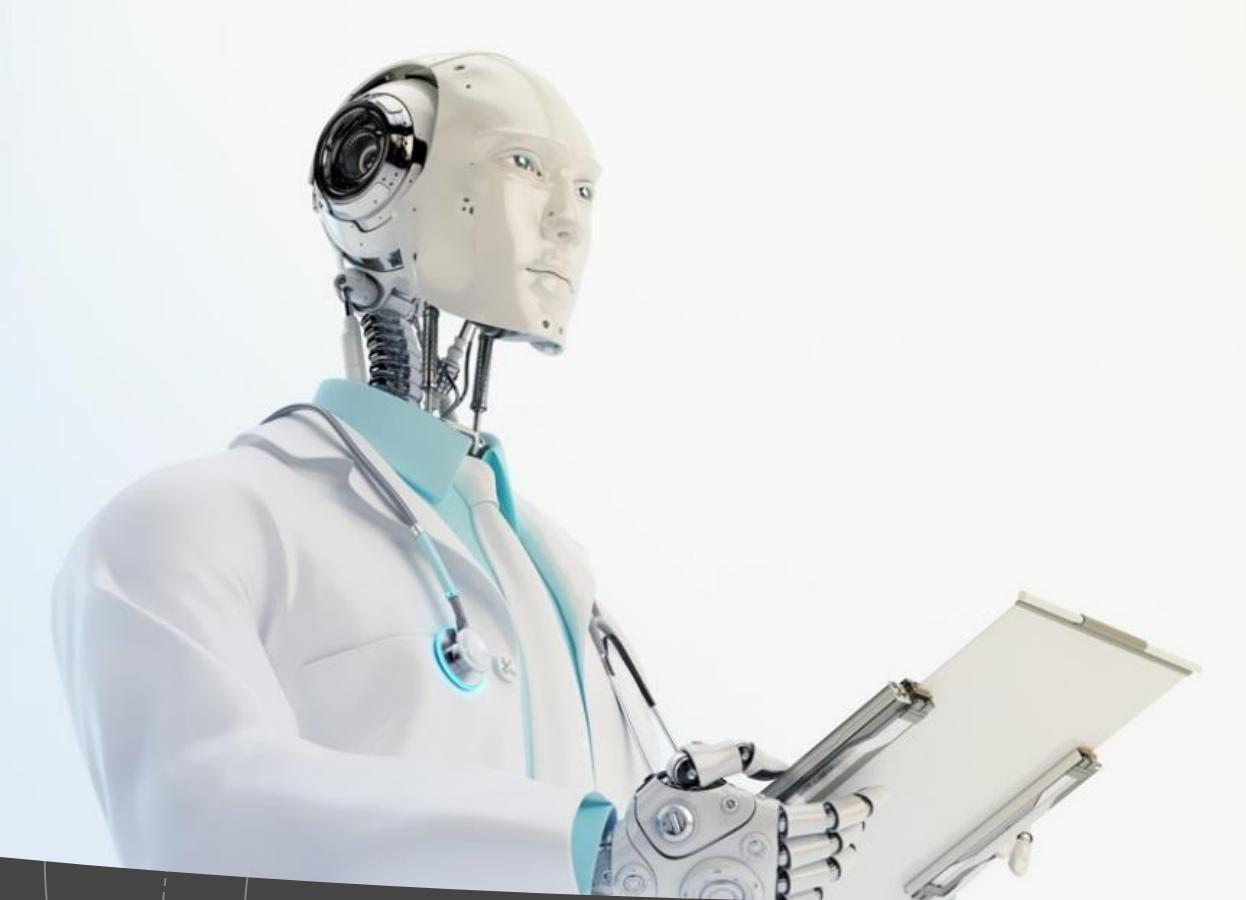


## Section 9

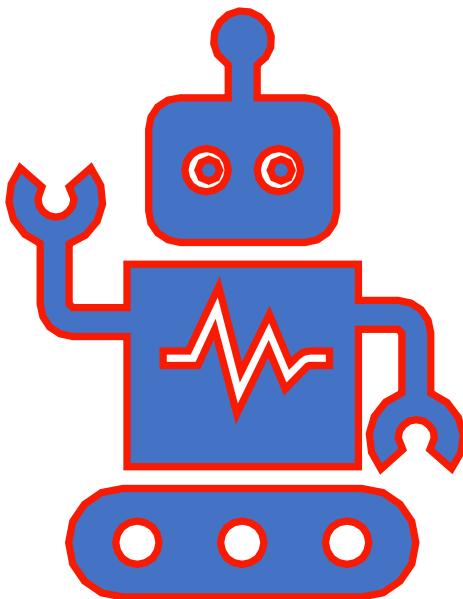
# Advances in Medical Technology

sinead.barton@mu.ie



# Medical Robotics and Technology

# Areas of Development



- Prosthetics – artificial limbs
- Assistive Technology/HomeCare
- Advanced Sensing
- Operating Theatre Technology
- AI controlled Diagnosis

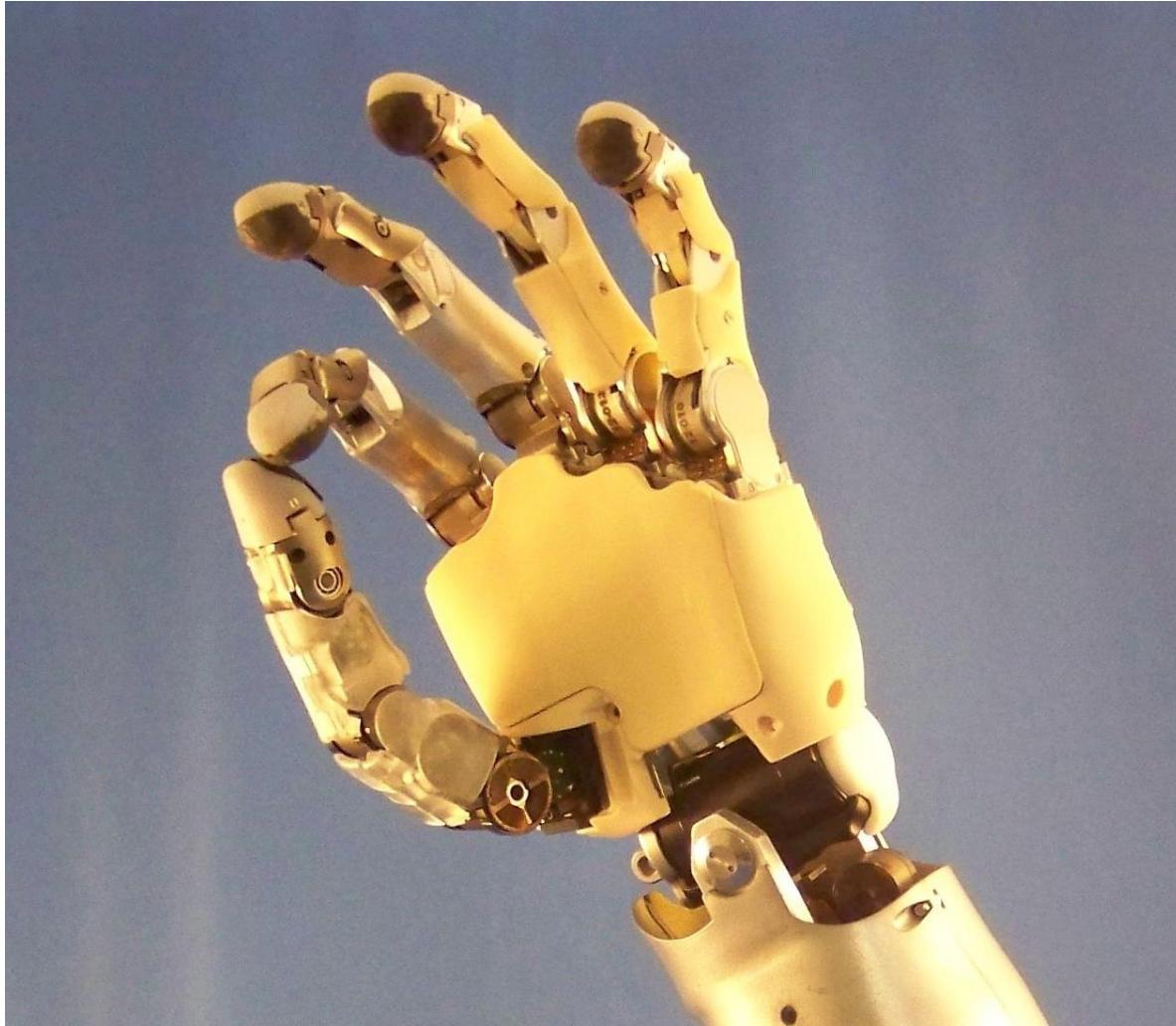
The greatest area of advancement is not in robotics but in intelligent machines. Advanced sensing and interpretation of the results.

Prosthetics and human replacement is the next big area at the moment.

Robotic Homecare has huge potential but suffers from the same “human experience” quality issues as child-care.



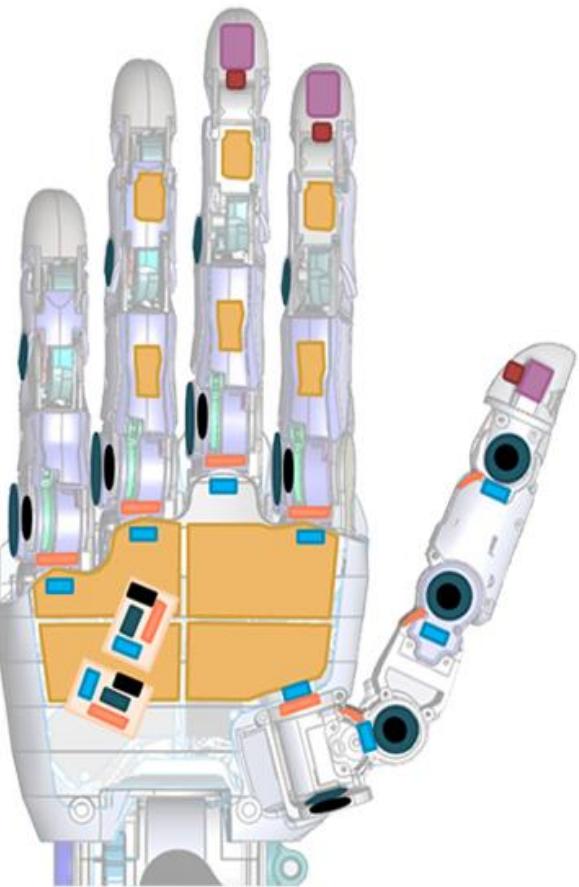
# Prosthetics - Victorian



## Prosthetics – Modern Era

Usually wrapped in a fake skin to make  
it look more realistic

# Prosthetics – Modern Era



Key	Sensor	Number
■	Absolute Position Sensor	21
■	Contact Sensor	10
■	Torque Sensor	14
■	Joint Temperature Sensor	17
■	3-Axis Accelerometer	3
■	3-Axis Force Sensor	3
■	Additional Sensors	41
	▪ Incremental rotor position (x17)	
	▪ Drive voltage (x17)	
	▪ Upperarm drive current (x7)	

- A very complex combination of sensors, motors, processors.
- In this example 109 sensors.
- Each finger joint needs a motor and then multiple motors in the palm
- You need special control to make sure everything works correctly and provides appropriate feedback
- No squishing allowed.

# Challenges in Prosthetics

It is possible to build very precise machines that do pre-programmed actions.

The real challenge is integration into the human. If you don't do this, then it's a wraparound to a person and it's not much better than a Victorian model.

Active prosthetics require

- an ability to provide sensory feedback to the brain
- an ability receive orders from the brain

You need to interface with the sensory and nervous system of the body

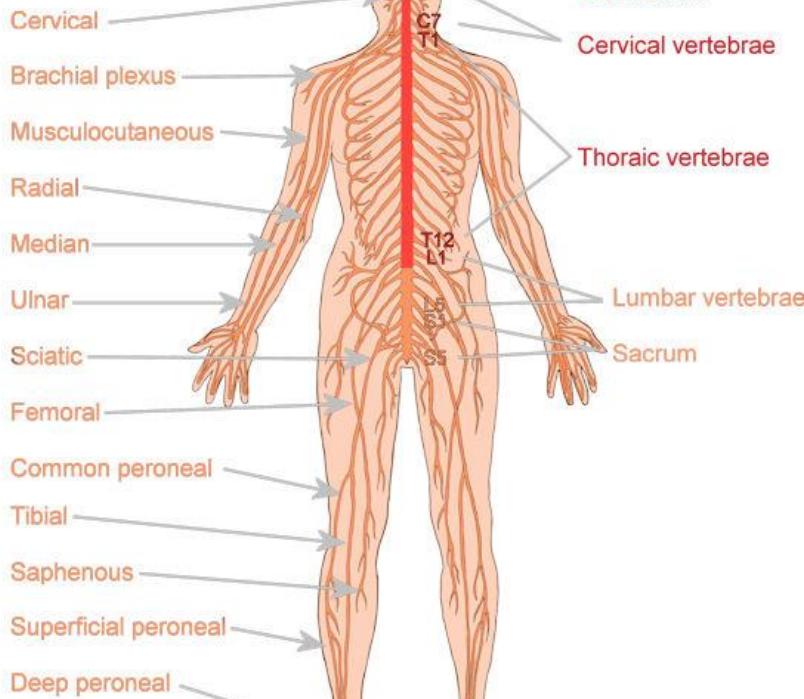
This area is called “neuro-prosthetics”

Some bits are easier than others.

## The Nervous System

### Peripheral Nervous System

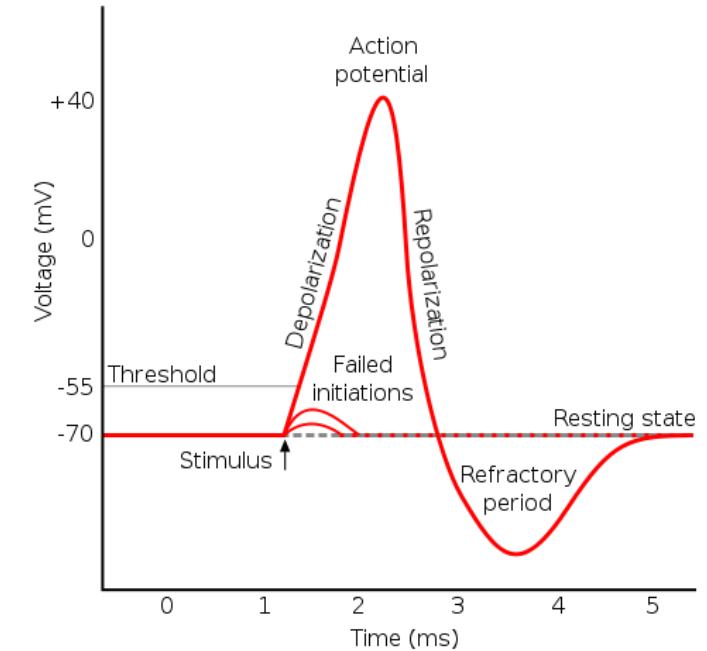
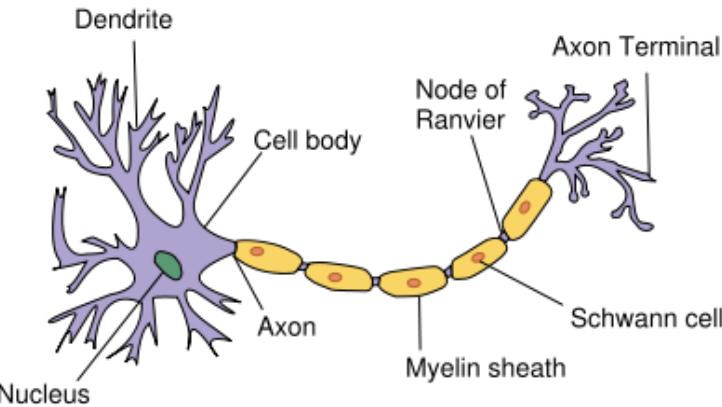
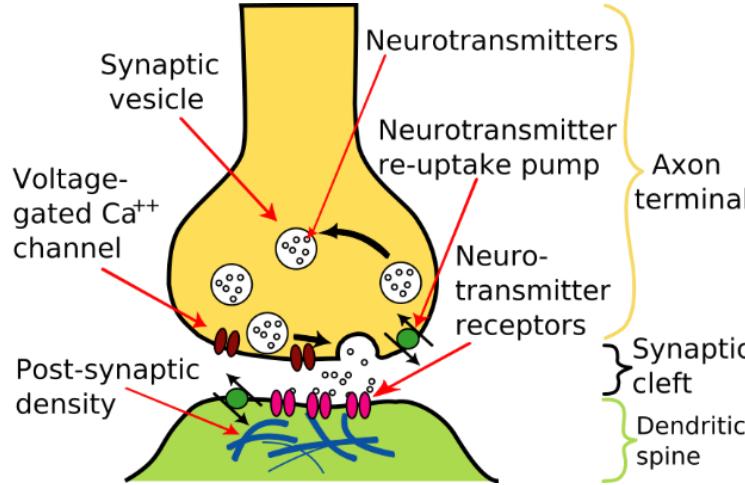
(the major Somatic (sensory and motor pathways to the extremities are labeled below)



© 2011 Essential Oils Books

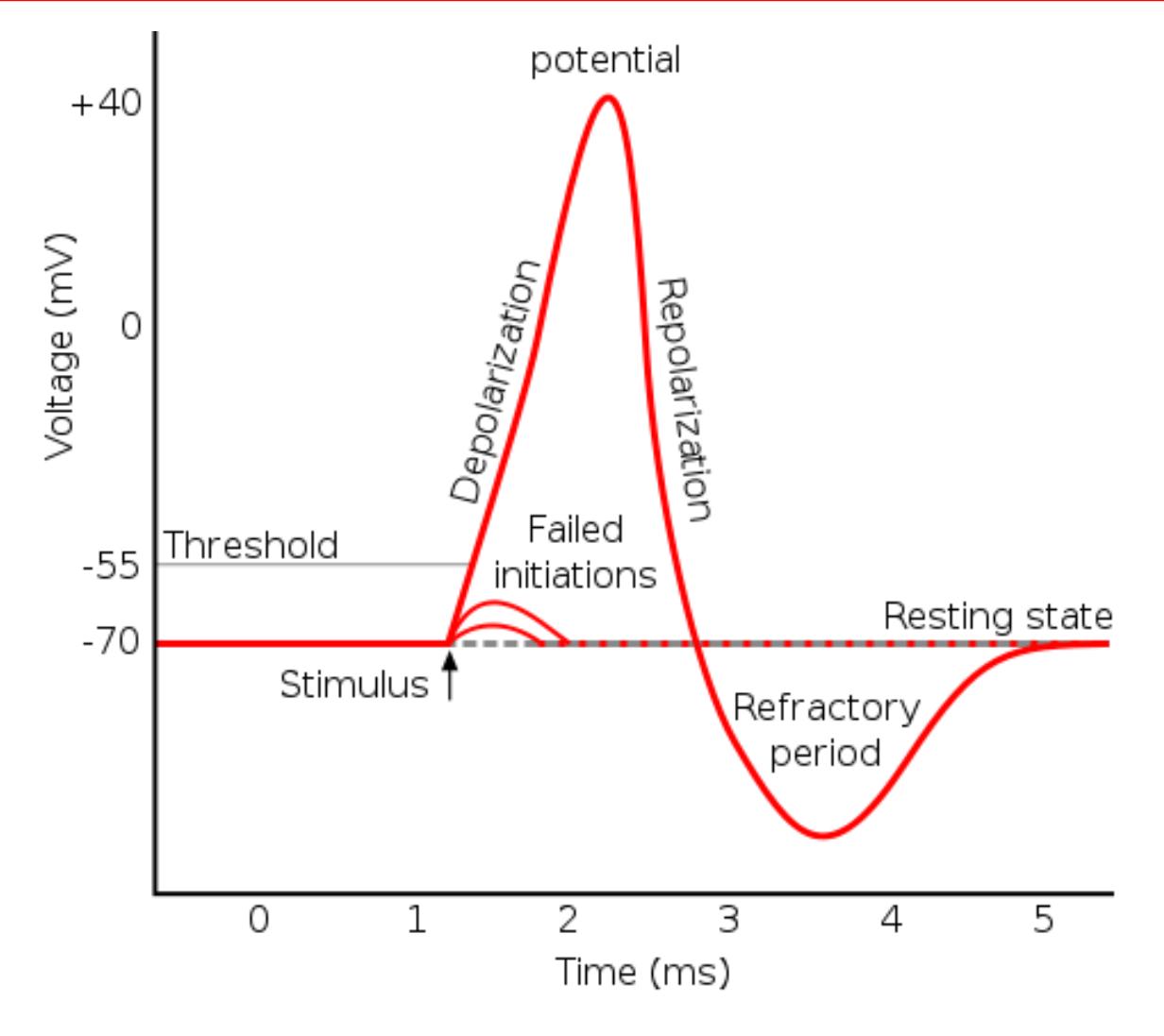
## Central and Peripheral Nervous System

**The nervous system is an electrical system**



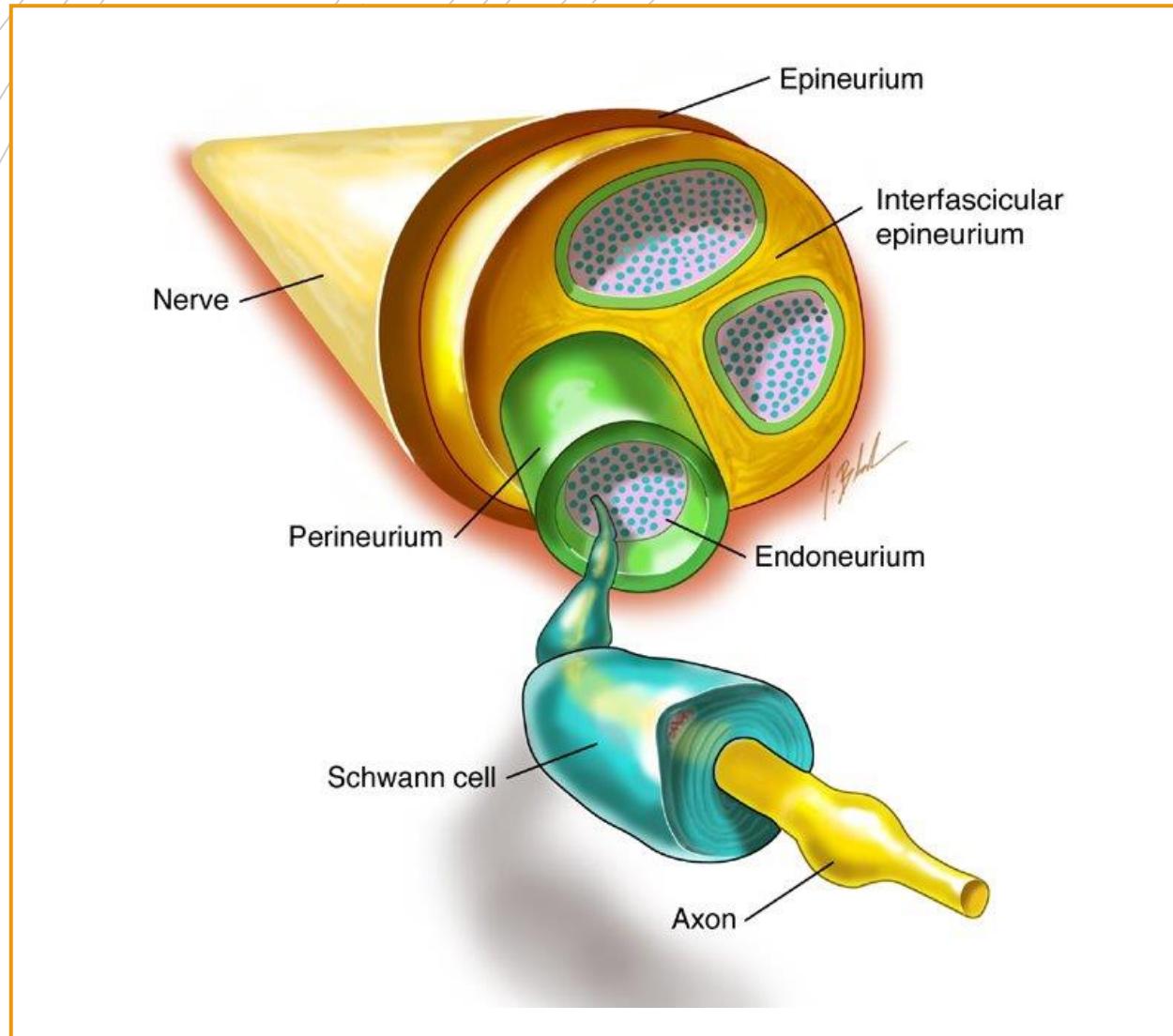
# Central and Peripheral Nervous System

A signal from a nerve is a small pulse of voltage going between -70 and +40 mV, over a period of 5 ms. Some nerves operate faster (eg eye, heart, reflexes)



## Action Potentials

- Action potentials are binary signals, you either have a pulse or not.
- The intensity of the signal from the nerve is based on the number of pulses sent, or pulses per second.
- It is easy for us to electrically generate such a signal and there are different ways to inject the electrical signal into the nerve



## Nerve Bundle (e.g. spinal cord)

- Axons carry the signals from the nerve endings
- They are bundled together in cords
- It is tricky to figure out which axon is carrying which signal.
- An axon is typically 5-20  $\mu\text{m}$

# Peripheral nerve interface

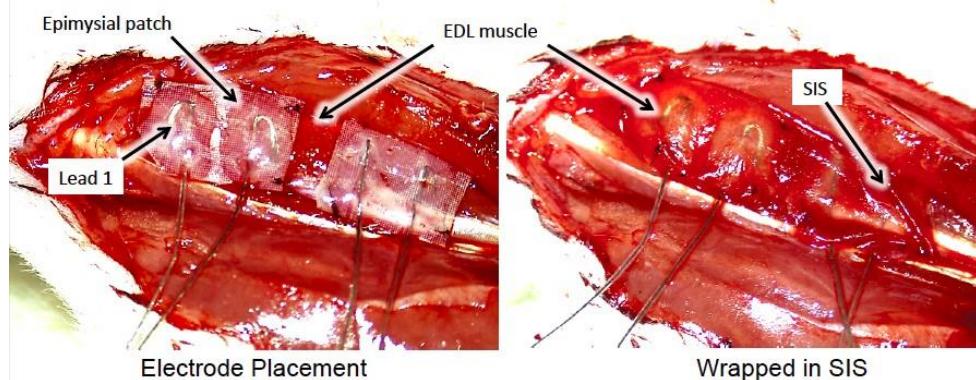


Figure 1: Epimysial patch implantation

## Epineurial electrode interface

In this scenario we run wires onto the surface of a nerve-bundle (epineurium) and we inject a signal. Depending on how you do it, by induction or coupling, you create a small copy of the signal in the nerve bundle. This is not selective so all the nerves in the bundle get triggered. Equally you can sense signals being passed down the nerve

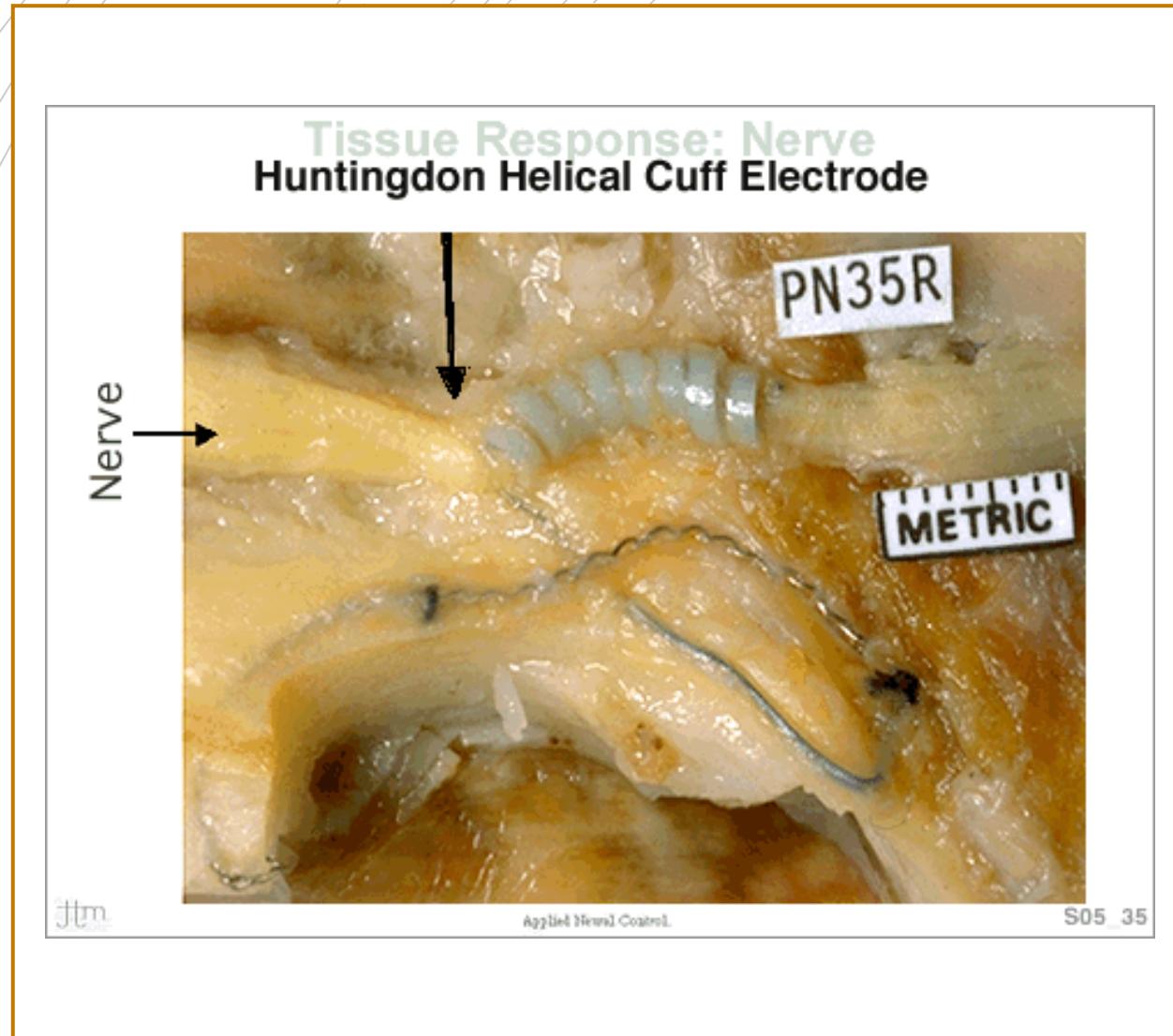
The quality of the control is based on the precision of your electrodes and how well you can separate out the different

## Peripheral nerve interface

A crude version of this is “slendertone” where electrical signals are inject to make your muscles twitch.



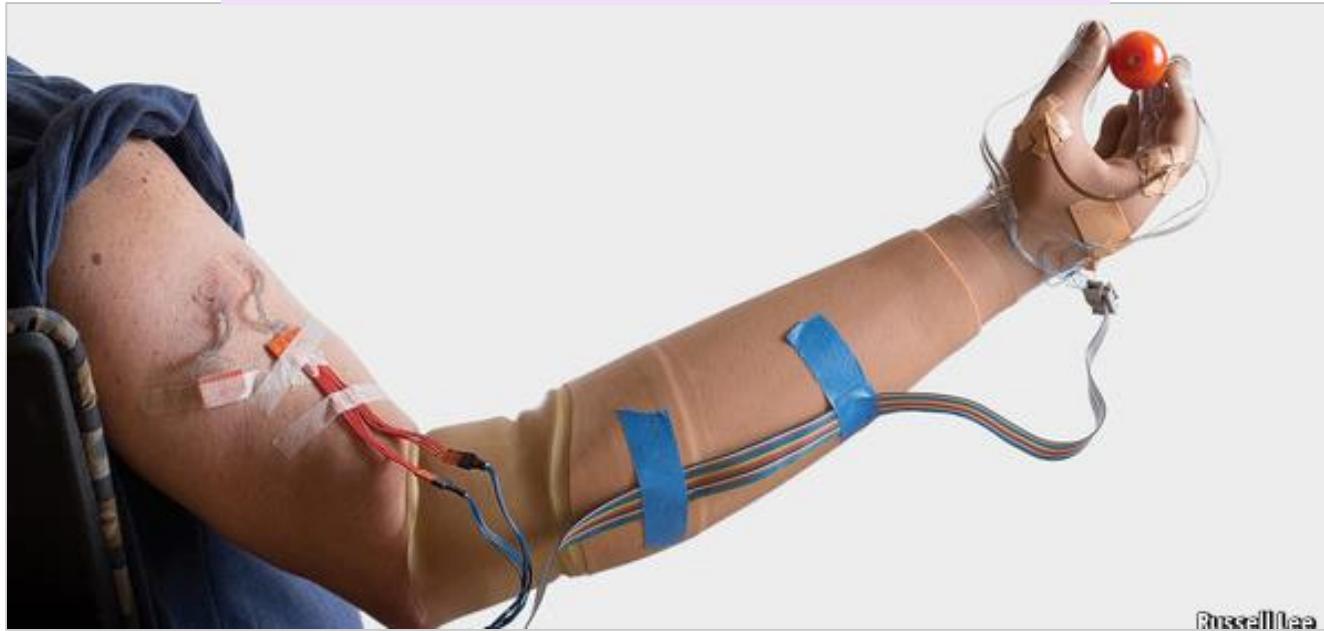
## Peripheral nerve interface



- **Helicoidal electrode interface**
- Helicoidal electrodes are placed circumjacent (wrapped around) to the nerve and are made of flexible platinum ribbon in a helical design. This design allows the electrode to conform to the size and shape of the nerve in attempts to minimize mechanical trauma.
- The structural design causes low selectivity (i.e. not precise)

# Replacements - ARM

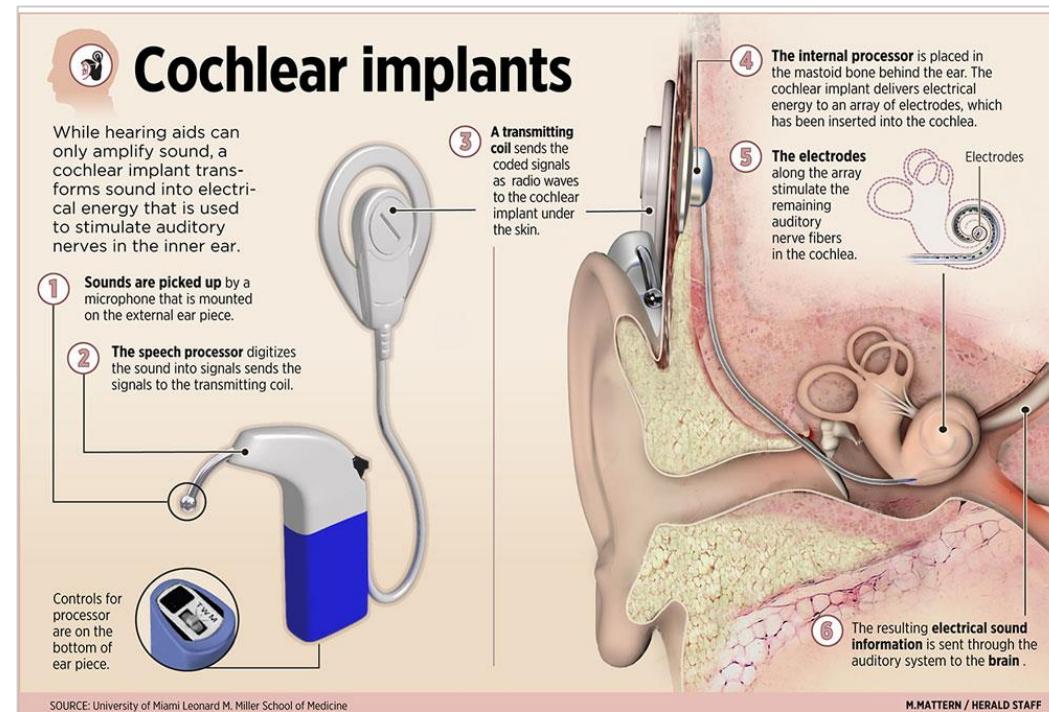
Louis Stokes Veterans Affairs Medical Centre, 2014



Russell Isaac

- Early days, but taps into original nerves in the upper arm that would normally send signals down to the amputated lower arm.
- Taps into them to control the movement of the robotic arm but also sends some sensory information back up to the brain, allowing the person to have fine control and not squish the tomato.

# Replacements - EAR

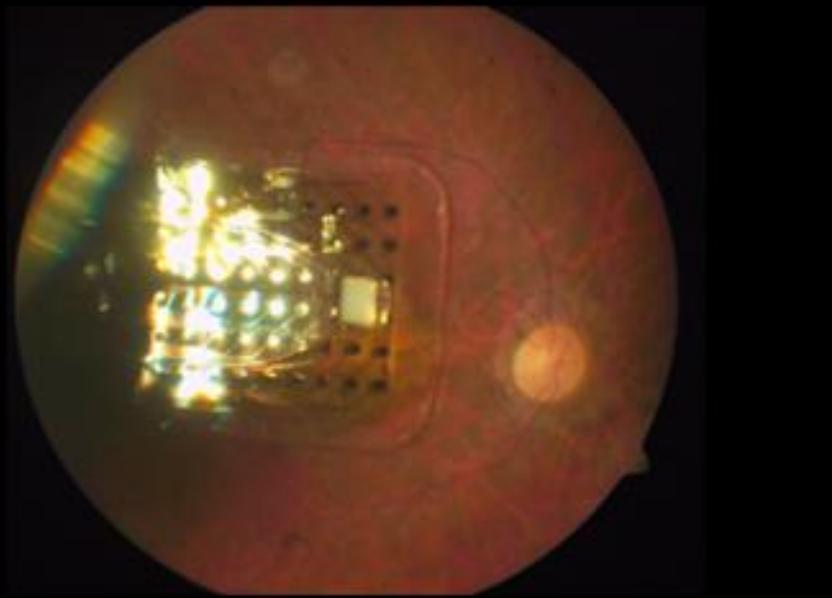


SOURCE: University of Miami Leonard M. Miller School of Medicine

M.MATTER / HERALD STAFF

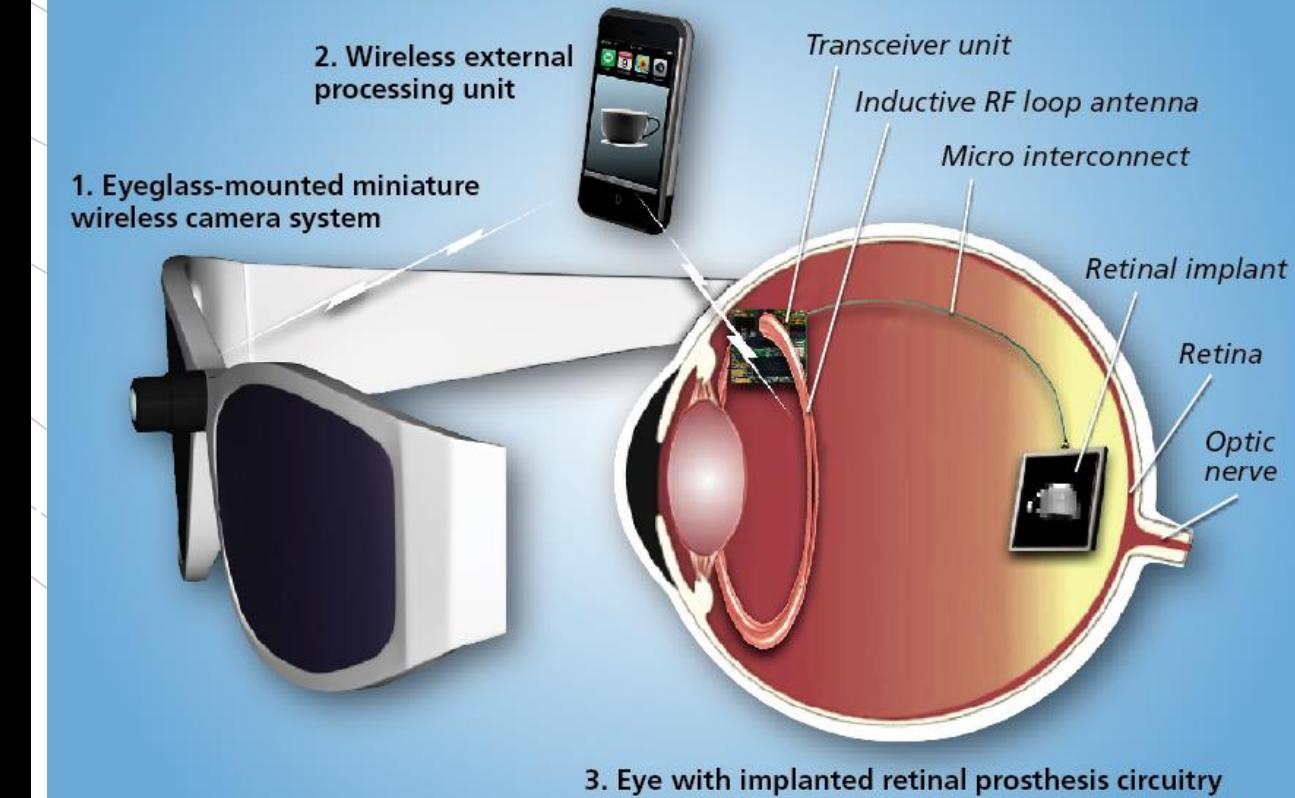
- Audio is a low-data rate system with a simple nerve interface. First developed in 1961 but the modern version was developed in 1977. About 500,000 implanted and success seems to be very good. Best results when implanted young
- For some in the deaf community, cochlear implants are an affront to their culture, which as some view it, is a minority threatened by the hearing majority.

# Argus 2



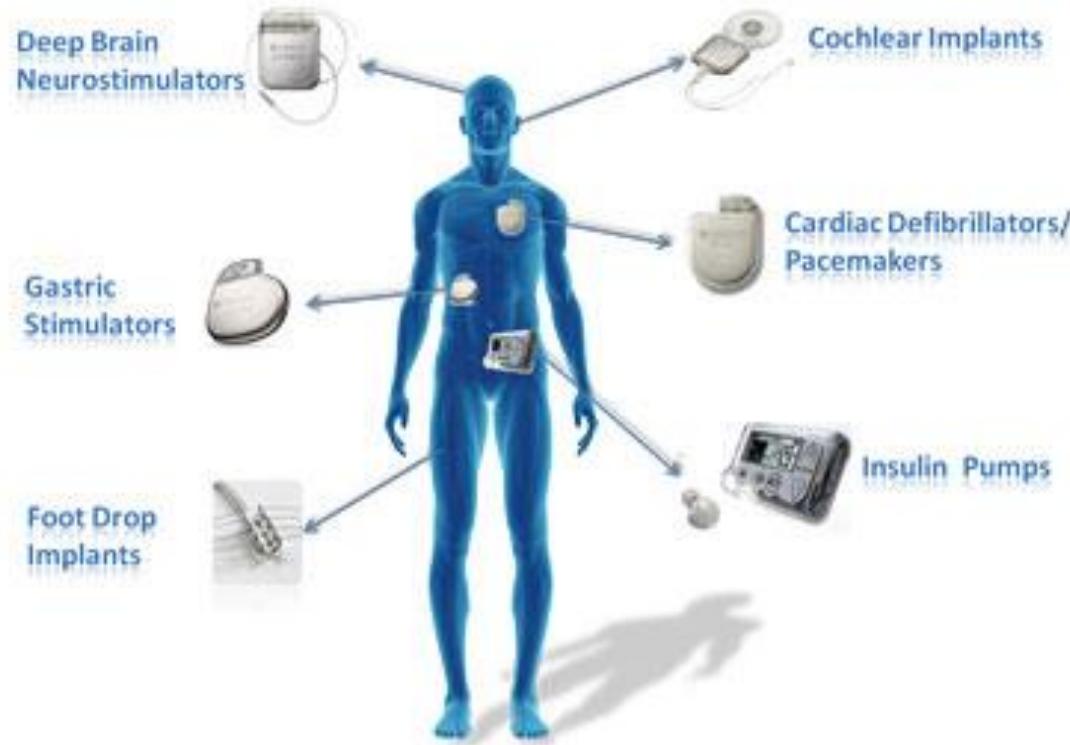
*Dept of Energy 2009*  
**Can provide 16x16 pixels of vision**

## How Retinal Implants Work



## Replacements - EYE

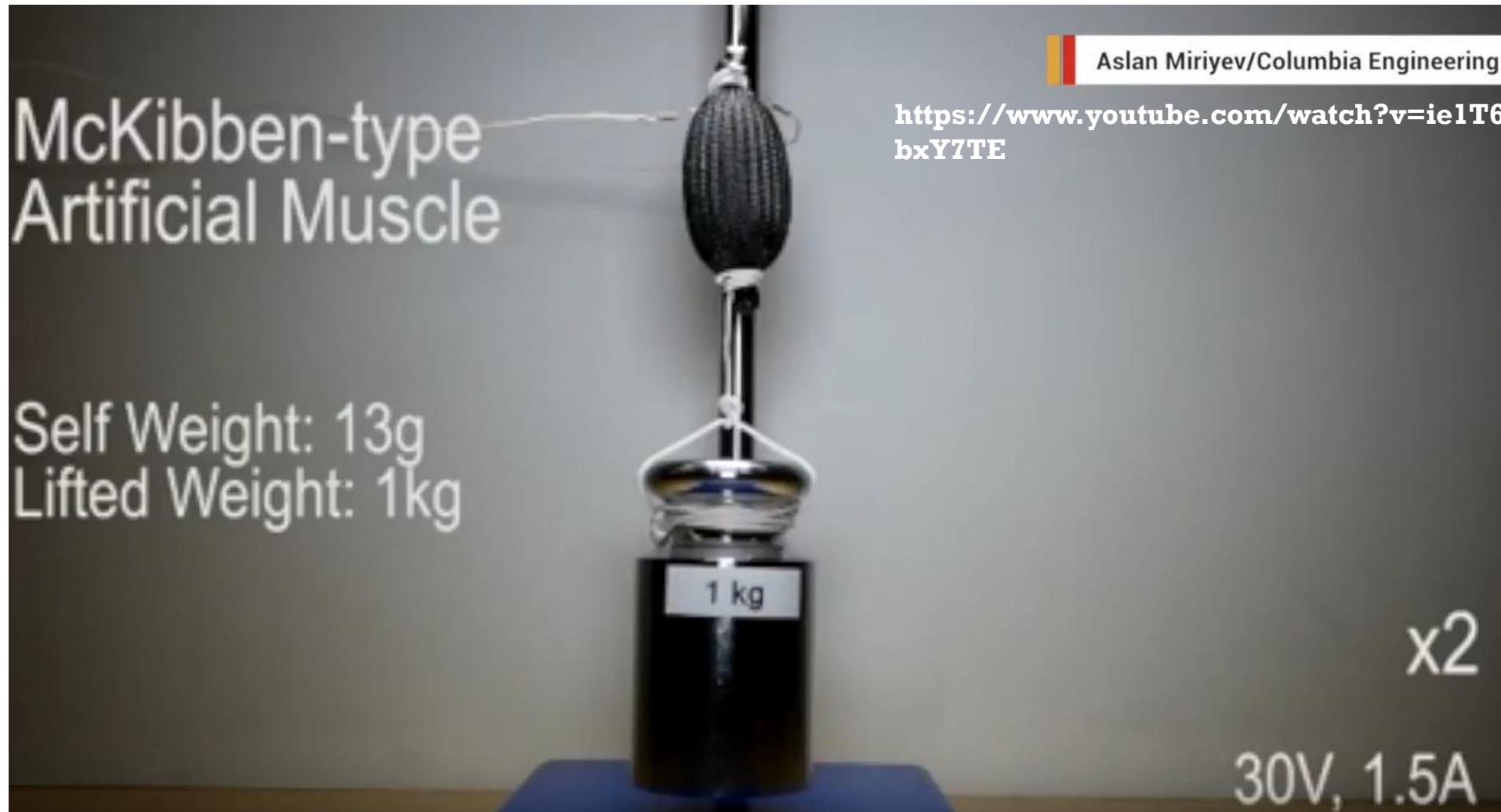
## WIRELESS IMPLANTABLE MEDICAL DEVICES



Implanted Sensors/Devices

# Improvements

Soon could be stronger than human muscle for the same volume/weight



# Improvements



We can do 256pixels today, probably a few thousand next year, a million eventually.

When would an artificial eye become superior

- 20 Mpixels (eg top quality cameras today)
- see in the infra-red and ultra-violet
- automatic zoom
- in-build computer display (HUD)

## Improvements

- Currently proven in rats but in early testing on humans.
- Helps create long-term memories
- Not yet able to figure out what memory is, but the aim is to have an electronic memory store accessible to the brain



Follow on: [f](#) [t](#) [in](#) [+](#) [w](#)

Engineering Topics ▾

Special Reports ▾

B

The Human OS | Biomedical | Bionics

### New Startup Aims to Commercialize a Brain Prosthetic to Improve Memory

By Eliza Strickland  
Posted 16 Aug 2016 | 18:00 GMT

A startup named [Kernel](#) came out of stealth mode yesterday and revealed its ambitious mission: to develop a ready-for-the-clinic brain prosthetic to help people with memory problems. The broad target market includes people with Alzheimer's and other forms of dementia, as well as those who have suffered a stroke or traumatic brain injury.

If the company succeeds, surgeons will one day implant Kernel's tiny device in their patients' brains—specifically in the brain region called the [hippocampus](#). There, the device's electrodes will electrically stimulate certain neurons to help them do their job—turning incoming information about the world into long-term memories.

Kernel's device will be based on a research effort led by [Ted Berger](#), director of the Center for Neural Engineering at the University of Southern California. Berger tells

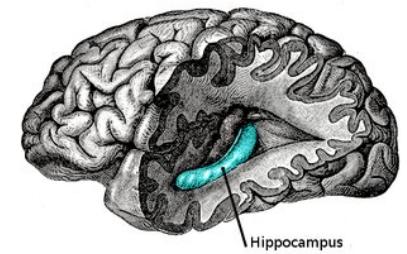


Image: Wikimedia Commons  
The hippocampus is a key brain region involved in memory formation and storage.

# Improvements

Home > Science

## AI implants will allow us to control our homes with our thoughts within 20 years, government report claims



16

By Sarah Knapton, SCIENCE INVENTOR

15 OCTOBER 2017 • 12:01AM

**A**rtificially intelligent nano-machines will be injected into humans within 20 years to repair and enhance muscles, cells and bone, a senior inventor at IBM has forecast.

John McNamara, who works at IBM Hursley Innovation Centre, in Hampshire, submitted evidence to the House of Lords Artificial Intelligence Committee, which is considering the economic, ethical and social implications of AI.

Mr McNamara said that within just two decades, technology may have advanced so much that humans and machines are effectively 'melded' together, allowing for huge leaps forward in human consciousness and cognition.

"Using this technology, embedded in ourselves and in our surroundings, we will begin to be able to control our environment with thought and gestures alone."



# Improvements

These artificial feet can be “superior” to normal feet for runners  
More bounce, less energy loss, So they will make a runner go faster!

Active ones can offer superior running and jumping characteristics

# Question?

- Perfect memory would be wonderful – maybe
- Perfect/enhanced eyesight (x-ray vision) would be wonderful – maybe
- When should you start enhancing yourself?
- When would you stop?

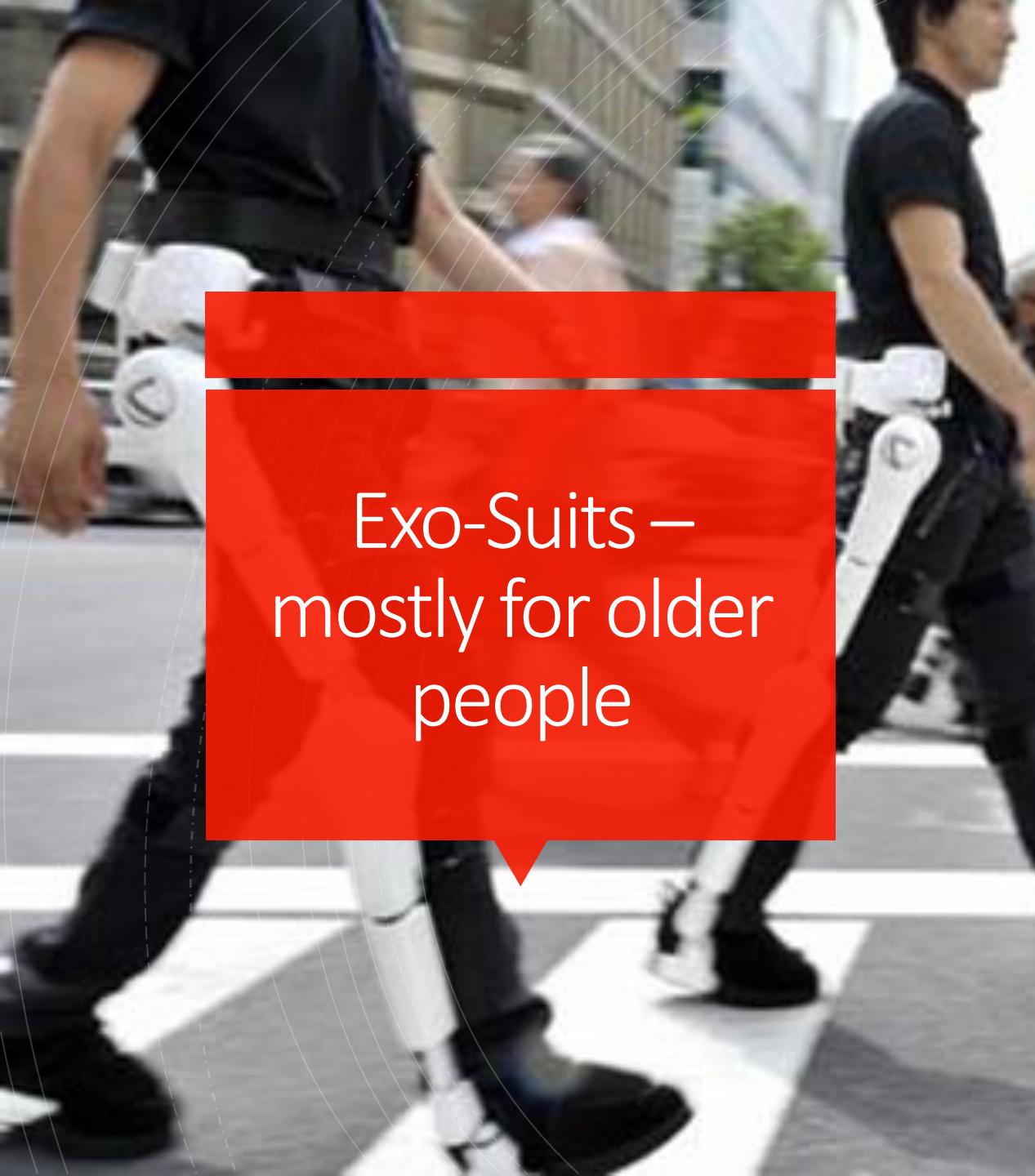


Photo: Jill Greenberg/Corbis Outline

No Achilles' Heels: Aimee Mullins and Hugh Herr foresee a day when upgrading a body is routine. Mullins, an actress and advocate for advanced prosthetics, was the first double amputee to compete at the highest levels of U.S. collegiate track-and-field events.



Assistive Technology/HomeCare



## Exo-Suits – mostly for older people



- Lower-body units to help people walk
- Upper and Lower units to allow people to have a greater range of functions

# Exosuits

- The motors are the easy bit, the key is the electronics and the software
- Key elements
  - Wireless connections to avoid draping wires
  - Bioelectric sensors to get information from the body
  - Lots of sensors to figure out what the exo-suit is doing and how well it is doing it, the posture of the person, their centre of gravity, etc
- Current exo-suits have a range of functions – like walking, squatting. They don't have full flexibility equivalent to a full limb – but they can cover a useful range of our large-scale movements.





## Assistive Technology / HomeCare



## Assistive Technology / HomeCare

Some things can be simpler but equally useful

The tremor spoon for people with Parkinsons or tremors



Asthma - Smart inhalers that adapt to the air conditions you are in

Assistive  
Technology/  
HomeCare



## Automated Medication Dispensing Service

★★★★★ (read 6 reviews)

Philips Automated Medication Dispensing service is a simple way to manage even the most complex medication regimens. So seniors who live alone can stay on track.

\$59.95/month

Add to cart

Or call us at 1-855-600-6127

Assistive Technology/HomeCare



## Assistive Technology/HomeCare

- **Bedroom** : Monitors how well seniors sleeping and if sleep patterns change
- **Bathroom:** Alerts caregivers if seniors are using the bathroom more or less than usual.
- **Kitchen:** Determines if refrigerator and cabinet use changes, eating more or less
- **General Movement** - Provides caregivers with confirmation seniors are up and about
- **Entrances:** Check for intruders or visitors, doors left open at night
- All sent to the cloud, data-mined, profiled, and health warnings auto-generated

- The point about most assistive technology in this area is:
  - It leverages human contact – allowing human carers do more. Not to replace them
  - Connected (i.e. linked to the internet) is critical in most homecare scenarios. Mostly supervised machines – even the robots.
  - In many cases, privacy can be a big issue and a lot of people resent the intrusiveness if it comes across as loss of independence.
  - Devices that make some more independent are always a big winner – e.g. the tremor spoon, exo-walkers

# Assistive Technology/ HomeCare

## Israeli developer of swallowable camera bought for \$860 million

Given Imaging, inventor of the PillCam, purchased by Ireland-based Covidien Plc

By JTA

8 December 2013, 11:53 pm | 4



The Pillcam, a swallowable camera to diagnose problems in the digestive tract, developed by Israeli company Given Imaging (screen capture: YouTube)

An Irish company will purchase Given Imaging Ltd., an Israeli firm that developed a swallowable camera to diagnose problems in the digestive tract.

## Colonoscopy Replacement

- Key technologies
- Cameras
- Power/battery
- Wireless comms

## Prototype UT equipment can detect rheumatoid arthritis

Date: September 27, 2017

Source: University of Twente

Summary: Researchers have designed a device that shows the difference between healthy fingers and arthritic fingers, according to a first clinical study published. The researchers responsible for the development of the compact device believe that it may in time help doctors to objectively diagnose the degree of inflammation in joints.

Share: [f](#) [t](#) [G+](#) [P](#) [in](#) [e](#)

### RELATED TOPICS

#### Health & Medicine

- > Medical Imaging
- > Medical Devices
- > Arthritis
- > Today's Healthcare

#### Matter & Energy

- > Medical Technology
- > Ultrasound
- > Detectors
- > Technology

### FULL STORY



Prototype.

Credit: Image courtesy of University of Twente

### ADVERTISEMENT

According to a first clinical study published in the scientific journal *Photoacoustics*, the University of Twente and various European partners have designed a device that shows the difference between healthy fingers and arthritic fingers. The University of Twente and Ziekenhuis Groep Twente researchers responsible for the development of the compact device believe that it may in time help doctors to objectively diagnose the degree of inflammation in joints.

# Handheld Arthritis Sensor

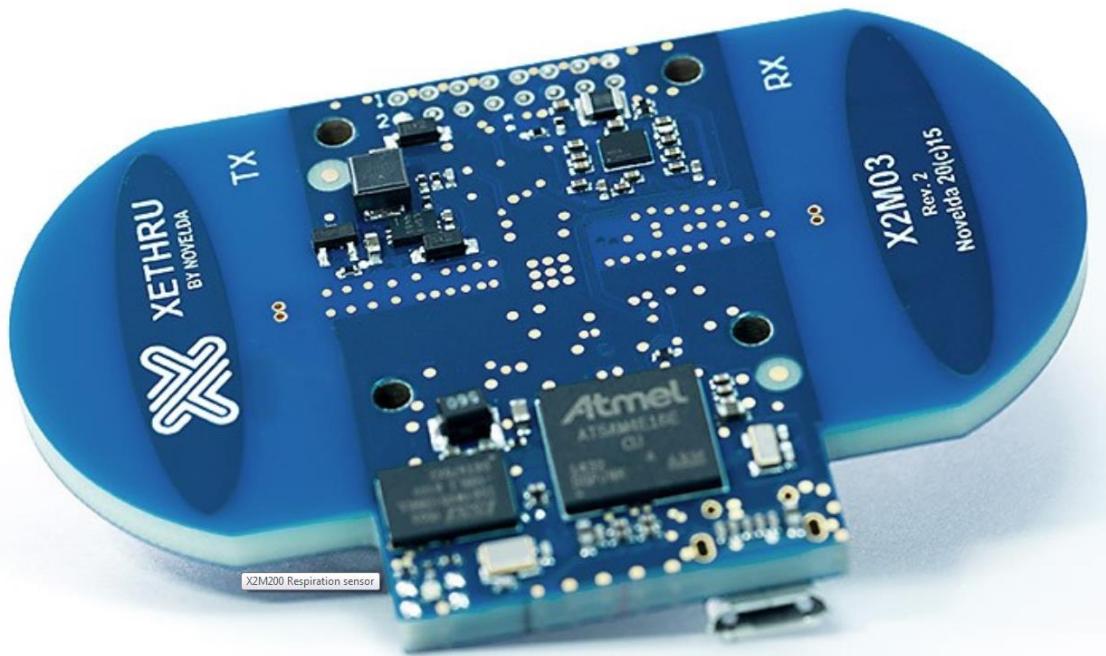
- Key technologies
- Ultrasonic
- Photo-acoustics
- Signal capture
- Signal processing
- Power/battery



## Smartphone Blood/Heart Monitor

- Key technologies
  - Bright light
  - Sensitive camera
  - Signal capture
  - Signal processing
  - Power/battery

## Respiration Detector (in a room)



- About 4 cm long
- Radio technology (ultra-wideband radio)
- Signal capture
- Signal processing
- Power/battery
- Communications (USB/Wireless)

## **VOYCE™ is a “health band” designed for animals**

- Measures temperature, activity/motion, and cardiopulmonary functions
- Similar to other wearable sports monitor devices (Fitbit, Nike Fuel, etc.)

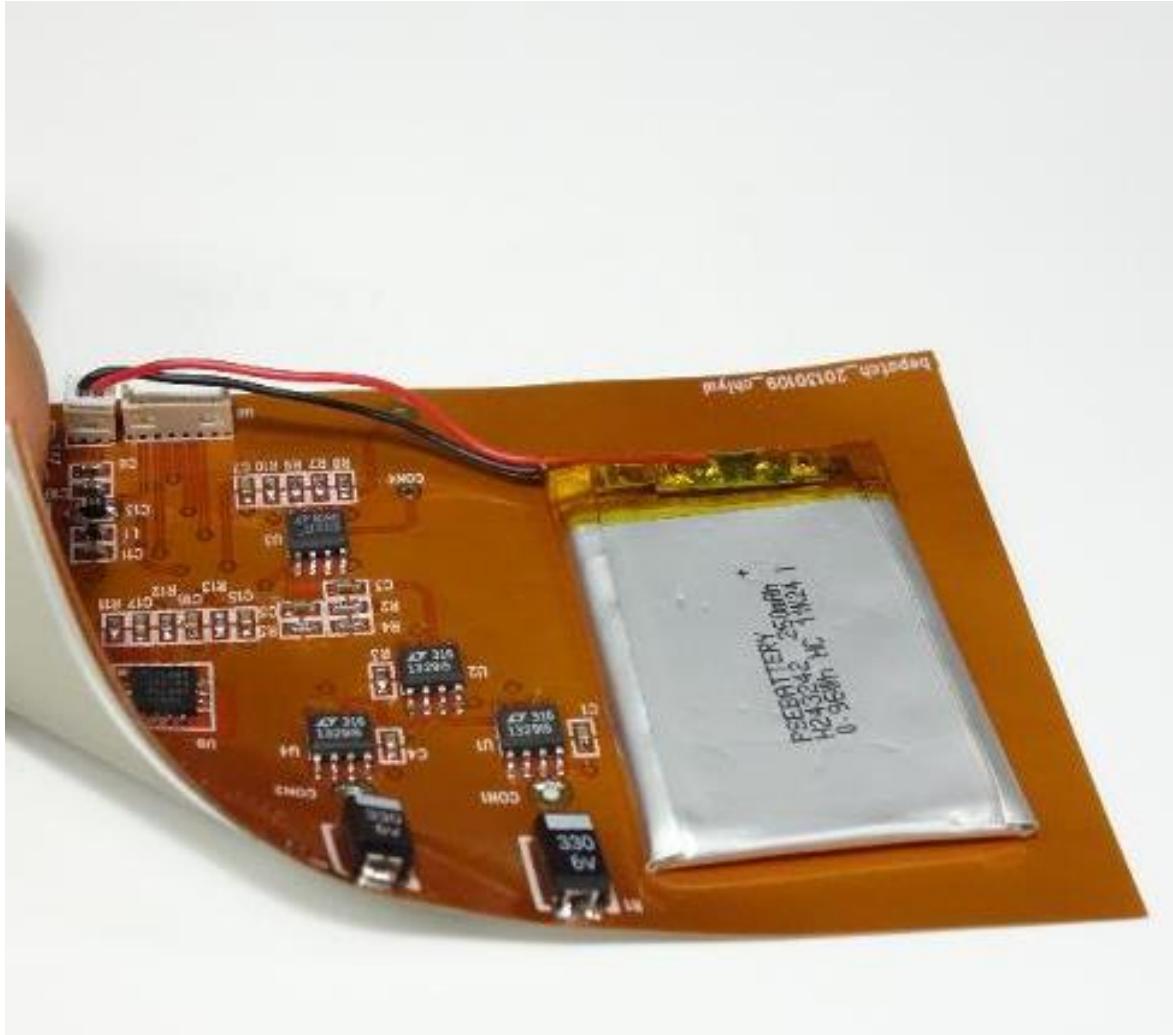
## **Sensor platform**

- Temperature sensor – environmental conditions
- Light sensor – time spent indoor/outdoor
- Triple axis accelerometer – activity, distance, calories
- UWB radar – resting cardiopulmonary rates



**Voyce™**

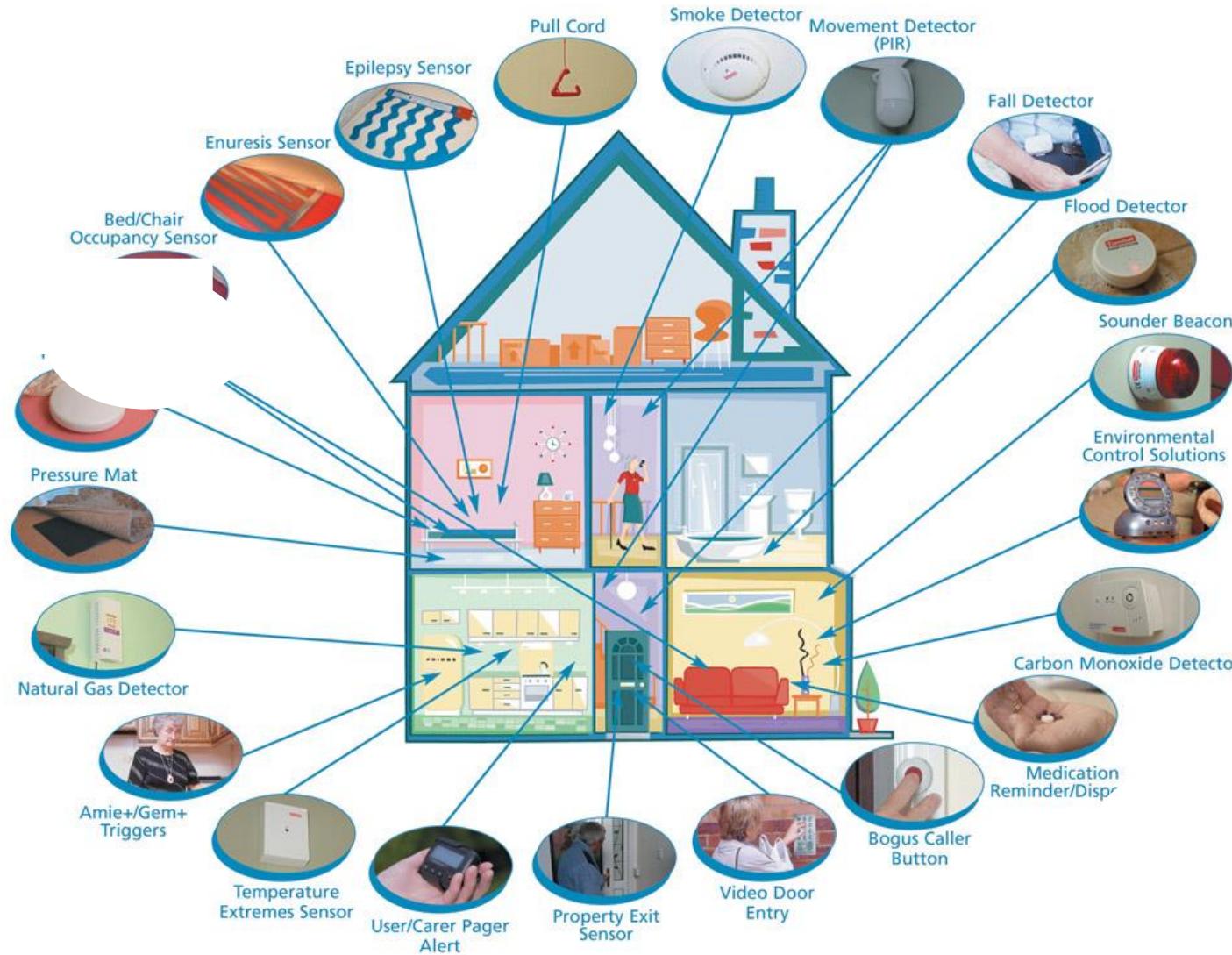
# Sensors for Animals



## Blood Pressure Measuring Patch (stick on)

- **Flexible blood pressure monitor**
  
- Key technologies
  - Flexible membrane
  - Sensitive camera
  - Signal capture
  - Signal processing
  - Power/battery

# Advanced Sensing



# Advanced Sensing

## What's in common

- **Electronic interfaces to very sensitive sensors**
- **Handheld or low power**
- **Signal processing and interpretation**
- **Wireless Communications**

## The key benefits

- **New sensing capabilities**
- **less invasive**
- **continual sensing,**
- **no need for trained personnel**

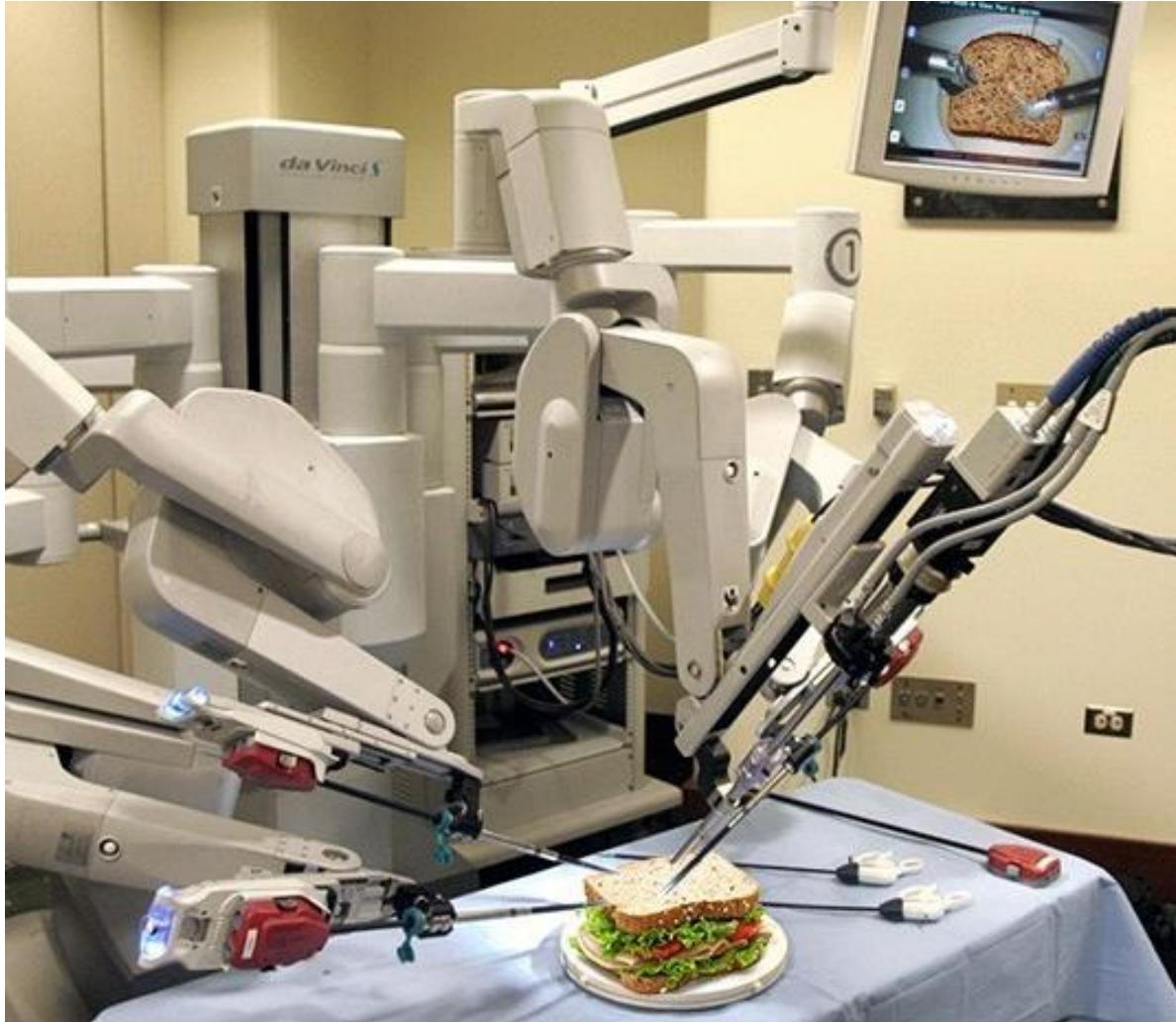
## Two types of surgical devices

**Robotic surgical devices** are designed to perform entirely independent movements after being programmed by a surgeon

**Computer-enhanced systems (or robotic assisted)** that places a computer interface and 3DHD vision system between the surgeon's eyes, hands and the tips of micro-instruments. The system mimics the surgeon's hand movements in real time. It cannot be programmed, nor can it make decisions on its own to move or perform any type of surgical manoeuvre. These systems have no intelligence – effectively remote controlled

The latter is more common, but the first is more interesting as it can be more precise than a human.

# Operating Theatre Technology



## Operating Theatre Technology

**Keyhole surgery, brain,  
back, etc**

**Robotic Assisted – human  
operator**



#### Precision

Scaling of movements and filtering of hand tremors yield unprecedented steadiness and precision, whilst standby functionality improves control and enables to relax during surgery by freezing the instrument position.



#### Safety

Whilst the hybrid setup allows the surgeon to maintain patient contact, the instrument minimizes residual eye movements by holding the cannula and safety boundaries are employed to limit instrument movements.



#### Workflow Optimization

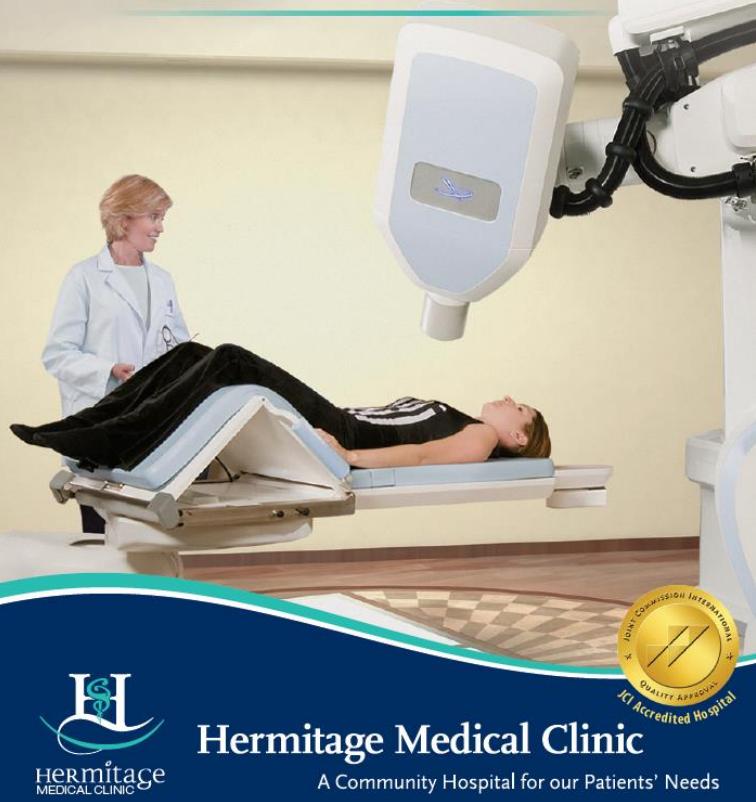
During surgery, the instrument is easily included to assist in a specific task and instruments are easily changed, whilst instrument movements are recorded for post-surgical evaluation and training purposes.

# Operating Theatre Technology

## Eye Surgery Robotic Assisted – human operator

## CyberKnife

*Information for patients receiving  
intra-cranial (brain) treatment*



Operating Theatre  
Technology

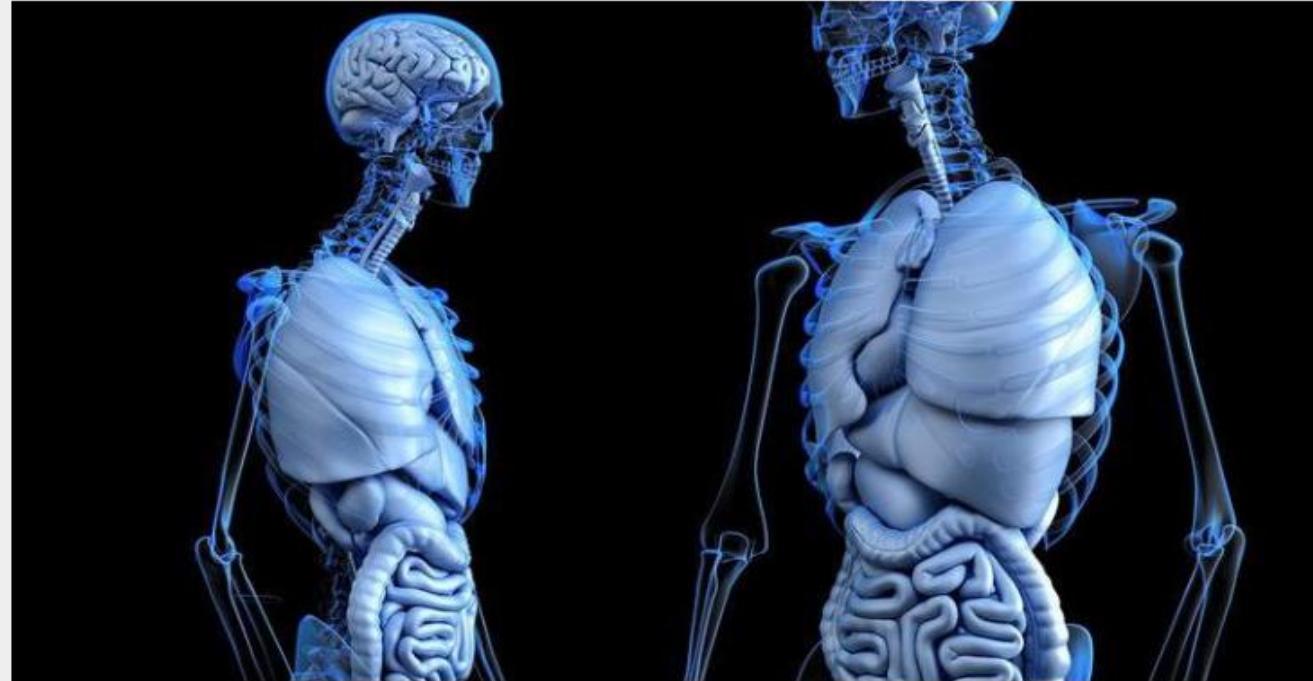
**Fully Robotic**

**Precise Radiation  
Treatment**

# Operating Theatre Technology

- Machines historically were tele-operated but now are supervised autonomous devices.
- Very few studies compare outcomes from human and robotic surgeons
- **It tends to be more expensive than human surgeons**
- But
  - **Medical outcomes seem to be similar**
  - **Significant reduction in complications**
  - **More precise requiring less intervention**
  - **Require less medical staff in the operating room**
- Roughly \$1 billion in sales of robotic surgery devices each year (2016) and rapidly growing

# AI controlled Diagnosis



Machine Learning News Work

## Japanese researchers say AI can detect bowel cancer in less than a second | ZDNet

November 8, 2017 Mike Rawson AI, Bowel, Cancer, Diagnosis, Health

New software built in Japan can detect bowel cancer in less than a second, researchers claim.

In recently-conducted trials, the artificial intelligence (AI)-powered system was able to spot colorectal adenomas — which are benign tumours that can evolve into cancer — from magnified endoscopic images. The images were matched against 30,000 others that were used for machine learning.

The system analysed more than 300 colorectal adenomas in 250 patients, taking less than a second to assess each magnified endoscopic image and determine the malignancy of the tumours with 94 percent accuracy, researchers claim.

"The most remarkable breakthrough with this system is that AI enables real-time optical biopsy of colorectal polyps during colonoscopy, regardless of the endoscopists' skill," said study leader Dr Yuichi Mori from Showa University in Yokohama, Japan, who presented the results at United European Gastroenterology Week in Barcelona.

AI controlled Diagnosis

## AI beats doctors at visual diagnosis, observes many times more lung cancer signals

By Graham Templeton on August 18, 2016 at 1:00 pm | [26 Comments](#)

722  
shares



A [new study](#) from Stanford University could ruffle feathers in the medical community, as the researchers report that their newly developed [machine learning](#) algorithm can identify tissue slides exhibiting a specific type of cancer with far greater accuracy than human epidemiologists. It's one of the first indications that computers aren't just capable of addressing the "subjective" portions of medicine, but that they're actually *better suited* to such problems than human doctors, in some cases.

## AI diagnoses skin cancers with dermatologist accuracy

A deep-learning algorithm produced a digital doctor that you might one day use with your smartphone. Angus Bezzina reports.



Can you tell if it's dangerous or not?  
CREDIT: PETER DAZELEY / GETTY IMAGES

**Harmless mole or potential melanoma?** A new computer algorithm can make that diagnosis from photos as accurately accredited dermatologists.

## AI controlled Diagnosis

Oncology and Genomics

## Watson for Oncology

Spend less time searching literature and the EMR, and more time caring for patients. Watson can provide clinicians with evidence-based treatment options based on expert training by Memorial Sloan Kettering (MSK) physicians.

[See how it works \(05:07\)](#) [Get the facts](#)

The amount of research and data available to help inform cancer treatments is growing exponentially. Yet the time care teams have to consume this information—locating insights specific to each patient's unique needs to potentially improve treatment outcomes—is more limited than ever.

Watson for Oncology helps physicians **quickly identify key information** in a patient's medical record, **surface relevant articles** and **explore treatment options** to reduce unwanted variation of care and give time back to their patients.

**NEWS FLASH**

# IBM Watson dishes out 'dodgy cancer advice', Google Translate isn't better than humans yet, and other AI tidbits

Machines aren't really better than us at much

By [Katyanna Quach](#) 28 Jul 2018 at 11:02

47 SHARE ▼

IBM Watson has made several “unsafe and incorrect treatment recommendations” to cancer doctors using the technology, according to leaked internal documents.

An investigation revealed the problem lies with the AI system **being carelessly trained**. Rather than being taught to diagnose people from real cancer cases, IBM Watson was instead trained using **synthetic records** by the company’s engineers and doctors working at the Memorial Sloan Kettering (MSK) Cancer Center in New York

Medical data is difficult to obtain for privacy reasons. However, relying on fake data meant the cloud service’s recommendations were based on a few experts’ opinions rather than real evidence.

“This product is a piece of shit,” a doctor at Florida’s Jupiter Hospital said to IBM

# How AI can spot Alzheimer's disease five years before diagnosis

**Crunching the numbers: AI could help doctors to diagnose Alzheimer's sooner**

09 Aug 2017

Murali Doraiswamy

Professor, The Duke Institute for Brain Sciences  
(DIBS)

Despite all the hype, artificial intelligence (AI) is not ready to replace doctors or automate brain surgery. But it can analyse immense amounts of data to help us better study, diagnose, treat and even prevent disease. Our hope is that it could reverse two decades of failed experimental therapies for Alzheimer's disease.

The amount of research and data available to help inform cancer treatments is growing exponentially. Yet the time care teams have to consume this information—locating insights specific to each patient's unique needs to potentially improve treatment outcomes—is more limited than ever.

Watson for Oncology helps physicians quickly identify key information in a patient's medical record, surface relevant articles and explore treatment options to reduce unwanted variation of care and give time back to their patients.

**ET Healthworld**  
From The Economic Times

Home News IndustrySpeak Feature Medical Specialties Data & Analytics HealthTV Events Brand Solutions

Hospitals Pharma Medical Devices Diagnostics Policy Industry People Movement GE Healthier India World Heart Day More

Health News / Latest Health News / Industry

Industry Xinhua Tsinghua University Robot national medical examination center iFlytek clinical diagnosis Beijing

## Chinese robot scores high in doctor qualification test

The robot, co-developed by leading Chinese tech firm iFlytek and Tsinghua University, has achieved a score of 456, higher than the national pass mark of 360.

PTI | November 08, 2017, 06:12 IST

[Share 4](#) [G+ Share](#) [Share 44](#) [Tweet](#)

[Print](#) [A A](#) [Newsletter](#)

  
Beijing, Nov 7 : A robot made in China has cleared a national-level qualification test for doctors in the country and obtained a high score.

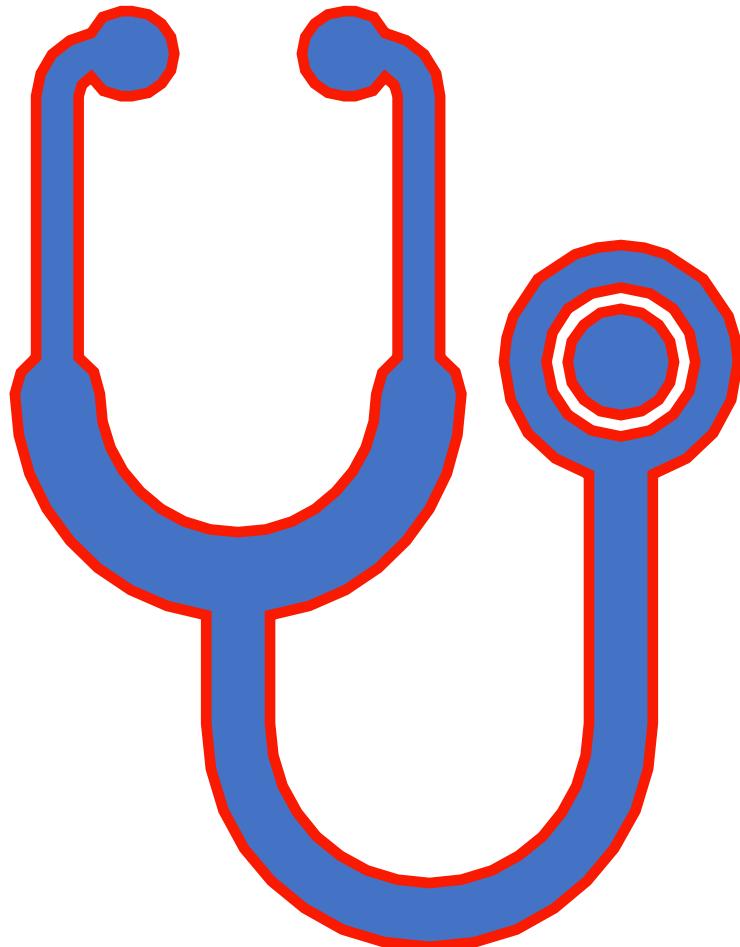
The robot, co-developed by leading Chinese tech firm iFlytek and Tsinghua University, has achieved a score of 456, higher than the national pass mark of 360, the health and family planning commission in Anhui Province said.

This year, around 530,000 people across the country took the examination in August. The National Medical Examination Center released the pass mark for the written test yesterday.

Watched by examination supervisors, the robot answered the same test paper at the same time as its human counterparts in a designated test room without internet access or signal. The whole process was recorded to prevent cheating, according to iFlytek.

# AI controlled Diagnosis

## AI controlled Diagnosis



- So the question becomes, would you trust a computer to do it?
- In practice, everything is human supervised and the aim is enhance the ability of the human to make a decision more quickly and with less risk of error.
- Faster doesn't mean better! Training is very important. You can train a machine to duplicate your mistakes ... very fast duplication.
- Garbage in means garbage out...