

Survival as a Digital Ghost

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ABSTRACT: You can survive after death in various kinds of artifacts. You can survive in diaries, photographs, sound recordings, and movies. But these artifacts record only superficial features of your self. We are already close to the construction of programs that partially and approximately replicate entire human lives (by storing their memories and duplicating their personalities). A digital ghost is an artificially intelligent program that knows all about your life. It is an animated auto-biography. It replicates your patterns of belief and desire. You can survive after death in a digital ghost. We discuss a series of digital ghosts over the next fifty years. As time goes by and technology advances, they are progressively more perfect replicas of the lives of their original authors.

1. Meet Your Digital Ghost

A digital *ghost* is a simulation of a specific human life. It is an intelligent computerized biography that can simulate you at any time of your life. Since your ghost carries information about your life, you survive after death as your ghost. Your ghost is an expert on your life. It is expert on who you are. Your ghost can ideally pass a *personalized Turing test*.¹ We take the name “ghost” from William Gibson’s *Mona Lisa Overdrive*.² Your ghost is composed of a *diary* and an *animator*. Your diary is all the information recorded about your life. Your animator is an artificially intelligent program that tries to reconstruct your internal first-person perspective from your diary. Your animator tries to replicate your psychology (your character, personality, preferences, etc.).

Your diary is a temporal database that records facts about your life. We can conceptualize it as a big spreadsheet. It is a table or matrix with rows and columns. The rows form a timeline. Each row is marked with a time. The columns are information channels. Each column is associated with a source of information. For example, your diary might have columns that record the position of your body (via GPS), photographs, audio, phone conversations, text messages, data files you receive, personal entries and notes to self, vital signs (blood pressure, heart rate, etc.). A new row is entered into your diary every time a source records some fact about your life. Since different sources are likely to record these facts at different rates, many rows will have many blank columns.

A diary has a channel that records facts about your body. Each cell in this column stores a model of your body. The model is your *ghost body*. Your ghost body has a part-whole structure that mirrors the part-whole structure of your natural body (your earthly body). The parts of a ghost body are *ghost organs*. The parts of ghost organs are ghost cells.

And their parts are ghost molecules. We can easily think of this part-whole structure as a collection of linked data objects. Each object has a *type* slot that specifies its physiological type (e.g. the heart); it has a *state* slot that records some information about it (e.g. heart rate and blood pressure); it has a *parts* slot that stores a list of pointers to its parts. Of course, ghost bodies vary in their level of detail or grain. A coarse-grained ghost records only a few superficial features and leaves most slots blank (e.g. it just records your heart rate). A maximally fine-grained ghost records all the facts about all the cells in your body at the molecular level. And there are many levels of intermediate grain or detail.

Your animator is a program that tries to simulate your inner life. It tries to reconstruct what it is like to be you from the information in your diary. An animator is invoked at a time in your life. It is invoked at a row in your diary. It tries to reconstruct what it is like to be you at that moment in your life. For instance, somebody might want to know what it was like to be you at age 10. So they set your animator to age 10. Your animator opens your diary at that moment (at that row) and builds a model of you at that time in your life. The least powerful animator is just a conversational interface for your diary. Someone can ask it questions and get answers based on your diary. A more powerful animator simulates your psychology at some level of detail. Perhaps it starts with a generic psychological model that it tunes using the information in your diary. A maximally powerful animator is a full simulation of your entire body (including and especially your brain).

Since your animator aims to replicate your psychology in a realistic way, it will replicate it with all its faults and deficiencies. As you get older, you forget more and more. If your animator is invoked at age 70, it isn't likely to remember much about your childhood. And although your diary might contain a very detailed description of your childhood, the need for psychological realism forces your animator to ignore that information. Of course this is unfortunate. So we might add a third component to your ghost. For the sake of vividness, we can call it your *spirit*. Your spirit is an artificially intelligent program that knows a lot about humans generally. Your spirit knows more about you than you do. Your spirit does not forget. And it understands your life at a deeper level than you do. It is able to see patterns in your diary that you cannot see. It is a higher first-person perspective.

2. Your Digital Ghost Today

Your diary doesn't really exist. At best it is a very poorly organized database. Your diary today probably consists of both paper documents and digital files. Paper documents are probably unorganized. Most are probably not even in your possession (e.g. your educational and medical records are probably stored somewhere else). Your digital files are probably on a personal computer. Tagging and indexing are primitive. Search is mostly by keyword. Some people have dedicated websites or blogs that serve as their ghosts (and, in some cases, represent them after death – see mydeathspace.com).³

A few people have some of their lives recorded on an almost daily basis. Much work is being done to build more advanced technologies for managing diaries. These technologies fall in the category of *Continuous Archival and Retrieval of Personal Experience* (CARPE). There are many CARPE projects.⁴ Probably the most advanced CARPE project is Microsoft's MyLifeBits (Gemmell, et. al, 2002, 2003a, 2003b).⁵ A few people have tried to record aspects of their personalities in software formalisms. Technologies that record individual psychological features are *personality capture* tools (Bainbridge, 2003). A few personality capture tools exist, but they are primitive and not widely used.⁶

Your animator doesn't exist. A few chatbots claim to model particular persons, but they are not intelligent in any sense. Your animator might be said to include all the preference or recommendation engines you've tuned.⁷ No human-level artificial intellect (AI) exists. Many primitive cognitive modules are available. These do not work together and are not tunable. They are mostly classical symbol engines and do not emulate the brain. Some *symbolic intellects* exist but their abilities are far below human functionality. Examples include SNEPs and Lenat's Cyc (www.cycorp.com). The brain is poorly understood. Whole brain simulations are in the early planning stages (Markram, 2006).

We'll present several possible future versions of your digital ghost. We describe possible ghosts ten years from now (2016), twenty years from now (2026), fifty years from now (2056), and one hundred years from now (2106). Our goal isn't to try to accurately predict the future. You might object that this or that piece of technology will be available sooner or later than we suppose. Such objections miss the point. Our goal is only to describe various likely stages in the evolution of digital ghosts. The precise timing really isn't important. We assume that civilization doesn't degenerate or collapse. We assume that technological progress goes on as it has (it goes on as an accelerating curve).

3. Your Digital Ghost Ten Years Out

Your digital ghost is initialized at birth. At birth you are given a personal computer (PC) that will manage your diary and store your animator. Your diary is initialized with a software model of a generic human infant. Whole-body simulations already exist.⁸ Your ghost body is tuned (it is personalized) with all the medical information gathered at your birth. One of the first things your parents or doctor does is to tune your ghost is to specify its sex. Male and female (and hermaphroditic) ghosts differ in all the expected ways. Your PC is much much more personal. Your operating system primarily organizes files along a timeline (a lifestream – see Freeman & Gelernter, 1996).

At fairly regular intervals, you sit down for a *digital interview*. For kids, the digital interview is likely to be a part of their birthday celebrations. For adults, digital interviews might take place on birthdays or during annual physical exams. A digital interview is a detailed recording of your bodily features. It uses various scanning techniques to build your ghost body. Although we think of digital interviews as special

events, all your visits to the doctor add data to your ghost body. Your medical records are entirely digitized.

Your digital interview starts with an analysis of your skeleto-muscular system. All the distances between your joints are measured. Your ability to flex your body at each joint is measured. These measurements might be taken by hand (using a tape measure), but more likely they will be derived from a series of snapshots of your body at various angles. Your ghost uses this information to build a 3D software model of your skeleto-muscular system. The software model represents all the bones and muscles in your body. It is a system of virtual or ghost muscles arranged on a virtual or ghost skeleton. A video is taken of your body in motion to produce an analysis of your gait.

Since your face is one of the most intensely personalized parts of your body, its features are mapped very carefully during your digital interview. Your ghost face is a precise 3D model of your natural face. Your ghost face has eyes and irises. Technology already exists that digitally records the structure of the iris. Your ghost eye stores your iris scan. The human face has many muscles under fine motor control. Your ghost face is tuned by taking movies of your face as you talk, smile, or display emotions. Your digital interview proceeds with an analysis of your voice. The analysis is used to tune your ghost's voice box.

Your ghost body has digital hands and digital fingers. It therefore has digital fingertips and fingerprints. Technology already exists that digitally records fingerprints. The fingerprints of your ghost can be tuned to exactly match your fingerprints. The hands, like the face, have many small muscles under fine motor control. Your ghost replicates them closely. It is tuned by analyzing movies of your hands moving or by recording movements of your hands while wearing data gloves (gloves with sensors that record bending).

Your ghost brain is a symbolic intellect. It is capable of carrying out a conversation. Although it has some approximation to normal human adult intelligence, it is not able to pass a Turing test. Your ghost brain is tuned mainly through psychological (behavioral) testing. You routinely take a battery of tests to measure your cognitive functions. You routinely fill in questionnaires on your PC (see Bainbridge, 2003). Your ghost brain includes many tuned preference engines. Brain scans may be useful for tuning your ghost brain, but they are not likely to be fine enough to reveal individual differences.

All through your life, between your digital interviews, all the biographically relevant actions you perform with your PC are logged. Your diary has a fiscal activity column that records all your electronic financial transactions. Your paychecks are deposited electronically and are logged. Anytime you purchase something electronically (e.g. over the Internet), that purchase is logged. Ordinary purchases are logged (e.g. with smartcards, cell phones, or implants). Your ghost body has a ghost ear that is linked to your music library. Whenever you listen to a music file, your ghost ear enters the information in its column. Your ghost body has a column for its ghost eyes. The ghost eye column stores (in chronological order) every photo or video you take. Your location

is noted via a GPS system on your body. It is linked to an advanced digital map. The map associates your GPS coordinates with a place (e.g. your home, place of work, shops, and so on). Your location is thus meaningfully recorded. File formats are standardized and tagged with meta-data.

Your animator lives in your PC. We'll refer to anyone who wants to interact with your animator as a *visitor*. When a visitor wants to interact with your animator, he or she selects a specific day of your life. Your diary from birth to that day is loaded into your animator. Your animator compiles a model of your body on that day. The model of your body on that day is your ghost body. Your ghost body is a simulated specific human animal on a simulated specific day of its life. Your animator thus appears as your *animated ghost body*.

The appearance of your animator is generated by interpolation from the measurements taken during your digital interviews. Your animator moves as you moved on that day. It walks with your gait. It has a face that very closely resembles your face at the selected day. Your animator can even display a movie of the temporal evolution of your body.

The simplest way for a visitor to interact it with your animator is by means of an ordinary text-based graphical user interface. Visitors talk to your animator by typing statements on a keyboard. Your animator has basic comprehension of written natural language. Your animator is mostly a query-response system. It can respond with answers to factual questions (e.g. Q: Where were you born? A: In New York City.). It has some ability to give explanations for your behaviors (e.g. Q: Why did you drive to State College PA? A: Because I was enrolled in college at Penn State, and Penn State is in State College PA.). Your animator responds to requests with various data objects. It can produce text output; display photos or videos; or produce audio output on loudspeakers. Your animator can control an external stylus or printer. It can exactly mimic your handwriting.

4. Your Digital Ghost Twenty Years Out

As before, your digital ghost is initialized at your birth. You have a PC that will manage your diary and store your animator. On your birthday, you have your first digital interview. Your blood is taken. You will be able to get a copy of your personal genome in the near future (Church, 2006). Your personal genome is computed. Your personal genome is used as much as possible to tune the physiological profiles of all your organs. As before, you have regular digital interviews that record detailed information about your body.

You are almost always accompanied by your *Personal Digital Biographer* (PDBs).⁹ Your PDB is a small device. You wear it like a piece of jewelry or watch. Your PDB records all transactions that involve any data (e.g. receipts of all purchases, all financial transactions, any photos you take, files you read, songs you listen too). Your PDB records your basic vital signs (blood pressure, heart rate, temperature, galvanic skin conductance). Your PDB has a global positioning system (GPS) so that it knows where you are at all times. Your GPS location is linked to a map that gives your functional

location (e.g. you are at work, at home, etc.). It records your keystrokes. It records your voice output.

Your ghost uses the data from your PDB to build your diary. Your diary is a very large database. Technologies for indexing and mining your diary are more refined. Programs exist that can automatically parse visual images (photos taken by your PDB). These photo-parsers tag your pictures with keywords. Your digital files are woven together into a highly cross-referenced database. Your diary is an associative or content-addressable memory. A variety of pattern recognition engines operate on your diary to infer your behavioral patterns. They find statistical regularities and correlations.

Your ghost brain is a symbolic intellect with near-human functionality.¹⁰ Your ghost brain is still not very tunable. Psychological testing is still used to tune your ghost brain. Your ghost brain is also tuned through the patterns abstracted from your diary. But one of the main sources of information for tuning your ghost brain is *supervised scenarios*.¹¹ A supervised drama is a kind of video game. You control an agent in this game as you would in a contemporary video game. You guide your agent through a scenario such as shopping for groceries or buying a car. The scenario presents you with challenges and choices. While you are going through the scenario, your actions are being recorded and analyzed. Brain scanning and your personal genome provide some useful information for tuning your symbolic intellect. All these sources of personal information are used to generate psychological theory that explains your behavior. You are a very complex object and your psychological theory is like any other scientific theory of a complex object.

Your ghost body has a digital replica of your immune system. Your immune system is highly tunable. It is tuned (it learns) as it is exposed to infections or gets vaccinations. Your immunological memory is the record of your infections. The immune system of your digital ghost stores a copy (more or less accurate) of your immunological memory. At present you can be tested for the presence of antibodies to various diseases. Current medical technologies are therefore sufficient for coarsely tuning the immune system of your ghost. A full-spectrum immunological scan may someday be able to reveal the exact and full content of your immunological memory. The digital B-cells and T-cells of your ghost could then be set up to duplicate your entire immunological memory.

Your animator lives in your PC. As before, when a visitor wants to interact with your animator, he or she selects a specific day of your life. Your animator compiles a model of your body on that day. Your animator presents an image of your animated ghost body on a computer screen. Your animator looks like your body on the selected day. As before, a visitor can interact with your animator via a text-based graphical user interface. But now your animator can hear and speak as you did (via audio devices). Your animator understands natural speech and can produce natural speech.

Your animator has a digital voice box runs a speech synthesis engine. It controls audio output devices and thus makes real sounds. So your animator has a real voice. It can talk to your visitor. Current speech synthesis technology is crude. It can do little more than

mimic the gender and overall pitch of a particular voice. We may suppose that speech synthesis will be more advanced in twenty years. Your animator thus has a voice box that closely simulates your voice. Your animator's voice is very much like your own. Your ghost face simulates your face. Your ghost face is coordinated with the speech synthesis engine. Your ghost lips and face move as your lips and face move when speaking. Your ghost face is able to display emotion (to smile, laugh, and frown as you would).

Your animator can perceive what is going on in the real world. It can listen to real sounds through its microphones. It can hear speech or music. Your animator can look at the real world through its cameras. It can analyze and comprehend the still or moving images coming through its cameras. It can look at real things. It may even have faculties of smelling and tasting. For any real world stimulus, your animator responds to it as you would have responded to it on the selected day of your life.

Although your animator has good perceptual abilities, it can't do much. It can make noises and display pictures. A visitor can interact more intensely with your animator in a virtual reality (VR). A visitor who wants to interact with your animator in a VR puts on the appropriate gear (VR helmet, data suit, etc.). Your visitor invokes your animator at a certain age. Your visitor enters a virtual world like a video game. This virtual world is constructed from your diary. It resembles the world you lived in on the selected day. Your animator appears in that virtual world as your ghost body at the selected age.

A visitor has a microphone in its VR helmet. Your animator can hear what your visitor says when he or she speaks into that microphone. Your visitor has a virtual body in the VR. Your animator can see that virtual body (as well as other objects in the VR). Your animator can move and act in the virtual world. Your animator and its visitor can interact through the sense of touch. They can feel one another. We may suppose your animator also has the senses of touch (and perhaps smell and taste). Within the VR, your animator and its visitor can interact in many ways. Your animator acts like you once acted.

5. Your Digital Ghost Fifty Years Out

As usual, your digital ghost is initialized at your birth. You have a PC that will manage your diary and store your animator. Your PC is initialized with a detailed model of a generic human infant. This model is your ghost body. On your birthday, you have your first digital interview. Your organs are scanned and your personal genome is computed. The information from your interview is used to finely tune your ghost body. As usual, you have regular digital interviews that record detailed information about your body.

Your diary is a high resolution chronology of your behaviors and internal states. As usual, your PDB records the features of the environment with which you interact. Your PDB has external devices as before (cameras, microphones, GPS). Your PDB has cameras that can read what you read. But most of your PDB is a system of chips implanted under your skin. Your PDB extracts data from your brain via implanted

electrodes (e.g. in your corpus callosum or even in your optic nerves and spinal cord). As usual, your ghost uses the information taken from your PDB to build your diary on your PC.

Your ghost starts with a model of your brain at birth. Your ghost uses the data taken from your PDB to update this model of your brain every day. Your diary thus contains a series of daily models of your brain. It contains a snapshot of your brain for every day of your life. Each snapshot is one of your ghost brains. Your diary has a ghost brain for every day of your life so that your ghost knows what it is like to be you on that day. It has a detailed understanding of who you are – of your first-person perspective. Your ghost brain on any day very closely models the functionality your natural brain on that day.

Your ghost uses several sources of information to build a detailed model of your brain on each day. Your ghost knows your personal genome. The relations between genes and brain functions are well understood. Your ghost uses that information to tune its daily models of your brain. Your ghost is equipped with artificial vision at near human level. It is able to analyze the visual data stream downloaded from your PDB. It parses it into visual elements and ties them together into a searchable structure. Your ghost has statistical analysis engines that can search through your diary to find psychological patterns.¹² Your ghost discovers your habits, preferences, dispositions, and personality traits. Your ghost uses its analysis of your diary to build its daily models of your brain. During your digital interviews, high resolution movies are taken of your brain while it performs tasks carefully designed to reveal crucial personal brain-features. Your ghost uses these movies to tune its daily models of your brain. Finally, psychological testing is still used to help your ghost build an accurate and highly detailed daily model of your brain.

Your ghost body on any day is a high resolution model of your natural body on that day. Your ghost builds the daily model of your natural body by tuning high resolution models of generic human organs. Your ghost uses several sources of information to tune these daily models. It uses your personal genome. It uses scans of your organs. It uses information from medical tests. Your ghost body (on any day) is a system of software objects that function almost exactly like their natural counterparts in your body on that day. For example, your ghost muscles are modeled down to the cellular level. The modeling is functional. Your ghost muscles perform as yours would on that day. Your ghost muscles metabolize glucose and oxygen as yours would. They produce waste products as yours would. They respond to hormones (e.g. adrenaline) as yours would. Your ghost brain on any given day knows what it is like to have your musculature on that day.

Your animator lives in your PC. As before, when a visitor wants to interact with your animator, he or she selects a specific day of your life. Your animator compiles a model of your body on that day. It compiles your ghost body. As usual, a visitor can interact with your animator by means of a verbal interface. But we may suppose that in fifty years almost all interaction is by means of a virtual reality interface. When a visitor

invokes your animator on a certain day in a VR, your ghost body appears to your visitor. Your ghost body looks like you did on that day; it walks and talks like you did on that day; it acts like you acted on that day; it thinks much as you thought on that day.

Your animator can interact with its visitor in most of the meaningful ways that natural humans can interact. Your animator can hear, see, and perhaps smell, taste, and feel the presence of its visitor. Since all the organs of your ghost body are modeled at a high level of physiological precision, your ghost body can do many things in the VR as you would have done them in the natural world. For example, your ghost body can play a musical instrument as you would have played it; your ghost body can run a mile as you would have; it can play basketball as you would have; it can make love as you would have.

Your ghost body does not merely simulate these acts behaviorally. For example, since your ghost body models your flesh at a high level of detail, it knows what your muscles feel like while you are running. It feels the pain that courses through its flesh with every step. It feels the thrill of the endorphins as they rush through its brain. Its pain and thrill are exactly like the pain and thrill you would have felt if you had run a mile on that day. It knows what it is like to do them and it can report on its inner states as you would have. Your ghost body is both conscious and self-conscious. It is conscious exactly as you were conscious and self-conscious exactly as you were self-conscious.

6. Conclusion

After you die, your digital ghost can live on in a virtual reality. You can have a virtual afterlife with a virtual body in a virtual world. Such virtuality is not unreal – virtual objects are made of mass-energy and so are physical (e.g. they are electrical or optical patterns in silicon chips). Your digital ghost can interact physically with the external world (the world outside of its computer). It can perceive the external world through a variety of input devices (e.g. cameras) and it can act on the external world through a variety of output devices. Hence it can be a personal presence in the external world. Although philosophers have wondered whether you are the same person as your digital ghost, questions about personal persistence may not be as interesting as questions about personal presence. At a certain level of realism, it becomes natural to regard a ghost as an autonomous and perhaps independent or novel person with its own rights and responsibilities (Steinhart, 1999). If ghosts are developed to that level of realism, it will be interesting to see how ethical, legal, and political systems adapt to add them to our all too human societies.

Notes

¹The original impersonal Turing test goes like this: A human judge is put in a sealed room containing only a teletype. It is linked to either a computer or to a human. The judge types questions and statements into the teletype and receives printed responses. A computer passes the Turing test iff it can convince the judge that it is a human. The personalized Turing test goes like this: A close associate (family member, friend, co-worker) of a human is put in a sealed room containing only a teletype. It is linked either to a natural human or the digital ghost of that human. The digital ghost passes the personalized Turing test iff it can convince the associate that it is the natural human. Kurzweil (2005: 383) mentions the personalized Turing test but does not define it or elaborate. We can extend these tests in various ways. Perhaps the computer or ghost has to fool many expert judges. Perhaps the interface is not a teletype but a system with visual and auditory channels.

²Science fiction writers and futurists have portrayed many things like ghost bodies. The distant ancestor of the ghost body is Bush's "Memex" system (Bush, 1945). A similar system is Norman's "Teddy" (Norman, 1992: ch. 6). The "recorded personalities" or "constructs" in William Gibson's novels are also like ghost bodies. The personality of McCoy Pauley (aka the Dixie Flatline) in Gibson's novel *Neuromancer* has been recorded and stored: "It was disturbing to think of the Flatline as a construct, a hardwired ROM cassette replicating a dead man's skills, obsessions, knee-jerk responses" (Gibson, 1984: 76 - 77). Ghosts play central roles in Gibson's *Mona Lisa Overdrive* (1988). But Gibson's ghosts are merely psychological. They are not ghost *bodies*.

³A variety of companies offer virtual memorial services (see virtualmemorials.com). These are websites dedicated to the deceased. They are little more than on-line scrapbooks.

⁴Many projects aim to make diaries. Early projects include "Lifestreams" (Freeman & Gelernter, 1996); "Memories for Life" (Andrew Fitzgibbon & Ehud Reiter, see <www.csd.abdn.ac.uk/publications/TR/2002/tr0207.pdf>. Accessed 22 September 2006.); and DARPA's Life Log project (see <<http://www.darpa.mil/ipto/Programs/lifelog/>>. Accessed 18 April 2006.). The CARPE Special Interest Group (SIG) of the Association for Computing Machinery is devoted to research on Life Logs. See <<http://www.sigmm.org/Members/jgemmell/CARPE>>. Accessed 18 April 2006.

⁵The web site for Microsoft's MyLifeBits project is <<http://research.microsoft.com/barc/MediaPresence/MyLifeBits.aspx>>. Accessed 18 April 2006.

⁶The personality capture tools developed by W. S. Bainbridge can be downloaded for Windows PCs at <<http://mysite.verizon.net/wsbainbridge/system/software.htm>>. Accessed 14 July 2006.

⁷Many primitive preference engines exist today. They are known as recommendation engines. Many current websites have recommendation engines. The website has a large database of possible choices (e.g. choices of books, of songs, etc.). Based on your past purchases, past searches, and choices of likeminded others, the recommendation engine builds an abstract profile of your desire. Recommendation engines exist today for books (amazon.com); they exist for music (e.g. Apple's iTunes music store); they exist for movies ([NetFlix](http://NetFlix.com)); they exist for clothes (amazon.com and myvirtualmodel.com). They also exist for travel (trails.com). You could also train recommendation engines to record

your preferences in food and art. Once your ghost knows your preferences, it can tell people whether or not you'd like something. For example, someone might show your ghost a digitized picture of a work of art; your ghost would say you don't like Picasso.

⁸Whole-body simulations are being developed by many groups. Examples include the *Virtual Human Project* (Krause, 2000) and the *Virtual Soldier Research Program* at the University of Iowa (www.digital-humans.org).

⁹Personal Digital Biographers (PDBs) are wearable data recorders. PDBs exist today (2006) but are cumbersome and not available for mass production. One example of a proposed PDB is the *Shadow* (Landay, Newman, & Hong, 1998).

¹⁰A Symbolic Intellect is a classical symbol-processing artificial intellect. It takes text as input. It has a symbolic memory (vocabulary, common sense knowledge). It can perform symbolic inference (deductive and inductive). It produces text as output.

¹¹The idea of using monitored video game scenarios to extract personal information was suggested to me by Humberto Castaneda at the AI@50 Conference at Dartmouth College on 14 July 2006. We further developed that idea together in discussion.

¹²If your ghost can find patterns in visual data, you will be able to tell your ghost about your romantic preferences by going through a database of photos of possible partners. Such databases currently exist (e.g. at eHarmony.com, hotornot.com, match.com, chemistry.com). As you rate the photos, your ghosts builds a model of your preferences.

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