Writing with a Computer

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Abstract: This essay conjectures that an author's planning process will be facilitated by a tool that represents his plan at various levels of abstraction as a network of subgoals, with the subgoals not necessarily restricted to a linear order. Machine reasoning on such structures has been explored in artificial intelligence research: our proposal is to make these structures available to the writer as a calculus for representing his essays and to use the computer as an interactive editing tool to manipulate them.

Writing and Planning

Machine planning: If we examine the literature on machine planning [1], it is apparent that data structures for plans must have a capacity to represent plans at various levels of abstraction. Otherwise the planning program is prematurely mired in unnecesary detail. Furthermore, at any particular level, the representation should minimize constraints on the order in which goals must be accomplished: it should be possible to express that two goals must be satisfied at a certain point in the plan, but in an unspecified order. Again, this is to avoid having the planning process become prematurely committed to a particular solution. It should also be possible to express at a more concrete level that the goals in question must be accomplished in a fixed order to satisfy constraints that arise at that level.

Problems of writing: These characteristics of the planning process apply to organizing an essay just as much as they apply to a robot choosing a path to some destination. An author has a variety of topics to present--his goals--and ought not to be prematurely tied down to a particular order early in his planning process. Furthermore, he should be able to consider the organization of these topics independently of their details.

Limitations of paper: Authors can meet the demands of planning with pencil and paper. They may work with outlines to deal with their material abstractly and 3x5 cards to avoid premature commitment to a particular ordering. However, as a medium for planning, paper has a number of difficulties. Exploring alternatives is cumbersome. It is difficult to maintain two versions of an outline or a file of cards. Backing up to a previous version is equally difficult, especially if some changes have been made that apply to both the new and old versions. Avoiding premature commitment to a particular organization is hindered by the linear nature of prose. Constraints regarding length, figures or citations must be remembered by the author with no help from the medium itself.

Virtues of the computer: The computer is a more flexible medium than paper for planning because it supports data structures that capture the nature of plans better than linear strings of text or files of index cards. The computer can represent alternative versions with shared structure, maintain a history of previous versions, represent nonlinear organizations of goals by means of networks, and express constraints as programs that monitor the evolving plan. These data structures can, of course, be sketched on paper, but they rapidly become too complex to edit easily. The computer can serve as an editing device that simplifies these data structures by means of filtered views and presents them graphically to an author so as to make them comprehensible and easy to edit.

An Example

To exemplify this, I will use my own experience in writing the introduction to this essay. While it is short, its generation nevertheless required the solution of a variety of typical writing problems. I shall show how the computer was employed as a tool for coping with these problems.

> This example is offered with an awareness that the value of the computer as a planning aid increases in proportion to the complexity of the writing task. In this respect, planning a journal article or a book would be a more compelling example than planning an introduction to a short essay. However, such an example would also be more complex and time-consuming to present. Hence, I have chosen a simple, but real case to present. The reader is asked to generalize this example to writing problems that he has encountered, especially in the context of longer and more complex documents.

As with any introduction to a research article, my subgoals were to present a brief statement of the problem that that I was attempting to solve, the nature of previous solutions, their limitations, the particular solution that I was proposing, and the evidence for this solution. The problem that I faced was how much to say about each of these topics and in what order.

Had I pursued this task with pencil and paper, I would typically have written several drafts of the introduction. The drafts would have included changes to both organization and the content of individual paragraphs. I might also have created and revised an outline of topics to be discussed, sometimes to serve as an initial plan, sometimes to analyze an existing draft.

Instead, I wrote this introduction using a writing environment implemented in PIE, a prototype personal information environment for the representation of designs [2]. Figure 1 is a graphic representation of the top level network that I constructed to represent an early plan for this introduction. The node labelled *Introduction* represents the main goal. It is preceded by the *Abstract* node and followed by the node that represents the goal for this section. The box in boldface linked to the *Introduction* node is the plan for accomplishing this goal. It consists of four subgoals that must precede the statement of my particular solution, but are as yet unordered.

The first return that I obtained from using PIE is reflected in its ability to express and manipulate a nonlinear sequence of topics. Plan 1 did not commit me to a particular order for discussing *G4* through *G7*.

Figures 2 and 3 show two alternative refinements of Plan 1. These refinements differ in the order in which they propose to discuss the subgoals. They are similar in that *G6* has been eliminated in both. The basis for this decision is that it is not a topic of sufficient interest to the intended audience--the members of the cognitive science society. The details of *G6* still remain in the computer database and available for other discussions of this research.

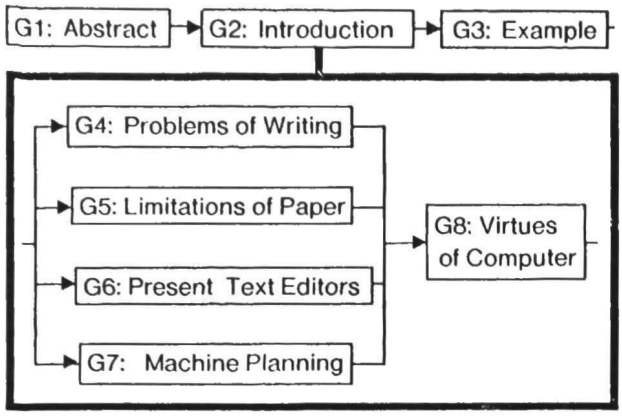

Fig. 1. Plan 1, an early plan in which the ordering of subgoals has not, as yet, been entirely determined.

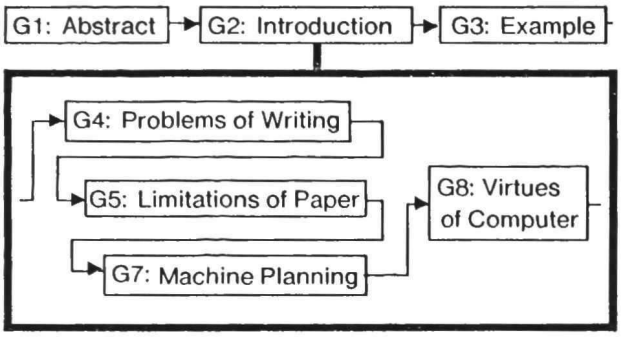

Fig. 2. Plan 2, a refinement to plan 1 in which G6 has been suppressed and the remaining goals ordered.

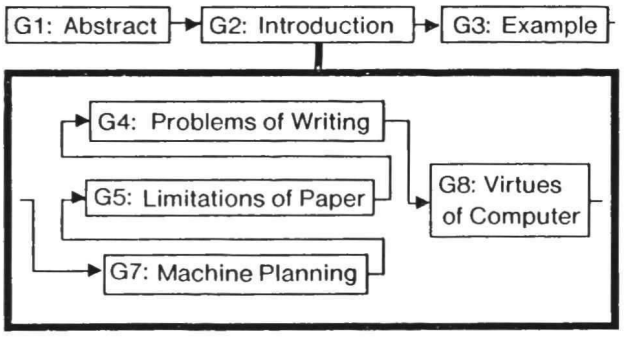

Fig. 3. Plan 3, an alternative to plan 2 in which a different order for the subgoals is chosen.

The ability to manipulate alternatives is the second return that I obtained from using PIE. With paper and pencil, multiple drafts present the difficulty that one cannot edit some paragraph common to two drafts and have the changes show up in both. Nor can one easily place two drafts side by side, with their differences highlighted. Both capabilities are present in a computer-based planning system. The link from *G4* in both plans can point to the same subnetwork; hence, changes to that network will be reflected in both plans. Analysis programs can examine two network structures and highlight their differences.

Ultimately, I chose Plan 3 based on a belief that the initial discussion of writing difficulties called for in Plan 2 was unnecessary because they were well known. The relevant difficulties of writing are mentioned three paragraphs later in the context of describing the application of machine planning to the writing task. The appeal of Plan 3 is that the discussion occupies less space, a significant virtue given a limit of 2000 words.

This leads to a discussion of a third virtue of PIE for document planning: the ability to assert constraints on the plan and have the computer monitor these constraints. PIE allows the designer--in this case, author--to assert predicates regarding properties of the network that he wishes to be monitored. One such predicate assigned to the node representing the document as a whole is that its entire length not exceed 2000 words. Another kind of predicate assigned to paragraphs that reference bibliographic material is that these citations appear in the bibliography. Similar consistency-related predicates apply to section and figure references. These predicates serve as reminders to the author and as a mechanism to preserve consistency among the various parts of the document being edited.

A fourth virtue of the system that is closely related to constraints is the ability to view the network through a filter. Here a constraint is imposed for the purpose of limiting the portion of the network that appears in a given view. Figures 2 and 3 exemplify one such filter: nodes that are not linked to a plan are suppressed. The result is that the node labelled *Present Text Editors*, which appears in Figure 1, is not present in these views. In general, a filter is a predicate on the network and results in some set of nodes and/or links being suppressed.

Objections

The reader has no doubt thought of objections to the claim that this approach will facilitate good writing. Here are three common criticisms, and possible replies.

Structures appropriate for representing machine plans are not appropriate for representing human plans.

Clearly some data structures appropriate for computers are entirely inappropriate as a calculus for people to employ for similar tasks. And any machine data structure is inappropriate if presented to people at too low a level of implementation. However, this is not to say that all formalizations of cognitive processes developed for machine problem solvers are useless for people.

I believe that the formalization of planning described here is useful because it is largely based on the nature of planning, rather than on the idiosyncracies of computers. As evidence for this, planning networks have been developed in the context of PERT charts to analyze and guide the planning of complex projects like the construction of ships. The similarities between these networks and the AI structures is far greater than their differences.

Conscious planning to the degree proposed here will act as a barrier to creative writing.

This is a version of the *centipede* argument--namely, that if a centipede thought about or planned his perambulation too carefully, he would fall over into a ditch in utter confusion. Better to just engage in the process without conscious examination.

Teachers of writing courses would take issue with the *centipede* argument. In such courses, students are taught many strategies for organizing their material, and the claim is made that attention to organizational issues repays the writer many times over at later stages of the writing process. Our position is that if planning is useful, surely the computer can provide a better mechanism than 3x5 cards.

We do not argue that a document should always be approached in a top-down mode. At certain times, the best strategy is to write a particular section in some detail before completing the plan for the entire document. Using the computer does not prevent this. The author can move from one level of the data structure to another at his choice. Figure 2, for example, might have been the first plan created by an author. Later, in searching for an alternative organization, he might step back and express the less committed plan of Figure 1, then refine it to the plan of Figure 3.

The overhead in using the computer is too high; better pencil and paper because it is easy to use and does not itself obstruct the writing process.

Unless careful attention is paid to the human factors of designing a planning editor, this objection is a telling one. Powerful planning structures are useless unless they are easy to manipulate and comprehend. The graphic display of the planning network used in the figures of this article constitutes an implicit proposal for a presentation mode that is easy to understand. The PIE system presently uses a non-graphic display of the network: one that requires more tutelage than the network diagrams, but is easier to implement. Research into the mental models that users have of such networks and into user-interface design that they find comfortable to employ is critical to the success of such tools.

However, even with a good interface, some planning overhead will remain. Hence, another reply to this objection is that only some documents justify the overhead. One-page memos do not. But our hypothesis is that for more complex documents, the planning overhead required by the computer can be less than the overhead required by pencil and paper.

A third response is that while authors are presently more familiar with pencil and paper than with computers, this will not be so a decade hence. For a large number of reasons, it is reasonable to predict that computers will become a universal technology, and that computer literacy will be as common a subject as penmanship. Hence, that part of the overhead due to unfamiliarity with computers is on the wane.

Extensions

We did not attempt to formalize the kinds of plans that an author might employ, beyond providing a means to represent subgoals and successor relationships. However, books on rhetoric and debate contain lists of such plans. This suggests that one might be able to define a set of generic planning schemata to represent different arguments such as argument-by-induction, argument-by-authority, and argument-by-deductive-proof. A given schema would contain slots for the various positions that a given argument requires: the axioms and logic of a proof; the set of examples for an inductive argument, etc. A writer could then expand a plan for a document as a series of instantiations of different schemata. Whether this would result in more coherent or compelling prose remains to be seen, but it would at least be useful as a device to articulate a formal theory of argument structure.

An application of the computer complementary to its use as a writing tool is its use as a reading instrument. The planning structures created by the author can serve as a roadmap and the computer can act as a device for examining these structures. Potentially, this increases the reader's ability to browse through material in idiosyncratic ways, rather than being tied to a fixed order of presentation selected by the author. It may also simplify the writer's task by eliminating the need to find a single linearization appropriate for all audiences. How comfortable a reader will be with nonlinear information structures and whether there are writing and reading skills uniquely appropriate to them are research questions that must be addressed.

Conclusions

This essay has proposed that planning is one writing skill that can be facilitated by the use of the computer as an design tool. Experiments to verify this proposal and research to investigate what other skills of writing might be facilitated by this medium remain for the future: what is certain now is that if we program these machines to imitate paper, as is the case for the current generation of text editing systems, we will never know if qualitative improvements in the handling of words can be obtained.

Bibliography

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