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STUDY OF MEDICAL MECHATRONICS

Yasodharan. R [1], Sivabalakrishnan. R[2], Priya. K[3]

[1]Assistant Professor, SNS College of Technology, Coimbatore, yaso.snstech@gmail.com
[2]Assistant Professor, SNS College of Technology, Coimbatore, sivaeinfo@gmail.com
[3]Assistant Professor, SNS College of Technology, Coimbatore, priyakrishnanjune10@gmail.com

Abstract

Medical mechatronics explains innovative solutions for exploiting mechatronics in the medical instruments by optimizing the available conventional instruments and also creating new innovative, intelligent and accurate instrument. This paper gives a brief introduction about sensing and actuating technologies, automation and control systems used in the medical field. The paper also discuss about the principles and methods of processing and controlling mechanism in mechatronics system. In controlling, the artificial neural networks (ANNs) and fuzzy expert systems are commonly used one. ANNs are biologically inspired computer programs designed to simulate the way in which the human brain processes information. Whereas fuzzy expert system uses predefine membership functions and fuzzy inference rules to map numeric data into linguistic variable terms and to make fuzzy reasoning work.

Keywords: *Medical Mechatronics, Sensors, Actuators, Artificial neural network, Embedded system*

1. Introduction to Mechatronics:

"Mechatronics" is a term coined by the Japanese to describe the integration of mechanical and electronic engineering. The concept may seem to be anything but new, since we can all look around us and see a myriad of products that utilize both mechanical and electronic disciplines. Mechatronics, however, specifically refers to a multidiscipline, integrated approach to product and manufacturing system design. As shown in Figure.1, mechatronics is the combination of mechanical, electrical, electronic, computer and various other systems. It represents the next generation of machines, robots, and smart mechanisms necessary for carrying out work in a variety of environments.

Early medicine emphasized external examination of the patient. Later, breakthroughs such as x-ray permitted internal examination from the outside. Electronic and photonic advancements have enhanced these diagnostic techniques, but new devices and extreme miniaturization now permit examination, sensing, and monitoring from inside the patient.

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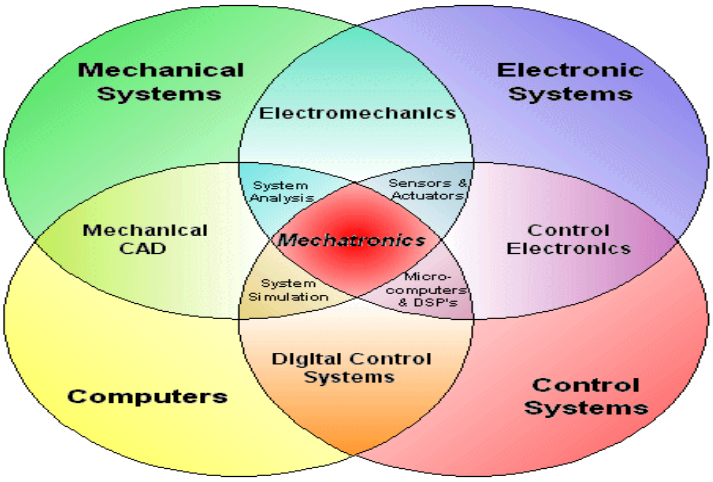

Figure.1 Mechatronics system

Concurrent breakthroughs in molecular biology and better understanding of coding and functions of DNA, is building up knowledge that will make diagnostics even more powerful and allow deployment of preventive and interceptive medical techniques much earlier for greater success. Molecular based medicine is the ultimate frontier.

2. Sensing and Actuating Technology:

A sensor is a device which is used to sense or measure a input quantity and converts it into an signal, which can be read by an observer or by an instrument. They are used to detect the physical, chemical, and biological signals, which can be measured & recorded. The various Physical properties that can be sensed include temperature, pressure, vibration, sound level, light intensity, load or weight, flow rate of gases and liquids, amplitude of magnetic and electronic fields, and concentrations of many substances in gaseous, liquid, or solid form.

With advances in micro machinery and easy-to-use microcontroller platforms, the uses of sensors have expanded beyond the more traditional fields of temperature, pressure or flow measurement for example into MARG sensors, Manufacturing and Machinery, Airplanes and Aerospace, Cars, Medicine and Robotics.

Sensors have played an important role in many industries, providing the mechanical "vision" used for counting, sorting, reading, and robotic guidance and also used to detect specific chemical pressures and fluid levels. Tactile sensors, typically piezoelectric materials, generate voltage when

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touched, squeezed, or bent, or when their temperature is changed. In the short term, sensors used in medical applications will emit a signal that can be read at the point of determination or transferred by wire or wireless transmission to remote locations. Advances in microprocessor technologies have created a smart sensor that unites sensing capability and data processing in a single integrated circuit chip. The next step is combining sensing and processing with an actuator, such as microelectromechanical systems. One of the major health care trends affecting mechatronics technology is miniaturization. The use of micro sensors and micro actuators is driving development of tiny mechatronics designs for

2.1 Instruments.

Tiny smart motion systems and all-in-one microstages move optics in hand-held scientific instruments for flow cytometry, DNA identification, IVD, pathogen detection, DNA sequencing and more. They enable smaller, field-portable systems and faster, lower-cost tests.

2.2 Endoscopic surgery. Steer a beam in an endoscopic laser scalpel, focus a lens in an in vivo camera, manipulate a scraper, collect a sample or dispense a liquid. Small enough to fit inside the endoscope head, our mechatronics systems improve accuracy and eliminate the need for a cable control system.

2.3 Electrophysiology. Motorized microdrive arrays enable precision electrode positioning.

2.4 Medical imaging. Small, precise modules for lens control and laser tuning enable systems for point-of care-diagnostics, home monitoring and telemedicine, real-time automated data collection and augmented vision eyewear.

2**.5 Implantable devices.** Adjust implanted devices in situ for drug delivery, orthopedics (bone growth and spine straightening), audiology, neurology, pain management, sleep apnea treatment and more. The implanted devices can be non-magnetic and MRI-safe.

2.6 Robotic surgical devices. Everything from robotic grippers and retractors to miniature mobile robots for minimally invasive surgery.

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3. Automation and control systems

Automation or automatic control is the utilization of several control systems for operating systems such as machinery, processes in factories, boilers and heat treating ovens, switching in telephone networks, steering and stabilization of ships, aircraft and other applications with minimal or reduced human intervention. On-off control is widely used in industrial applications. An example is the thermostats used on household appliances. Although technically it is a form of automation, its capabilities are primitive. (Old style HVAC systems used crude thermostats that were limited to on-off control, but some modern systems use more sophisticated sensors and digital controllers for variable speed fans or controlling other functions.)

Sequence control, in which a programmed sequence of discrete operations is performed, often based on system logic that involves system states. An elevator control system is an example of sequence control. The advanced type of automation that revolutionized manufacturing, aircraft, communications and other industries, is feedback control, which is usually continuous and involves taking measurements using a sensor and making calculated adjustments to keep the measured variable within a set range

All the elements constituting the measurement and control of a single variable are called a control loop. Control that uses a measured signal, feeds the signal back and compares it to a set point, calculates and sends a return signal to make a correction, is called closed loop control. If the controller does not incorporate feedback to make a correction then it is open loop. An operator monitoring signals from various sensors and manually making corrections either physically, such as turning the handle on a valve, or remotely, such as using a dial on a control panel, is performing open loop control. Timers and sequence controllers using logic, such as those on an elevator, are also open loop.

Feedback control is accomplished with a controller. To function properly, a controller must provide correction in a manner that maintains stability. The theoretical basis of feedback control is control theory, which also covers servomechanisms, which are often part of an automated system. Maintaining stability is a principal objective of control theory. Stability means that the system should not oscillate excessively around the set point or get into a situation where it shuts down or runs away.As an example of feedback control, consider a steam coil air heater in which a temperature sensor measures the temperature of the heated air, which is the measured variable. This signal is

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constantly "fed back" to the controller, which compares it to the desired setting (set point). The controller calculates the difference (error), then calculates a correction and sends the correction signal to adjust the air pressure to a diaphragm that moves a positioner on the steam valve, opening or closing it by the calculated amount.

4. Processing and controlling mechanism

Embedded system has faced a vast growth in medical field nowadays. The efficacy of embedded system in medical Mechatronics provides a various benefit like small devices capable of capturing patient data and making control decisions in treatment for the patients with the reduction of size, low power consumption, increase in processing power, may help in providing patients with better treatments. A case study about embedded system in medical field depicts in controlling the speed of a centrifugal pump of a heart-lung machine as shown in Figure.2. This application requires the real time patient data from various sensors to analysis the condition of the patient and able to make control on medical device for better functioning of artificial organs. The fuzzy controller are used in this application as a closed loop control to increase flexibility and easy computation in analysis the patient data.

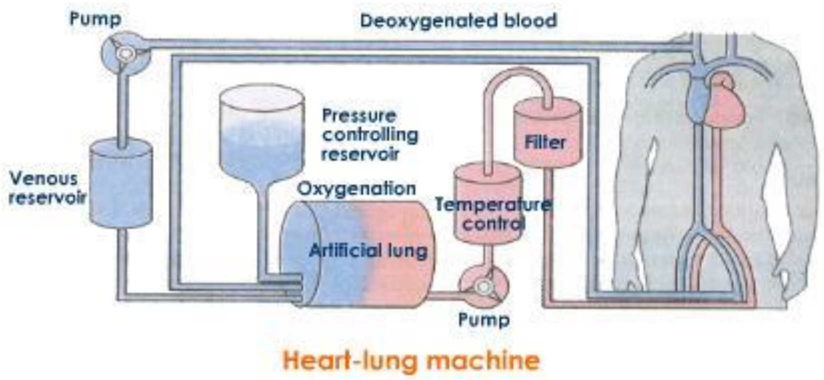

Figure.2 Heart lung machine

4.1 Artificial Neural Networks

The neural structure of the brain is taken as the model to create the Artificial Neural Networks. In general the brain basically learns from our day to day experience. It is practical

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proof that some problems that are beyond the scope of current computers are indeed solvable by small energy efficient packages. Artificial Neural Network is a brain modelling which promises a less technical way to develop machine solutions. This new approach to computing also provides a more graceful degradation during system overload than its more traditional counterparts.

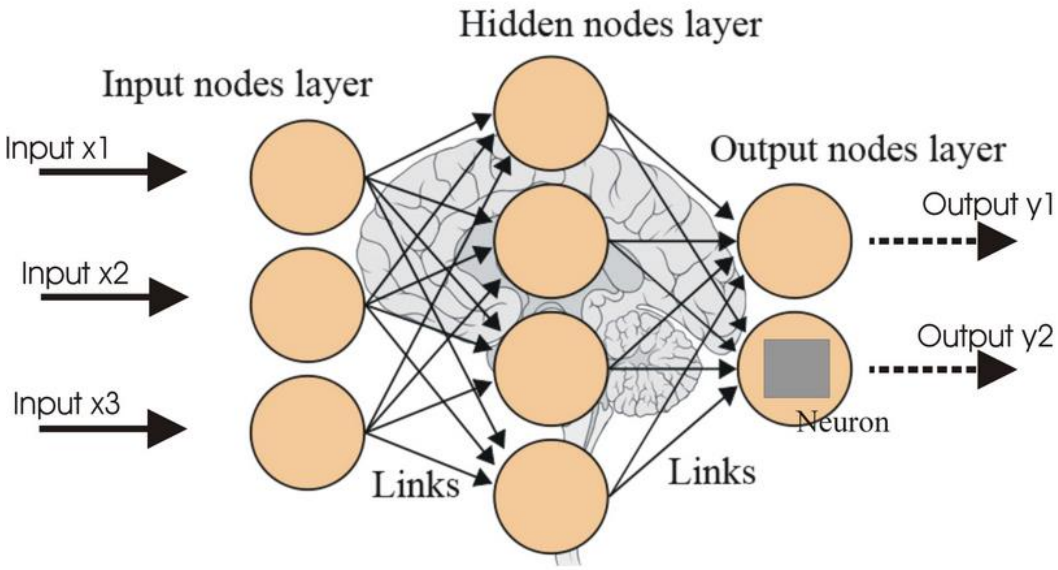

Fig.3 Artificial Intelligence Neural Network Nodes

The basic unit of neural networks are the artificial neurons, simulate the four basic functions of natural neurons. Neural Network (NN) is a system composed of several artificial neurons (see Figure.3) and weighted links binding them. This set of neurons that process information, is organized into interconnected layers along chosen patterns. Every neuron in its layer, receives some type of stimuli as input, processes it and sends through its related links an output to neighbouring neurons. In the field of Artificial Intelligence, NN models are also called Artificial Neural Network (ANN) in contrast to their biological counterparts that strongly inspired researchers in the beginning.

These biologically inspired methods of computing are thought to be the next major advancement in the computing industry. Even simple animal brains are capable of functions that are currently impossible for computers. Computers do rate things well, like keeping ledgers or performing complex math. But computers have trouble recognizing even simple patterns much less generalizing those patterns of the past into actions of the future.

Now, advances in biological research promise an initial understanding of the natural thinking mechanism. This research shows that brains store information as patterns. Some of

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these patterns are very complicated and allow us the ability to recognize individual faces from many different angles. This process of storing information as patterns, utilizing those patterns, and then solving problems encompasses a new field in computing. This field, as mentioned before, does not utilize traditional programming but involves the creation of massively parallel networks and the training of those networks to solve specific problems. This field also utilizes words very different from traditional computing, words like behave, react, self-organize, learn, generalize, and forget.

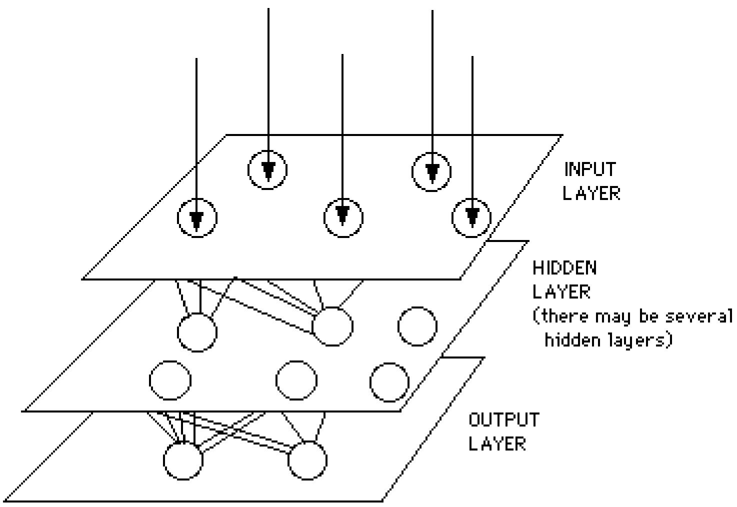

Figure.4 Structure of artificial neural networks

Basically, all artificial neural networks have a similar structure or topology as shown in Figure.4. In that structure some of the neurons interfaces to the real world to receive its inputs. Other neurons provide the real world with the network's outputs. This output might be the particular character that the network thinks that it has scanned or the particular image it thinks is being viewed. All the rest of the neurons are hidden from view.

But a neural network is more than a bunch of neurons. Some early researchers tried to simply connect neurons in a random manner, without much success. Now, it is known that even the brains of snails are structured devices. One of the easiest ways to design a structure is to create layers of elements. It is the grouping of these neurons into layers, the connections between these layers, and the summation and transfer functions that comprises a functioning neural network. The general terms used to describe these characteristics are common to all networks.

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Although there are useful networks which contain only one layer, or even one element, most applications require networks that contain at least the three normal types of layers - input, hidden, and output. The layer of input neurons receive the data either from input files or directly from electronic sensors in real-time applications. The output layer sends information directly to the outside world, to a secondary computer process, or to other devices such as a mechanical control system. Between these two layers can be many hidden layers. These internal layers contain many of the neurons in various interconnected structures. The inputs and outputs of each of these hidden neurons simply go to other neurons.

4.2 Fuzzy control system

A fuzzy control system is a control system based on fuzzy logic—a mathematical system that analyses analog input values in terms of logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0 (true or false, respectively).

Fuzzy logic is widely used in a machine control. The term "fuzzy" refers to the fact that the logic involved can deal with concepts that cannot be expressed as the "true" or "false" but rather as "partially true". Although alternative approaches such as genetic algorithms and neural networks can perform just as well as fuzzy logic in many cases, fuzzy logic has the advantage that the solution to the problem can be cast in terms that human operators can understand, so that their experience can be used in the design of the controller. This makes it easier to mechanize tasks that are already successfully performed by humans.

5. Conclusion

In this paper we discuss about the brief introduction about the mechatronics system, their components. Sensing and actuating techniques were studied detailed. Then software techniques. In general Medical mechatronics is a branch of mechatronics in which electronic instruments and equipment are used for such medical applications as diagnosis, therapy, research, anaesthesia control, cardiac control, and surgery.

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