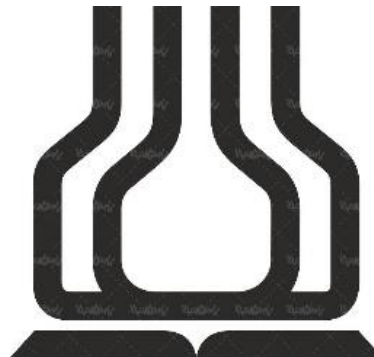


UNDERSTANDING THE USE OF INFORMATION TECHNOLOGY IN MEDICINE



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FURTHER READING

- Information Technology for health professions (4th edition), Lillian Burke & Barbara Weill, 2013 (whole book).
- E-Health Care Information Systems, Joseph Tan, 2005 (chapter 16).

مزایای استفاده از تکنولوژی اطلاعات در پزشکی

■ دسترسی به اطلاعات بیمار بطور همزمان و از راه دور

■ ارائه خدمات مراقبتی با کیفیت، سهولت و سرعت بیشتر

■ بهبود آموزش و تحقیقات

■ منطقی نمودن هزینه های خدمات مراقبتی

The application of technology in medicine

Technology	Application
Information Resources	Web-based information resources, patient access to electronic medical records, direct access to health information
Messaging	E-mail, chat groups, consumer health networks, personal clinical electronic communications (PCEC)
Telephone	Scheduling, triage
Remote monitoring	Remote monitoring of pacemakers, diabetes, asthma, hypertension, CHF.
Remote interpretation	PACS, remote interpretation of radiographic studies and other images, such as dermatologic and retinal photographs.
Videoconferencing	Wide range of applications, from low-bandwidth telehome care over telephone lines, to high-bandwidth telerobotics and telepsychiatry
Telepresence	Remote Surgery, telerobotics

Technology and Medicine



Hardware used in medicine

Cell phone

Cell phone: In places without electricity and without landlines, wireless networks using cell phones and PDAs (*Originally could hold only a notepad, a calendar, and an address book. These computers usually do not have keyboards but rely on touchscreen technology for input.*) are both bringing health information to people and gathering information to track the spread of disease.

Using cell phones, pagers, and handheld devices to alert patients about doctor's appointments, or remind patients of scheduled medication, vitamins or supplements, self-administered blood sugar tests, walking and stretching exercises. Physicians can write prescriptions on cell phones & PDAs.

The use of **Global Positioning System (GPS) technology**, which can pinpoint your location to within several feet, is widely available.



Spirocall: measuring lung function over a phone cell



Peek vision: a portable eye examination kit on smartphone



mHealth (mobile health)

Medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices as well as wearable devices such as smart watches .



mHealth involves the use and capitalization on a mobile phone's core utility of voice and short messaging service (SMS) as well as more complex functionalities and applications including general packet radio service (GPRS), third and fourth generation mobile telecommunications (3G and 4G systems), global positioning system (GPS), and Bluetooth technology.

OPPORTUNITY OR THREAT?



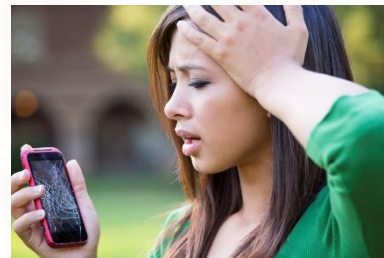
AS A THREAT



In 2011, International Agency for Research on Cancer (IARC) classified mobile phone radiation possibly Carcinogenic.



Risk of Traffic Accidents:
3-4 times higher



Mental Health issues
such as Stress and
Sleep Disturbances



Risk Of Chronic Pain
&
Eye Vision Problems



Risk of the Quality of
Doctor - Patient
Relationship



Environmental Impacts



Costs



Security & Privacy



Addiction

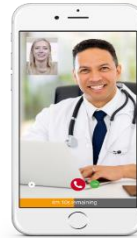
AS AN OPPORTUNITY



Soon everyone will have access to mobile phone



Voice Call



Video Call



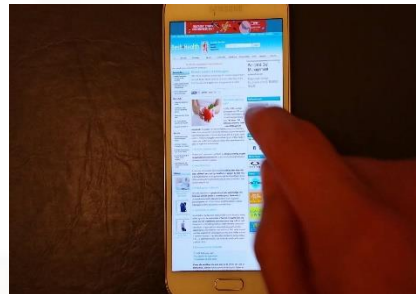
Text message



Wireless Connections



picture taking



Internet Browsing



Apps



Social media

The embedded computer

The embedded computer: is a single-purpose computer on a chip of silicon, which is embedded in anything from appliances to humans. An embedded computer may help run your car, microwave, pacemaker, or watch. A chip embedded in a human being can dispense medication, among other things.



Digital Camera

Digital Camera: Vision input systems are currently being developed and refined. A computer uses a camera to digitize images and stores them. The computer “sees” by having the camera take a picture of an object. The digitized image of this object is then compared to images in storage. This technology can be used in adaptive devices, such as in glasses that help **Alzheimer’s patients**. The glasses include a database of names and faces; a camera sees a face, and if it “recognizes” the face, it gives the wearer the name of the subject.



Smart glasses for blind people

HOW THEY WORK

1 Infra-red laser beams out thousands of spots of light

2 Normal video camera records detail

3 Infra-red camera picks up reflected spots from objects and sends to a computer in rucksack. Position of spots reveals an object's shape and distance

4 Images from both cameras are merged and projected on to glasses. The closer the object the brighter the image

5 Cameras could scan written information such as bus numbers and relay through earpiece

The diagram features a man wearing the smart glasses. Red dotted lines with arrows represent the laser beams and reflected spots. An inset image shows a dog's head, and another inset shows a white line drawing of the dog's head, illustrating the depth-sensing technology.

Speech input systems

Speech input systems: allow you to talk to your computer, and the computer processes the words as data and commands. A system geared toward medicine would include an extensive vocabulary of digitized medical terms and would allow the creation of patient records and medical reports. This system can be used as an input device by physicians who, in turn, can dictate notes, even while, for example, operating.

Speech recognition is also especially beneficial as an enabling technology, allowing those who do not have the use of their hands to use computers.



Sensors

Sensors: A sensor is a device that collects data directly from the environment and sends those data to a computer.

Sensors are used to collect patient information for clinical monitoring systems, including physiological, arrhythmia, pulmonary, and obstetrical/ neonatal systems. In critical care units, monitoring systems make nurses aware of any change in a patient's condition immediately. They detect the smallest change in temperature, blood pressure, respiration, or any other physiological measurement.



Sensors



Mobile Phone Serves as ECG device



Human-biology input devices

Human-biology input devices: allow you to use your body as an input device. Biometrics identify people by their body parts. Biometrics include fingerprints, hand prints, face recognition, and iris scans. For instance, **Line-of-sight** input allows the user to look at a keyboard displayed on a screen and indicate the character selected by looking at it. Implanted chips have allowed locked-in stroke patients to communicate with a computer by focusing brain waves (brain wave input).



Smart glasses can see cancer



wireless technologies

Bluetooth: Bluetooth technology is used to create small personal area networks. Bluetooth is a **wireless technology** that can connect digital devices from computers to medical devices to cell phones. For example, if someone is wearing a pacemaker and has a heart attack, his or her cell phone could automatically dial 911.

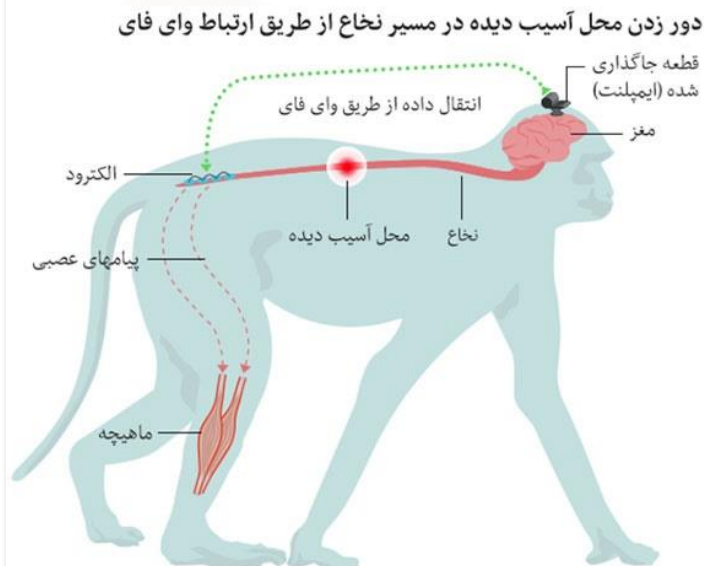
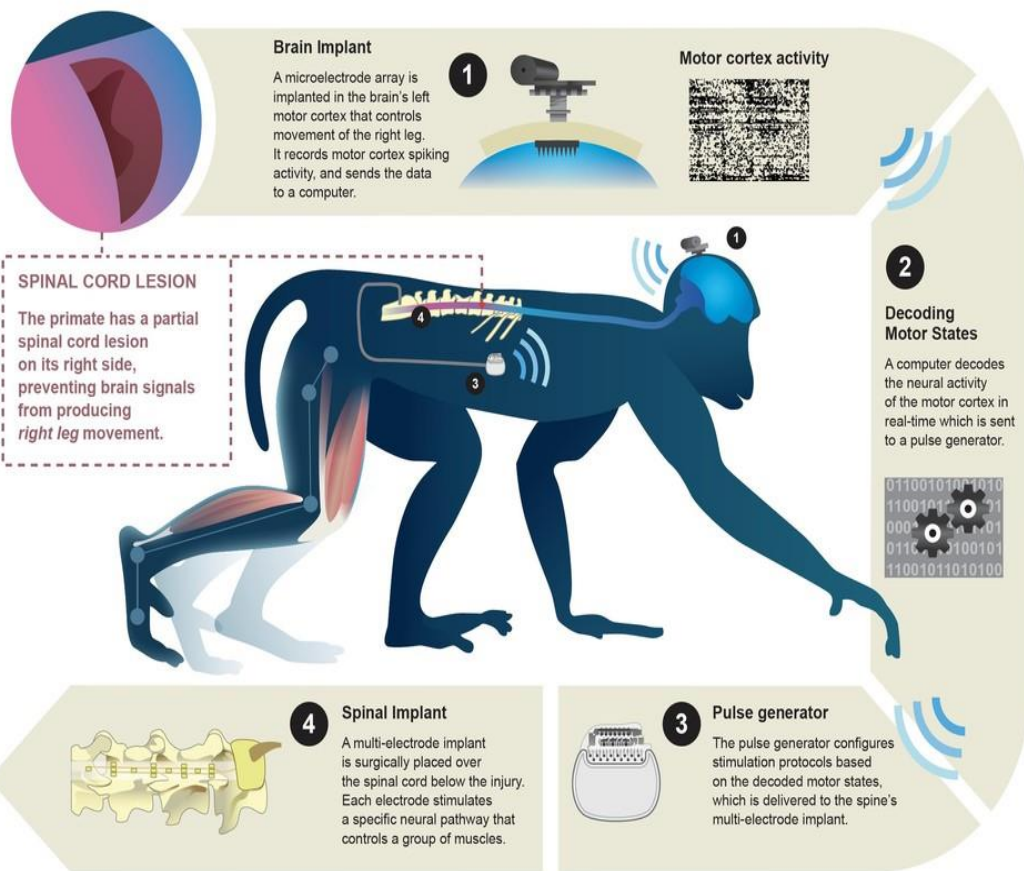
Wi-Fi: is a **wireless technology** that allows you to connect, for example, a PDA (and other devices) to a network (including the Internet) if you are close enough to a Wi-Fi access point.



Brain and spine implants let a paralyzed monkey walk again

Primates Regain Control of Paralyzed Limb

Non-human primates regain control of their paralyzed limb. A neuroprosthetic interface serves as a wireless bridge between the brain and spine, completely bypassing the injury.



Near Field Communication (NFC) technology

Near Field Communication (NFC) technology: is a **wireless communication** standard which enables two devices in a short range to establish a communication channel within a short period of time (100-150 milliseconds) through radio waves in the 13.56 MHz frequency range. NFC can be a useful technology for data transfer between two devices (two-way connections) in close proximity to one another (less than 10 cm). It is more secure than other wireless technologies like Bluetooth and Wi-Fi. The biggest differentiating factor for NFC over RFID is that it is a two-way communication tool, one of the devices/cards can have a passive NFC tag.

In particular **Implantable Medical Devices (IMD)** require privacy and security to reduce the third party interference and proper health maintenance. These features can effectively be achieved by NFC compared with other wireless technologies. For example, using **heart rate monitors**

WIRELESS IMPLANTABLE MEDICAL DEVICES



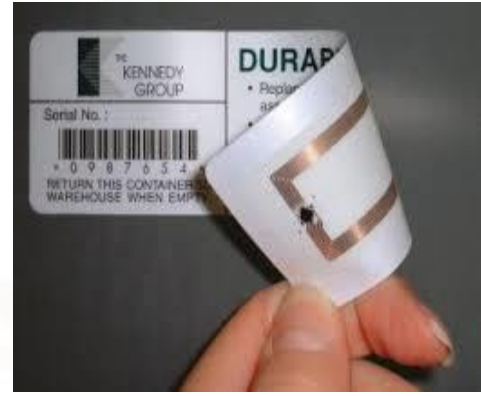
Radio frequency identification (RFID)

Radio frequency identification (RFID) tags: is the wireless non-contact use of radio-frequency electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking tags attached to objects. The tags contain electronically stored information e.g. medical history.

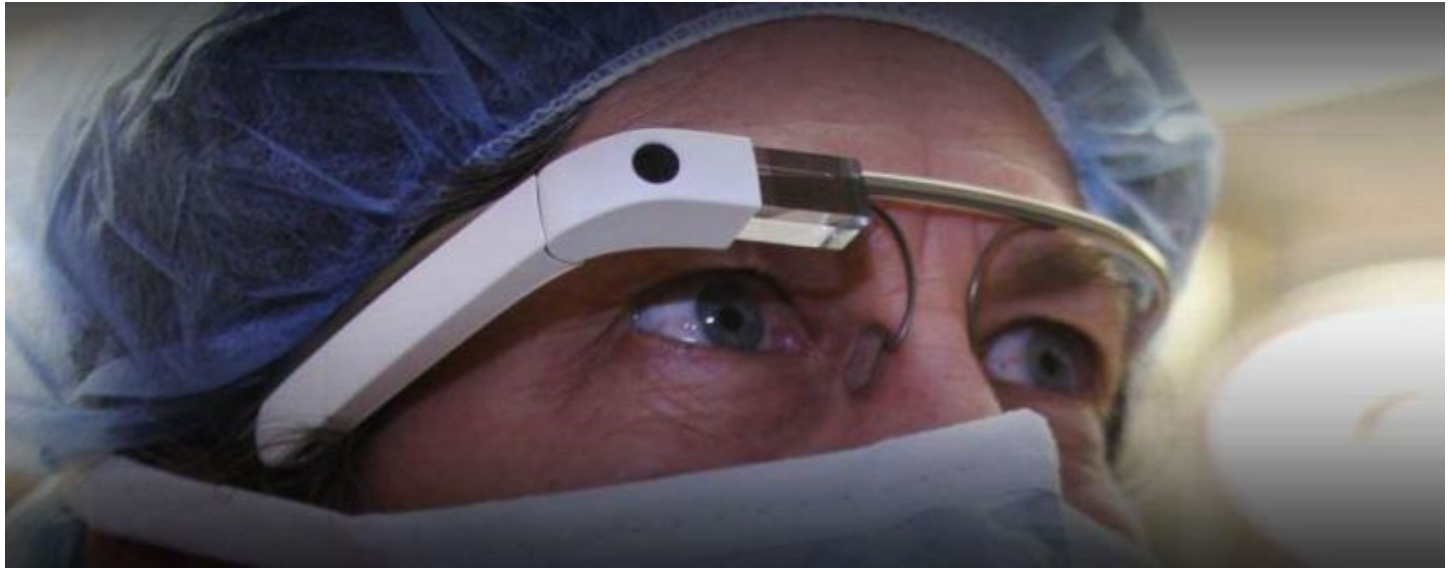
Radio frequency identification (RFID) is part of the family of Automatic Identification and Data Capture (AIDC) technologies that includes 1D and 2D bar codes. It is now used to identify anything the surgeon left in your body.



Small RFID chip, here compared to a grain of rice, is incorporated in consumer products, and implanted in pets, for identification purposes



Wearable Intelligence in Healthcare



Robots in medicine

DA VINCI: A robotic surgical system. It is designed to facilitate complex surgery using a minimally invasive approach, and is controlled by a surgeon from a console. It was made by the American company Intuitive Surgical in 2000.

RIBA: An improved nurse robot called Riba (Robot for Interactive Body Assistance) that can lift patients from beds and wheelchairs. Developed in Japan (in 2009). The robot can lift a patient up to 80 kg in weight.

PARO: Therapeutic Robot. PARO is an advanced interactive robot developed by AIST (in 2001), a leading Japanese industrial automation pioneer.



Paro: healing robotics seal



VGO: It is located in Nashua, NH, USA (in 2007). It replicates a person in a distant location. See, hear, talk and move around as if you were there. For healthcare staff and doctors, students, remote workers, and visitors in healthcare, education, and business.



PEARL: An American robot. University of Pittsburgh and the Carnegie Mellon University developed the Pearl nurse robot (in 2000). It is a personal and social robot which helps the elderly go about their daily routines. The Pearl can remind the elderly about their hygiene, physicians' visits, and other vital information that they also remotely send to human caregivers and health providers. Pearl can also act as a companion, especially to patients who are living alone, as this robot is also socially active.



Nurse bot Pearl



موارد کاربرد تکنولوژی اطلاعات در پزشکی

- کاربردهای مدیریتی (Administrative Application)؛ شامل استفاده از کامپیوتر در امور مربوط به اداره امور بیمار می باشد.
- کاربردهای بالینی (Clinical Application)؛ شامل استفاده از کامپیوتر در خدماتی که بطور مستقیم مربوط به مراقبت از بیمار می باشد نظیر خدمات تشخیصی و درمانی.
- کاربردهای اختصاصی (Special Purpose Application)؛ شامل استفاده از کامپیوتر برای کاربردهای خاص مانند آموزش و تحقیقات می باشد.

❖ انجام امور اداری و دفتری نظیر ارسال و دریافت و آماده سازی نامه های الکترونیکی

❖ نرم افزارهای حسابداری شامل صورتحساب های بیمار، دریافت ها، پرداخت ها، لیست های بیمه و دستمزد کارکنان، گزارشات بستانکاری ادارات بیمه طرف قرارداد، انبارداری و اموال مانند **EMC (electronic media claim)**

❖ نرم افزارهای پذیرش و ترخیص شامل تعیین وقت ملاقات، انتقال، تهیه آمار، کد گذاری

کاربردهای بالینی (Clinical Application)



Using message (e-mail) in patient care

- Prescription renewals
- Appointment requests
- Referrals to specialists
- Name, address, phone number, or insurance information changes
- Non-urgent medical issues
- Monitoring chronic conditions (e.g., diabetes, asthma, headaches)
- Monitoring effects of therapy
- Follow-up on behavioral interventions (e.g., smoking cessation, dietary changes)

Situations in which message (e-mail) should not be used

- Medical emergencies or time-sensitive issues because of its asynchronous nature
- Issues requiring lengthy messages
- Issues requiring negotiation through long volleys of messages that become cumbersome
- Communicating bad news, which is best done in person
- Sensitive issues at risk of disclosure due to potentially weak security mechanisms
- When confronted with a patient who is unable to respond electronically

Video games are changing medical practices



Video games as treatment for traumatic brain injuries: gaming improves attention, problem solving



Recovering from a stroke: her arm motions move a fish around a rectangle in a video game .

Bedside Monitoring

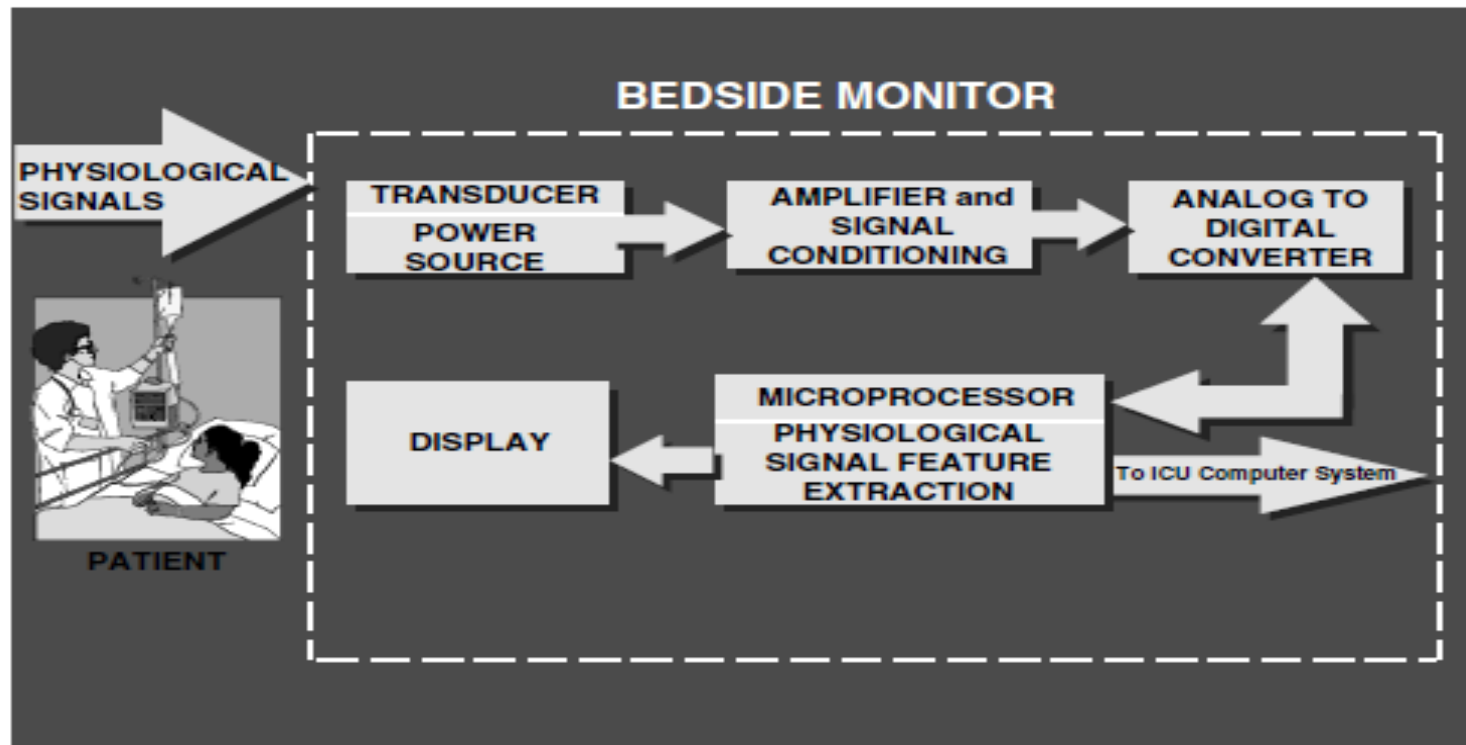


Figure 17.3. Block diagram of a modern Bedside Monitor. Physiological signals from the patient are acquired by transducers. These transducers convert the appropriate physiological signal into an electrical signal that is then amplified and conditioned (usually an analog filter of some sort) and then present the signal to an Analog to Digital converter (ADC) . The ADC sends the data to a microprocessor based signal processor which extracts features such as heart rate and blood pressure. After processing, the physiological signals are displayed on a display device and usually sent to a centralized ICU display system and frequently to a electronic patient record.

Point Of Care Systems

POC (point of care) systems include services provided to patients at the bedside such as diagnostic and laboratory testing using automated information entry systems.



For example, automated data capture from bedside medical devices is now possible using the IEEE MIB 1073 communications standards (the Institute of Electrical and Electronics Engineers Medical Information Bus P1073 standard) . With these standards in place, it is possible for vendors and hospitals to implement “plug and play” interfaces to a wide variety of bedside medical devices such as bedside monitors, IV pumps, and ventilators.

Bedside Electronic Devices



Figure 17.11. Blood analysis point of care device and a bedside physiological monitor. (Source: Courtesy of Philips Medical Systems.)

TELEMEDICINE

Telemedicine uses computers and telecommunications equipment to deliver medical care at a distance. From plain old telephone service to the Internet.

The medical information transmitted can be in any form including voice, data, still images, and video.

- * Teleconferencing: videoconferencing, Tele-consulting, telecommunication, used in prison
- * Telesurgery: robotic surgery
- * Teleradiology: uses store and forward technology
- * Telecardiology: heart and lung sound, chest pain, pacemaker
- * Telepathology: microscopic images
- * Telenursing: telehome cares, remote monitoring, recommendation, teletriage (the method of deciding who receives medical treatment first, according to how seriously someone is injured or needed).
- * Remote Monitoring: used in ambulances, telehome cares
- * Telepharmacy
- * Teledentistry

Telepresence

- Telepresence involves systems that allow clinicians to not only view remote situations, but also to act on them e.g., Telesurgery, nursing home and other long-term facilities, remote video rounds
- Telepresence requires high bandwidth, low latency connections.
- uses **Real-time** (live interactive or Synchronous) technology



Remote presence



Image Courtesy of InTouch Health

STORE-AND-FORWARD TECHNOLOGY

Store-and-forward (SAF) technology involves sharing information in a time- and place-independent way over the Internet. The information is **stored**, digitized, and then **sent (Asynchronous)**. If a medical specialty is image based, store-and-forward technology may be appropriate. The information may include digital images and clinical information. It may be as simple and inexpensive as attaching an image to an e-mail and sending it over telephone lines. store-and-forward technology is cheap and does not require sophisticated equipment or broadband lines. The earliest use of store-and-forward technology was in **teleradiology**. It is appropriate to specialties where diagnosis is based on images, such as **dermatology** and **pathology**.

INTERACTIVE TECHNOLOGY

Allows doctors to consult with each other and with patients in **real-time (Synchronous)**, at a distance. A patient may be in his or her primary physician's office with a camera and a telecommunications link to a specialist's office. All can see and hear each other in real time. It might require only a video-phone and a connection to the Internet. However, the most sophisticated systems involve microphones, scanners, cameras, medical instruments, and dedicated telephone lines. One form of **video-conferencing** is the remote house call, involving only one medical practitioner and a patient in another location.

INFORMATION TECHNOLOGY IN RADIOLOGY

- Digital X-ray: less radiation, 3-D, quality is the same, Can be Manipulated and shared, more expensive
- Ultrasound: computer generates an image, producing a 2-D moving picture on a screen.
- Digital imaging: Computerized Tomography Scan, Magnetic Resonance Imaging, Positron Emission Tomography, Single Photon Emission Computer Tomography
- Interventional radiology (Bloodless Surgery)

مزایای کاربرد تصویر برداری پزشکی دیجیتالی

- ایجاد تصاویر شفاف تر، درست تر و با جزئیات بیشتر از اندامهای داخلی
- ایجاد تصاویر سه بعدی
- امکان تصویر برداری از بافتهای نرم و عملکردهای شیمیایی مغز
- کاهش نیاز به جراحیهای کاوشگرانه
- کاهش مدت اقامت در بیمارستان
- انجام اعمال جراحی دقیق تر و بهتر
- کمک به تشخیص بهتر بیماریهای مغزی

INFORMATION TECHNOLOGY IN SURGERY

❄️ **Computer-Assisted Surgical Planning: Virtual environment, Virtual Reality (VR) Technology** (is a computer-simulated environment that can simulate physical presence in places in the real world or imagined worlds. Virtual reality could recreate sensory experiences, including virtual taste, sight, smell, sound, touch, etc.). For example, VR software enables estimates of cancer invasion to surrounding organs based on virtual cancer images of individual patients.

❄️ **Minimally Invasive Surgery (MIS)**

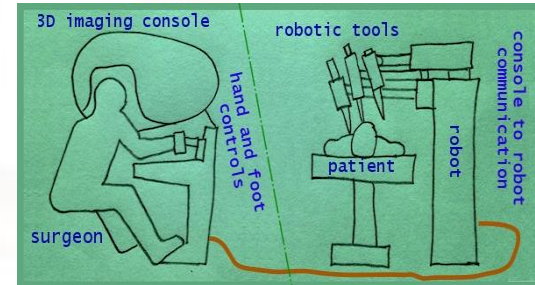
❄️ **Computer Assisted Surgery and Robotics**

❄️ **Tele-presence Surgery**

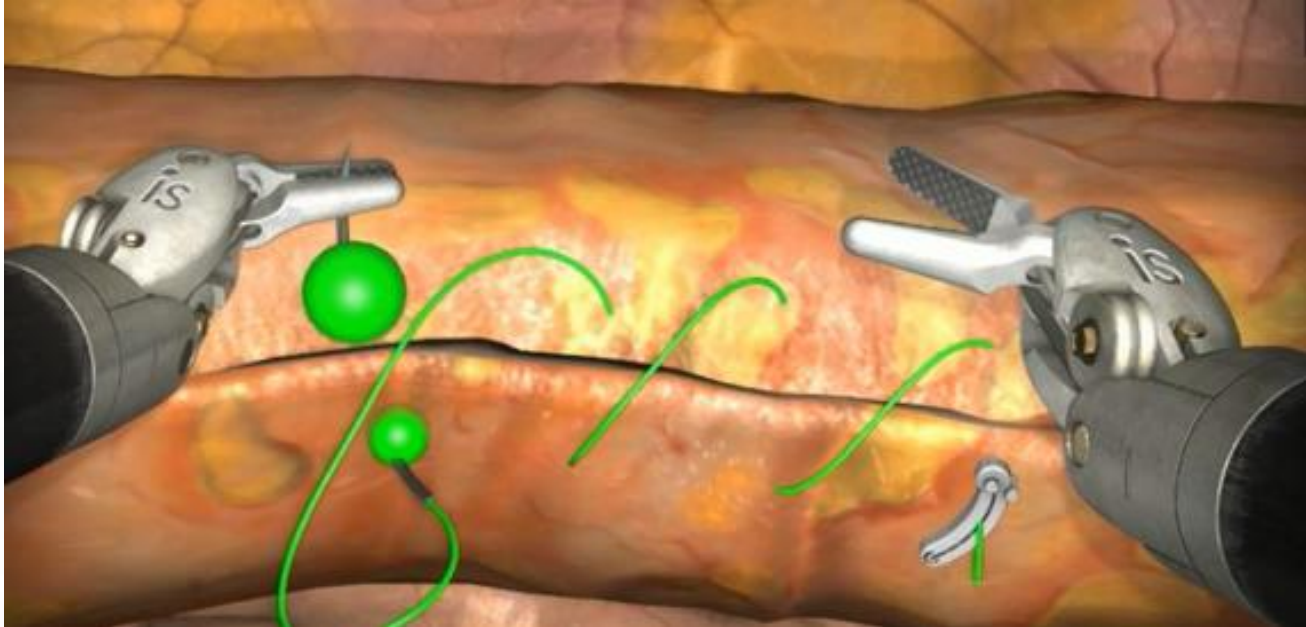
❄️ **Augmented Reality Surgery:**



Virtual Reality Pain Reduction



Robotic Surgery



آیا تاکنون جراحی از راه دور در دنیا انجام گرفته است؟

اولین جراحی از راه دور بر روی انسان با استفاده از ربات بیش از پانزده سال پیش یعنی در ابتدای قرن ۲۱ صورت گرفته است. این عمل جراحی **Lindbergh Operation** نام گرفت.

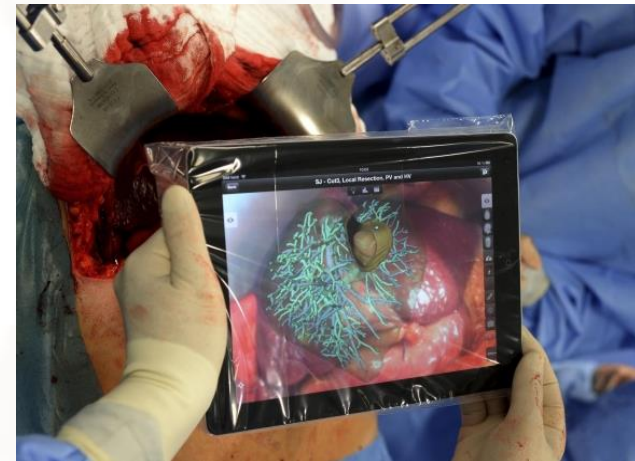
در ۷ سپتامبر ۲۰۰۱ در طی یک عمل جراحی از راه دور در فاصله ۶۴۰۰ کیلومتری از تیم جراحی، کیسه صفرای زنی ۶۸ ساله که در بیمارستان دانشگاهی **Strasbourg** فرانسه بستری شده بود، توسط تیم جراحی که در نیویورک آمریکا قرار داشت، برداشته شد. پزشک مستقر در نیویورک

پروفسور **Jacques Marescaux** وسایل جراحی قرار داده شده در اتاق عمل را توسط ربات بکارگیری کرد. این عمل با کمک خط فیبر نوری پرسرعت و با استفاده از سیستم جراحی روباتیک لاپاروسکوپی **Zeus** به مدت ۵۴ دقیقه به طول انجامید. در این عمل بیمار بعد از یک هفته فعالیت عادی خود را از سر گرفت.



Augmented Reality

Augmented reality is the integration of digital information with the user's environment in real time. Unlike **Virtual Reality**, which creates a totally artificial environment, augmented reality uses the existing environment and overlays new information on top of it. Boeing researcher **Thomas Caudell** coined the term augmented reality in 1990.



Augmented reality iPad app used in liver surgery to aid tumor resection

Intra oral Fiber Optic Camera:

نمایش تصاویر از کانال ریشه و نمایش آن روی صفحه نمایش جهت دندانپزشک و بیمار
تهیه مدل تاج دندان با استفاده از نرم افزارهای کامپیوتری

Cosmetic Dentistry:

ایجاد یک تصویر فرضی از صورت بعد از عمل به منظور نمایش تغییرات

Digital Radiography

Digital Imaging Fiber Optic Transillumination: the transmission of light through tissues of the body

Surgery: Planning, Dental Implants

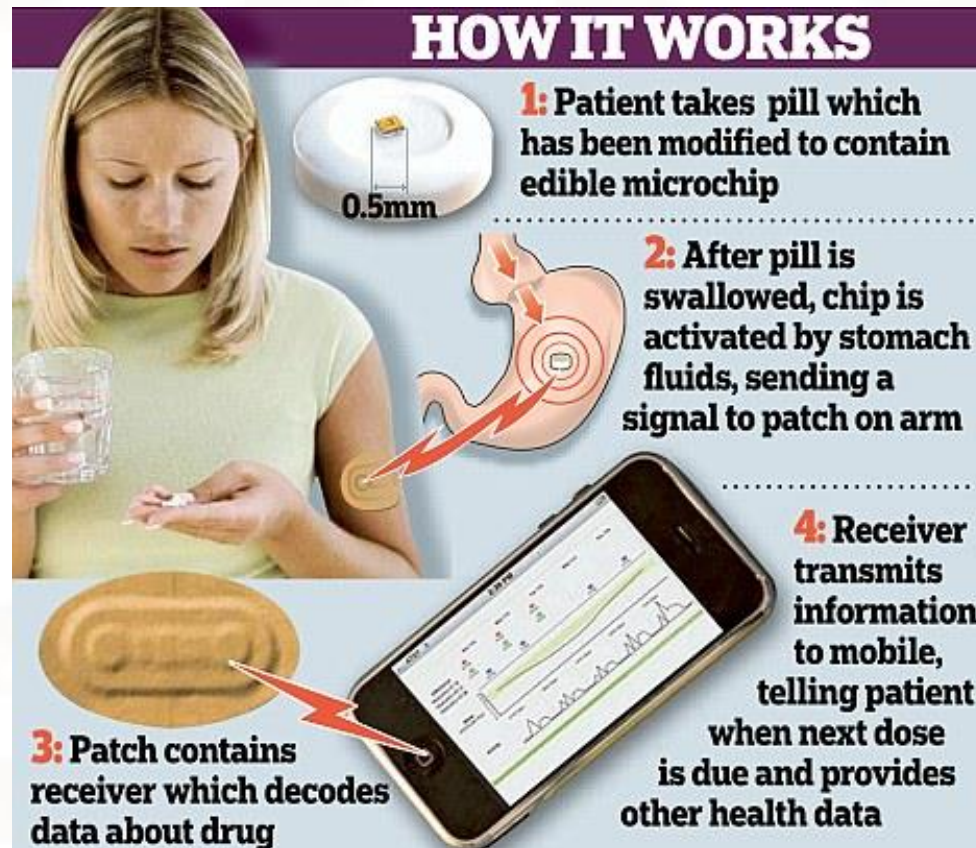
Use of **3-D visualization** tools coupled with interactive modeling (which allow the users to participate actively) allows dentists to better understand jaw articulation, while simulation of jaw movements helps dentists to deal with complex contact points and observe the actual functioning of the human jaws, thereby learning how to better treat their patients.

■ استفاده از نرم افزار در کمک به طراحی و آزمایش داروهای جدید: از طریق ایجاد مدل های گرافیکی سه بعدی از مولکول های هدف.

- Computer- Assisted Drug Trials: To simulate Clinical Trials
- Computer- Assisted Drug Review and Approval Process
- The Computerized Pharmacy: Drug order, Patient's Medication Profile
- Computer Warning and Drug Errors: Prescription errors (legible, dosage), Medication errors, Drug Interactions, Patient's Allergies

- **The Automated Community Pharmacy:** use of Robotic systems and Bar cods
- **Automating Drug Distribution Systems:** similar to ATM machines
- **Point of use drug dispensing:** at the nursing unit
- **Drug Delivery on a Chip:** deliver several medication, deliver specific doses at predetermined times

Intelligent or Smart Pills: The chips in the pills send signals to a patch attached to the patient's shoulder when swallowed. Technology in the patch monitors when the pills are swallowed and can send a text if the patient forgets to take medication.



BoxPicker: automated pharmacy storage system



- ◆ **Computerized Functional Electrical Stimulation:** electrical stimulation to muscles
- ◆ **Computerized Monitoring Systems:** physiological monitoring systems, arrhythmia monitors, pulmonary monitors, fetal monitors, neonatal monitors
- ◆ **Computerized Devices in Optometry / Ophthalmology :**
Corneal topography

3D-printed prosthesis



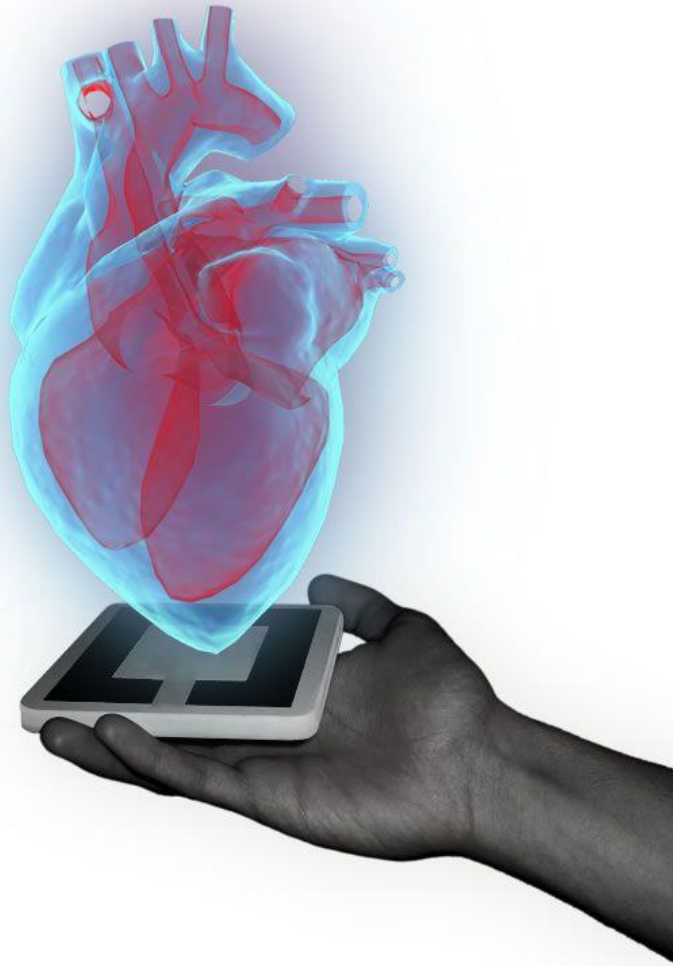
کاربردهای اختصاصی

(Special Purpose Application)



- **Computer Assisted instruction:** virtual human anatomy, three-dimensional (3-D) visualization of anatomy (also is used in surgery), software, using augmented reality.
- **Virtual reality simulations:** For example, those with Down's syndrome and autism. The **Learning in Virtual Environments (LIVE)** program is the product of a network of researchers working together to develop tools for severely **learning-disabled people**. In this instance, users are exposed to virtual activities that simulate real life scenarios such as riding on a plane or shopping at a market to give them a feel of what can happen in real life activities.
- **Critical situations:** For example, Software can be combined with geographical information systems to simulate rescue operations for terrorist attacks.

Augmented Reality- the heart



Virtual Reality of Human Anatomy



INFORMATION TECHNOLOGY IN MEDICAL RESOURCES

- Digital Library: ebooks, ejournals
- Databases: PubMed, *Cochrane*

