Notes about Vannevar Bush's As We May Think

Gene Michael Stover

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1 What is this?

These are my notes about "As We May Think", by Vannevar Bush [1]. Though the edition I cite was published in 1996, the article was originally published in 1945.

Motivation to read "As We May Think" came from Ted Nelson's "Complex information processing: a file structure for the complex, the changing and the indeterminate" [4], which I read about a week ago. I made some notes about that, too. [5]

"As We May Think" contains a lot of cool ideas. Most have been implemented as of 2005. Instead of out-dating the article, current technology makes it more relevant. It also contains at least one idea, *memex*, which is technically implemented but not yet conventionally implemented.

2 Quaint(?) Ideas of Technology

In the year 2005, we can get a chuckle out of some of Vannevar Bush's predictions about technology. He imagined that machines would read in visual form (but not using the glyphs humans use). Nevertheless, he mentions at least on case of magnetic storage, so his mind was open to it.

Vannevar Bush says that microfilm of the time could (or maybe of the near future would) have a volume $\frac{1}{10{,}000}^{th}$ that of the original material. A set of *Encyclopaedia Britannica* would occupy the same volume as a matchbox. I guess that's about $3cm \times 2cm \times 0.5cm$, which is $3cm^3$.

A compact disc or DVD is a cylinder 6 cm in radius & 0.12 cm thick, giving it a volume of $(6cm)^2\pi \times 0.12cm \rightarrow 13.57cm^3$. Assuming I could put the same *Encyclopaedia Britannica* on a compact disc or DVD, it would occupy a volume about 4.5 times greater than that of Bush's encyclopaedia on microfilm. So we haven't caught up with Bush's prediction of miniaturization yet, though we're in the same ball park, & I'll bet I can *grep* my encyclopaedia faster than Bush imagined would be possible.

Bush predicted that computers of the future would be at least 100 times faster than those of 1945. On the one hand, we blew past the "100 times" mark a long time ago & by so much that it's funny. On the other hand, his prediction was "100 times, if not more", so he was conservative, but he was right. Maybe his other predictions were similarly conservative.

When speculating about future computers, Bush says that a future computer will "take instructions & data from a roomful of girls". There was a time, probably not long before 1945, when a computer was a person, & the people who were employed as computers were girls. When mathematicians estimated the amount of work required for a problem, the unit of work they used was the *girl hour*.

3 Artificial Intelligence

Vannevar Bush's distinction between repetitive thought & creative thought is insightful & practical.

His assertion that logic is suitable for mechanical computation is not yet appreciated. I like this part:

> It is readily possible to construct a machine which will manipulate premises in accordance with formal logic, simply by the clever use of relay circuits. Put a set of premises into such a device & turn the crank, & it will readily pass out conclusion after conclusion, all in accordance with logical law, & with no more slips than would be expected of a keyboard adding machine.

I believe Doctor Doug Lenat wrote some programs which start with a database of assumptions, then use those assumptions to derive conclusions until there is

nothing left to derive. Those programs created a new mathematical theorems [3], [2]. (As of 2005 May, I have not read those papers yet.) (Dr Lenat is also originated the Cyc project, & I think he manages it now.)

4 Memex

[1] is valuable for many reasons, but it is remembered most for *memex*.

The requirements of an implementation of Vannevar Bush's *memex* are:

1. Documents are accessible & viewable from the memex system.
2. Documents may exist on many media: text, pictures, audio.
3. The memex can keep the "trail" of documents you read while you follow your curiosity. (Basically, it's a persistent history of URLs as you surf the web.)
4. You can create associations between documents.
5. You can enter original material.

Notice that HTML's hyperlinks are not the same document associations that Vannevar Bush mentions. HTML links are at a lower-level. Hyperlinks in the raw are just citations that can be followed for you by your computer. A memex association between two documents has context.

Vannevar Bush gives an example of memex use. A human is interested in why the short Turkish bow was superior to the English long bow. His memex keeps track of the documents he reads while he does his research. This forms a new, original document. He makes notes while he studies. He eventually makes a conclusion, & writes it in the new document. He names the new document.

With a little discipline, you could achieve a memex-like system. As you read on-line & offline documents in pursuit of an idea, keep a list of the documents you read, making notes as you go. You descriptive title, such as "Notes about ditch digging". When you've finished, if you feel you've written something that others might like to read, you put the new document on your web site.

For his Xanadu project, Ted Nelson desired associations between parts of documents. We are not there yet.

I also speculated about implementing a memex in [5]. As of Sunday, 2005 May 15, I think the ideas I've written here are better than those I wrote in [5].

5 In Brief

- Humanity's collective library of information is so big that specialists are necessary to make sense of it, but specialists don't make connections between their specialty & others.

  The problem is worse now than it was when Vennevar Bush wrote the essay.

- Mentions Mendel's experiments with peas & how their importance was not understood for at least twenty years. By coincidence, I recently read the well-written tale in [6].

- Is "thermionic tube" an archaic synonym for cathode ray tube?

- Vannevar Bush says "Two centuries ago Leibniz invented a calculating machine..." I know of Leibniz, of course, but I had not heard that he invented a computer. Was it mechanical? I thought Babbage invented the first mechanical computer. This deserves research.

- Mentions Babbage. So in 1945, they had not forgotten Babbage's work. (I am under the impression that Babbage's work was forgotten for a time. If so, in 1945, it had been re-discovered.)

- His fixation with photography, especially miniature cameras & dry photography, is cute. He'd get a serious kick out of digital photography, since cameras can be about the size of the camera "walnut" Bush discusses, & the "film" is unlimited if you can upload & then delete the pictures often enough. And many digital cameras come with a wireless phone attached, too!

- Do Polaroids count as dry photography?

- Apparently, fax machines were in existence, if not common use, in 1945. (To find Bush's description of fax machines, look for the paragraph which begins "This scheme is now used in facsimile transmission". The description begins on the previous paragraph.)

  An interesting detail about that system of fax is that it is digital in that it divides the document into discrete lines, but each line is analog.

- The emphasis on microfilm seems primitive. We store information in more versatile forms these days.

- Vannevar Bush's suggestion for how to create a dictation machine, where you'd speak to the machine & it would convert your speech into text, underestimated the effort required for this task. It is only now (well, about 1997) that it was mostly solved in the general sense.

- His suggestion that natural language must change to accommodate automation is the only over-the-top thing he says, in my opinion.

- He mentions Hollorith notation. I haven't seen that since some kind of history of computers class I took early in college. Didn't Hollorith also have a fast sorting algorithm for his census machine? Isn't that now called the *bucket sort*?

- Correctly predicted that computers of the future would be electrical, possibly using *thermionic tubes*, not mechanical. (For all I know, that was obvious to everyone in 1945.)

- I get the idea that Bush understood that mathematics is a formal language. He probably understood the significance of formal languages in general. I get this idea from many little clues he wrote, but here is one in particular:

  > 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.

  However, he, like early artificial researchers, thought that artificial intelligence was just a matter of applying logic.

- Vannevar Bush did not foresee networking. At least, he did not mention it in [1].

- Vannevar Bush imagined that we would purchase documents, possibly on microfilm, & insert them into our personal memexes. The RIAA would have loved that.

A Other File Formats

- This document is available in multi-file HTML format at http://lisp-p.org/nmemex/.

- This document is available in Pointless Document Format (PDF) at http://lisp-p.org/nelf/nmemex.pdf.

References

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[4] T. H. Nelson. Complex information processing: a file structure for the complex, the changing and the indeterminate. In *Proceedings of the 1965 20th national conference*, pages 84–100, New York, NY, USA, 1965. ACM Press. http://doi.acm.org/10.1145/800197.806036 (Must be ACM member or Digital Library subscriber to access.).

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[6] PhD Thomas F. Lee. *The Human Genome Project : cracking the genetic code of life*. Plenum Press, 1991. ISBN 0-306-43965-4.