NATIONAL SCIENCE FOUNDATION
1800 G STREET, WASHINGTON, D.C. 20550
SCIENCE and TECHNOLOGY to AID THE HANDICAPPED

Donald R. McNeal, Ph. D., Program Manager

Study of Fast Feature-Extraction for Blind Mobility
Standard Grant: PFR 79-06299
Smith-Kettlewell Institute of Visual Sciences
San Francisco, California 94115

Carter C. Collins, Ph. D.
Principal Investigator

This research will investigate the feasibility of employing real-time automatic obstacle and landmark recognition for increasing and improving the mobility of the blind. Mobility continues to be a major problem for the blind, despite the use of guide dogs and long canes.

Data from a miniature television camera will be processed in real time to provide information about obstacles and navigational landmarks. The data will be presented to the blind pedestrian by means of machine-generated speech, and tactile coding in the form of a matrix of vibratory elements in contact with the skin.

A small television camera is currently available. An algorithm for image recognition will be developed and implemented, using the latest microprocessor technology to achieve the required computational speed in a small, lightweight package. Tactile coding and machine-generated speech are currently available, but what information to present and how best to do it must be determined.

Electrical Stimulation of the Skin as a Basis for Sensory Prostheses

Columbia University
New York, N.Y,. 10027
Continuing Grant: PFR 79-17634

William H. Dobelle, Ph. D.
Principal Investigator

A systematic investigation of electrocutaneous display methods will be conducted, using psychophysical techniques, to provide a body of basic information about the ability of human observers to perceive complex dynamic patterns of input imposed on the skin. Alternate sensory input techniques are desperately needed for persons who have suffered severe sensory losses (the blind, the deaf, and persons who have lost body sensation through amputation or damage to the nervous system).

Electrical current will be applied through an 8x8 matrix of electrodes imposed on the surface of the skin. Stimulus parameters will be selected to yield optimum discriminability and identifiability of electrocutaneous patterns. Questions related to apparent movement on the skin produced by sequential activation of neighboring electrodes, and masking interactions between sequentially presented stimuli, will be investigated. In short, this research will identify parameters and techniques of electrocutaneous stimulation to maximize the information rate through a given set of electrodes.

An Ocular-Controlled Intelligent Speech Prosthesis
Continuing Grant: PFR 79-17358
University of California (UCLA)
Los Angeles, California

Kenneth M. Colby, M.D.
Principal Investigator

This research will investigate the feasiblity of using ocular control to generate synthetic speech to provide a means of communication for persons who are unable to speak intelligibly. Currently available communication aids are controlled by a keyboard or a binary switch. Many nonvocal persons do not have sufficient manual dexterity to operate a keyboard, and a binary switch slows the input so that the construction of even a simple utterance is a long and difficult task. Ocular control systems (using infrared light optics to monitor eye position relative to head postion) and intelligent speech generating systems are currentlyavailable. The two systems will be interfaced and tested on various nonvocal populations, including those who have suffered damage to language areas of the brain.

Key questions to be answered are the speed and accuracy of speech generation using ocular control, the ease of use, and the amount of information which can be transmitted.

Automatic Measurement of Laryngeal Vibratory Patterns

Standard Grant: PFR 78-16965
University of Florida
Gainesville, Florida 32611

Donald G. Childers, Ph. D.
Principal Investigator

This study will establish a relationship between laryngeal vibratory motion and the sound produced. These results could eventually be used to design better machine aids for teaching speech to the deaf. Films that show laryngeal motion along with simultaneously recorded sound output have already been obtained from subjects with a normal organ for voice production and normally functioning vocal cords. Hardware and software techniques for the automatic processing and data reduction of the laryngeal film data will be developed. These data will be analyzed and correlated with simultaneously recorded phonations. The reduced data will then be made available to people in the scientific community who are interested in testing hypotheses concerning the speech mechanism, and in developing a comprehensive theory of speech production.

Replacement of Sensory Capabilities for the Physically Handicapped

Continuing Grant: PFR 79-15314
Southern Research Institute
Birmingham, Alabama 35205

Donald R. Cowsar,Ph. D.
Principal Investigator

This research will develop a material which can be fabricated into a thin sheet to partially replace the senses of touch and pain in neurologically injured patients. Loss of these sensations produces severe functional impairment and can cause incapacitating injuries because normal warning

mechanisms of the body are inactivated.

A conductive elastomer will be developed in which the electrical conductance is related to static pressure. These pressure sensors will be fabricated into a 12 x 12 array to form a thin flexible sheet that can be used to determine a pressure profile over a surface on which it is placed. Highly conductive strips of elastomer will connect each sensor to the measuring circuit. The key research goal is to develop a conductive elastomer in which the pressure-conductance relationships are reducible, hysteresis is minimal, and recovery is sufficiently rapid that the dynamics of changing pressures in various clinical applications can be accurately measured.

Neurophysiologically-Based Controllers for Assistive Devices

Standard Grant: PFR 79-17348
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

Neville Hogan, Ph. D.
Principal Investigator

This project will develop a controller for interfacing a disabled user with an assistance device (such as an artificial limb), taking advantage of the state-of-the-art in both technology and neurophysiology. Myoelectric activity (the natural electrical activity of muscle) will be used for communication between man and machine. The controller will use the natural patterns of simultaneous contraction of opposing muscles to control the adjustment of an artificial limb. The manner in which the human operator adjusts parameters of his musculoskeletal system (such as its mechanical stiffness) in the performance of normal movements will be investigated, and the results of this investigation will be used to design a controller to provide an upper-extremity prosthesis with the same adjustable capabilities as the natural limb. A wearable, versatile artificial limb simulator, which can be programed to mimic the behavior of any proposed artificial limb design, is available for this investigation. The final design will be implemented in a self-contained artificial limb.

Needs and Design Concepts for Voice-Output Communications Aids

Standard Grant: PFR 79-17629
Telesensory Systems, Inc.
Palo Alto, California 94304

Stephen Breugler
Principal Investigator

Requirements and specifications will be established for low-cost voice-output modules to aid vocally disabled individuals in communicating more effectively. It is estimated that there are 750,000 persons in the United States who are unable to speak intelligibly. Machine generated speech offers an opportunity for these individuals to communicate effectively; however, no one has yet investigated the basic research issues related to the appropriateness of a technology that speaks for the user — as opposed to a technology that speaks to the user.

This project will identify those factors that are important in the design of voice prostheses for nonvocal persons. Existing communication aids will be evaluated and consumer re-requirements will be analyzed. Alternative approaches will then be formulated and tested.

On the basis of results from these tests, design concepts for useful, practical voice-output commmunication aids will be developed and disseminated.

Application of Personal Computing to Assist the Handicapped

Standard Grant: PFR 79-21124
Applied Physics Laboratory
The Johns Hopkins University
Laurel, Maryland 20810

Paul L. Hazan,
Principal Investigator

The purpose of this project is to manage and administer the problem definition phase of a second project — to organize a series of regional and national competitions among individual personal computer users. These competitions will direct the creative imagination of a broad spectrum of the general public toward innovative uses of home computers to assist the handicapped. An Advisory Committee, which includes handicapped individuals, will be formed to define the program, establish the evaluation procedure and develop an overall publicity plan. Service organizations and professional societies will be contacted to support and administer the regional and national competitions.

Children's Auditory Discrimination and Perception of Monosyllabic Words

Standard Grant: PFR 79-06496
Northwestern University
Evanston, Illinois 60201

Lois L. Elliott, Ph. D.
Principal Investigator

The objective of this research is to gain increased understanding of the processes that underlie children's auditory perception of simple monosyllabic words. Although normal children will be studied, project results may have potential applicability to handicapped populations, such as hearing-impaired (moderate loss) and language-delayed children. Previous research has demonstrated that the auditory perceptual "thresholds" for monosyllabic nouns that are standardized to be within the receptive vocabularies of inner-city three-year-old children decrease as a function of chronological age — and do not

asymptote until the age of ten years.

This project will seek answers to the question of exactly what perceptual processes are associated with this developmental change. Four hypotheses pertaining to differences between children's and adults' perception of words will be tested. Results of these experimental tests will be used to refine a proposed working model of word perception.

Visual Feedback Speech Training for the Deaf

Phase II, Small Business Solicitation: PFR 78-21347
Integrated Sciences Corporation
Santa Monica, California 90401

Walter C. Gish, Principal Investigator

This project is the initial phase of an effort to develop a visual feedback system to assist in teaching the deaf to speak. Previous visual aid systems have not been successful because they were not able to extract speaker-invariant features of speech, particularly for the high-pitched voices of women and children. The aim of this phase of the research is to provide an analysis of speech into components based on a linear speech production model and an accurate parameterization of these components.

The speech signal will first be separated into voiced and unvoiced components. The voiced component will be further separated into two components corresponding to the glottal volume velocity waveform and vocal tract impulse response. Finally, the spectral envelope of the vocal tract impulse will be parameterized.

The next phase of this program would use this data to determine the speaker-invariant features of speech sounds.

Integrated Electro-Mechanical Transducer Systems

Continuing Grant (Jointly funded with the Div. of Engineering): ENG 78-22167
Stanford University
Stanford, California 94305

John G. Linville, Principal Investigator

Electrical, mechanical and piezoelectric properties of the polymer polyvinylidene fluoride (PVF_2) will be studied to determine the material and fabrication technologies necessary to build devices using PVF_2. This polymer is different from other piezoelectric materials in that it can be manufactured in thin, flexible sheets, exhibiting piezoelectricity in both the transverse and thickness modes. Potential applications for PVF_2 include tactile stimulation elements for the Optacon (a reading aid for the blind) and imaging array elements (for a mobility aid for the blind).

Microprocessor-Based Prosthetic Control

Phase II, Small Business Solicitation: PFR 78-21670
Scientific Systems
Cambridge, Massachusetts 02138

Donald E. Gustafson, Ph. D. Principal Investigator

This research is concerned with the design of a system to provide control signals for a multifunctional prosthesis from a set of myoelectric signals (signals normally produced by contracting muscles) which are recorded from the surface of the skin. Techniques to control a multifunctional, upper-extremity prosthesis rapidly and reliably are not currently available.

In this project, temporal and spatial variations in myoelectric signals recorded from at least four electrodes will be analyzed in an attempt to extract all available information. The signals will be modelled as multivariate Markov processes. A multiple-model Kalman filter will be designed to detect and identify each intended prosthesis function. Electrode locations will be analyzed to maximize discrimination accuracy and to determine the minimum number of required electrodes. The optimal sampling rate of the myoelectric signals will also be determined. The feasibility of microprocessor implementation will be evaluated through simulation.