Brain machine interface

- A brain Computer Interface (BCI) , sometimes called a neural-control interface (NCI), mind- machine interface(MMI), direct neural interface (DNI), or brain-machine interface(BMI), is a direct communication pathway between an enhanced or wired brain and an external device.
- Brain Computer Interface (BCI) technology is a powerful communication tool between users and systems.
- 5.5.1 BMI functions:
- Applications of Brain Computer Interface base its functionality on either observing the user state or allowing the user to deliver his/her ideas.
- BCI system records the brain waves and sends them to the computer system to complete the intended task.
- The transmitted waves are therefore used to express an idea or control an object. The following subsections give a brief introduction to those BCI operations.

Communication and control:

- Brain Machine interface (BMI) systems build a communication bridge between human brain and the external world eliminating the need for typical information delivery methods.
- They manage the sending of messages from human brains and decoding their silent thoughts. Thus they can help handicapped people to tell and write down their opinions and ideas via variety of methods such as in spelling applications , semantic categorization , or silent speech communication.

- BMIs can also facilitate hands-free applications bringing the ease and comfort to human beings through mind-controlling of machines.

User state monitoring:

- Early BMI applications have targeted disabled users who have mobility or speaking issues. Their aim was to provide an alternative communication channel for those users.
- But later on, BMI enters the world of healthy people as well. It works as a physiological measuring tool that retrieves and uses information about an individual's emotional, cognitive or effectiveness state.
- The target of brain signals utilization has been extended beyond controlling some object or offering a substitution for specific functions, in what is called passive BMI.
- BMI User state monitoring function is considered a helpful hand in Human Computer Interfaces and adapts them according to the estimated user emotional or cognitive state
- It also contributes in the development of smart environments and emotion controlling applications.
- Working conditions' assessment and educational methods' evaluation are examples of other fields that could benefit from measuring user's brain state .

BMI system components:

- BMI system consists of four basic components. They include
- ❖ Signal acquisition
- ❖ Signal preprocessing
- ❖ Feature extraction, and
- ❖ Classification.

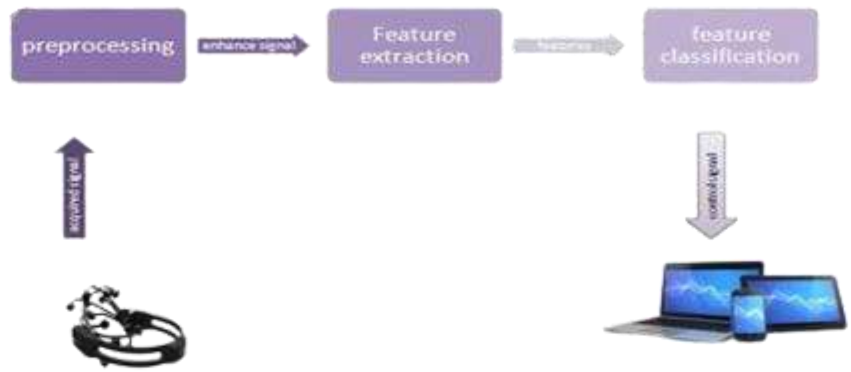


Fig:5.4.1 BMI system

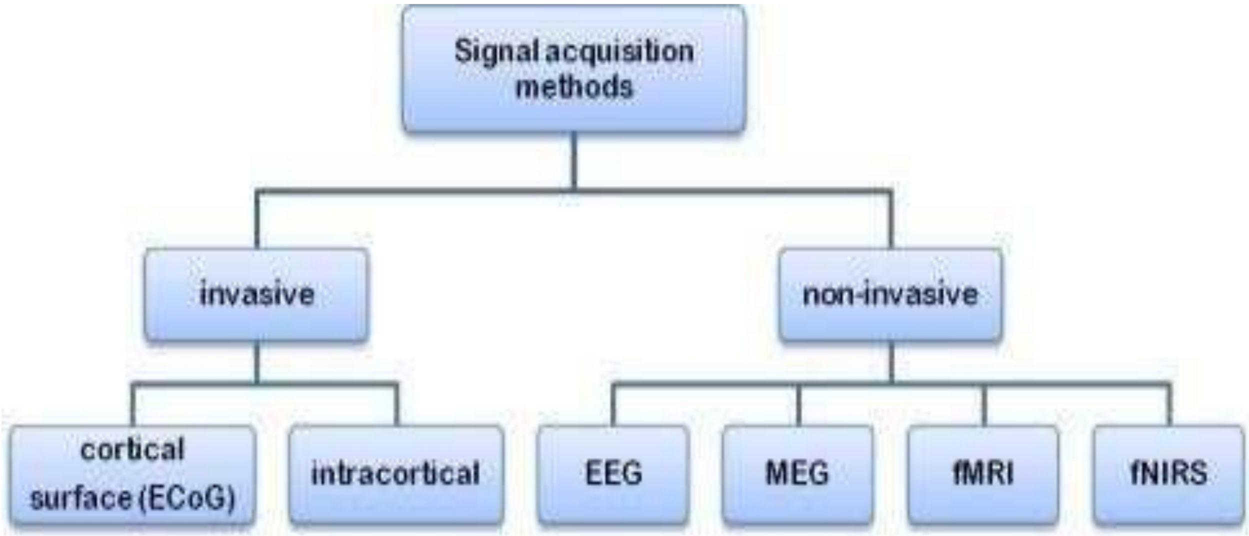
- Signal acquisition component is responsible for recording the brain waves and sending them to the preprocessing component for signal extraction and noise reduction.
- Feature extraction component generates the discriminative characteristics for the improved signal, decreasing the size of the data applied to the classification component.

Signal acquisition:

- Measuring brain generated oscillations is one of the main components in any BMI based system. It reflects the voluntary neural actions generated by user's current activity.

As shown in Figure, there are two general classes of brain acquisition methods: invasive and non-invasive methods.

- In invasive technology, electrodes are neurosurgically implanted either inside the user's brain or over the surface of the brain, while in non-invasive technologies, the brain activity is measured using external sensors .



Invasive BCIs

- Invasive BCI requires surgery to implant electrodes under scalp for communicating brain signals. The main advantage is to provide more accurate reading; however, its downside includes side effects from the surgery
- They measure the neural activity of the brain either intracortically from within the motor cortex or on the cortinal surface (electrocorticography (ECoG)).
- This greatest advantage is that provide high temporal and spatial resolution, increasing the quality of the obtained signal and its signal to noise ratio.
- However this techniques suffer from a lot issues.
- The small size of the monitored brain regions by those implants is considered one of them. Once implanted, they cannot be shifted to measure brain activity in another area.

Non-invasive BCIs

- These recording methods follow the approach that does not require implanting of external objects into subjects brain. Thus it avoids the surgical procedures or permanent device attachement needed by invasive acquisition
- Various assessment methods for different types of measured signals such as functional magnetic resonance imaging (fMRI), functional near infrared spectroscopy (fNIRS), magnetoencephalography (MEG) and electroencephalogram (EEG) are presented.

Endomicroscopy

- Endomicroscopy is a technique for obtaining histology-like images from inside the human body in real-time, a process known as ‘optical biopsy’.
- It generally refers to fluorescence confocal microscopy, although multi-photon microscopy and optical coherence tomography have also been adapted for endoscopic use.
- Commercially available clinical and pre-clinical endomicroscopes can achieve a resolution on the order of a micrometre, have a field-of-view of several hundred µm, and are compatible with fluorophores which are excitable using 488 nm laser light.
- he main clinical applications are currently in imaging of the tumour margins of the brain and gastro-intestinal tract, particularly for the diagnosis and characterisation of Barrett’s Esophagus, pancreatic cysts and colorectal lesions.
- A number of pre-clinical and transnational applications have been developed for endomicroscopy as it enables researchers to perform live animal imaging.
- Major pre-clinical applications are in gastro-intestinal tract, toumous margin detection, uterine complications, is chaemia, live imaging of cartilage and tendon, organoid imaging etc.
- Conventional, widefield microscopy is generally unsuitable for imaging thick tissue because the images are corrupted by a blurred, out-of-focus background signal.
- Endomicroscopes achieve optical sectioning (removal of the background intensity) using the confocal principle - each image frame is assembled in a point-by-point fashion by scanning a laser spot rapidly over the tissue.

- In table-top confocal microscopes the scanning is usually performed using bulky galvanometer or resonant scanning mirrors.

- Endomicroscopes either have a miniaturised scanning head at the distal tip of the imaging probe, or perform the scanning outside of the patient and use an imaging fibre bundle to transfer the scan pattern to the tissue.

Types of Endomicroscopy :

- **Single Fibre Endomicroscopes**
- **Fibre Bundle Endomicroscopes**
- **Distal Scanning Endomicroscopes**
- **Non-Confocal Endomicroscopes**
- **Confocal Endomicroscopes**

Single Fibre Endomicroscopes:

- Single Fibre Endomicroscopes use the tip of an optical fibre as a spatial filter, enabling miniaturisation of the microscope.
- 488nm blue laser passes from the source through an optical fibre to a flexible hand-held probe.
- Optics in the probe focus the laser to a spot in the tissue, excitingfluorescence.
- Emitted light is captured into the optical fibre and passed through an optical filter to a detector.
- An image is generated by scanning the focused spot throughout the image plane and compiling the point intensity measurements.
- The image plane can be translated up and down in the sample, allowing generation of 3D imagestacks.
- Single fibre endomicroscopes have similar resolution of a conventional confocal microscope.

Fibre Bundle Endomicroscopes

- Fibre bundles were originally developed for use in flexible endoscopes. and have since been adapted for use in endomicroscopy.
- They consist of a large number (up to tens of thousands) of fibre cores inside a single shared cladding, are flexible, and have diameters on the order of a millimetre.
- In a coherent fibre bundle the relative positions of the cores are maintained along the fibre, meaning that an image projected onto one end of the bundle will be transferred to the other end withoutscrambling.
- Therefore, if one end of the bundle is placed at the focus of a table-top confocal microscope, the bundle will act as a flexible extension and allow endoscopic operation.
- Since only the cores, and not the cladding, transmit light, image processingmust be applied to remove the resulting honey comb-like appearance of the images.
- Each core essentially acts as an image pixel, and so the spacing between fibre cores limits the resolution.
- The addition of micro-optics at the distal tip of the bundle allows for magnification and hence higher resolution imaging, but at the cost of reducing the field-of-view.

Digtal Scanning Endomicroscopes

- Digtal scanning endomicroscopes incorporate a miniature 2D scanning apparatus into the imaging probe.
- The laser excitation and returning fluorescent emission are sent to and received from the scanning head using an opticalfibre.
- Most experimental devices have either used MEMS scanning mirrors, or direct translation of the fibre using electromagneticactuation.

Non-Confocal Endomicroscopes

- Widefield endomicroscopes (i.e. non-depth sectioning microscopes) have been developed for select applications, including the imaging of cells.
- Optical coherence tomography and multi-photon microscopy have both been demonstrated endoscopically.
- Successful implementations have used distal scanning rather than fibre bundles due to problems with dispersion and light loss.

Applications:

- ➢ Endomicroscopy has been used to study many gastrointestinaldisorders
- ➢ Small bowel disorders investigated with Endomicroscopy include celiac disease and graft versus host disease.
- ➢ Gastric cancer and helicobacter pyloric gastric cancer have been imaged with Endomicroscopes
- ➢ Endomicroscope has been used to help target biopsies in all these disorders as well and may also reduce the number of biopsies needed to achieve diagnosis.

Confocal Endomicroscopes

- Confocal Endomicroscopes is recently developed endoscopic technology that allows for histological analysis of tissue in vivo. Conventional endoscopy involves identifying lesions grossly followed by biopsy for histologicalanalysis.
- Confocal Endomicroscopes allows for the performance of real time biopsy during endoscopy by observation of the mucosal layer of the gastrointestinal tract at the cellular level. Images are displayed in real time during the examinations.
- Two systems are currently available and have been approved by the FDA,
- ➢ Tip-integrated confocal laser endoscope and
- ➢ A flexible fibre-based confocal miniprobe.

- The technique of Confocal Endomicroscopes has been used for diagnosis of upper gastrointes-tinal disorders such as Barrett's esophagus, gastric carcinoma, Cerliac disease.
- It also has application in diagnosis of lower gastrointestinal and biliary tract disorders such as colon polyps, Ulcerative colitis and pancreaticobiliary strictures.
- Confocal laser endomicroscopy (CLE) is an endoscopic modality developed to obtain very high magnification and resolution images of the mucosal layer of the GI tract. CLE is based on tissue illumination with a low-power laser with subsequent detection of the fluorescence of light reflected from the tissue through a pinhole (Fig. 1).1 The term confocal refers to the alignment of both illumination and collection systems in the same focal plane.
- The laser light is focused at a selected depth in the tissue of interest and reflected light is then refocused onto the detection system by the same lens. Only returning light refocused through the pinhole is detected. The light reflected and scattered at other geometric angles from the illuminated object or refocused out of plane with the pinhole is excluded from detection. This dramatically increases the spatial resolution of CLE allowing cellular imaging and evaluation of tissue architecture at the focal plane during endoscopy

.

- Confocal imaging can be based on tissue reflectance or fluorescence.
- Confocal devices based on tissue reflectance do not require any contrast agents, but current prototypes using 2-photon strategies have relatively low resolution, which significantly compromise in vivo imaging and

clinical utility. CLE by using topical and/or intravenous fluorescence contrast agents generates images with resolution similar to traditional histological examination.

- CLE systems have included through-the-scope probes or dedicated endoscopes with integrated CLE systems.

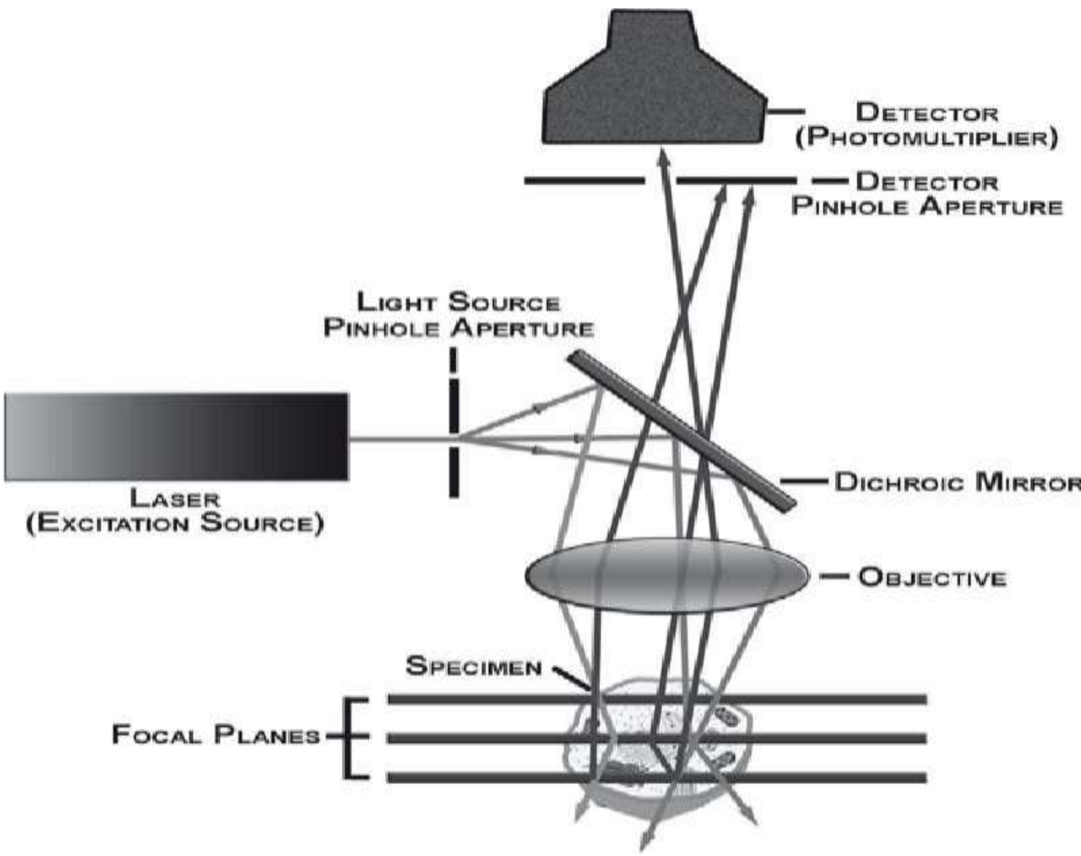


Fig:5.4.1. Schematic of confocal laser endomicroscopy principles.-Source-Web

Probe-based CLE(Confocal laser endomicroscopy)

- Probe-based CLE The probe-based CLE (pCLE) system comprises a fiberoptic bundle with an integrated distal lens that is connected to a laser scanning unit (Fig. 2).
- The probe-based system to date has a fixed focal length and so it can only scan in a single plane unlike current microscope systems that can create cross-sectional images at different depths.
- In pCLE systems, the individual optical fibers function as the pinhole
- CholangioFlex probes, designed for use during ERCP, require an endoscope accessory channel of at least 1.0 mm, whereas the other probes designed for use in EGD and colonoscopy require a channel of at least 2.8 mm. All probes generate dynamic (9-12 frames/s) images.
- The depth of imaging from the surface of the confocal lens is 40 to 70 mm for CholangioFlex probes and 55 to 65 mm for both GastroFlex UHD and ColoFlex UHD probes.
- The maximal field of view for CholangioFlex probes is 325 mm and 240 mm for Gastroflex UHD and ColoFlex UHD probes
- The resolution of the CholangioFlex probe is 3.5 mm, whereas for GastroFlex UHD and ColoFlex UHD probes, it is 1 mm (Mauna Kea Technologies).
- probes can be reused after disinfection for as many as 10 to 20 examinations.

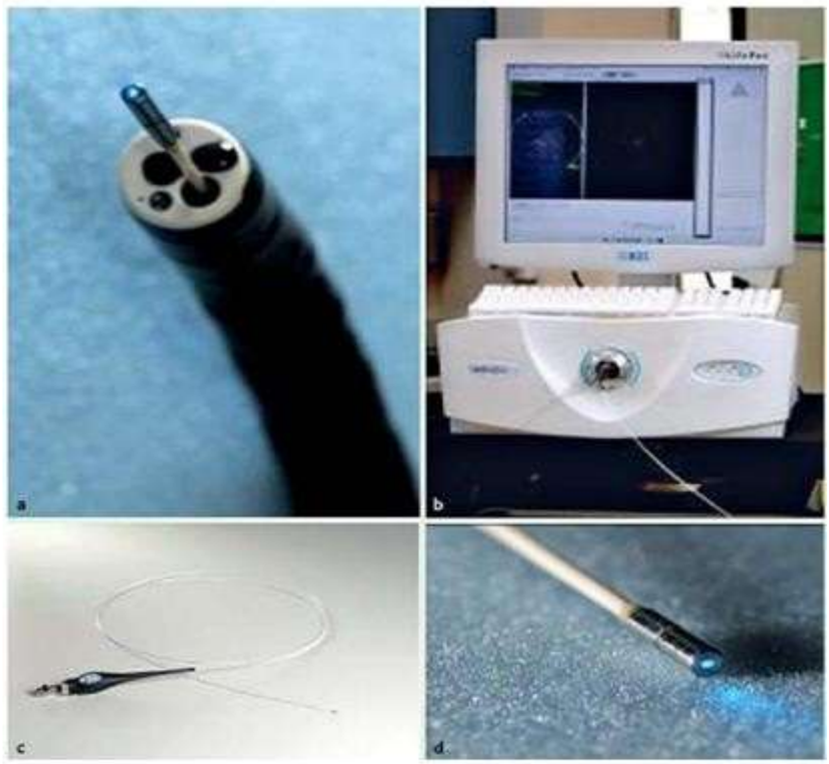


Figure 5.4.2. Probe-based confocal laser endomicroscopy (pCLE) system (Cellvizio; Mauna Kea Technologies, Paris, France) showing endoscope with a probe via an accessory channel (A), laser scanning unit (B), pCLE probe (C), and pCLE with laser illumination (D)-Source-Web

Endoscope-based CLE

- Endoscope-based CLE (eCLE) uses a confocal microscope (Optiscan, Victoria, Australia) integrated into the distal tip of a conventional endoscope
- The diameter of the eCLE endoscope is 12.8 mm, and the tip length is increased to accommodate the laser microscope so that there is a 5-cm rigid portion

It can be used for upper and lower GI tract examinations, but is toolarge for pancreaticobiliary imaging.

- With this setup, white-light endoscopy and eCLE can be performed simultaneously with images displayed on dual monitors
- Images are collected at a scan rate of 1.6 frames/s (1024 512 pixels) or 0.8 frames/s (1024 1024 pixels) with an adjustable depth of scanning ranging from 0 to 250 mm, a field of view of 475 475 mm.

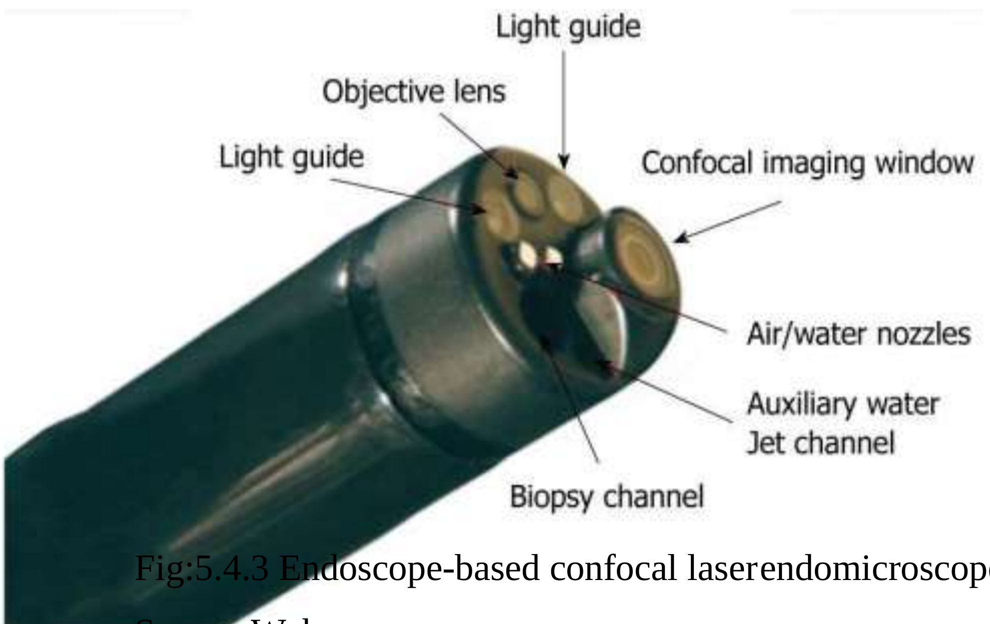


Fig:5.4.3 Endoscope-based confocal laserendomicroscope

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INSULIN PUMPS

- Blood glucose regulation is of great concern for insulin-dependent patients with excessive glucose in blood (hyperglycemia) or low glucose profile (hypoglycemia) due to excess insulin delivery.
- Both conditions can cause dangerous complications for diabetic patients and hence glucose regulation in blood is of prime importance.
- Insulin pumps are used to deliver insulin in small quantities, allowing glucose level to remain as close as possible to that non-diabetics person.
- Different control techniques are used to maintain the glucose level and most of them depend on an exact mathematical or empirical model of insulin- glucose interaction.
- Insulin pumps are small, computerized devices that mimic the way the human pancreas works by delivering small doses of short acting insulin continuously (basal rate).
- The device also is used to deliver variable amounts of insulin when a meal is eaten (bolus). The basal insulin rates are usually set up in patient pump with doctor, and patient can have one or multiple basal settings programmed in pump, based on patient needs.
- Patient program the amount of insulin for patients mealtime bolus directly on the pump. Most pumps come with built-in bolus calculators to help you figure out how much insulin need at mealtime based on glucose levels and the amount of carbohydrates.
- The pump, which is about the size of a smart phone or deck of cards, is worn on the outside of body and delivers insulin through a tube (catheter), connected to a thin cannula, placed into the layer of fat under skin, typically around stomach area. The

- pump can be worn around waist in a pump case or attached to a belt or bra, in a pocket, or on an armband. There are a variety of custom-made accessories available.

- To use an insulin pump, patient will need hands-on training from diabetes care team. They will teach how to fill a pump reservoir, prime tubing, select an infusion site, change an infusion set, disconnect the device, calculate and program basal and bolus doses, troubleshoot potential problems, create backup plans in case of pump failure, and prevent diabetic ketoacidosis.

Types of Pumps

A variety of insulin pumps are available, and your diabetes care team can help you choose the best pump for you. In general, there are two types of pump devices:

1. **Traditional Insulin pumps** have an insulin reservoir (or container) and pumping mechanism, and attach to the body with tubing and an infusion set. The pump body contains buttons that allow you to program insulin delivery for meals, specific types of basal rates, or suspend the insulin infusion, if necessary.
2. **Insulin patch pumps** are worn directly on the body and have a reservoir, pumping mechanism, and infusion set inside a small case. Patch pumps are controlled wirelessly by a separate device that allows programming of insulin delivery for meals from the patch.

✓ Many pumps connect wirelessly with blood glucose meters, which measure blood sugar levels using a drop of blood from the fingertip. Some pumps connect wirelessly with continuous glucose monitoring devices, which are inserted under the skin and monitor blood sugar levels all day long.

✓ Pumps vary in how much insulin they hold, whether or not the pump has a touch screen or is waterproof, and have a variety of advanced features as well as safety

✓ features. Safety and user features may include programmable bolus, customizable reminders, alerts for missed bolus dose or missed glucose measurement, and alarms in the event of a blockage that prevents the continuous infusion of the insulin through the pump. One of the integrated systems that combines insulin pump and continuous glucose monitoring sensor can also be programmed to suspend insulin delivery if the glucose levels reaches a preset low threshold level.

The Parts of an Insulin Pump

Traditional insulin pumps contain three main parts:

- **pump.** Traditional insulin pumps are battery powered and contain an insulin reservoir (or container), pumping mechanism, and buttons or touch screen to program insulin delivery. Pumps send insulin through tubing into an infusionset that delivers the insulin to your body.
- **tubing.** A thin plastic tube (catheter) is connected to the insulin reservoir and insulin flows into the subcutaneous tissue through the infusion set. There are several length sizes of tubing length. They are chosen based on how you wearthe insulin pump. For example, longer tubing may be good for people who wear their pump far from the infusion set.
- **infusion set.** Infusions sets are made of Teflon or steel and attach to your skin with an adhesive patch. On the underside of the infusion set is a short thin tube (cannula) that is inserted in your skin with a small needle that is housed within the cannula to deliver insulin into a layer of fatty tissue. The needle is necessary to puncture the skin and insert the set. After insertion, the needle is removed and the thin cannula stays under the skin. The set is usually implanted around your stomach area, but can be placed on the thigh, hips, upper arms

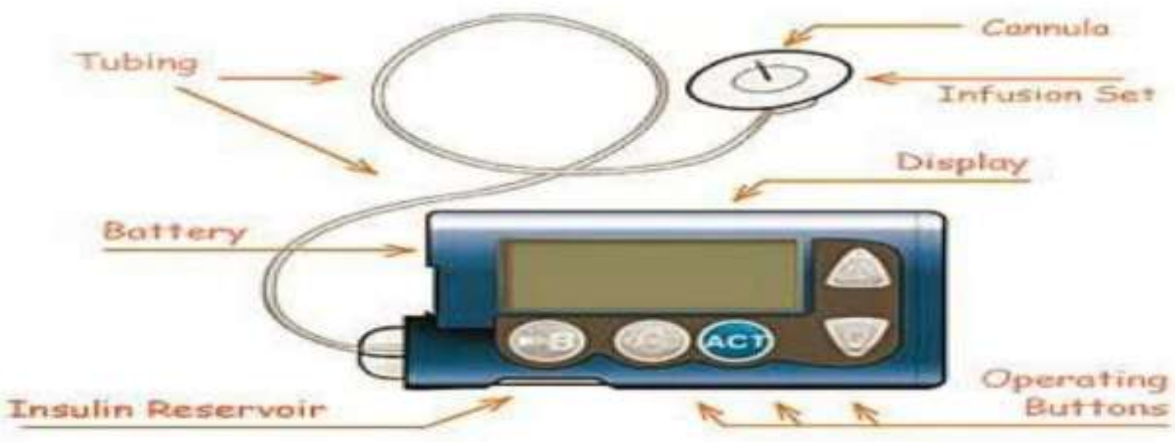

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Fig: 5.2.1 Dosing of Insulin , (Source:web)

Advantages of an Insulin Pump

- A pump is more accurate than shots, helping you better manage blood sugar levels.
- It may improve your A1c levels.
- It's easier to plan for exercise.
- It's easier to bolus.
- It helps manage early morning high blood sugar, also called the "dawn phenomenon."

Disadvantages of an Insulin Pump

- Patient need to enter information into the pump all day and change out the infusion set every few days.
- Patient need to commit to using it safely, including checking your blood sugar to make sure the pump is working right. Otherwise, you risk a life- threatening problem called diabetic ketoacidosis (DKA).
- Patient need training to learn to use the pump, which means several visits with health care team or a full day of outpatient training.
- Pump supplies can be expensive.

Lab on a chip

Lab-on-Chip technology implies those techniques that perform various laboratory operations on a miniaturized scale such as chemical synthesis and analysis on a single chip leading to a handheld and portable device. In other words, LoC is a device which is capable of scaling the single or multiple laboratory functions down to chip-format. The size of this chip ranges from millimeters to a few square centimeters.

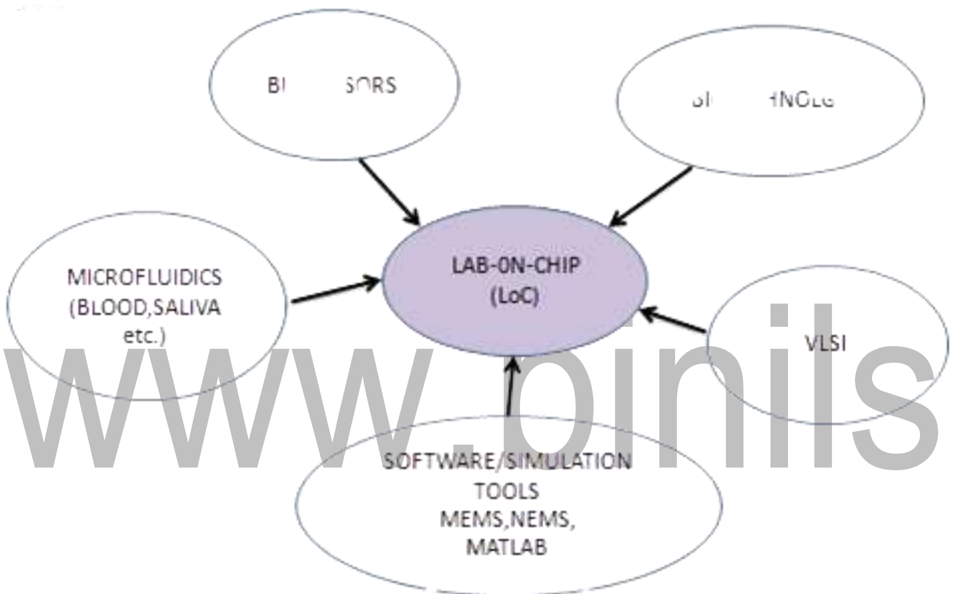


Fig 5.5.1: Interdisciplinary Field of LoC

Source: Leslie Cromwell, ―Biomedical Instrumentation and Measurement‖, Prentice Hall of India, New Delhi, 2007.

LoC is basically the integration of fluidics, electronics, optics and biosensors LoCs prove to be useful for finding the methods for the early stage diagnosis of deadly and chronic diseases.

Due to the advent of advanced technologies such as MEMS, NEMS, the integration of large number of interdisciplinary modules on a single chip is possible as shown in figure 1.

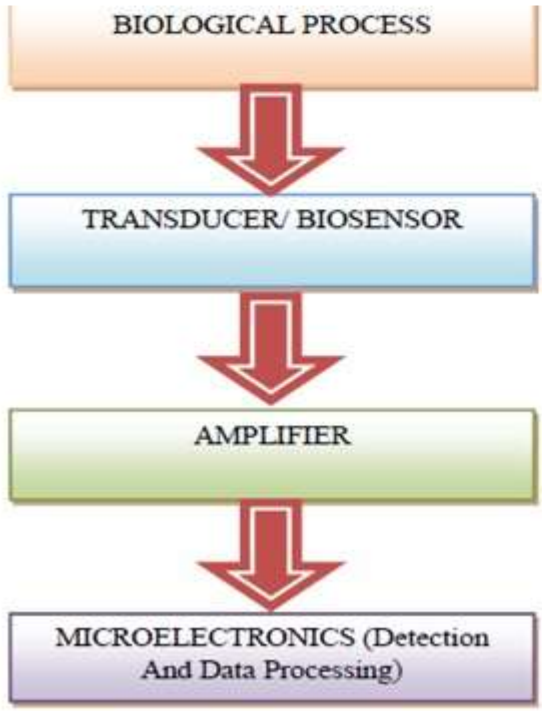


Fig:5.5.2 Represents the various steps involved in Lab-on-Chip processing.

Source: Leslie Cromwell, ―Biomedical Instrumentation and Measurement‖, Prentice Hall of India, New Delhi, 2007.

- The LoC processing initiates by collecting the physiological sample and then from this sample, the extraction of particular analyte/biomarker is done.
- Depending upon the biomedical application, the transducer will act on the analyte electrically, electromechanically optically or mechanically.
- The next step involves counting, sorting and amplification of the transducer output is performed according to the application.
- Finally, the amplified sample is processed using microelectronics techniques.

Design Constraints of Lab-on-Chip Technology

- A LoC is a device which is capable of scaling the single or multiple laboratory functions down to chip-format.
- The size of this chip ranges from millimetres to few square centimetres. Extremely small fluid volumes of less than pico litres can be handled by LoC.
- High throughput screening and automation also becomes possible by the introduction of LoC technology.
- LoC devices are often indicated by "µTAS" (Micro Total Analysis Systems) and are a subset of MEMS (Micro -electro-mechanical systems) devices.
- LoC technology is closely related to the microfluidics which is primarily the combination of physics, the study and manipulation of small quantities of fluids.
- The major difference between LoC and µTAS is that µTAS generally indicates the integration of the total sequence of lab processes in order to perform chemical analysis whereas LoC is dedicated to the integration of one or several of the lab processes onto a single chip.
- The MEMS approach known as microflidics helps in the handling of small fluid volumes even less than picolitres.
- The scaling of one or several of the lab processes onto a single chip-format is known as LoC which has the capability of handling micro and nano particles by combining several laboratory functions on one chip.
- To perform chemical analysis, MEMS is used. Photolithography which is directly derived from microelectronic fabrication is the the basis for most LoC fabrication processes
- Integration of multiple microfluidic components leading to fully automated lab on a chip systems are

- (i)Multilayer Soft Lithography;
- (ii) Capillary Driven and Paper-based Microfluidics;
- (iii) EWOD Driven Droplet Microfluidics;
- (iv) Multiphase Microfluidics;
- (v) Centrifugal Microfluidics;
- (vi) Electrokinetics, and
- (vii) Hybrid Microfluidics.

- The two major challenges that come in the way for the rapid development of microfluidic Lab-on-Chip systems are

- Investigate the technologies and new polymer materials for chip preparation and To choose the best label-free method for the detection of analytes in microchannels

LOC Device materials

The main issues in the manufacturing techniques for microfluidic LOC devices usually lie in the area of forming microfluidic channels which are micro/nanostructures.

Various materials are used for the manufacture of microfluidic channels.

1. Silicon: microfluidic channels were patterned directly into silicon. In general, the advantages of using silicon as a structural material include its good mechanical properties, excellent chemical resistance, well-characterised processing techniques and the capability of integrating control/sensing circuitry.
2. Glass: Glass substrate is also used due to its excellent optical transparency and ease of electro-osmotic flow. One of the most successful examples in the capillary electrophoresis chip, which is manufactured using glass etching and fusion bonding techniques.
3. Polymers: Nowadays polymers are plastics have become popular materials due to their low cost, ease of manufacture, and favorable biochemical reliability and

capability. Polymers are promising materials in LOC applications, because they can be used for mass production using casting, hot embossing, injection modeling and soft lithography techniques.

4. Paper: Recently, the manufacturing of paper based LOCs has been introduced, allowing an even cheaper and more simplified method for manufacturing LOC devices. Paper based LOC devices, commonly referred to as microfluidic paper based analytical devices often have the ability to analyze a single liquid sample for multiple analytes

Application of Lab-on-Chip Technology

- The increased demand of LoC devices in many areas is due to the various technological advantages of LoC technology such as portability, automated sample handling, re-configurability etc.
- Immunoassay LoC for bacteria detection, Real time PCR detection chips, DNA chip, Gene Chip, Cellular Analysis chip, Flow Cytometer LoC (for HIV) etc. are some of the applications of LoC technology in the biomedical field.
- LoC to be used for meeting the requirements and improving the efficiency of Point-of-Care diagnostic systems.
- Since the required functional modules and working principles generally depend on target analytes, so the applications of POCT systems are categorized according to the type of analyte such as cells, proteins, metabolites and nucleic acids. POCT systems have the ability to detect specific biomarkers from these analytes.
- The development of disposable and fully-integrated Lab-on-Chip devices for microfluidic and clinical applications especially in biological fluids for the

point of care testing and monitoring of simultaneous parameters. This chip is fabricated by the integration of biosensors, optical filters and electronic circuits on a single chip.

- A Lab-on-Chip device is proposed that uses acoustic streaming technique for promoting the pumping and mixing of microfluids inside microchannels so as to improve the microfluidic device performance.
- To generate this acoustic streaming, a transducer is used which is based on a piezoelectric material like β-PVDF (polyvinylidene fluoride prepared in its β-phase). This polymer is processed to be functionally graded for being able to maintain the heating and to control the movement of fluids in conjunction with the input signal that is applies to the transducer.

Radio pill

- Radio pill is an instrument that transmit measurement by radio impulses from within the body.
- A capsule containing miniature radio transmitter that can be swallowed by a patient.
- During its passage through the digestive track a radio pill transmitsinformation about internal condition.
- It is modern wireless type of endoscopic monitoringsystem.
- The Radio pill is a small capsule shaped electronic pill that can be comfortably swallowed by any normalpatient.
- It consists of lens, antenna, transmitters, camera or sensors andbattery.
- It can reach regions such as small intestine and provides the video wirelessly to the receiving device connected to the monitoring system outside the human body and kept at distance of 1meter.
- The transmission of data takes place through the radio communication between electronic pill transmitter and externalreceiver
- This is mainly used for diagnosis of internal part mainly gastrointestinal system which cannot be easily done with the help of normal endoscope.

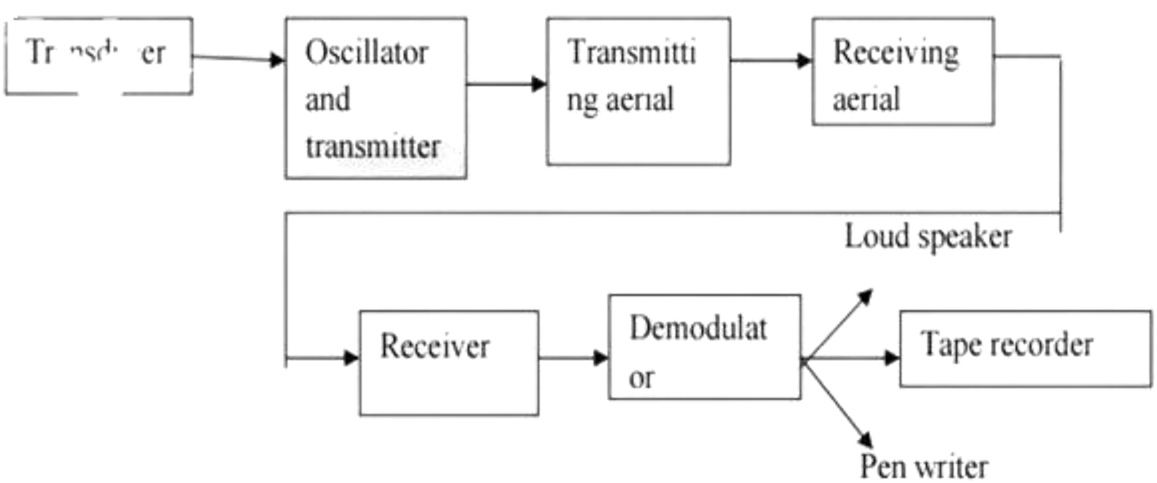
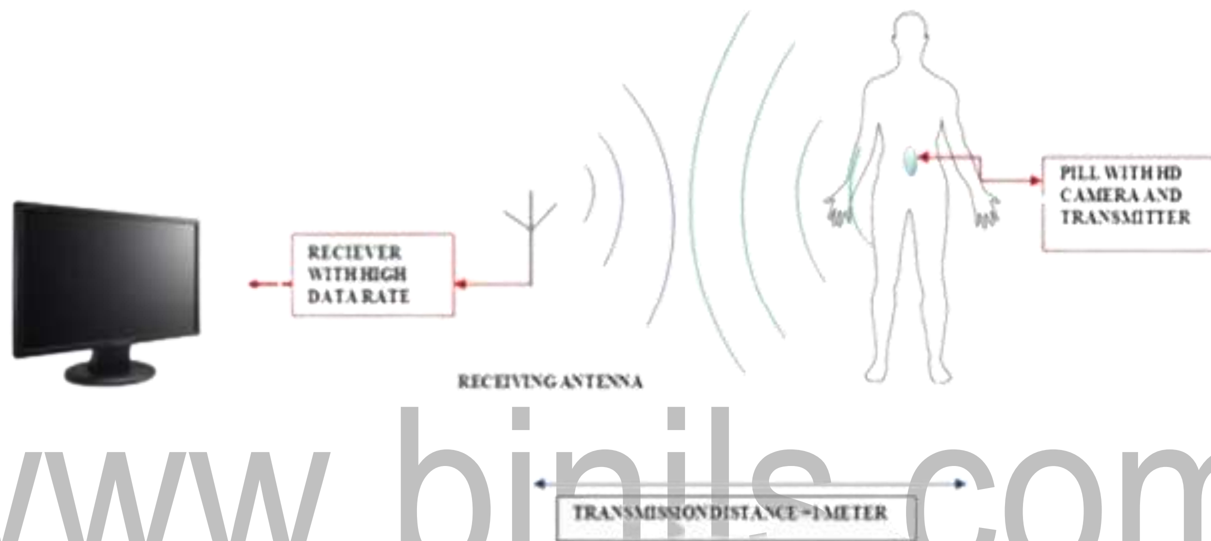


Fig:5.3.1Block diagram of Radio pills ,Source: Web

- Parameters such as temperature, pH and pressure of gastrointestinal tract can be measured, for the detection of diseases and disturbance in gastro intestinal system which prevents the entry of conventional endoscopic tube, a micro pill with single channel radio telemetric function is preferred.
- The invention of semiconductors provides ease in development of concise electronic pill capable to carry and transmit huge amount of data at a time without affecting the human body.



- The diagram below represents the wireless video transmission between transmitter and receiver

Fig:5.3.2 wireless video transmission between transmitter and receiver

(Source: Web)

- A Radio pill construction requires narrow band transmission and has limited camera pixels. One of the commercially available endoscopic devices designed by the company "Given Imaging" uses Radio Frequency chip for wireless communication for real time video transmission based on the Medical Implant Communication Service band.
- The channel bandwidth allowable for this band is limited to 300 kHz; the low frequency application provides high transmission efficiency through layers of skin.

- The fabrication of sensors of electronic pill are done on two silicon chips which is generally kept at the top of the capsule and the first chip encompasses diode, the pH ISFET sensor, temperature sensor and conductivity sensor with two sensor. The chip has thermometer and oxygen sensor
- The method which provides the baud rate of 100Mbps is Wideband Technology. This technology is currently used in radar, Image processing and In-door entertainment. But, the major problem in high frequency is the major loss in body tissue.
- All Radio pill is powered by a battery, in order to utilize the device in internal remote locations. There is scanning receiver which captures the wireless radio signal from pill through a coil antenna. A computer system is required for the control of data acquisition unit which acquires data in analog form from the scanning receiver. It provides recording of data on the computer.
- The schematic diagram ofpill is represented by the figure below:-

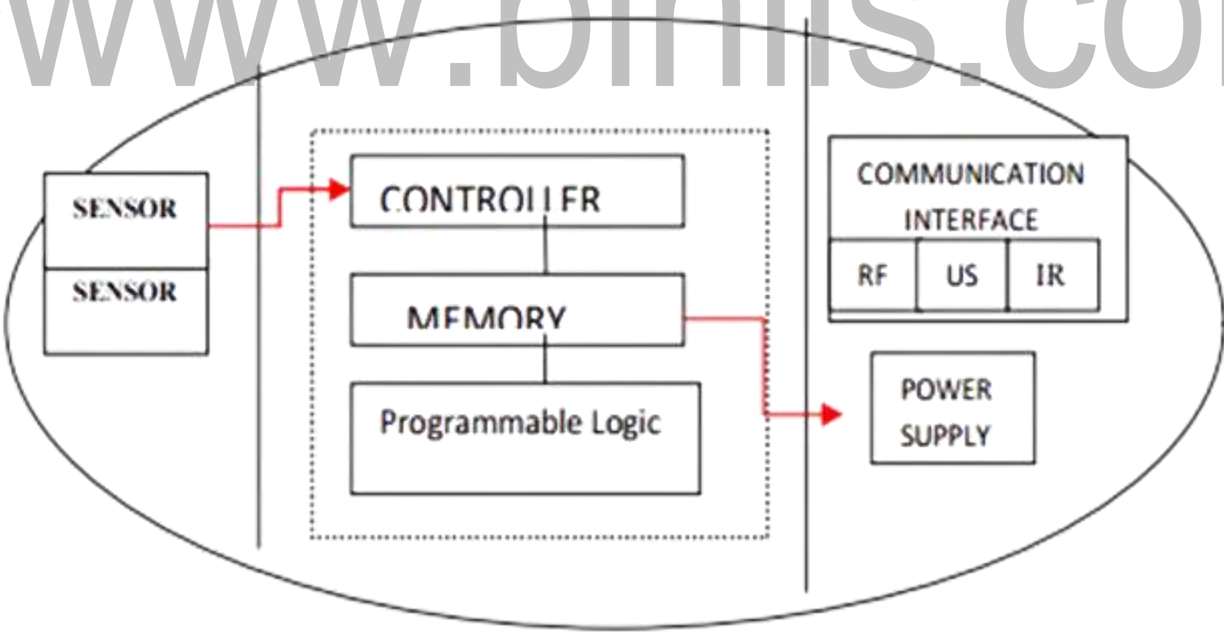


Fig:5.3.3 schematic diagram of pill , **Source: Web**

- All Radio pill is powered by a battery, in order to utilize the device in internal remote locations.
- There is scanning receiver which captures the wireless radio signal from pill through a coil antenna.
- A computer system is required for the control of data acquisition unit which acquires data in analog form from the scanning receiver. It provides recording of data on the computer. Stable transmission frequency must be constantly maintained. The transmission frequency is measured with the

help of change in temperature. The change in frequency is measured with the help of scanning receiver, and the result obtained is used to evaluate the advantage of crystal stabilized unit.

- The power consumption of microelectronic including transmitter and sensors connected is calculated to 12.1 milli watt with current rating 3.9mill Ampere at

3.1 volt voltage supply, where as free running radio transmitter consumes 6.8milliwatt.Two silver oxide batteries SR44 are used to provide operating time of more than 40 hours.

- The pH measurement ranges from 1 to13 can be carried out .The dissolved oxygen is up to 8.2 mg per liter. The temperature measurement is done from 0ºC to 70ºC
- The pH ISFET sensor operated in constant current mode, with the drain voltage connected to the positive supply and the source voltage changes as per gate potential and gate potential is grounded. In control chip, the noise from application specific integrated circuit provides a constant level of 3Mega volt peak to peak, which provides single Least Significant Bit of Analog to Digital Convertor; the second Least Significant Bit is used to provide an adequate noise

margin, and here to have an effective resolution of 8 bits the 10 –bit Analog to Digital Convertor is used.

- The components of capsule must be capable to protect itself from corrosive environment in gastro intestinal tract and it must be nontoxic to the humanbeing but as the battery electrodes are toxic in nature, so care must be taken to prevent leakage of toxic fluids into the digestive system.

Telemedicine :

- **Telemedicine** refers to the practice of caring for patients remotely when the provider and patient are not physically present with each other.
- The World Health Organization (WHO) refers to telemedicine as "healing from a distance". It is the use of telecommunications technology and information technologies to provide remote clinical services to patients. Physicians use telemedicine for the transmission of digital imaging, video consultations, and remote medical diagnosis.
- Telemedicine is the remote delivery of healthcare services, such as health assessments or consultations, over the telecommunication infrastructure. It allows health care providers to evaluate, diagnose and treat patients without the need for an in-person visit
- The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of diseases and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals.

Four elements are relevent in telemedicine:

- Its purpose of clinical support.
- It is intended to overcome geographical barriers, connecting users who are not in the same physical location.
- It involves the use of various types of ICT (Information and communication Technology).
- Its goal is to improve health outcomes.
- Types of Telemedicine:
- Telemedicine is practiced on the basis of three concepts.

1. Real Time (Synchronous)
2. Store and Forward (Asynchronous)
3. Hybrid systems.

1. Real Time (Synchronous):

- Real Time Telemedicine could be as simple as a telephone call or as complex as robotic surgery.
- Video conferencing equipment is one of the most common forms of technologies used in synchronous telemedicine.
- There are also peripheral devices which can be attached to computers or the video conferencing equipment which can aid in the interactive examination.
- A tele-otoscope allows a remote physician to see inside a patients ear and a tele-stethescope allows the consulting remote physician to hear the patients heart beat.

- Medical specialities conductive to this kind of consultation include psychiatry, family practice, internal medicine, rehabilitation, cardiology, pediatrics, obstetrics, neurology and pharmacy.

2. Store and Forward (Asynchronous):

- Store and Forward telemedicine involves acquiring medical data and then transmitting this data to a doctor or medical specialist at a convenienttime for assessment offline.
- It does not require the presence of both parties at the same time.
- Dermatology, radiology and pathology are common specialists that are conductive to asynchronous telemedicine.
- A properly structured medical record preferably in electronic form should be a component of this transfer.

3. Hybrid systems:

- Hybrid systems combines capabilities of Real Time and store and forward telemedicine.
- Combining stored still or motion video with Real Time video conferencing is an example of a hybrid telemedicine system.
- For example, video clips of patient examination stored and forwarded to a specialist for assessment can be useful for teleconsultation of ocular motility disorders associated with neuro-ophthalmology conditions.
- The specialist doctor can play, pause or sequentially step throughdigitized video movies.

Concepts of Telemedicine System:

- The Telemedicine technology includes hardware, software, medical equipment and communication link.
- The technology infrastructure is a telecommunication network with input and output devices at each connected location.

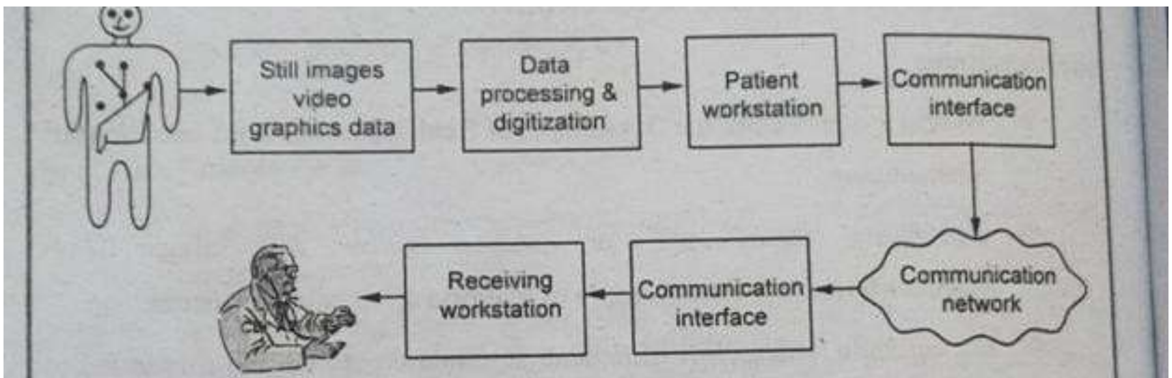


Fig.5.1.1: Basic concept of Telemedicine

Source: web

- The following type of information is required to be obtained and transmitted in a telemedicine system.

  Data: Non-medical patient data such as personal data, admission information and release, payments, insurance status, disease history, status of physiological parameters such as blood pressure, pulse, respiration rate, temperature.

- Audio: For medical diagnosis, some patient data is primarily acoustic. For example, ausculation of heart sounds, sounds from respiratory movements.
- Still Images: X-ray, CT, MRI Images, Skin Images, Images of tissue and cellular specimens.

- Video: Video of images of the patient, echocardiography, video conferencing.
- Primary patient data: Name, age, occupation, sex, address, telephone number, registration number etc.
- Patient history: Personal and diagnostics reports.
- Investigations: Complete analysis reports of haemotology and biochemistry tests, stool and urine examination.

Applications:

A telemedicine system may have all or some of the following medical devices at a telemetry transmitting station.

- Telecardiology: PC based Digital ECG Machine Electronic Stethescope.
- Telepathology: Video microscopy system microscope, CCD camera, single chip camera, three chip camera.
- Teledermatology: Dermascope with digital camera.
- Miscellaneous: Document camera- CCD based camera that forms the image of the document placed over its flat bed.