INIS-mf--13741

PK 9300042

COMPUTER AUTOMATION AND ARTIFICIAL INTELLIGENCE

DR. Syed Bashirul Hasnain

Abstract

Rapid advances in computing, resulting from microchip revolution has increased its application manifolds particularly for computer automation. Yet the level of automation available, has limited its application to more complex and dynamic systems which require an intelligent computer control. In this paper a review of Artificial Intelligence techniques used to augment automation is presented. The current sequential processing approach usually adopted in artificial intelligence has succeeded in emulating the symbolic-processing part of intelligence, but the processing power required to get more elusive aspects of intelligence leads towards parallel processing. An overview of parallel processing with emphasis on transputer is also provided. A Fuzzy Knowledge based controller for automating drug delivery in muscle relaxant anesthesia on transputer is described.

1. Introduction

Automatic control systems are part of our daily life. We have them in our body, one controls our body temperature within close limits, another controls our balance, so that we can stay upright. The temperature of a house, its oven, refrigerator, hot tank may all be controlled by automatic systems. In engineering workshops laboratories and plants automatic systems can be found controlling a number of variables including displacement, velocity, force, pressure and temperature. Recent development in computer technology has refined aufomation techniques with an improved efficiency.

2. Automation

Automation refers to the act of making a process more automatic than before.

Automation involves the integration of four types of devices.

1. Sensors:- Detect the state of the system under control. (e.g. thermocouple, transducers etc.)

2. Computing Element:- Which compares the observed measurements with desired state of the system and determine what corrective actions if any should be taken. (e.g. Digital and Analog logic elements)

3. Actuators:- Whichperform the control actions as directed by the computing elements. (e.g. Valves, Solenoids, Switches)

4. Operational Units:- Which comprise the system and actually carry out the desired process. (necessary part even no automation is involved)

3. Computer Automation

The availability of cheap, compact processing capability in the form of computer has revolutionized the field of automation. Computers are very good in processing the stored data to issue command signals for a specified process. Computers have been successfully used in automating a number of jobs particularly in the fields of process industry, medicine, banking, transportation and defence.

Central feature of automation is the feedback of observed state data to the regulatory process for automatic correction of error. Before computer/digital control was used the controllers of an automatic process were pneumatic, electronic or electro-pneumatic. The disadvantages of conventional control was that these systems were bulky, expensive and exhibit little flexibility outside the precise purpose for which they were originally designed. If a change is to be made in the system involving pneumatic control equipment, significant rebuilding is usually required. Direct digital control has the advantage of minimal bulk and low cost. Such systems are very flexible and minor changes can be incorporated by modifications in the software.

Some complex process require human interaction, human intelligence is used to input some variable, judge some performance or monitor some level. Human interface along with its benefits of intelligence introduces human errors, and limitations. To remove the human interaction and to make the computers completely independent some level of intelligence is provided to computer enabling it to simulate the intelligent human behaviour. This leads us to a formal definition of Artificial Intelligence (AI) as given by Arron Barr & Edward A. Feigesbaum [1] "Artificial Intelligence is the part of computer Science concerned with designing intelligent computer systems, that exhibit the characteristics we associate with intelligence in human behaviour".

4. Areas of Artificial Intelligence

There are identifiable areas of AI research, they are described briefly as under [2].

4.1 EXPERT SYSTEMS.

An expert system is a computer program designed to act as an expert in a particular domain (area of expertise). The foundation of expert system's authority is its knowledge base, which contains all the relevant expertise that can be extracted from human experts in a given field. This expertise is usually stored in the form of rules or heuristics typically if/then statements. Given an initial set, the system can map out a set of contingencies, that might arise from the first set. A heuristic does not guarantee results. Rather, it suggests a general direction that is likely to prove fruitful. Expert systems are designed to assist experts, not to replace them. They have proven to be useful in diverse areas such as medical diagnosis, chemical analysis, geological explorations, some important expert systems are listed in table 1.

Table 1 : EXPERT SYSTEMS	
SYSTEM	EXPERTISE
DIPMETER	Oil Exploration
PROSPECTOR	Mineral Exploration
AQ11	Diagnosis of Plant Diseases
CONSULT 1	Medical Diagnosis
EL	Analysis of Electrical Circuit
MYCIN	Diagnosis System for Infectious Diseases
MEDAS	Computer Consultant For Handling Emergency Case

4.2. NATURAL LANGUAGE PROCESSING.

The utilities of computer are often limited by communication difficulties. Traditionally computer uses a set of commands or a computer language to communicate with the computer. The goal of natural language processing is to enable people to communicate with computer in a natural(human) language, such as English rather than a computer language.

The field of natural language is divided into two subfields.

— Natural language understanding which investigates methods of allowing computer to understand instructions given in ordinary English.

— Natural language generation, which strives to have computers produce ordinary English language so that people can understand computer output directly.

4.3. SPEECH RECOGNITION.

The focus of natural language processing is to enable computers understand written English words or sentences. However the primary method of communication used by humans is not reading or writing; it is speaking.

The goal of speech recognition research is to allow computers to understand human speech so that they can hear out voices and recognize the words we are speaking. Like natural language processing, speech recognition can be divided in two fields.

— Speech Recognition: The recognition and understanding of spoken language by a computer.

— Speech Generation: The generation of speech by computer.

4.4. COMPUTER VISION.

Vision is generally used by Humans as primary means of sensing their environment; we generally see more than we hear, feel, smell or taste. The goal of computer vision research is to give computers the same powerful facility for understanding their surroundings. A visual image received by a camera is digitized and stored in the computer memory as pixels. Computer vision systems analyze patterns to find visual clues that can help determine various features of the image. These include colour, depth, texture and motion. Currently one of the primary uses of computer vision is in the area of Robotics.

4.5. NEURAL NETWORKS.

Neural Networks have attracted many researchers recently due to the versatile field of operation they offer, and the possibilities of tackling problems for which are conventional computational approaches have proven ineffective.

A Neural Network is a system of interconnected elements modelled after the human brain. It is a highly parallel dynamical system. It consists of a large number of interconnected simple processing elements called neurons. Each processor examines a large number of inputs, applies a simple decision process, and process a single output. Inputs may come from a sensor, or may be the outputs from processors in a previous layer of the network. Most processors simply multiply each input by a weight and add them together. If the total exceeds a set threshold, the processor turns on its output in an analogous way to the brain firing.

Neuron Nets provide a greater degree of robustness or fault tolerance than Von-Neuman sequential computers because there are many more processing nodes, each with primarily local connections. Damage to a few nodes or links thus need not impair overall performance significantly. A large number of models of the neural networks type have been proposed [3,4].

A multi layer neural network for 3 inputs as designed for a medical diagnoses system is shown in Fig 1 for illustration. [5].

5. Artificial Intelligence and Parallel Processing

AI computer programs can be very time consuming, researchers, in the field and users of AI software think it is possible to exploit high degree of parallelism in large AI programs in order to reduce processing time and bringing it more closer to real time applications [6].

The structure of knowledge base computer programs has the following major consequence.

1. The programs are very flexible and the system components are very loosely connected and each module such as an IF-THEN rule can be easily connected or dropped without necessarily destroying the rest of the system.

2. Multiple modules can be processed in parallel since the conditions that trigger their execution may be satisfied by more than one module.

Another source of parallelism can be found in AI programming languages such as PROLOG and LISP. Prolog clauses can be regarded as pattern directed modules, Parallel Lisp, Qlisp, Multilisp on the other hand allow parallel execution by using special constructs and extensions to sequential dialect of the language. For a real time AI application not only parallelism in software is important but hardware parallelism can also provide the required speed of execution. Some special purpose computer architecture of AI include a single chip computer SCHEME-79 for Lisp, Connection Machine from thinkning machine is a cellular machine with 65,536 processing element and the revolutionary single chip computer by Inmos called TRANSPUTER.

5.1 Transputer.

The Transputer is a single VLSI device with processor, local memory and four communication links for input/output. A transputer is either a 16 or 32 bit processor in its simplest form providing 10 million instructions per second processing power with 2 Kbytes of memory, block diagram of T800 transputer is shown in Fig 2. Each link is capable of transferring 10Mbits/second. The links enable transputers to communicate with each other, as shown in Fig 3. Because of these links any number of transputers can be joined together to form a network of computers with all the transputers capable of operating concurrently.

An Occam program can be easily mapped onto any number of these transputers, which can run in parallel and communicate by exchanging messages using the input/output links. The number of transputers in the network can be increased or decreased with slight modification in the Occam program. The transputer can therefore be used as a building block for concurrent processing systems, with Occam as the associated design formalism [7].

6. Fuzzy Logic & AI Case Study

In most computer programs a decision is made on yes or no, black or white basis. There is no grey level, unless the program is using a new concept called Fuzzy set theory. Fuzzy Logic as it is more commonly called introduces the element of probability to computer operation, which is more close to human thinking. Lotfi.A.Zadeh professor of computer science at University of Berkley is credited with first codifying the principles of fuzzy logic[8]; forsaking the traditional series of

Yes-No decisions made in computer programs and substituting a percentage probability assessment. The computer thus decides which alternatives are most likely to yield the desired result.

Since its introduction by Zadeh in 1965, Fuzzy Logic has been used successfully in a number of control applications [9,10]. The major shortcoming of previous work is the slow response time of the fuzzy logic controller, caused by the large calculations essential for the algorithm. This makes it unsuitable for dynamic operations. In this work an attempt is made to speed up the calculation time by splitting the fuzzy logic controller in different processes and running them in parallel on one or a combination of transputers. A novel technique to store the linguistic rules in LISP (an A.I language) and use it by the fuzzy logic controller on a transputer network (11)The fuzzy controller relates to the monitoring of muscle relaxant drugs used by anaesthetists during a major operation [12].

The fuzzy logic controller is implemented on an array of 4 transputers (Fig 4). The LISP code containing the rules (Knowledge) was loaded on the root transputer, and the process which was the muscle relaxant model, along with the Fuzzy control algorithm was loaded on the slave transputers. Whenever a decision point is reached by any slave transputer it gains advice from the LISP system by communicating over the channels.

The development of an IC for processing fuzzy data brainchild of Yamkawa Takeshi at Kumamoto University in Japan, opens new possibilities for fuzzy logic computers. "Such a machine might be the ultimate computer" described by Patrick H. Winston Director of the AI Laboratory at MIT. "A machine that reasons from analogy, not deduction, and applies experience gained from past situations to new ones. In the process it would formulate new insight and new knowledge and learn".

7. Artificial Intelligence and Military Applications.

Artificial Intelligence is being applied in the industry to solve a wide variety of problems since 1970's. This experience has demonstrated the usefulness of such techniques in the real world, and has resulted in commercially available hardware and software that can be exploited for military applications.

Prototype AI systems have been operating in defense roles since the mid-1980's, and several saw their first use during the Gulf War. A.I is an umbrella term covering a plethora of technologies that are being used, individually or togather,to automate a multitude of military tasks. Fields that benefit include all five battlefield functional areas. (Intelligence, electronic Warfare, maneuver control, fire support, air defense and combat service support), naval decision aids, mission planning, piloting of single seat combat aircrafts, and diagnostics and maintenance.

The US Air Force logistics command's artificial intelligence support centre identifies 137, specialized technologies, grouped in eight to 12 general areas that are covered by the system description. These include subjects as desired Knowledge Based Systems, Natural Language Processing, Neural Networks, Speech Recognition and Machine Vision.

7.1 Military Intelligence System

One example is MIPS (Military Intelligence Processing System) being developed by the Advanced Computing Technologies Laboratory of Mc DonaldDouglas Electronics Systems Company. MIPS running on a network Sun Spare Stations, comprises a distributed arrangement of cooperating subsystems that analyze free-text messages, fuze and correlate battlefield intelligence, assess tactical situations and recommend appropriate cources of action. MIPS incorporates a Text understanding system (TexUS), Expert System for Situation Assessment (ESSA), Adaptive Situation Recogniser(ASR) and Situation Manager.

7.2. Submarine Operational Automation System.

The US army Laboratory Command's Human Engineering Laboratory (HEL) is working with Carnegie Group on developing an AI-based decision support system for logistics planning and diagnostics. For Navel decision aids GE Aerospace's advanced Technology Laboratories are developing SOAS (Submarine Operational Automation System). SOAS combines a variety of AI approaches, including expert systems, to provide submarine commanders with decision support. ASDICS (Aided Sonar Detection Integration and Classification System) a research prototype that emulates the actions of a sonar operator. In the early work target ships are classified from paper lolargrams of narrow-band sonar data.

7.3. Captain's Combat Aid

GEC-Marconi's Combat Systems Group is developing the Captain's Combat Aid (CCA) for the UK Royal Navy, which will be deployed aboard its aircraft carriers and type 42 destroyers from April 1993. The CCA will provide the Captain with the best course to steer in order to defend his ship against detected threats. The aid's knowledge base contains embedded tactical doctrine, and information on the performance of the ships and its weapon systems.

7.4. Neural Networks & Military Decision Aid System.

The combination of Expert System and Neural Networks can be used to form an hybrid that can solve complex problems. The two approaches are often complementary ; expert systems are symbolic, logical,mechanical and closed, while neural networks are numeric, associative, biological and self-organising. The US army combined arms Command's Future Battle Laboratory, one of the leading agencies in the field has developed MIDAS(Military Intelligence Decision Aid System). MIDAS combines operator trainable Neural Networks with expert systems to fuze and correlate information about the enemy, producing his order of battle, this system has been successfully used in the Gulf war.

Among the most obvious uses of self-organising adaptive Neural Networks are for real time pattern recognition tasks. The detection of target signatures buried in clutter and noise is possible with conventional computer systems, but due to long search cycles it cannot be done in real time. The assistance of neuro computer will speed up process and thus provide the extra few seconds needed for defense against an incoming missile.

An experiment conducted by the Hughes Laboratory to demonstrate the decision making capabilities is related to air defense scenario. The problem involved the rapid location of a small number of true targets among a very large number of false ones. The difficulty of solving this problem increases exponentially with the number of targets. For example in a typical scenario involving 15 true targets hidden among numerous ghosts, a digital Vax 11/780 computer can solve the problem within 10 seconds. But if the true targets number is more then 40, the computing time required is estimated in years. In a simulated environment and employing a neural network, Hughes scientists arrived at an average processing time of 15 micro seconds for the discovery of 36 targets among a total of thousand ghosts, this represents six order of magnitude faster processing then with conventional computer systems. Such experiments and their results are still preliminary but are already indicative of neural network capability.

REFERENCES

1. Avron B and Feigenbaum, E.A., " The hand book of artificial intelligence". William Kaufman Publishers, 1981.

2. Mishkoff H.C., "Understanding artificial intelligence", Texas Instruments, 1985.

3. Carpenter, G.A and Grossberg,S., "Neural dynamics of category learning and recognition". Brain Structure, Learning and Memory, AAAS Symposium Series, 1986.

4. McClelland, J.L and Rumelhart, D.E., "Explorations in parallel distributed processing", MIT Press, 1988.

5. Hasnain, S.B., "Self organising control algorithms and their transputer implementation", Ph.D Thesis, University Of Sheffield, England, 1990.

6. Kowalik J.S., "Parallel computation and computers for artificial intelligence", Kluwer Academic Publishers, 1988.

7. Fleming, P.J.; "Occam model for parallelism", In Parallel Processing in Control-the transputer and other architecture, ed Fleming, P. J, Peter Peregrines Ltd, 1988.

8. Zadeh, L.A., "Outline of a new approach to the analysis of complex systems and decision processes", IEEE trans. 1973, SMC-3,pp.338-353.

9. Mamdani, E.H., and Assilian, S. " An experiment in linguistic synthesis with a fuzzy logic

controller", Int J. Man-Machine Stud., 1975, 7,pp.1-13.

10. Larkin, L.I., "A fuzzy controller for aircraft flight control", in Industrial applications of Fuzzy Logic control, ed Sugeno, M.,Elsevier Publisher, 1985.

11. Hasnain, S.B., and Linkens, D.A,"Self-organising fuzzy logic control and application to muscle relaxant anesthesia",IEE Proc.D., 1991, 138,pp.274-284.

12. Linkens, D.A., Asbury, A.J., Rimmer, S.J., and Menad, M., " Identification and control of muscle relaxant anesthesia", IEE Proc.D.,1982,129,pp.67-70.

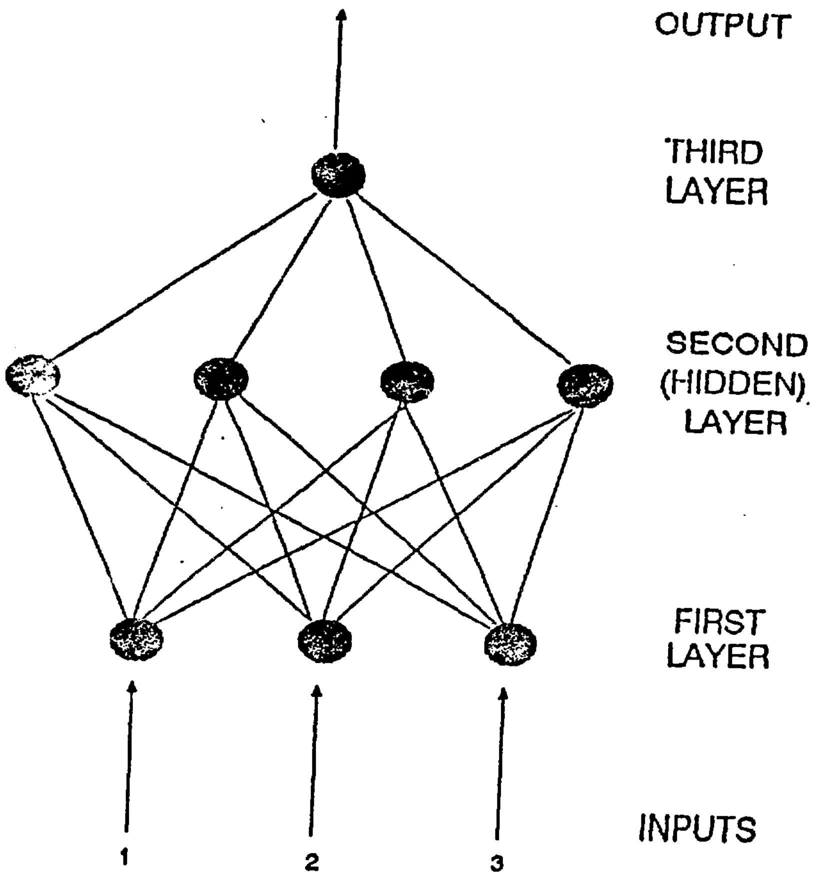

FIG.1: NEURAL NETWORK CONFIGURATION FOR MEDICAL DIAGNOSIS

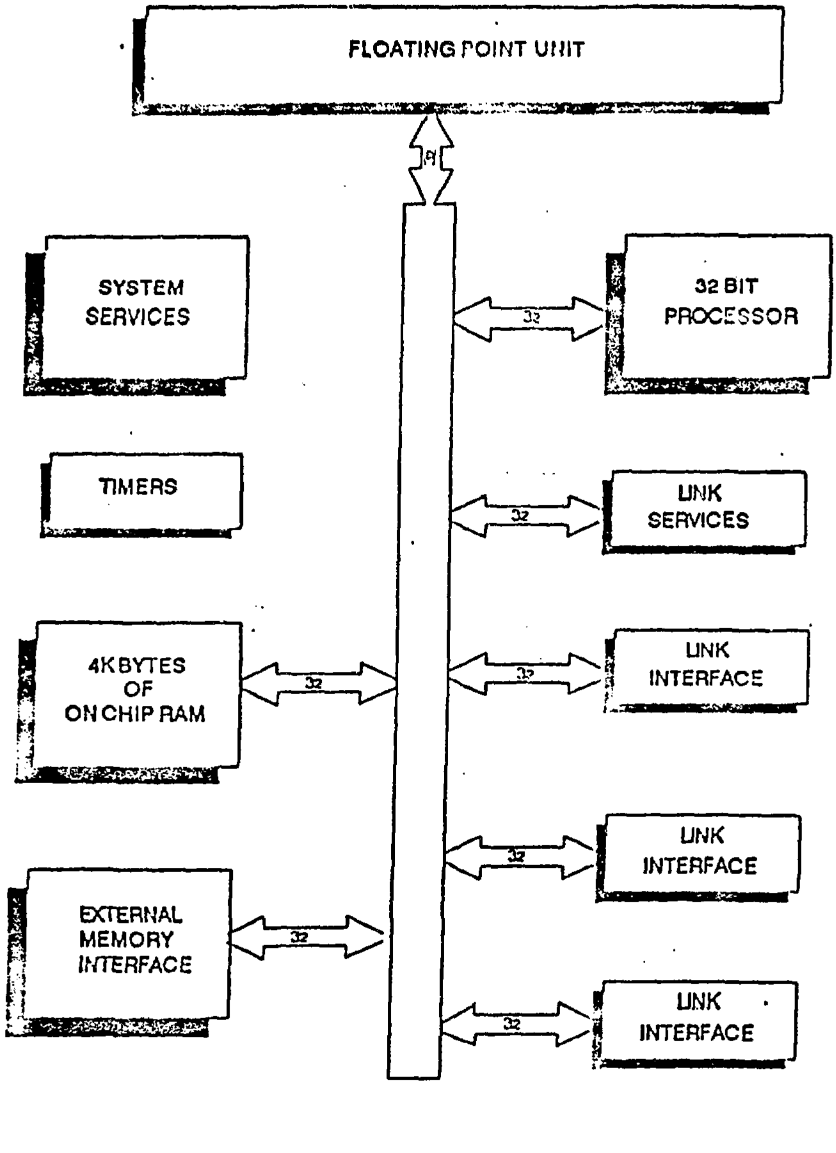

FIG. 2: INMOS T800 TRANSPUTER

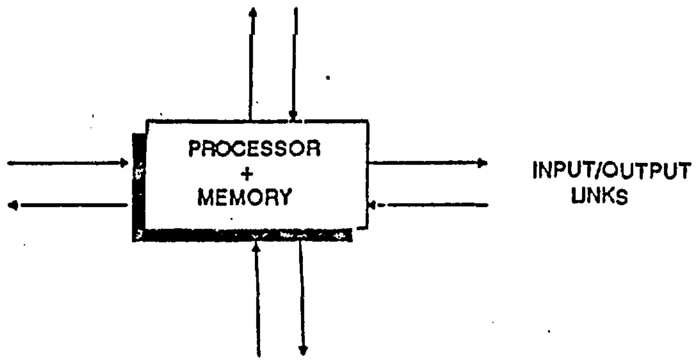

FIG.3 (a): A SINGLE TRANSPUTER

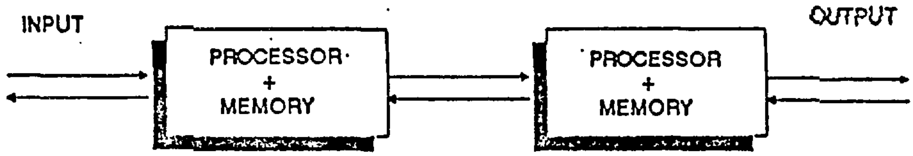

FIG. 3 (b): A TWO PIPELINE TRANSPUTER SYSTEM

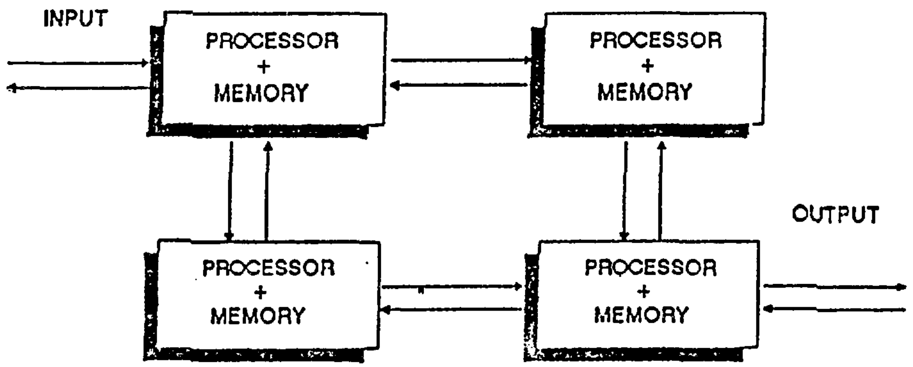

FIG.3 (c): AN ARRAY OF TRANSPUTERS

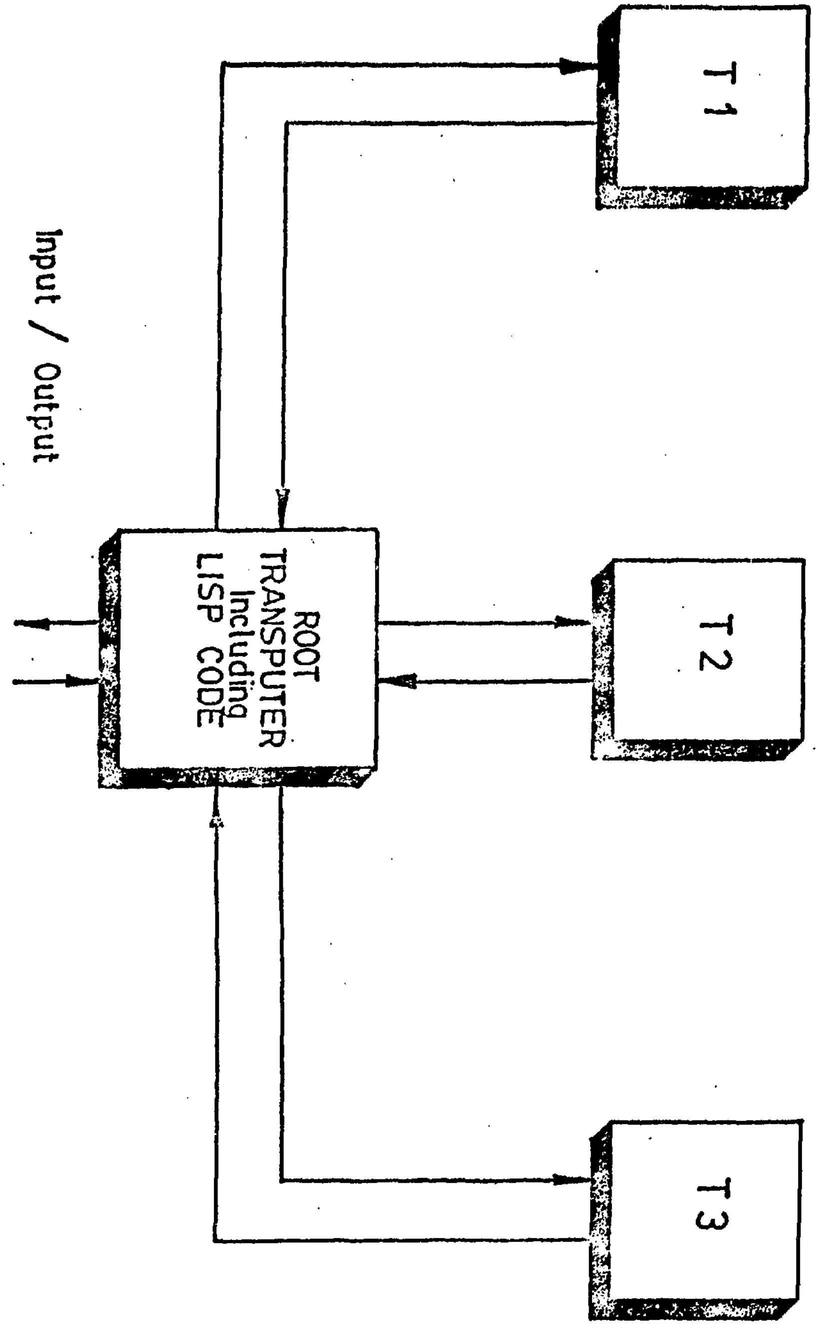

FIG.4: TRANSPUTER ARRANGEMENT FOR FUZZY CONTROL