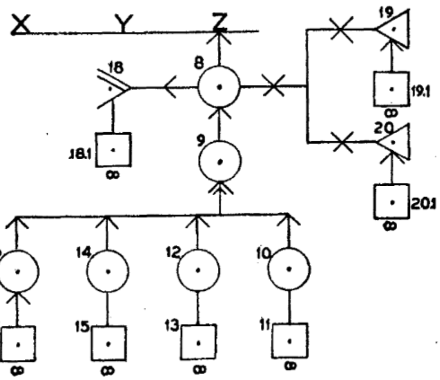
Having started with the "AV" roots to CSAV, we now start to uncover some "CS" roots. The contribution of Vannevar Bush to the invention of hypertext as a way to easily connect fragments of information has been documented exhaustively (for a retrospective from within the hypertext community, see Brown/MIT, 1995). In his 1945 article *As We May Think*, Bush (1945) envisioned a near future system based on microfilm records that could support the construction of trails of ideas for personal information management, and for sharing with others.

> Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and, to coin one at random, "memex" will do. A memex is a device in which an individual stores all his books,

records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory. (Section 6)

§ 33. Same: an Example Charted. We shall thus have charted the results of our reasoning upon the evidence affecting any single probandum. But this probandum will usually now in its turn (*ante,* § 8) become an evidentiary fact, towards another probandum in a catenate inference. The process of charting and valuation has then to be renewed for this new probandum; and so on until all the evidence has been charted, and the ultimate probanda in issue under the pleadings have been reached.

The following portion of a chart will illustrate (taken from the case of *Com.* v. *Umilian, post,* § 38):



Z is one of the ultimate probanda under the pleadings, viz. that the accused killed the deceased. Circle 8 is one of the evidentiary facts, viz., a revengeful murderous emotion. The arrowhead on the line from 8 to Z signifies provisional force given to the inference.

Figure 1.1: John Henry Wigmore's *Chart Method* for analyzing the evidence presented in a legal case, showing how different kinds of evidence (signaled by different node shapes, e.g. for *Testamonial Assertions and Circumstances*) are assembled to support or challenge (signaled by different arrow types) various *Propositions* (X, Y, Z, e.g. John Smith murdered Anne Baker). Each numbered node has an explanatory entry summarizing the evidence (e.g. John Smith knew that Anne Baker lived at Flat 42). (Reproduced with permission, Wigmore, H.J.A. 1931, p. 56: The Principles of Judicial Proof as Given by Logic, Psychology and General Experience and Illustrated in Judicial Trials. Boston: Little Brown, 2nd Edition).

In describing the "trail blazing" user interface, Bush envisages a rudimentary spatial display for connecting the two 'nodes':

When the user is building a trail, he names it, inserts the name in his code book, and taps it out on his keyboard. Before him are the two items to be

> joined, projected onto adjacent viewing positions. At the bottom of each there are a number of blank code spaces, and a pointer is set to indicate one of these on each item. The user taps a single key, and the items are permanently joined. In each code space appears the code word. Out of view, but also in the code space, is inserted a set of dots for photocell viewing; and on each item these dots by their positions designate the index number of the other item.
>
> Thereafter, at any time, when one of these items is in view, the other can be instantly recalled merely by tapping a button below the corresponding code space. Moreover, when numerous items have been thus joined together to form a trail, they can be reviewed in turn, rapidly or slowly, by deflecting a lever like that used for turning the pages of a book. It is exactly as though the physical items had been gathered together from widely separated sources and bound together to form a new book. It is more than this, for any item can be joined into numerous trails. (Section 7)

It is natural for us to want to re-read Bush's article through 'CSAV lenses', for any clues that he explicitly envisioned argumentation as an application of associative linking, perhaps even a particularly important application. Alert to the risks of reading too deeply into a work to bolster one's prejudice, it is interesting, nonetheless, to find that in discussing the application of machine logic to supporting intellectual work, Bush states:

> A new symbolism, probably positional, must apparently precede the reduction of mathematical transformations to machine processes. Then, on beyond the strict logic of the mathematician, lies the application of logic in everyday affairs. *We may some day click off arguments on a machine with the same assurance that we now enter sales on a cash register.* But the machine of logic will not look like a cash register, even of the streamlined model. (Section 5, emphasis added)

It is unclear what the intriguing "new symbolism, probably positional" refers to. It has connotations in today's human-computer interaction paradigm of a visual language of some sort. However, his use of the term positional in other places in the article suggests that he may have had a lower level machine processing logic in mind, such as punch card/photocell processing. His focus on argumentation is, however, unambiguous, and consistent with his focus on scholarship as a primary beneficiary of the Memex. Moreover, Bush proceeds to give examples to convince his reader why such a machine might have practical use. He begins with an historian collecting and organising disparate materials into a trail:

> The owner of the memex, let us say, is interested in the origin and properties of the bow and arrow. Specifically he is studying why the short Turkish bow was apparently superior to the English long bow in the skirmishes of the Crusades. He has dozens of possibly pertinent books and articles in his memex. First he runs through an encyclopedia, finds an interesting but sketchy article, leaves it projected. Next, in a history, he finds another pertinent item, and ties the two together. Thus he goes, building a trail of many items. Occasionally he inserts a comment of his own, either linking it

> into the main trail or joining it by a side trail to a particular item. When it becomes evident that the elastic properties of available materials had a great deal to do with the bow, he branches off on a side trail which takes him through textbooks on elasticity and tables of physical constants. He inserts a page of longhand analysis of his own. Thus he builds a trail of his interest through the maze of materials available to him. (Section 7)

Obviously, we can imagine that the "semantics" of the comment that accompanies a trail might clarify the nature of the unclassified steps along the trail ("…is evidence for…", "…is inconsistent with…", "…tackles the same problem as…"), but Bush does not elaborate. The "twist in the tale" of this scenario from a CSAV perspective is that the trail is used later as evidence to substantiate an historical argument:

> And his trails do not fade. Several years later, his talk with a friend turns to the queer ways in which a people resist innovations, even of vital interest. He has an example, in the fact that the outraged Europeans still failed to adopt the Turkish bow. In fact he has a trail on it. A touch brings up the code book. Tapping a few keys projects the head of the trail. A lever runs through it at will, stopping at interesting items, going off on side excursions. It is an interesting trail, pertinent to the discussion. So he sets a reproducer in action, photographs the whole trail out, and passes it to his friend for insertion in his own memex, there to be linked into the more general trail. (Section 7)

With respect to visualization, given the inherently spatial metaphor underpinning the Memex, it is perhaps surprising that Bush does not discuss diagrammatic overviews of trails; trails are constructed, viewed and navigated serially, albeit very rapidly if desired. His contribution to CSAV is nonetheless enormous, having envisaged the hypertextual linking that underpins navigation in many CSAV tools, all in the context of a specifically scholarly application to the organisation of information into coherent trails. It was left to some of his readers to take the project the next step, in particular, Doug Engelbart, reviewed shortly.

1.2.3 Mapping the Structure of Practical Arguments

The second AV root we review is *The Uses of Argument* by Stephen Toulmin (1958), originally written as a challenge to the dominance in philosophy of formal, Aristotelian logic. Toulmin's aim was to develop a view of logic which was grounded in the study of reasoning practice. Taking argumentation as the most common form of practical everyday reasoning, he posed the question, "what, then, is involved in establishing conclusions by the production of arguments?" His analysis of the logical structure of arguments led to a graphical format for laying out the structure of arguments, a representational approach reflected in much subsequent argumentation work.

The notation consists of five components and four relationships (Figure 1.2). According to the analysis, whether or not it is made explicit, all arguments logically comprise a fact or observation (a *Datum*), which via a logical step (a *Warrant*), allows one to make a consequent assertion (a *Claim*). The Warrant can be supported by a

1.2.5 Concept Mapping

A parallel stream of work developing in the worlds of education and critical thinking, goes under names such as Concept Mapping and MindMapping™. The earliest work on these is represented by individuals such as Joseph Novak and Tony Buzan. From the first studies in 1972, Novak has pursued a programme of work on concept mapping as a tool for high school and university students to construct, reflect on and discuss their conceptions of a domain with peers and tutors (Novak, 1976; 1998; Novak and Gowin, 1984). His work, grounded in a constructivist epistemology, has sparked significant research into the pedagogical properties of concept maps, student's ability (or lack thereof) to construct such diagrams, and their utility (e.g. in contrast to traditional essays) as a means of communicating, and assessing, learning. On a related theme, but to a different audience, Buzan has written extensively as a popular writer on improving thinking skills, from his 1974 BBC series and book *Use Your Head* (Buzan, 1974) to educational and organisational consultancy on the use of MindMapping™ (MindMap.com) for analysis and decision making.

Both of these strands emphasise the "visual" as a fundamental, but untapped, dimension for refining and communicating one's thoughts (cf. Horn, 1998, for a detailed analysis of visual communication). From an historical perspective, it is unclear how early on these two roots fused. (This author has not yet tracked down examples from before the 1990s of concept mapping researchers overlaying argumentation schemas to classify nodes and links.) Certainly, relatively recent work on concept mapping in educational technology has introduced the vocabulary of argumentation (e.g. as an aid to teaching scientific reasoning). Together with other educational technology research (Andriessen et al., in press; Baker, 1999; Veerman et al., 1999), diagrammatic reasoning (Diagrammatic Reasoning, 2002; Glasgow et al., 1995) and psychology of programming (PPIG, 2002), theoretical and methodological foundations for the rigorous analysis of diagrammatic representations are being laid, on which the CSAV research community should build. This brings to earth vaguer writings on 'tapping the hidden potential of the visual dimension', which is (not surprisingly) often short on detail when it comes to explaining exactly how visual representations support (or obstruct) individual (or collective) cognition in different contexts.

1.2.6 The Argumentative Approach to Wicked Problems

In the early 1970s, design theorist Horst Rittel characterised a class of problem that he termed "wicked", in contrast to "tame" problems. Tame problems are not necessarily trivial problems, but by virtue of the maturity of certain fields, can be tackled with more confidence. Tame problems are understood sufficiently that they can be analysed using established methods, and it is clear when a solution has been reached. Tame problems may even be amenable to automated analysis, such as computer configuration design or medical diagnosis by expert system. In contrast, wicked problems display a number of distinctive properties that violate the assumptions that must be made to use tame problem solving methods.

Wicked problems:

- cannot be easily defined so that all stakeholders agree on the problem to solve;
- require complex judgements about the level of abstraction at which to define the problem;
- have no clear stopping rules;
- have better or worse solutions, not right and wrong ones;
- have no objective measure of success;
- require iteration – every attempt to build a solution changes the problem;
- often have strong moral, political or professional dimensions, particularly for failure.

Rittel and Webber, made two testable claims of direct relevance to this review: first, that many design problems are "wicked," in contrast to "tame" or "benign" problems which can be modelled computationally, and secondly, that an "argumentative process" was the most effective way to tackle such problems.

> "Wicked and incorrigible [problems]...defy efforts to delineate their boundaries and to identify their causes, and thus to expose their problematic nature." (Rittel and Webber, 1973).

Such problems lack a single, agreed-upon formulation or well-developed plans of action, are unique, and have no well-defined stopping rule, because there are only "better" or "worse" (rather than right or wrong) solutions. Closure is often forced by pragmatic constraints (e.g. managerial or political) rather than "rational scientific" principles. Such problems could not be solved by formal models or methodologies, classed by Rittel as the "first-generation" design methodologies. Instead, an *argumentative* approach to such problems was proposed (a second-generation design method). The essence of this perspective is that an open-ended, dialectic process of collaboratively defining and debating issues is a powerful way of discovering the structure of wicked problems:

> First generation methods seem to start once all the truly difficult questions have been dealt with already (...) The second generation deals with difficulties underlying what was taken as input for the methods of the first generation.
>
> [Second generation] methods are characterised by a number of traits, one of them being that the design process is not considered to be a sequence of activities that are pretty well defined and that are carried through one after the other, like "understand the problem, collect information, analyse information, synthesise, decide," and so on...
>
> My recommendation [for the future of design methodologies] would be to emphasise investigations into the understanding of designing as an argumentative process ... how to understand designing as a counterplay of raising issues and dealing with them, which in turn raises new issues, and so on...
>
> [Argumentative design] means that the statements are systematically challenged in order to expose them to the viewpoints of the different sides,