The Prospects for Building Intelligent Communication Systems

Patrick Demasco

Introduction

In this paper, I will discuss my Visions for the field of Augmentative communication during the next decade. I will address the technological perspective, and specifically focus on the prospects for applying artificial intelligence to future generation systems. My views are motivated by what I believe to be two major goals for the research and development community:

- Improvement of the quality of communication by current users;
- Improvements to technology that will enable us to serve new populations (e.g., cognitively impaired)

To discuss any vision for the future of a specific discipline or topic, it is necessary to establish some set of assumptions about what the rest of the world will be like. In the case of augmentative communication, it would be appropriate to consider a "Technological Context". Specifically, we want to ask the question: "What technology might be available for the AAC system user by the year 2000?".

A Technological Context

John Naisbitt in his 1982 book, *Megatrends*, forecasted ten future directions for our society. Perhaps his most important (and most obvious) prediction is the shift of the American economy from an industrial base to an information base. He further states that an information-based economy and the development of information supporting technology (e.g., computers) are symbiotic in nature. Consequently we can expect technological development to continue at an extremely rapid pace (i.e., exponential) for some time to come.

In trying to project what computing technology will be available to AAC users**,** it is most reasoanble to look at what might be available in portable computers. I use this as a benchmark for two reasons. First, there is an increasing trend toward the use of portable computers as communication systems. I believe this trend will continue in the future. Second, if AAC manufacturers are to continue producing dedicated hardware, then they will need to keep competive with portable computer technology. It would be reasonable to project by the end of this decade that portable computers will have the following capabilities:

- Computational performance comparable to today's high-end work-stations in the range of 50 MIPS, 100mB physical memory, 1000 mB mass storage.
- Greater use of parallel processing in the CPU and in IO subsystems (e.g., display).
- Interactive high resolution color and gray scale displays, integration of digital video,and high quality audio output.
- Graphically-based multi-tasking operating systems.
- Extensive communication and networking facilities including wireless connections.

I would expect that these portable computers will typically be networked to other computers (such as business, school or home computers), information networks, and computer-based systems such as home control and monitoring.

Visions

I believe that the field of Augmentative Communication will be able to take advantage of technological advances in a number of ways:

Technology Integration

It is impossible to conceive that AAC and other assistive technologies can be researched, developed and applied in isolation. Advances in software technologies that will produce more modular systems will pave the way for the integration of Communication, Mobility, Environmental Manipulation, and other technologies that might exist in the user's environments.

Graphics

The availability of high resolution interactive displays with color or gray-scale capabilities in conjunction with display coprocessors (and greater memory capacities) will provide the capability of developing graphics based systems. Full motion video will also be available for applications such as animated graphical languages.

Physical Interfaces

Increases in computing power will provide the opportunity to create more powerful physical interfaces. Most likely, these interfaces will be tightly integrated with human physiology. Technology may finally begin to support reliable, moderate cost eye gaze input. Software technology will allow users and clinicians to configure unique input devices from the available physical input signals.

Intelligent Systems

The internal processing component within a communication system integrates all of the physical components and provides the system's operating strategy. This includes an internal representation of language (i.e., vocabulary set) and the selection technique. The opportunity now exists to incorporate Artificial Intelligence into the processing component of AAC systems. I would like to address some of the possibilities in the remainder of this paper.

The Promise of Artificial Intelligence

Within the Computer Science community, there has always been debate as to what Artificial Intelligence is and whether it is achievable. Robert Sokolowski (1988) in his essay *Natural and Artificial Intelligence* asserts that part of the controversy revolves around the intent of the word "Artificial".

> "One of the first things that must be clarified is the ambiguous word *artificial*. This adjective can be used in two senses, and it is important to determine which one applies in the term *artificial intelligence*. The word *artificial* is used in one sense when it is applied to flowers, and in another sense when it is applied to light. In both cases something is called artificial because it is fabricated. But in the first usage artificial means that the thing seems to be, but really is not, what it looks like . The artificial is the merely apparent; it shows how something else looks. Artificial flowers are only paper, not flowers at all; anyone who takes them to be flowers is mistaken. But artificial light is light and it does illuminate. It is fabricated as a substitute for natural light, but once fabricated it is what

> it seems to be. In this sense the artificial is not merely apparent, not simply an imitation of something else. The appearance of the thing reveals what it is, not how something else looks.

If we accept the second notion of artificial as the appropriate sense (as Sokolowski does), then artificial intelligence has indeed been achieved. In the context of communication systems, intelligentprocessing has been applied primarily in the area of rate enhancement (e.g., prediction). There are however limits to the methods used in current techniques that I believe will impede significant progress in the future.

One important characteristic of intelligent systems is the acquisition and utilization of knowledge. For example, a word prediction systems might maintain knowledge about word or word transition frequencies. Unfortunately, methods based on statistical tables can suffer from combinatorial explosion when the dimensionality of tables are increased. We need to develop more sophisticated models of language knowledge, if we are to continue to make progress. Specifically, we need to embrace the idea of systems based upon heuristics that are dynamically modified by both the system's experience, and by the user's preferences. I believe that Natural Language Processing (a sub-discipline of AI) provides some of the answers.

Applications of Natural Language Processing

Rate Enhancement

One of the most obvious applications of Natural Language Processing in the coming decade will be in the refinement of existing rate enhancement techniques and the development of new techniques that were previously not possible. In our own work, we have chosen to pursue both paths. We are looking at how word prediction can be improved through the use of NLP principles, specifically the application of Systemic Grammar (Yang, Mccoy, & Demasco, 1990). In addition, we have developed a new technique called Compansion that allows the user to select the root forms of sentence content words and outputs a well formed sentence (Demasco, McCoy, Gong, Pennington, & Rowe, 1989). Common to both projects is an attempt to "understand" the user by forming a semantic representation of his/her message. The prediction project goes a step further and attempts to use pragmatic information. For example, the relationship between the two individuals contributes important information to the prediction process.

Message Formulation Assistance

I believe that one of the most exciting application areas will be the use of AI to assist language impaired individuals in formulating messages. We can consider strategies as simple as spelling checkers that are directed at spelling errors that a language impaired individual might make (rather than typographical errors). We might also imagine systems that provide help with sentence formulation. A system could constrain choices presented to the user based on previous input and proper sentence formulation rules. For example, if the user selected the words "JOHN AND" the system would not provide verbs and prepositions to the user.

Supporting Interaction

The "Chat" system developed at the University of Dundee by Norman Alm, Alan Newell and John Arnott (1987) provided a new way of looking at the technological side of communication interaction. Vocabulary sets have been tradtionally represented as having three dimensions: row, column and level (or page). By considering conversational patterns, they were able to add three new dimensions to the notion of vocabulary organization: conversational phase, mood, and content mode (i.e., substance or filler). This basic idea of supporting communication "interaction" opens the door to a vast range of other possibilities. One possible application is in the area of message repair. A predominant concern among those individuals studying communication interaction is that of “Communication Breakdowns” (Kraat, 1987). We might imagine an intelligent system that supports a number of message repair strategies such as elaboration and reformulation.

The Reality

Because of the demands that intelligent processing places upon computational resources, I believe that the first applications of Artifical Intelligence will not be in the actual operation of communication systems, but in the areas that indirectly support the communication process. Expert Systems (the most commercial of current AI technologies) has already been applied to both the design of vocabulary sets (Shein, 1988) and to the selection of interfaces (Hsi, Agogino, & Barker, 1988). What are some of the other possibilities for the future?

System Configuration

The notion of “device prescription” is rapidly becoming obsolete due to the increasing “customizability” of communication systems. Clinicians in the coming decade will have systems of enormous flexibility available and will most likely have a much greater amount of quantitative data about their client. They will be faced with tremendously complex decisions to make about the system configuration. Fraser Shein’s work is important in that his system is not assisting the clinician in making a selection from a fixed set of choices. It assists the clinician in the design process based on the assumption of a flexible vocabulary set. This approach must be extended to all aspects of augmentative communication systems, especially the physical interface.

Intelligent Tutoring

Sometimes the creation of “better” communication systems is accompanied by greater complexity that results in more demands for systems training. In addition, if we are successful in extending augmentative communication to cognitively impaired individuals, I believe we will see a need for extensive (and repetitive) training protocols. Unless our service delivery system makes some dramatic changes in the coming decade, we may face a “crisis” in the delivery of system training. The development and delivery of technology could be held back by our inability to adequately train users. While I think that the ultimate answer is a re-assessment of the way in which we currently deliver AAC technology related services, it may be possible to use technology as a way to extend services to the end user. Intelligent tutoring systems could assist a clinician or teacher in training the user how to use an AAC system.

Research Priorities

I would like to discuss four research priorities for the coming decade. Two of them are technical and two are non-technical:

1. It is only in the last 2 or 3 years that we have even tried to applyArtificial Intelligence to Augmentative Communication. We must continue to explore what techniques within the AI community will be useful to AAC. These efforts should be directed towrds the application of existing AI research to the AAC problems.

2. David Waltz (1988) in his essay *The Prospects for Building Truly Intelligent Machines* states (among other things) that we need to make significant advances in software engineering in order to construct the complex programs required for intelligent behavior. I believe that this field could take advantage of its small size and collaborate in the development of code . We need to stop reinventing the wheel and investigate methods for sharing software components.

3. The data that has come out of the work done in communication interaction must be reexamined from the perspective of intelligent systems. I think that this would help to provide some guidance for the technical research as well as generate some new ideas for what would be desirable intelligent behavior from an AAC system.

4. Finally, I think research must be conducted in the area of user's attitudes towards system usage. By embedding "intelligence" into communication systems we run the risk of the "locus of control" being shifted from the user to the machine. While this may be somewhat reasonable in the context of a training session, it is essential that the machine maintain the user's control during actual communication.

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