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Extended Memory: Early Calculating Engines and Historical Computer Simulations

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In the field of cognitive science, the extended mind hypothesis claims that the human brain is not the boundary of the human mind. According to British cognitive philosopher Andy Clark, “The computational circuitry of human cognition flows both within and beyond the head” [1]. As humans think, we depend on innumerable external systems and on diverse social and technological networks. Intelligence involves rich interfaces between humans and their environment (as discussed, for example, in the work of John Sutton) via cognitive technologies (see, for example, Andy Clark). Cognitive technologies, according to Clark, are “deep and integral parts of the problem-solving systems that constitute human intelligence. They are best seen as proper parts of the computational apparatus that constitutes our minds” [2]. Although by cognitive technologies Clark means a variety of systems, codes and devices (including PDAs, cybernetic prosthetics and scientific equipment, such as the microscope) [3], the study of technological tools can reveal cognitive structures and can provide examples of extended mind in history and in everyday life.

For example, compared with a human brain, a calculator determines mathematical relationships very quickly and efficiently. In a historical context, the 19th-century computational devices of British mathematician Charles Babbage were rudimentary calculators that provoked a shift in human cognition. This inventor’s initial designs enhanced accuracy—a requirement of scientific truth and discovery, of honesty and of verification of reality. As Clark might say, this calculating machine was an extension of the mind: Babbage’s concept complemented the mind, which is prone to error during computation and transcription. As accuracy became automated, the mind became free to apply the results, rather than to compute and record them.

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ABSTRACT

When framed within cognitive theory’s extended mind hypothesis, Charles Babbage’s 19th-century calculating machines illustrate a distinction between accuracy and flexibility. These properties affect how historical data and memory are organized, providing conceptual linkages for mind-machine integration. The distinction between accuracy and flexibility is also apparent in present-day computer simulations that use historical scenarios, such as virtual reality software designed for the Bloody Sunday Inquiry, history-based video games and other art and entertainment software applications. These contemporary examples share one important feature of extended mind: the incorporation of history or personal memory into a shared memory system.

PROTO-COMPUTERS: BABBAGE’S CALCULATING ENGINES

In 1821 Babbage (Article Frontispiece) set out to improve accuracy in mathematics, because mathematical tables in use at the time contained many inaccuracies due to human error. He conceived the first of several calculating machines, called the Difference Engine, to correct the errors he identified. Although not completed during Babbage’s lifetime, the Difference Engine is the first machine correctly designed to automate mathematical calculation. This pioneering effort sought to improve accuracy—a requirement of scientific truth and discovery, of honesty and of verification of reality. As Clark might say, this calculating machine was an extension of the mind: Babbage’s concept complemented the mind, which is prone to error during computation and transcription. As accuracy became automated, the mind became free to apply the results, rather than to compute and record them.

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Fig. 1. Part of the Analytical Engine, under construction at the time of Charles Babbage’s death. (© Science Museum, London and Science & Society Picture Library, London)
lace, once a student of Babbage, famously remarked in 1843 that the “Analytical Engine weaves algebraic patterns just as the Jacquard-loom weaves flowers and leaves” [4]—referring to an automated loom that uses punch-card instructions to determine designs. The Science Museum in London calls the Analytical Engine “one of the startling intellectual feats of the nineteenth century,” because it separated its memory and processing functions as modern computers do. People today can, as the museum says, “appreciate the full extent to which Babbage was indeed the first pioneer of computing” [5].

Babbage first solved his initial problem of calculating accurately and then applied his results to the more flexible design in order to analyze logical relationships mechanically. Lovelace suggested a link between this specific technological innovation and a more general scientific advance:

[Analytical Engine] can do whatever we know how to order it to perform. It is likely to exert an indirect and reciprocal influence on science itself. In so distributing and combining the truths and the formula of analysis, they may become most easily and rapidly amenable to the mechanical combinations of the engine [6].
Her prediction of a broad impact on knowledge has proven surprisingly prescient. Babbage’s Analytical Engine marked a cognitive shift from engines of accuracy to engines of abstract, flexible analysis (precursors to the modern digital computer). This distinction between accuracy and flexibility in Babbage’s calculating engines is also relevant to properties of contemporary technology.

Both accuracy and flexibility are evident in today’s computer programs that build simulations from historical data. These historical computer simulations rely variously on accuracy and flexibility as guiding principles. Some examples are the virtual assistant used in Northern Ireland’s Bloody Sunday Inquiry; the controversial video games Waco Resurrection and JFK: Reloaded; a virtual battlefield by artist Maurice Benayoun; and an educational simulation of life in the ancient city of Pompeii. These contemporary examples all share one essential feature relevant to extended mind: the incorporation of history or personal memory into a collective memory system.

“Memory bridges not just past and present, but outside and inside, machine and organism, dreams and reason, invention and sadness, creation and loss,” says Australian philosopher John Sutton. In the case of computer simulations, memory integrates these diverse realms, and, as Sutton explains, “internal memory systems and external information systems have been coevolving ever since the beginnings of visuographic symbolic invention, pictorial representation, and writing” [7]. Increasingly, human cognitive functions are integrated into complex technological systems via memories and historical data. One fascinating example of human-machine integration is the computer simulation that incorporates individual personal memories of a civil rights protest in Northern Ireland.

VIRTUAL COURT ASSISTANT: BLOODY SUNDAY INQUIRY

On 30 January 1972, a peaceful civil rights march in Derry, Northern Ireland, turned ugly (Fig. 2). Thirteen protesters were shot dead by British officers, and a 14th died later. Bloody Sunday, as the day is now called, was promptly investigated, but after a scant 11 weeks, a British government report exonerated the officers. In 1998, Tony Blair’s government established a tribunal—named the Bloody Sunday Inquiry—to reopen the investigation in an effort to “establish the truth about what happened on that day” [8].

The search for the truth is central to many legal proceedings, yet memories can be unclear, incorrect or even fantasized, and they can change or fade with time. The Bloody Sunday Inquiry sought accurate testimonies and took great care in making public the memories of that day. Years of hearings and an estimated £150 million in expense supported the Inquiry’s impressive scope and depth, which involved sophisticated information management and advanced technology [9]. Integral to the proceedings were daily postings of transcripts on the Internet, closed-circuit televisions for local viewing, a high-tech media center for journalists and custom virtual-reality software to assist with witness testimony. While the Internet, closed-circuit feeds and a press media center are common in high-profile legal cases, the Inquiry’s use of VR software was novel.

Commissioned in 2001 by the Inquiry, the VR software was developed at the Northern Ireland Centre for Learning...
Resources based on historical photographs, maps, architectural drawings and television footage, in order to re-create Derry’s Bogside district after decades of change. The resulting simulation permitted the more than 900 witnesses to move through historically accurate, panoramic views of 1972 Bogside (Fig. 3). Describing the interface, the senior developer on the project said, “The witnesses can choose where they want to go, what they want to view and point to what they saw. When a witness talks about gunfire of a specific event, they can draw on the screen . . . and the computer records this” [10]. By helping witnesses recall their experiences while recording their testimonies, this history-based simulation compensated for fallible memories and corrected uncertain accounts. Since the legal context demanded historical accuracy as well as accurate records of testimonies, the simulation software anchored hundreds of different perspectives on the event.

The Bloody Sunday VR links numerous human memories via computer simulation—an unusual application for a technology that is more often used for fantasy, training and edutainment. According to a BBC correspondent, “Virtual reality software has had a poor press, dismissed by many as a gimmick for gamers rather than something of genuine value. But what the Bloody Sunday model has demonstrated is that VR can work for ordinary people” [11]. Nevertheless, the widespread use of historical material—people, events and locations—for interactive simulations largely serves entertainment, and in these contexts, historical accuracy becomes mutable. The opportunity to replay and remake historical events, for instance, attracts people to a genre of history-based computer games [12]. Examples include Iran Hostage Mission, Praetorians, Titanic and Gettysburg. In contrast to the Bloody Sunday simulation, these games do not aim for precise historical accuracy but rather for a veneer of authenticity. Purportedly written by victors to support their ascendency, history is now being reimagined as simulations that may or may not conform to official versions.

**VIDEO GAMES: JFK: RELOADED AND WACO RESURRECTION**

Some software developers create games from disturbing historical episodes, thereby renewing the difficulties posed by the original events. For example, JFK: Reloaded (2004) simulates the 1963 John F. Kennedy assassination. Players, cast as Lee Harvey Oswald, repeatedly shoot at a simulated JFK motorcade, allegedly to test the single shooter hypothesis. According to the Scottish game developer Traffic, this game “enables players to examine the challenges that faced Oswald and determine on their own if he was, in fact, the only shooter on that fateful day” [13]. This lofty rhetoric is belied by the project’s probable audience of youth injured to violence and seeking vicarious thrills. While acceptable as free speech, games with divisive themes, such as the re-creation of specific historical murders, flout propriety by exploiting painful memories.

In another gaming project, Waco...
Resurrection, the 1993 FBI siege and destruction of the Branch Davidian compound in Waco, Texas, has been recreated from the perspective of David Koresh (Figs 4 and 5). Sponsored in 2003 by C-Level in Los Angeles, this project developed from the collaborative efforts of artists Michael Wilson, Eddo Stern, Brody Condon and Jessica Hutchins, among others. Players “enter the mind and form of a resurrected David Koresh through custom headgear, a voice-activated, hard-plastic 3-D skin” [14]. The use of headgear simultaneously masks and isolates users while permitting their sense of hearing to be bombarded by the game’s audio. As the simulated confrontation escalates, the player hears loud music [15], hears the character speak verses from the Book of Revelation to rally supporters, emanates a mystical aura and uses firearms to battle federal agents. While the historical standoff and its violent conclusion were documented by news media from an exterior position, the simulation depicts the unsettling psychological context of the worshipers inside the labyrinthine compound.

Both JFK: Reloaded and Waco Resurrection portray controversial real-world events, the inconclusive historical records of which can support different interpretations. Both games provide the opportunity for players to experience historical agency, and both also imply that each person or player constructs his or her own particular version of history. Along with first-person agency, then, these simulations offer roles to participants as first-person historians who decide for themselves which interpretations are possible, likely or most entertaining.

Clark contends that “the linguistic and technological environments in which human brains grow and develop are thus poised to function as the anchor points around which such flexible neural resources adapt and fit” [16]. Computer simulations, as interfaces of mind and machine, reflect the two properties under discussion—accuracy and flexibility. In some contexts, as we have seen, the accuracy of data can and will be eclipsed by its adaptation to a fantasy environment. Just as history can be interpreted variously, it can also function differently in

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contexts of knowledge, edutainment, fantasy, etc. Two other computer projects—an artwork by Maurice Benayoun and a simulation of Pompeii—show that historical facts can function within complex, interactive scenarios without necessarily being subverted.

A VIRTUAL ART ENVIRONMENT: WORLD SKIN

French artist Maurice Benayoun elegantly balances fact and fantasy in a history-based simulation called World Skin. Designed for the CAVE at Ars Electronica in Linz, Austria [17], his project comprises a 3D landscape with war imagery. Up to 10 viewers stand clustered inside a 3-x-3-x-3-meter space while surrounded on three sides by a projected VR landscape—an endless, rocky plain populated with soldiers, tanks, planes, debris and half-destroyed buildings (Figs 6 and 7). These images are easily recognizable as historical photographs of World War II and the Vietnam conflict. One viewer navigates the artificial terrain with a handheld control, and four small cameras hang from the ceiling, allowing other viewers to record the experience. As they take pictures, rectangular swaths that correspond to the cameras’ views are eliminated from the landscape: the traces of the past are destroyed by the act of taking pictures. At the end of the visit, viewers are provided with souvenir printed images captured during their visit to the endless battlefield.

World Skin’s historical source imagery has been adapted to a macabre fictional landscape that is accessed by camera-toting tourists. The specific historical content of the photographs used to create this simulated terrain has been removed; nonetheless, the viewers’ experience is poignant [18]. As Benayoun explains,

[In World Skin] being engulfed by war is an immersion in a picture, but it is a theatrical performance as well. . . . The rawest and most brutal realities are reduced to an emotional superficiality in our perception. . . . Some things cannot be shared. Among them are the pain and the image of our remembrance. The worlds to be explored here can bring these things closer to us—but always simply as metaphors, never as a simulacrum [19].

Benayoun acknowledges the impossibility of fully knowing the past by incorporating the disappearance of visual fragments into the project. Not intending to maintain an accurate historical context, World Skin conforms to the artist’s vision of confronting the violent past, as difficult or impossible as it may be. Instead of using history to authenticate simulated scenes, this project examines the limits of knowing and accurately experiencing history.

AUGMENTED REALITY: SIMULATION OF POMPEII

Another project that blends historical accuracy and flexibility is a simulation of ancient Pompeii, intended for visitors of the archaeological site. Wearing a headset and toting a computer in a backpack, the user experiences graphic depictions of ancient life overlaid atop the physical ruins (Fig. 8). Called the Lifeplus Project [20], this augmented reality (AR) simulation projects the images onto semi-transparent lenses in the headset’s eyewear, through which the user sees virtual and physical realities simultaneously (Fig. 9). For instance, images of figures preparing and eating food are added to the experience of an ancient eatery. Coupled with an audio tour, these fictional depictions enhance the site’s physicality, which is composed of archaeological traces. In this case, historical accuracy in presenting an ancient past means representing what could have happened, although it cannot be confirmed. The simulated phenomena in this historical context adapt to the user’s position without undermining or unduly fictionalizing the historical record.

Memories and history are stored not only in the mind but also in the outside world; they are woven through internal and external systems. Like Babbage’s calculating machines, computer simulations function as cognitive technologies, but rather than manipulating sums and logical relationships, these contemporary visualizations can invent, augment and even defy human memories. As Sutton says, “Representations in the external systems with which human memory is compared may in various ways complement, rather than replicate, quite different operations inside the head” [21]. As we have seen, computer simulations are capable of complementing the mind in diverse ways; some applications emphasize historical accuracy, while other applications are designed as flexible, interactive scenarios.

The extended mind hypothesis attempts to explicate how minds operate through and with technological systems. For numerous cognitive technologies, memory is the primary medium of mind-machine integration; these technologies process, organize and manipulate stored information, including human memories and historical data. The properties of accuracy and flexibility help distinguish among diverse functions and behaviors in man-machine systems, thereby enriching our understanding of cognitive structures.

REFERENCES

2. Clark [1].
9. As of early 2006, the Inquiry’s final report is forthcoming, though preliminary findings suggest that the officers acted with excessive force.
11. Casciani [10].
13. As outlined in their press release “Game Company Launches War on Terror.”
16. Blaring music is a tactic of psychological warfare, used in this case by the FBI.
17. Clark [1].
18. Computer Aided Virtual Environment (CAVE) was invented in 1991 by Dan Sandin, Tom DeFanti and Carolina Cruz-Neira at the Electronic Visualization Laboratory at the University of Illinois, Chicago; there are over 25 CAVEs or related virtual environments worldwide.
CALL FOR PAPERS

Live Art and Science on the Internet

The Internet has become a venue and medium for art as a means to broadcast ideas to a worldwide audience. Leonardo and Guest Editor Martha Wilson seek texts on the subject “Live Art and Science on the Internet” for a series of special sections in the international journal Leonardo, both in print and online.

As artists and others produce live art on the Internet, liveness, presence, mediatization, on-line activism, surveillance and identity/gender, among other issues, are being explored. We seek texts documenting such work, as well as texts on the history of this field of practice and on the vocabulary being used to describe it. We also seek texts from scientists who have used the Internet to conduct science investigations live on-line.

Wilson and her peer review committee seek statements (500 words plus one image describing one work), notes (2,500 words plus six images describing a body of work), galleries (750-word curator’s introduction plus up to 10 images by individual artists, each with a 200-word caption) and articles (5,000 words plus 12 images). Texts describing the work of a living artist or scientist must be written by the artist or scientist him/herself, with a co-author if necessary.

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Please send an initial statement of interest with a brief explanation of your project to Martha Wilson: <Leonardo@franklinfurnace.org>. For author guidelines, follow the link “Info for Authors” on Leonardo On-Line <www.leonardo.info>.

David Mather is an independent curator and writer living in Los Angeles. He is pursuing his Ph.D. in the history of creative technology at University of California, San Diego. He organized the 2004 exhibitions “Active Interiors: Ten Years of Stanza’s Interactive Art,” a survey of British artist Stanza, and “Sound Migration: An Exhibit of Sound Art and Music,” an audio installation including artists and musicians from around the United States. He has also published features on artists Steina and Woody Vasulka.