

Preface

Visual Prosthetics as a Multidisciplinary Challenge

This is a book about the quest to realize a dream: the dream of restoring sight to the blind. A dream that may have been with humanity much longer than the idea that disabilities can be treated through technology – which itself is probably a very old idea. Long ago, when blindness was still considered a curse from the gods, someone must have had the inspiration of building a wooden leg to replace one that had been crushed in a natural calamity or in battle. Many centuries lie between the concept of creating such a crude prosthesis to treat disability and today's endeavors to replace increasingly complex bodily functions, but the wish to restore useful function and the researchers' creative spirit remain the same.

Around 1980, the developers of the cochlear implant were performing the first modest clinical trials of a technology to make the deaf hear again, or even hear for the first time. From those humble first attempts sprang a field that has become a model for modern neuroprosthetics, with tens of thousands of cochlear implants used successfully around the world. The development of the cochlear prosthesis illustrates the importance of bringing together professionals from a wide range of disciplines, from basic biology and engineering to rehabilitation, to create a functional substitute for a human sensory organ.

In 1995, the editor of *IEEE Spectrum* magazine determined that artificial vision might be the next technological frontier, and that it should be the topic of a special issue. He invited a half dozen vision researchers to contribute articles about their expectations in two areas, visual prosthetics and machine vision, combined under the title "Towards an Artificial Eye." He instructed the authors not to feel constrained by existing technology, but rather to envision the steps that would be required to replace natural vision. Most of the ideas presented in that May 1996 issue have not yet been realized, especially those for prosthetic vision. Machine vision has made larger strides, which just goes to show that biology is more stubborn than technology - but also more resourceful, as machine vision researchers realize on a daily basis: Segmenting and recognition tasks that our visual system performs effortlessly can pose formidable problems for a computer-based image analysis system. Yet, encouragingly, some visual prosthesis designs predicted in that 1996 magazine are now being tested in clinical trials.

This is an exciting time for the field of visual prosthetics. Obviously, it is exciting for the hope it brings that vision can be restored. It is exciting for its challenge to researchers, technicians, clinicians, rehabilitation workers, and people in many other fields to commit their talents to the solution of a problem with so many dimensions. It is exciting for the experimenters when, seemingly against all odds, a blind study participant with a few dozen electrodes on the retina recognizes an object or letter “E” and finds a path around traffic cones in the lab without a cane or guidance. It is exciting for the participants in these trials, who feel they can play an active role in realizing the dream. It is exciting for their loved ones and the public at large, for whom the developments can’t come quickly enough. And it is, unfortunately, too exciting for some media types who can’t stop themselves from running ahead of the facts.

This is also a field of setbacks, as when the new electrode coating that was supposed to withstand conditions inside the body for 20 years starts peeling off during its initial high-temperature soak test; of unpleasant surprises, as when the simple idea of putting together many small phosphenes to create an image runs up against the reality that phosphenes overlap and blur the image beyond recognition; and of patience put to the test, as when investors and the public do not get the miracle cure they may have been expecting.

But mostly this is a field of great dedication by hundreds of researchers in dozens of labs in countries on four continents; of amazing tenacity by study participants learning to make sense of a way of seeing that is so different from the vision they lost; and of true collegial spirit among all who share the dream, despite the realities of commercial interest. This collegial spirit was evident even in the days of the *IEEE Spectrum* issue: Throughout the 1990s, the National Institute of Neurological Disorders and Stroke sponsored an annual neural prosthesis workshop that was attended by all researchers competing for the scarce development funds then available for neuroprosthetics. Although the competition could be fierce, the annual workshop attendees formed a community that collectively solved stubborn problems of interfacing technology and biology, and attracted many new and talented researchers to the field. Looking back, I feel that these workshops had a limitation: They were, by the nature of the research contracts given out, strongly geared towards technology, and less towards integration with physiology or rehabilitation. This was inherent in NINDS’s mission to foster development of devices with broad application, but non-engineers were less likely to attend these highly technical gatherings.

In the year 2000, Dr. Philip Hesburg at the Detroit Institute of Ophthalmology had the inspiration to foster a new collaboration among visual prosthesis researchers, clinicians, and workers in low vision rehabilitation by creating and sponsoring a series of biennial meetings that he calls “The Eye and the Chip.” Successful beyond Dr. Hesburg’s expectations, these meetings have become the premier gathering place for researchers from all parts of the world and from very different backgrounds. Invited speakers are scientists who are advancing the field, yet the scale and atmosphere allow all researchers, patients, and the media to come and be updated about progress over the past 2 years. More perhaps than at other scientific

meetings, where investigators tend to gather within disciplines, participants at The Eye and the Chip are challenged to be open-minded, learn about and critique each other's work, and return home with fresh ideas for interdisciplinary approaches. The interdisciplinary character of this book reflects that same spirit.

This book is also a reality check, an assessment of where we stand in 2010, almost 50 years after G.S. Brindley put the first revolutionary electrode assemblies under a blind patient's skull, yet in a field that is still very young. And this book is an introduction for people outside the field who may want to join the quest, or just be better informed. The book is unusual in being aimed at a readership as diverse as the disciplines contributing to the field: basic scientists, tissue and biomedical engineers, clinical researchers, and rehabilitation specialists.

Most of all, this book is a tribute to the visionaries, the inventors, the creators of devices, the biomedical engineers, the surgeons and medical staff, the research psychophysicists, the occupational therapists, and the patient pioneers and their loved ones. In the chapters that follow, a few dozen workers in the field present their work and that of many colleagues. Each of their accounts conveys a passion for this multidisciplinary journey of discovery, a sense of urgency, a precise and meticulous effort to get it right and to learn – from the damaged visual system and from study participants – how to further improve the technology.

If the reader comes away from this book with a sense of the breadth of the enterprise, the hope for solutions that will truly help blind individuals, and the excitement shared by so many working in the field, then it has accomplished much of what the authors set out to do. If it allows practitioners in one discipline participating in this development to get a better appreciation for what their colleagues in other disciplines are trying to accomplish, then the authors have clearly hit the right notes. And if it inspires enthusiastic young minds to join the quest, and to help turn the visual prosthesis into the next cochlear implant, then we will truly have succeeded.

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