Neural-Type Robotics - An Overview

by

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Abstract:

Neural-type robotics is the field of robotics where intelligence and control functions are carried out by neural-type signal processors, the latter being electronic microsystems that emulate biological neural systems. Areas of application include intelligent industrial and medical robots for varying environments and prosthetic robotic devices, such as artificial organs, for the handicapped.

This paper gives an overview of the field including the structure of generic neural-type systems, a review of the rather limited past accomplishments, a survey of the present undertakings, many of which are just under initiation, and a look at the very promising future with its vast implications.

I. NEURAL-TYPE Robotics

A neural-type robot (NTR) is a slave device that can intelligently perform multifunctional manipulations. It would consist of microelectronic signal processors, that mimmick the nervous system vicariously, and mechanical actuators for execution of desired functions.

II. CONTEMPORARY CONCEPTS

A Neural-Type robot processing scheme [1] is outlined in Fig. 1. The vision processing section would consist of a camera that is interfaced with the neural-type processor circuitry. The neural-type processor or the robot brain would consist of signal processors, calibration circuits, memory, and a function discriminator. This is then interfaced to the electromechanical motion actuators. After every period of 'processing' that would be of a finite duration the vision section would form a feed-back loop for the next processing duration. An autonomous self correction loop in this scheme would consist of local intelligence to be able to trigger actuators much faster, without having to go through the vision loop. This would be primarily initiated by extremity mounted sensors that would sense dangerous levels of temperature or pressure capable of damaging the neural-type robot. This could be part of the neural-type processor.

An area of application of NTRs is intelligent industrial robots, with the developments in artificial sensory hardware for perception of touch or pressure and temperature, in an attempt to make robot intelligence more anthropomorphic. Another area is prosthetic robotic devices with microelectronics that emulates a neurobiological system.

In the past little practical effort has been made to make industrial robots be perceptive, or artificially intelligent, as is now possible with the advent of VLSI technology with shrinking microcomputers. Nevertheless, "conscious robots" have been theoretically mentioned in the literature [2] while the demand for "intelligent robots" in industry has been recognized with a potential market modestly estimated to be $3 billion in the near future in Japan alone [3, p.43]. By contrast [4] in the prosthetics field the electromyographic (EMG) signal, more recently myoelectric (ME) signal, has been analyzed at the surface of and internally to the human arm via various electrode configurations [5, p. 539]. The analysis of this ME signal is complex because it consists of numerous motor unit action potential trains (MUAPT) which are received superimposed at an electrode [6, p. 149] and are repetitive with an interpulse interval [7, p. 158]. These EMG or ME signals have been used for the control of limbs since the early 1950s, first in the USSR and then Europe, Canada and the USA [4]. Of most interest to the NTR field is the Boston arm developed by R. Mann and first reported in 1966 [8]. This conclusively shows that neural-type signals can practically function to control robotic devices, in this case an arm. Clearly the results generalize to control other limbs; the state of the art in 1981 is nicely summarized in Mann's ALZA lecture [9]. The multifunctional prosthetic versions of the Boston Arm, the Utah Arm and the Sweedish Arm, utilize only the average power level or spatial distributions of the ME signal power to discriminate between limb control functions. Graupe, et al. [4], have developed a technique of analysing the temporal content of the ME signal, thereby reducing the number of interface electrodes. They used the ARMA (autoregressive moving-average) parameters and Kalman filter techniques to derive a parametric recognition algorithm so that a multifunctional control could be achieved from a strongly correlated signal. A single function input feature occurs with the use of amplitude-level coding [5, p. 253]. They further developed a microprocessor system for multifunctional control via single site ME signal identification [10, p. 541], see Fig. 2.

LeFever et al., [6][7] developed a procedure to decompose an ME signal into its constituent MUAPTs and further tested it for its accuracy by decomposing a mathematically synthesised myoelectric signal.

Jacobsen et al. [11], developers of the Utah Arm, pointed out the technical and nontechnical problems. The latter stressed the clinical, marketing and economic factors that seriously impaired prosthetic arm developments.

III. THE FUTURE

Niznik and Newcomb give a detailed cost effectiveness of neural-type robotics and outline an overall robotization rate of return analysis for such complex neural-type robotics [1]. Work on neural-type vision systems has been initiated [12] and appears to give a promising and challenging area for future research. Toward this Gutierrez [13] has introduced an image description technique for plane objects that should prove practical for the NTR field.

Present day difficulties in the development of neural-type robotics are small market size and high developemental costs. However, with the advent of VLSI, microcomputer modules will become smaller and this should accentuate developments in the area. Especially it is important to develop a structure theory for the microelectronics which is pertinent to NTRs. The work of Dimopoulos [14] is at least a first step in this direction.

The future for NTR is promising as it would make industrial robots highly intelligent. In prosthetics the sophistication of existing control systems, prehension feedback, and direct skeletal attachment is envisioned. The ultimate would be towards practical realizations of android design and implementation, and the evolution of android sciences capable of super human android fabrication.

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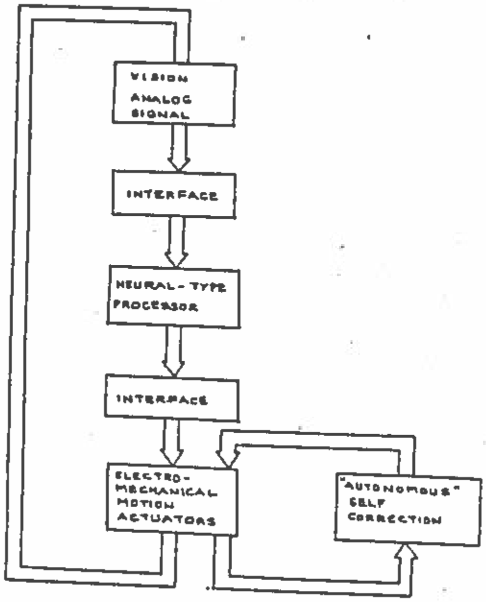

Fig. 1. NEURAL-TYPE ROBOT PROCESSING SCHEMA.

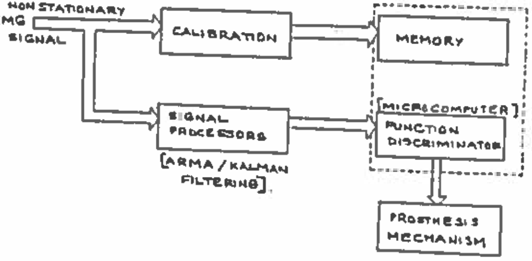

Fig. 2. NEURAL-TYPE PROCESSOR FOR PROSTHETICS

Proceedings of the

Twenty-Sixth

MIDWEST SYMPOSIUM
ON
CIRCUITS AND SYSTEMS

August 15-16,1983

Edited by
Edgar Sánchez Sinencio

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