Information Technology for Health

Utpal Ghosh,

CSE 3rd Year

No Computer No Life. That's what seems to us nowadays. We can't think beyond computer today. Computer is everywhere. We all know how deeply it has changed the shape of our life. But many of us don't know what is its contribution to the medical science, which saves our life. Here is a small attempt of casting light on how attempt is going on to use IT in medical science.

Creating The Digital Human:

How would it be if there is a complete digital representation of the human body? One would be able to understand diseases or practice complex surgeries before doing them live. One could simulate the reactions of the human body to external stimuli like an electrical shock or vehicle crash. The amount of details one would need of the human body for doing all this is enormous. The visible human project marries some macabre "surgeries" with powerful workstations and super computers to deliver this.

The first visible human was created by the US National Library of Medicine or rather the first visible human database was created there with work starting in 1986.The images thus created represent a huge database, which is not of much use as is. It is here that powerful workstations, visualling software and super computers step in. Many offshoots of this project have successfully created animations of the human body. A fully functional, virtual human being could be just one big step away.

Software In Medical Imaging:

Imaging systems, particularly internal –imaging systems, play a key role in modern medicine. Once an image is acquired, it can be used to diagnose or decide the nature of intervention required. For example, an X-ray of a broken limb can help determine the extent and nature of bone injury (diagnosis) while an MRI of a tumor can help decide the details of the intervention (surgery) required, like where and how deep.

One acquire such images of human internals X-rays, radio frequencies or magnetic resonance (MR) depending on the organ being investigated and what the end use of the image is to be.

Once an image has been acquired using a scanner or camera, the rest of the work on it can be done using software, at a viewing station.

UNIX & WINDOWS:

Unlike commercial PCs or servers, medical-imaging systems have a very long lifetime (ten to twenty years or more). Also, hardware and software upgrades are not frequent or easy as with traditional computing systems. The software for medical-imaging systems run on systems that have traditionally run different flavors of UNIX, like Solaris and even Digital VAX. More recently, developers have started experimenting with the embedded versions of Windows.

From the traditional monolithic architecture of the software and hardware, there is currently a move towards using off the shelf components and componentized software.

Standards:

All software currently being written for medical-imaging systems have to confirm to the DICOM (Digital Imaging in Communication in Medicine) standards to ensure that different systems from different vendors can successfully share information. So, one can, for example, acquire the image from a Siemens, and do the processing on a Philips viewing station.

Viewing Stations:

Multimodal viewing stations (the same station being able to process say MRI as well as CAT scan images) are already in common use. Vendors are also able to send private information that only their own software and viewing stations can read, so as to enhance their equipment. For example, a Philips image-acquisitions system can acquire and transmit more information than prescribed by the standard. Such extra information can be deciphered only by a compatible Philips station, while say a Toshiba viewing station would get only the information prescribed in the standard.

Even though the basic job is that of image processing, the algorithms used in medical software can be vastly different from those say used in other commercial image-manipulation software like movie software or Photoshop. The reason behind this is that medical systems have to preserve a very, very high degree of accuracy and detail, or there could be fatal results, while such constraints may not exist for commercial image-manipulation software.

Colour or Grayscale:

Overall, the use of colour is less prevalent than the use of grayscale in medical imaging. But, there is a slow changeover to colour where it adds value. For example, in MRI, colour can better depict variations in internal tissue layers, and hence using colour here can add value. On the other hand, X-rays just provide a two-dimensional image of the bone structure, and hence adding colour here may not be of any value. To get colour, the acquisition system need not be colour enabled. The processing software can subsequently add colour to the image.

The internet has caused another major change that is happening in this field. On one side the equipment needs to be made capable of being used for remote diagnostics and telemedicine applications. On the other hand, Internet enablement makes it possible to remotely diagnose, repair and even software upgrade the machines themselves! How much effort does it take to create such a system? It takes up to a thousand people years (a hundred to a hundred and fifty people working form about five years) to develop an image-acquisition and processing system, ground up. And the bulk of the work is in the software effort.

Hardware in Medical Imaging:

We all know that the image processing and rendering requirements of even elementary games are huge. That is why the graphics cards of today build in humungous amounts of their own dedicated processors. But the volume of data they have to process pale to insignificance when compared to the volume of data handled by a medical image-acquisition system.

Unlike a gaming PC, where there is no separate image acquisition and where processing and display happen on the same unit, a medical image-acquisition system acquires the image at one point, and then transfers it to another point (for example, to a viewing station) for processing . And often, the acquisition and processing/viewing is real time, with the physician or technician adjusting the source, according to what is being viewed. Thus, a medical image-processing system should be capable of not only processing humungous amounts of image information, but also of transmitting the same amounts of information.

The computing systems used in these machines have to match processing and transfer requirements, which far exceed that of traditional PCs and workstations, even though they are classified as embedded systems, and many of them do not run anywhere near the gigahertz range of processor speeds that even entry-level PCs run.

Machines like a CT scanner run multiple embedded systems, with each doing specific job. On top of this there are specific microprocessors that control the movement of the gantry and the patient table.

Data that is acquired by systems like CT or MRI scanners is sent to processing equipment that are really workstations. Medical-equipment vendors have their own workstations.

Another area where IT equipment comes into play is in storage. Huge amounts of data are acquired by these imaging systems and need to be archived. Storage and archival systems start from hard disks and range through CD writers and different types of tape backup.

Many of these systems let service technicians' access, diagnose and repair them remotely. Such remote access is through secure connections over the Internet, using ISDN modems and the like.

Simulated Surgery:

Surgical simulation simulates the working environment of a surgical procedure using a computer and puts doctors in the perspective of the camera that is at the point of operation.

The first major shift from 'hand -eye connect' medical procedures was with the advent of tiny cameras and instruments that could be inserted into a patient's tract and monitored closely on a video monitor. Modern day endoscopic surgery relies on these tools to perform surgeries faster and with minimal risks. This is called MIS (Minimally Invasive Surgery). Doctors, however, found it a little difficult to them; hence, the surgical simulation. This concept is not restricted only to endoscopic procedures.

How It Works:

Surgery simulations are manipulation of already existing 3D models of organs. In essence, a surgical simulator performs three tasks: model organs and deformations, simulate actions like cutting of tissue and calculate and generate force feedback reactions. Models are generated by 3D-modeling software from real images taken during actual procedures. Data on the geometric and elastic properties of organs is also fed into the simulator. So much so that 3D model of vascular system is also superimposed to simulate the blood flow. To iteratively calculate the actions and reactions, FEM (Finite Element Modeling) is used. The force feedback system uses detachable surgical tools mounted on force-feedback devices. Untoward event scenarios and multimedia clips are incorporated to aid the process of learning.

VR(Virtual Reality) is extensively used in simulations for surgical training. This extends the concept of MIS, which already use video monitors extensively. An MIS simulation involves a computer-generated 3D model of surgical representations like body organs. The doctor then inserts instruments into the model and performs the surgery virtually.

VR ensures that the organs look and behave like them. So, organs would move, reflect light and get compressed when touched virtually. By means of VRML (Virtual Reality Modeling Language) and Java, the simulation is easy to model and implement. End users could even work on VRML-capable browsers. Doctors could go through multiple iterations on the virtual model before carrying out the procedure on the live patient.

Existing, virtual surgery tables are still in infancy. These are actual physical operating tables that have multi-user projection systems. They incorporate active and passive, high-resolution stereo projection system to enable a group of users to work on either side of the table on same or different set of data.

Computers and Dentist:

Filling of carious teeth, capping or crowing of teeth comes under restorative dentistry. Traditional restorative dentistry requires several visits by the patient, who must endure extensive drilling, the rubbery impression material in his mouth, a fragile temporary restoration, and a two to four week wait for the laboratory to fabric the crown.

CERC (Chair side Economical Restoration of Esthetic Ceramics), a computerized dental-restorative system, takes as less as an hour. It allows dentist to quickly restore damaged teeth with natural-colored ceramic (porcelain) filing, saving patient's time and inconvenience.

CERC uses CAD/CAM technology, incorporating an intra-oral digital camera, computer and milling machine in one instrument. The dentist uses this special camera to take an accurate picture of the damaged tooth. This optical impression is transferred and displayed on a color computer screen, where the dentist uses CAD technology to design the restoration. Then CAM takes over and automatically creates the restoration while the patient waits. Finally, the dentist bonds the new restoration to the surface of the old tooth. The whole process takes about one hour. The restorations have been proven precise, safe and effective.

Cosmetic dentistry, Cosmetic imaging, Dental radiography, Orthodontics are the other successful stories of using IT for dentists.

Remote Medicine:

Telemedicine is delivering medical diagnosis and treatment over long distances, either in real time (live) or store and forward modes. In real time, a patient consults the doctor over a teleconferencing system, while the patient's data is collected and transmitted to the consulting doctor. The data transmitted includes the patient's medical history. In store and forward, clinical data is collected, stored and latter forwarded for interpretation. So, the patient and doctor are not required to be available at the same time. Computing systems used here have to capture and store still or moving digital images, audio and text.

What technology do such techniques require? A secure (encrypted) telecommunications network (high bandwidth ISDN or satellite connections), network-conferencing systems, codecs (to compress very large, moving digital images), storage devices and database-management software all come onto play to create a stable and recurring telemedicine system.

Most telemedicine units are PC based, capable of transferring digital images over an ISDN-based WAN or LAN. High quality codecs and audio systems are important, as there can a lag between video and audio synchronization.

There are also room based telemedicine systems with one or two large screens. They may also have white-boarding features and scanner, printer and VCR interfaces.

In India, telemedicine has great scope, particularly given that the experts are in cities, where patients from far away towns and villages will have difficulty in accessing them. What started off as a social experiment by a few government hospitals is slowly drawing the attention of larger private hospital networks also.

Medical Transcription:

Amongst the services being outsourced to India, medical transcription is a well-known one. There's been a lot of talk about the logic of outsourcing: the low cost of English-speaking labor in India and the fast turn-around time because of the time difference between India and the US.

Briefly, here is what medical transcription involves. Doctors in the West record their diagnosis, prescriptions and a patient's medical history and send them as audio files to the medical transcription center (usually over e-mail). This makes security and having broadband connection important issues. Transcription equipment providers usually offer encrypted transmission over a network or the Internet, without the involvement of a third party.

At the transcriber's end, what hardware and software required? A PC (with sound card), foot pedal (to rewind, forward, pause and stop the audio files. This comes with the USB or serial connection), headset, line counter, medical dictionaries and books, lists of medical transcription references and transcription practice tapes. In terms of the software, you need a transcription application (one that can play most audio files: MP3, True Speech, Vox) and codec support on one's PC. Also important are medical and pharma spell-check tools (like Spellex Medical); a good spell checker contains spelling of diseases, medical procedures, surgical terms, medical acronyms and abbreviations. People trained in medical transcription and transcription checking is also needed.

Enhancing Medical Equipment:

Computers are being used to enhance the functionality of all types of medical equipment. This is being done either manufacturing process itself, or later on as an add-on. Two cases in point are two companies called Maestros and MIST (Medical Information and Software Technologies). While the former is into manufacturing of equipment for cardiology, gynecology and imaging, the later is into development IT solutions for the medical world. As for example, Maestro has developed a device called CardioVigil which using EPROM chips containing the controlling software can monitor three medical parameters, namely ECG, Oxygen content in blood, and non-invasive BP measurements (NIBP) of patients. The number of measurable parameters can go up to five by simply upgrading the EPROM chip. This device also has an RS232 interface for connecting it to a PC, and there is a Windows-based software for controlling. One CardioVigil device is kept to each patient's bed in a hospital ICU and those are connected to a single PC using a hardware interface box containing multiple RS232 ports for connecting those devices on one side, and a PC interface on another. This way all the patients can be monitored from a single remote location outside the ICU. MIST has many products, which can be used in various applications, including ultrasound, endoscopy, pathology and digital radiography.

Hospital Management:

There is a hospital information system called MEDICUS aimed at hospital & patient management. It stores and processes patient data, accounting information, hospital administration and inventory updates with a client-server approach. The interface is user-friendly and simple.

MEDICUS comes with a multimedia help feature. If the computer has a sound card, the audio help instructs the user at every stage. The multimedia help can be switched off at any stage. The application can run in Internet Explorer or Netscape. But as more as we say it will be too little about use of IT in medicine. There are so many fields of medical arena using IT nowadays, is beyond of scope to discuss in this article. And in many cases it is in infancy. But, hope, the day is not far when IT will be indispensable in medical science.

Lastly, a matter to add, there is a flip side to the usage of IT. The problem lies with the way we use it. In a well-established hospital at a given time several patients are fighting with their lives. These patients are under constant monitoring. So far so good. Only, right around midnight, an old dot-matrix printer starts its high-pitched screech somewhere inside the unit. Maybe they print bills or instructions for next shift. But, surely, the patients could have done without this unpleasant sound right at the time they are battling for life itself!