Appeared in exhibition catalog: Steve McQueen. (2003) *Speaking in Tongues*. Musée D'Art Moderne de la Ville de Paris. 7 Février – 23 Mars, pp. 44–46.

The Next Voyager Record: A Technological Perspective

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Looking back from the 21st century to when Voyager record was produced in 1977, we are perplexed: How could anyone produce a multimedia record of Earth without digital cameras, scanners, or hypertext? But more importantly, the record lacks software, computer programs, that could make the material more meaningful and provide an instructive experience to the extra-terrestrial (ET) discoverer of the Voyager spacecraft.

Voyager's pictures are simply analog video images, with none of the structured relations ("hyperlinks") between pictures, text, and sound we take for granted on the world wide web today. Using a conventional "web page" editor, even a home hobbyist could have related the "Sounds of Earth" to the images of Voyager, in a way that would have delighted Sagan twenty-five years ago. Using a selective device, such as a touch screen display, ET could explore the relation between minor details (such as numbers on runners' shirts) and other notations in the sequence of images. For example, selecting a number in an arbitrary image could jump to the page where our number system is explained.

Beyond this, "artificial intelligence" (AI) programming methods allow creating an interactive learning device. Indeed, just as the Voyager disk was being prepared, I was completing my PhD dissertation, a "knowledge-based tutor" for medical diagnosis[1]. Such a program engages a student in a conversation about a patient (a "case dialogue"). The student gathers information in any order as the program constructs a detailed description (a "model") of what an expert physician would know, using the information available to the student. When the student offers a diagnosis of what ails the patient, the program compares the student's hypothesis to the expert model and thus infers what medical knowledge the student has applied. By detecting what causal relations between symptoms, diseases, and treatment the student might not know, the tutorial program uses a Socratic method of questioning to point out gaps in the student's reasoning.

We could adapt this "model-based" programming approach to provide ET with a conversational way of learning about Earth and our language. ET could ask questions like, "What is the relation between a meter and the size of your planet?" The computer could test ET's understanding by asking questions that review the material ET has

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[1] W. J. Clancey, *Knowledge-Based Tutoring: The GUIDON Program*, Cambridge: MIT Press, 1987. For information about how this work was later reinterpreted and agent systems, see http://bill.clancey.name.

apparently examined (e.g., "Were there other species of primates living on Earth when Voyager was launched?"). This kind of "mixed-initiative dialogue" provides a very flexible way of learning from a computer model. It is well within our technical capability today to create computer "knowledge" models that formalize all of the scientific facts represented in Voyager's diagrams, for ET to study in any order, with examples, histories, and question-answer tests.

Of course, in using hypertext and mixed-initiative dialogues, we assume that ET can progressively understand the notation or language we have provided in the computer's models. Using other methods in AI programming, we could send computer programs that interact with ET to establish a common vocabulary, even using words (or symbolic markings of some kind) that are not part of any language on Earth today. We could do this using special programs called "agents"—computer systems capable of learning new models from experience ("beliefs") and taking initiative to interact with their environment. Agents have a primitive capability to learn through experience, by experimenting to understand and change their environment in predictable ways, and adapting their models to fit what they observe.

Agents learning how to interact with ET will need to proceed very slowly and carefully, just to be understood. Probably the best approach is to talk about the Voyager spacecraft itself, rather than to begin with Earth's politics. Agent programs could use gestures to refer to different parts of the spacecraft and interact with ET to develop shared names and descriptions. For example, the program could cause the camera to twist from side to side and by showing photographs establish that it is a camera. Other gestures and diagrams could show how the camera's motions are controlled, and thus convey our engineering methods.

ET and Voyager's agents might call the camera a "donfso," but they will know what they are talking about because they will establish a language together. Using Luc Steels' idea of *Talking Heads*[2], ET and Voyager's agents could play a kind of game. While ET listens and watches, Voyager would play the role of teacher, introducing a word while making a gesture to refer to a part of the spacecraft. Now ET would use the touch screen to point to a corresponding image or diagram on the display. If ET guessed wrong, Voyager would highlight that part of the image by flashing or changing its color. As the example illustrates, first ET and Voyager must establish some extra-linguistic protocol, for making references and showing success, and of course ET must understand that they are playing a language game.

These ideas are on the edge of our programming technology today, and in some respects on the edge of our philosophy, too. Nevertheless, multimedia agent technology presents a radically different alternative to the static primer of the Voyager record, and perhaps we will try something like this when we send messages to the stars again. Sending computer programs that could learn how to communicate with ET would be like sending a representative of ourselves (a "proxy") into space. Eventually we might construct an

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[2] L. Steels, The puzzle of language evolution. *Kognitionswissenschaft*, 8(4), 1999.

agent whose models of Earth and individual people might be so sophisticated, that speaking to this agent would have some of the characteristics of speaking to a real person. We might send a model of Carl Sagan, in the form of an agent who could talk to ET about his vision and passion for exploring the universe.

Despite all these exciting proposals, a technology perspective must always be down to Earth. Using today's technology, it is unlikely a computer with a touch screen and the like would be functional after eons in the radiation of space. Ironically, the primitive technology of the analog, gold-plated recording of 1977 Voyager has perhaps a better chance of surviving and communicating successfully than any space-hardened AI machine we might devise today.