Reflections on The Unfinished Revolutions in Personal Computing

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Ivan Sutherland’s 1963 Sketchpad System

- Almost all key elements of an interactive graphics system in the first paragraph of his Ph.D. thesis:

  "The Sketchpad system uses drawing as a novel communication medium for a computer. The system contains input, output, and computation programs which enable it to interpret information drawn directly on a computer display. It has been used to draw electrical, mechanical, scientific, mathematical, and animated drawings"
1. Introduction and History

Psychologists have estimated that as much as eighty per cent of our sensory data is received in the form of visual stimuli. It is therefore surprising to find that the field of computer driven visual displays has lagged behind the development of the computer complex as a whole,
6 visions that inspired me

User Interfaces

“Information at your fingertips”

Information management

“Personal computing”

“Connect the world”

“What we want

“Ubicomp”
“The term, information at your fingertips, is to remind people what a broad role the personal computer will be playing. It's not a computation device, it's not a word processing or a spreadsheet device. It's a window onto the world of information.”

Machine That Changed The World; The Interview with Bill Gates, 1990
Part of From the Vault, Considering Our Tech-nostalgia
11/20/1990

http://openvault.wgbh.org/catalog/V_7C97C4381B7849D791CD357588C2FE89
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Company news

@google
Starting this week, you can now make high quality #GoogleDuo calls from your web browser — https://t.co/jNB787vmpF
https://t.co/KYIQ2yjCUy

AI
Doing our part to share power responsibly
Great Library of Alexandria – 3rd Century BC

“The Great Library of Alexandria in Alexandria, Egypt, was one of the largest and most significant libraries of the ancient world.... comprising a collection of scrolls, Greek columns, a peripatos walk, a room for shared dining, a reading room, meeting rooms, gardens, and lecture halls, creating a model for the modern university campus.”


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Paul Otlet – 1868-1944

Early 20th Century Networked Knowledge and Global “Internet” Pioneer

Original Mundaneum
Brussels, Belgium
1910

New Mundaneum
Mons, Belgium
1998
Paul Otlet – 1868-1944

“From afar, anyone would be able to read any text, expanded or limited to the desired subject, projected on an individual screen. Thus, anyone from his armchair would be able to contemplate the whole of creation or particular parts of it.”

“Everything in the universe would be registered at a distance as it was produced. Thus a moving image of the world would be established....
Van nevar Bush – “As We May Think”, The Atlantic, July 1945

A machine to rapidly select documents recorded as microfilm images on reels of 35 mm movie film

Coding of document topics as dot patterns on film

Strobotron to fire photo cell detectors matching a topic pattern “mask”
The young lady above is holding a film chip containing an entire copy of the Bible. On this 2 inch by 2 inch frame are stored 1245 pages of text. The 2000 copies shown in the picture represent a document collection of 2,500,000 pages. This display dramatizes the storage and dissemination capabilities of NCR's new photochromic micro-image technology.

NCR MICRO-IMAGE BIBLE*
2. Information Management: annotations, threaded discussions, and catalogs

- Talmud: 2nd – 5th Centuries CE
- Hadith: 8th and 9th Centuries CE
- King James Bible: 17th Century CE
- Book Catalog of Christopher Columbus’ son: 15th Century CE
- Book Wheel: 16th Century CE
- David Foster Wallace: 20th Century CE

https://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/

"Selection by association, rather than indexing, may yet be mechanized. One cannot hope thus to equal the speed and flexibility with which the mind follows an associative trail, but it should be possible to beat the mind decisively in regard to the permanence and clarity of the items resurrected from storage."

"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.

And his trails do not fade."

"Wholly new forms of encyclopedias will appear, ready made with a mesh of associative trails running through them,..."

"There is a new profession of trail blazers..."
NLS (oN-Line System) Contributions

- MOAD: Mother of All Demos at FJCC 1968
- Interactive authoring and reading on screens
- Hierarchy (outline) with hyperlinks
- Multiple windows
- Real-time teleconferencing and synchronous collaborative editing
- Bi-manual operation (chord and mouse), cmd-line driven (NOT GUI)
- Links as text strings (like URLs)
- Systematic architecting and software engineering, tools
- Bootstrap community
Ted Nelson - Contributions

- Coining and evangelizing the word “hypertext”
- Tackling complex issues of structuring, authoring, and “reading” hypertexts
- Describing mechanisms or provenance of authorship and micropayments
- ComputerLib/Dream Machines evocative publications
- Instigator/consultant/client, HES (Hypertext Editing System)
A Half-Century of Hypertext Research at Brown

HES (Hypertext Editing System) - 1967

FRESS - 1968

EDS - 1982

Intermedia - 1985

EBT (Electronic Book Technology): DynaText - 1990

TAG (Touch Art Gallery) - 2015
Sir Tim Berners-Lee - WWW

- Hypertext Transfer Protocol (HTTP)
- First open (universal) hypertext
- Hypertext at scale
- But with Mosaic we lost equality of authoring and reading
- A recent Google Doodle:

The World Wide Web (WWW) is the combination of all resources and users on the Internet that are using the Hypertext Transfer Protocol (HTTP). A broader definition comes from the World Wide Web Consortium (W3C):
"The World Wide Web is the universe of network-accessible information, an embodiment of human knowledge."
Importance and Evolution of Search

- JIT search has largely replaced hard-wired links, but they are complementary mechanisms
- Google/Bing provide great search over text, with improving image and video search
- Page-rank algorithm, scaling expertise
- Machine learning for pattern recognition
- Many problems can be formulated as pattern recognition problems (e.g., games)
- But, search is still in its infancy
  - ill-specified “human” search requests that depend on text/history/common sense knowledge and reasoning not yet there, e.g., “smart speakers”

Alon Halevy, Peter Norvig, Fernando Pereira. "The Unreasonable Effectiveness of Data" IEEE Intelligent Systems, V24:N2, March-April 2009
3. Personal Computing

- Bill Gates’ 1980 Microsoft corporate mission statement:
  “A computer on every desk and in every home”
Confluence of Two Movements

- Microminiaturization and riding the cost curve (eventually resulting in "Moore’s Law")
- Rebellion against “the Man”: anti-establishment, anti-DP, anti-military, anti-dehumanization
  - democratization, e.g., “Information Wants to be Free” – Stewart Brand

- Irony of the monopoly powers of FaceBook, Google, ...
Visionaries in Personal Computing

- Vannevar Bush – Memex
- Ivan Sutherland – Sketchpad
- Doug Engelbart – NLS
- J.C.R. Licklider, Vint Cerf, Bob Kahn – ARPAnet
- Bob Taylor – Xerox PARC
- Alan Kay – Dynabook, with Adele Goldberg et al., Smalltalk Environment
- Butler Lampson, Chuck Thacker, Bob Metcalfe, … – Alto bitmapped graphics workstation, Ethernet
- Dan Bricklin and Bob Frankston – VisiCalc on the Apple II
- Don Estridge – IBM’s “Father of the PC”
- Steve Jobs – from Apple-II to Macintosh
4. “Connect the World”

- Facebook’s original mission statement: “To give people the power to share and make the world more open and connected.”
5. “Ubicomp” Ubiquitous Computing

- Mark Weiser
  - Xerox PARC – ubiquitous computing
    - pervasive, location-aware
- Norbert Streitz – “Smart Future” EU project
  - smart everything everywhere, ambient intelligence, IoT
- Many smart office, home research projects
  - Georgia Tech’s “Aware Home” (1998 to present)
  - yet vision of integrated real and virtual space with real-time collaboration still not realized
Ubicomp: Ubiquitous ➔ Ubietous Computing

- Buxton’s 2018 lectures on Ubiety:
  - importance of **place** – where and how to use smart devices
  - “moral order”/**context** – appropriate behavior
  - obeying **social relationships**, not just physical constraints

- Ecosystem of human activity
  - relationships among locations, devices, roles, time, ...
    - **graph structure**
      - **arcs** are the relationships, the transitions between activities
      - **nodes** are different states, i.e., devices, roles, times
    - complexity management via ecosystem PoV and collaboration

- Example (Buxton talk at Brown in 2018)
  - Xerox PARC – PARCslate & PARCtab with Liveboard ecosystem
    - “Inherent in that design was ubiety not ubiquity”
    - “Every device had value on its own independently but together they could work cooperatively in reasonable ways”
    - “Think about changing the relationships as opposed to making a new device”
6. Natural User Interfaces (NUIs)

What is the role of a UI?

- To mediate between user(s) and environment(s)
- To manage the complexity of such an ecosystem
- To create a harmonious user experience

How to manage complexity of interacting with real and virtual objects and participants?
The Ultimate User Interface (1/3)

- None! UIs are a necessary evil
- Counterpoint:
  - the aesthetics of a good UI
- Want to communicate and control as we do in and with the real world
  - objects
  - tasks
  - other participants (real and software agents)
The Ultimate User Interface (2/3)

- Models for agents:
  - Jeeves –1915-1974 (P.G. Wodehouse)
    - knows context and place
    - anticipates, infers intent
    - requires NLU, knowledge base
    - vision: Apple’s Knowledge Navigator – 1987
  - Beware HAL-9000 (Clarke/Kubrick 2001)
The Ultimate User Interface (3/3)

- **Best today**
  - transparency
  - minimize cognitive load, maximize muscle memory, automaticity, ...

- **Current brain-computer interface research - “cogito ergo fac”**
  - invasive embedded electrodes
    - BrainGate Research Team, 100 neurons – 1990s to present
  - non-invasive scull caps
    - fNIRS (near-infrared spectroscopy)
      - Chaudhary et al. PLOS 2017 article
    - U Minnnesota EEG robot control
Limitations of WIMP GUIs

- Designed for one user, at one desktop, with one mouse and keyboard
  - limited
    - vision (flat, 2D)
    - focus
    - audio
    - tactile
    - movement
  - no
    - speech
    - gestures
  - one-handed interaction
  - systems unaware of user
Characteristics of Post-WIMP, Multi-modal UIs

- Also called Perceptual Uis, Natural Uis (NUIs)
- Multiple simultaneous devices, sensory channels, or humans
- High bandwidth, continuous, noisy input
  - body part tracking (head, gaze, hand, ...)
  - gesture and speech recognition
- Probabilistic disambiguation, “unification” (sensor fusion)

Rand Tablet - 1964

PLATO IV – Touch Panel - 1972
“Put That There” as an Early Research Example

- “’Put That There’: Voice and Gesture at the Graphics Interface” – Richard Bolt, MIT 1980

Human-robot interaction

Multimodal Belief Fusion

- Combine multiple sensors to estimate true state
  - Speech, gesture, pose, eye-gaze
  - Called ‘sensor fusion’ or ‘belief fusion’
- Bayesian Filtering: Model world as Hidden Markov Model
  - Each sensor outputs a probability distribution over the true state
  - Combine each sensor’s probability distribution with the state estimate from the previous timestep.

Multimodal Belief Fusion

- Step 1: Start with an initial estimation (uniform is a common choice)

Multimodal Belief Fusion

- Step 2: Collect sensor measurements
  - Note: each sensor is considered conditionally independent from one another
  - Some sensors such as hand-tuned models, some are machine-learned

Multimodal Belief Fusion

- Step 3: Average sensor estimations
  - Element-wise addition + normalization to make sure probabilities sum to one

Multimodal Belief Fusion

- Step 4: Integrate with previous estimate
  - Same element-wise addition and renormalization, this time with previous estimate

Mixed Reality as a Bidirectional Communication Interface for Human-Robot Interaction
WWW: What We Want in our Apps/UIs (1/2)

- Ubiety: “place”-adaptive in capabilities and constraints
  - agile switching between
    - multiple I/O interaction languages based on platform: direct interaction, speech, agents
    - focused, localized, and multi-threaded modes
      - e.g., in the shower thinking of three different problems/tasks and
      - wanting to take notes on all, create sketches
    - Ex.: intelligent mail reader for driving

- Less direct manipulation and more shorthand
  - “set the table for our visitors” – based from context
Autonomous computer-assisted knowledge work still far off

- limited human-computer collaboration for now
- autonomous vehicles are easier!

Increasingly we’ll have a federation/society of appliances/devices around us and in us – need:

- focus-in-context, e.g., fisheye views, LoD, ...
- situational awareness
- summarization and inferencing
Assessment of Where We Are: Information

- Worldwide accessibility through Internet, smartphones, and laptops
- “Information at Your Fingertips” and information management largely achieved
  - suites of tools such as Microsoft Office and the Google Suite
- Amount of information still overwhelming
- Mostly uncurated – very difficult to find trusted PoV
- Democratization of online "publishing" has had many negative intended and unintended consequences
  - journalists replaced by bloggers, death of newsprint...
Assessment of Where We Are: Technology

- Internet hardware and software infrastructure scales astonishingly well, but:
  - “connecting the world” is devolving because of nationalization, e.g., China and Russia
  - inadequate technology and human control causing escalating cyberfraud/crime, data breaches, ...

- Integrated environments of ’60s and ’70s have devolved into
  - silos and lack of interoperation due to commercial imperatives

- Far from ubietous computing with its seamless, frictionless portability of the user's environment

- “smart home/office/city” field is growing exponentially

- but it remains frustratingly inadequate, buggy, and turbulent (“Google’s Nest”)
  - + the usual privacy/security issues

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Assessment of Where We Are: User Interfaces

- Core technologies still inadequate
  - voice and gesture recognition, interaction in 3D
  - IVR and its easier-to-adopt cousin AR/MR still very early stage
    - comfort/safety of headsets; tracking
    - autostereoscopic displays
    - distributed haptic feedback
- Bewildering proliferation of apps & their incompatible UIs
  - still no good multi-modal UIs in common use
- Need to control the society of devices around us, and, increasingly, within us, without overwhelming us
  - future of "Human-in-the-Loop" systems, e.g., Boeing 737 Max, jet fighters, semi-autonomous vehicles?
Assessment of Where We Are: Societal Implications

- Growing security/privacy issues
- Influence of fake news: fauxtography, deep fakes
- Astonishingly explosive growth of, and dependence on, social media
  - but they all too often play an undesirable, even dangerous role
  - “social media considered harmful”...
- ....
Societal Impact and Ethics

Kranzberg’s First Law

- “Technology is neither good nor bad; nor is it neutral”
- Our techno-optimism was unjustified
- Our “not our job/problem” attitude harmful
Some Societal Problems

- Addiction – games, social media
- Disproportionate and huge influence of social media
  - behavior modeling → prediction → modification → impact on individuals and on society
  - market dominance, unregulated monopolies
Social Media

- Faustian bargain
  - “free” more compelling than privacy/security
  - companies reap rewards of monetizing our data
  - surveillance capitalism is the new economic driver

- Scale, e.g., billions of users, changes the type of global impact
Four Related Problem Areas in Social Media

- Addiction
- Invasion of privacy: monetizing your data
- Filter Bubbles and the hacking of society
- Economic dominance, surveillance capitalism
1. Addiction: Attention as a Commodity

- “Time on task” and focus for task performance vs. engagement and “stickiness” to increase lock-in and ad revenue
- ➡ addiction
- 2017 – Tristan Harris’s TED talk “How a Handful of Tech Companies Control Billions of Minds Every Day”
  - attention-grabbing strategies that foster addiction to distracting media
Addiction strategies: AI algorithms fed by personalized data

- Based on psychological research (gambling and game industries): brain chemistry + algorithms
  - started with behaviorism
  - Stanford Persuasive Technology Lab
  - bright colors, high-energy sound, micro-rewards (badges, “likes”), all increase dopamine
  - collaborative filtering, recommender systems, affinity groups vs. queue up the next ad or video
  - FOMA (fear of missing out), social insecurity, and the need for approval
  - people increasingly live in the online world where approval is at least as dominant as in the real world -> instant feedback
    - not just viewing but responding to postings – guilt, fear
    - “Teens explain the world of Snapchat's addictive streaks, where friendships live or die”
2. Invading Privacy and Monetizing Your Data (1/2)

- Personalized data (including metadata)
  - You are the most valuable commodity
  - vulnerable to de-anonymizing, theft, tampering

- Data gathered from both app/user and from other users and their apps via social graph
  - without their knowledge, let alone consent
  - “30K data points/person” – Roger McNamee
  - definition of data point? queries, images, extracted and inferred profiles?
3. Behavior Modification

- Behavior manipulation is a very old art, often called propaganda
  - rulers control their populations, ads influence attitudes and buying behaviors
  - Freud’s nephew Edward Bernays wrote the book on PR “Propaganda”, the bible of PR
  - Vance Packard covered advertising, PR, government (1957)
    - warned about “depth approach” to manipulation of our subconscious, leading to behavior modification
    - Center for Advanced Study in the Behavioral Sciences at Stanford
    - big difference between susceptibility to ads (effectiveness still controversial) and the effects of microtargeting
3. Behavior Modification (2/3)

- Behavior modeling $\rightarrow$ behavior prediction $\rightarrow$ behavior modification via **microtargeting** mechanism
  - your personal data blended with aggregate statistics of your “kind” to target your profile

- **Filter bubbles**
  - you see what you prefer to see – contract rather than expand PoV
  - biases are reinforced, outrage and shock travel faster and have more impact than evidence-based, rational argumentation
  - perversely, contrary evidence more likely to harden a belief
    - The “post-truth” world of alternative facts
    - proof by vigorous assertion $\rightarrow$ the big lie, AgitProp
  - fake news: bad actors + bots + dupes
3. Behavior Modification (3/3)

- Brain- and democracy-hacking through filter and preference bubbles,
  - “the echo chamber”, “weaponization of information”
  - deaths: Myanmar, Sri Lanka, “vaccination causes autism”, the resurgence of whooping cough, measles,…
  - hacking of society: Trump election, Brexit, Cambridge Analytica; Brazil, …(cf. paper on Russia’s IRA (Internet Research Association) influence on 2016 election)

- (Trump win aided by deliberate
  - gerrymandering (redrawing voting districts to favor incumbents)
  - voter suppression, aided by fake news)

- Tribalism
  - divisiveness, hollowing out of the center, accommodation
  - decline of civic responsibility

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4. Surveillance Capitalism (1/2)

- Surveillance State – Big Brother is here, now
  - cameras, GPS, smart speakers, smart appliances
- Zuboff’s “The Age of Surveillance Capitalism”
- The new economics, based partially on “laissez-faire”
  - aka “robber baron”, libertarian/Ayn Rand economics rather than Keynesian economics
- Social media created a Golem/Frankenstein but now benefit
  - they are addicted to growth and wealth
4. Surveillance Capitalism (2/2)

- Unregulated **monopoly** power’s vicious cycle
  - **Zuckerberg’s** 60% controls Facebook, with 2.7B+ users
  - more power and influence than the US president
    - FB, Google,... not just neutral platforms but also “curated content” providers
    - freedom of speech vs. dealing with hate speech – “who appointed him czar?”
  - fierce resistance to regulation, but clearly repeated failures show they can’t self-regulate
    - data breaches, content monitoring, “catch and kill” to suppress potential competitors
    - “Deny, deflect, ...” rather than let’s **really** work together to try to deal with the admittedly really hard issues
    - Google disbanded its Advanced Technology External Advisory Council (b3/26 – d4/5)

- Government regulation, e.g., rights in data
  - individual, corporate, government
  - Europe’s GDPR (General Data Protection Regulation) as a first step
Human-Centered Design ➔ Humane Design

- Design can’t just be concerned with effectiveness
  - but has to include a concern for the human and societal consequences
  - uses to which the design could be put
  - potential safeguards
- Center for Humane Computing
  - http://humanetech.com/
- AI as a bellwether
Some “Ethics in AI” Efforts (1/2)

- Concerns about societal impact of social media parallels and intersects with that about AI
  - older and more substantial efforts to learn from...

- Wired stories
  - “Tech Firms Move to Put Ethical Guard Rails Around AI”
  - “Tech Giants Team Up to Keep AI from Getting Out of Hand”

- Partnership on AI: [http://partnershiponai.org](http://partnershiponai.org)
  - Accenture, ACLU, Amazon, BBC, Facebook, Google, IBM, MSFT,....
  - “The Partnership on AI to Benefit People and Society was established to **study and formulate best practices** on AI technologies, to advance the public’s understanding of AI, and to serve as an open platform for discussion and engagement about AI and its influences on people and society.”
Some “Ethics in AI” Efforts (2/2)

- OpenAI initiative [https://openai.com/about/](https://openai.com/about/)
- New Research Institute for Ethics in Artificial Intelligence at Technical University of Munich
  - [https://www.wi.tum.de/new-research-institute-for-ethics-in-artificial-intelligence/](https://www.wi.tum.de/new-research-institute-for-ethics-in-artificial-intelligence/)
- One Hundred Year Study on AI, reports every 5 years [https://ai100.stanford.edu](https://ai100.stanford.edu)
- Microsoft’s Aether Committee: AI and Ethics in Engineering and Research
- Microsoft’s “The Future Computed”
Microsoft Golden Rule Ethical Principles for AI (1/4)

**FAIRNESS**
Treat all stakeholders equitably and prevent undesirable stereotypes and biases.

**PROMPTS**
From the perspective of your stakeholder, how could the decisions made by this system treat people unfairly based on a personal characteristic they cannot change?
How could the system perpetuate bias or stereotypes?

**RELIABILITY**
Build systems to perform safely even in the worst-case scenario.

**PROMPTS**
How could the system malfunction?
How could the system be misused or cause harm?
Microsoft Golden Rule Ethical Principles for AI (2/4)

PRIVACY & SECURITY
Protect data from misuse and unintentional access to ensure privacy rights.

PROMPTS
What concerns might your stakeholder have about the data the system collects, stores, or uses?
What data should you NOT collect?

INCLUSION
Empower everyone, regardless of ability, and engage people by providing channels for feedback.

PROMPTS
Will the system work well for everyone who uses it?
Have you accounted for physical, cognitive, social, or situational differences that could exclude someone or entire groups?
Microsoft Golden Rule Ethical Principles for AI (3/4)

TRANSPARENCY
Create systems and outputs that are understandable to relevant stakeholders.

PROMPTS
What does your stakeholder need to know to understand the system and how decisions are made?
What might they want explained and how will you provide that information?

ACCOUNTABILITY
Take responsibility for how systems operate and their impact on society.

PROMPTS
Who is responsible if something goes wrong or if stakeholders have concerns about how it performs?
How can you undo harm caused by the system or fix mistakes?
USER CONTROL
Stakeholders, particularly end users, should be able to understand and impact how the system works.

PROMPTS
How much control do stakeholders have over the system and their data?
What information do they need to make those choices?
Ethics in the CS Curriculum

- “Ethics Education in Context: A Case Study of Novel Ethics Activities for the CS Classroom”

- “Tech’s Ethical ‘Dark Side’: Harvard, Stanford and Others Want to Address It”

- “Harvard & MIT Among Nation’s First to Introduce CS Ethics Courses”

- Embedding ethics in computer science curriculum
  - https://www.seas.harvard.edu/content/embedding-ethics-in-computer-science-curriculum
  - Brown CS new “Ethics TAs”
What to Do? My Call to Arms

- Minimize use of screens
  - social media, games, inane messaging, ...
- Lobby for anti-monopoly and data privacy legislation
- Lobby for subscription vs. ad model
- Demand much greater investment in combatting the negative mechanisms and outcomes
  - great intellectual challenges – e.g., freedom of expression isn’t absolute but who shall police based on what criteria?
- Develop, discover, advocate, and pay for trusted PoV
- Educate
- Lobby for ethical behavior within school and job
  - humane design
    - include social benefits, not just universal design
    - design for accessibility and inclusion
  - Center for Humane Technology, ...
- You have a choice of what to work on...
Engelbart’s Grand Vision

- The glass is half full...we have great tech, e.g., the smartphone ecosystem, but tech hasn’t advanced as fast or as well as we might have expected in half a century
  - Arthur Clarke and Stanley Kubrick’s classic movie “2001”
- Augmenting Human Intellect, increasing our societal IQ
  - has not materialized
  - in some ways we are going backwards
- Don’t just be great technologists, help make tech societally responsible – we CAN fix this...
“To Infinity and Beyond...”