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CSCI 101
Connecting with Computer Science
Lecture 4: Applications of CS I

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2020 Fall Semester (S3)

Overview

- Focus: Computing Science in Production
- Architecture: von Neumann
- Readings: 4, 5
- Core Ideas:
    1. Basic Introduction
    2. BioInformatics

Applications of CS

Where CS is essential

P1
Intro

What we are NOT talking about

- How information can be stored/accessed in computers instead of in the library/bookkeeper’s closet
- How much faster computers are, comparing to manual computation
- How much convenient it is to use a computer to communicate
- The products made possible through computers
- etc.

P1
Intro

What we ARE talking about

- How computers are pushing forward human boundaries
- I especially want to discuss a few highly complex fields:
  - Medical Science
  - Automated Research / Experiments, Physical Simulations
  - Robotics, 3D printing

Computers are making our lives easier

- but not just easier. It is slowly changing what it means to be human.
- CS is one of the few technologies in human history that revolutionises everything else
- CS is essential for all professions, even philosophy!

P1
Intro

The Digital Revolution

Education

Transport

Manufacture

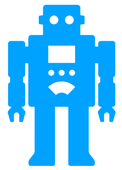
Entertainment

Food

Fashion

Medicine

Research



Robotics

Concept

P2
BioInfo

Bioinformatics

Where Medical Advancement is Aided by CS

Summary

Definition

Medicine

- BioInformatics: the use of computers and computer science to study biological questions (also called computational biology)
  - It is an interdisciplinary field
    - **Medical Science**
      - Biology, Psychology
      - Chemistry and Physics
    - **Computer Science**

Concept

P2
BioInfo

Bioinformatics

Medicine

- What you can do (with data)

  1. Using computers to store/access patient records
     All data are stored in the cloud and protected. Your doctors will have your full health history, no matter which hospital you go

  2. Analysing Biometric data

     - Patient Data: records and examination outcome

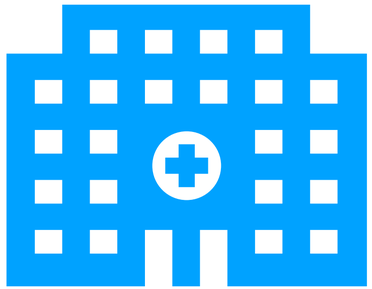
     - Human Genome Project

Concept

P2
BioInfo

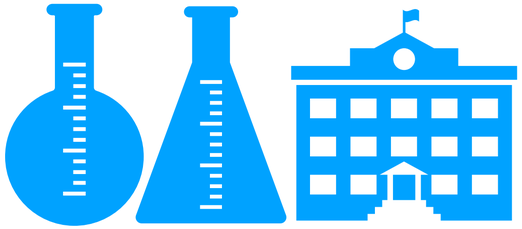
What is currently being done?

Medicine



Hospitals

Patient Oriented



Universities and Labs

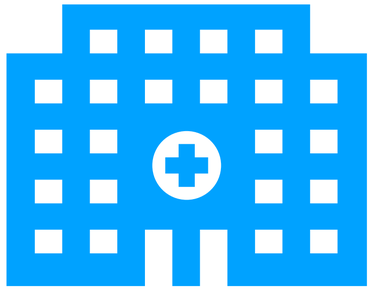
Knowledge Oriented

Concept

P2
BioInfo

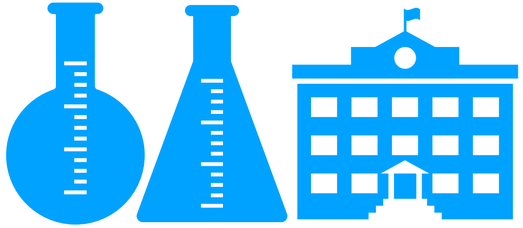
What is currently being done?

Medicine



Hospitals

Patient Oriented



Universities and Labs

Knowledge Oriented

- Digitisation of Patient Records database optimisation
- Computer analysis of Individual Examination Reports
- Quantitative Analysis including HGP
- Study biology, develop new treatments

Concept

P2
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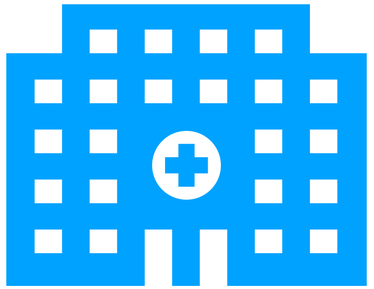
What is currently being done?

Medicine

- Digitisation of Patient Records
  - Mostly a database project
  - privacy, efficiency, bureaucracy
- Computer analysis of individual examination reports
  - Statistical analysis
  - Artificial intelligence



Hospitals

Patient Oriented

Concept

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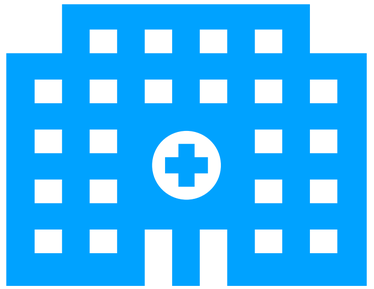
BioInfo

What is currently being done?

Medicine

- Digitisation of Patient Records (challenges)
  - Data structure
    How is the data stored
  - Privacy
    How can the data be accessed
  - Efficiency
    How can the database handle hundreds of requests
  - Bureaucracy
    What are the legal requirements? What about universal healthcare?



Hospitals

Patient Oriented

Concept

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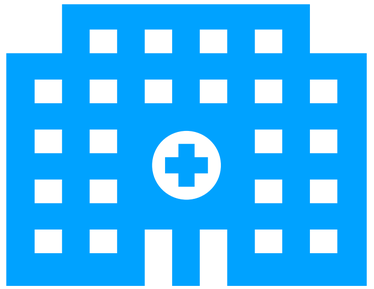
What is currently being done?

Medicine

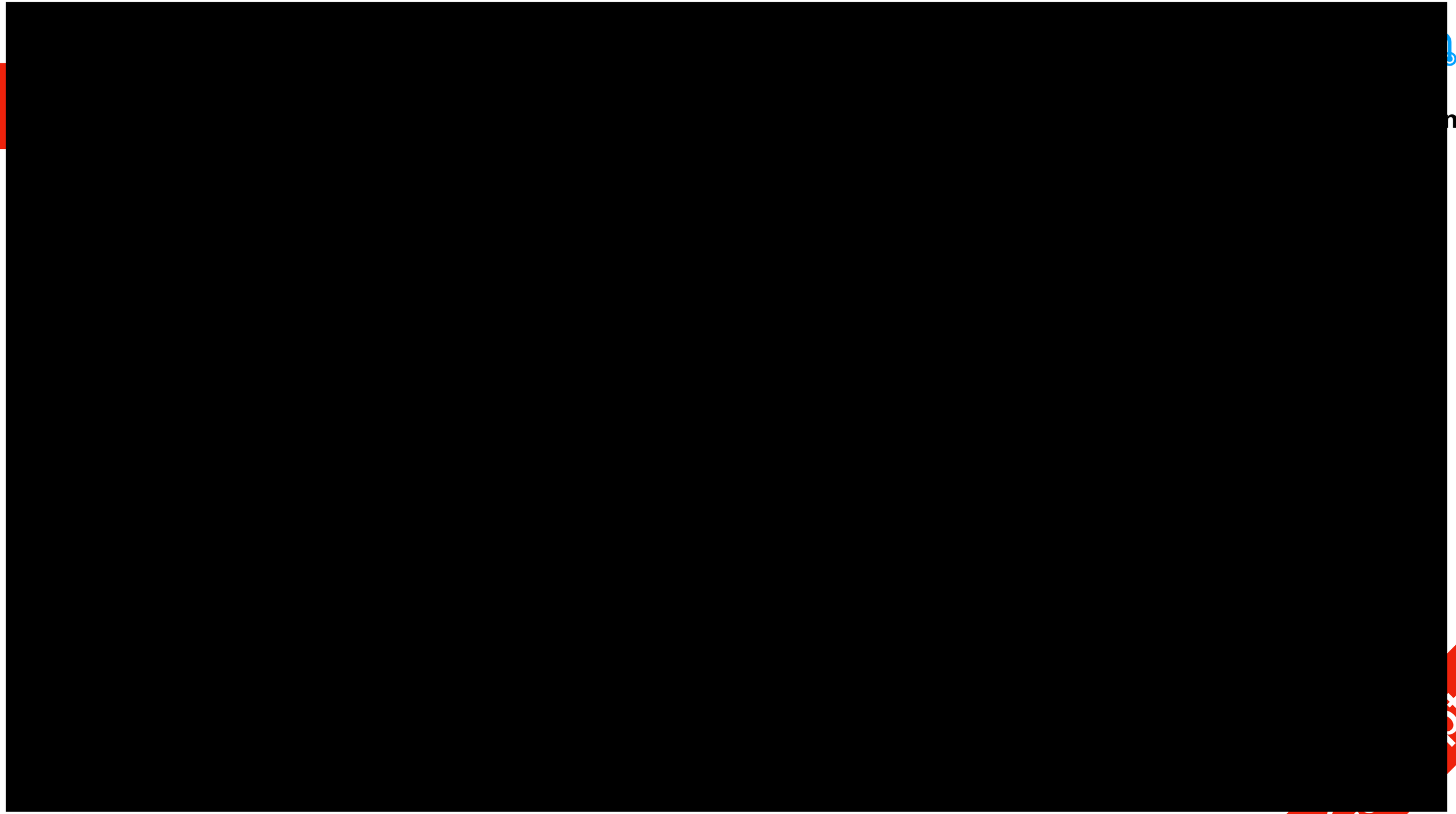
- Computer analysis of individual examination reports
  - Basic statistic analysis
    Spotting abnormal indices
  - Using AI to spot possible problems
    e.g. cancer detection



Hospitals

Patient Oriented

Concept



1. https://www.youtube.com/watch?v=Mur70YjlnmI

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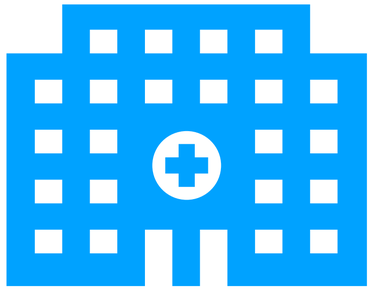
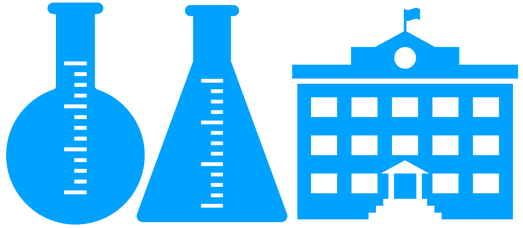
What is currently being done?

Medicine



Hospitals

Patient Oriented



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Knowledge Oriented

- Digitisation of Patient Records database optimisation
- Computer analysis of Individual Examination Reports
- Quantitative Analysis including HGP
- Study biology, develop new treatments

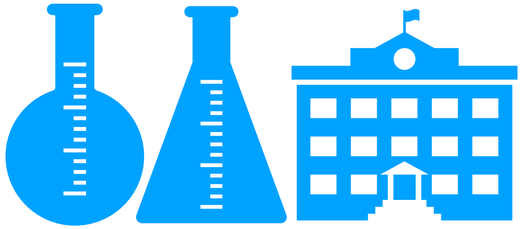
Concept

P2
BioInfo

What is currently being done?

Medicine

- Quantitative Analysis
  - Patient records are very valuable resources
  - Discover patterns between medications and symptoms
  - Long-term assessment of health conditions
- Study biology, develop new treatments
  - Prosthetic Arms and BCI
  - Human Genome Project



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Concept

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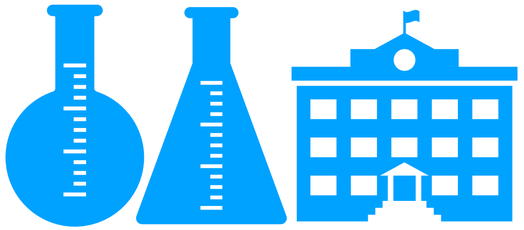
BioInfo

What is currently being done?

Medicine

- Quantitative Analysis
  - Patient Records comes in natural language (human language)
  - Information Extraction
  - Data analysis



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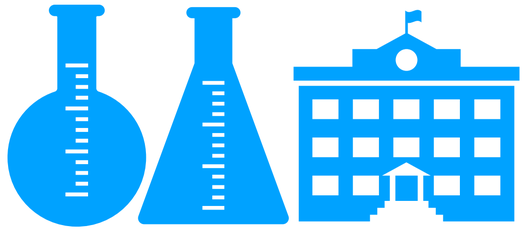
What is currently being done?

Medicine

- Quantitative Analysis
  - Patient Records comes in natural language (human language)
  - **Information Extraction**
  - Data analysis



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adj. n. adj. n.

Record: Patient suffering major knee injury, under excessive pain.

Extracted information:

- **Location: "knee"**
- **Degree: "major"**
- **Condition: external injury**
- **Patient feeling: pain, level 0.7**

Concept

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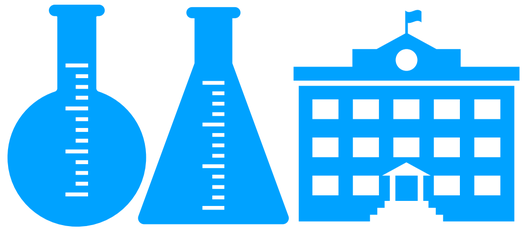
BioInfo

What is currently being done?

Medicine

- Quantitative Analysis
  - Patient Records comes in natural language (human language)
  - Information Extraction
  - **Data analysis**



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Knowledge Oriented

100 patients with knee injury

- **Location: "knee"**
- **Degree: "substantial" -> "major"**
- **Condition: external injury**
- **Patient feeling: pain, level 0.5-0.7**

- **Treatment A: recovery in 30 days**
- **Treatment B: recovery in 15 days**

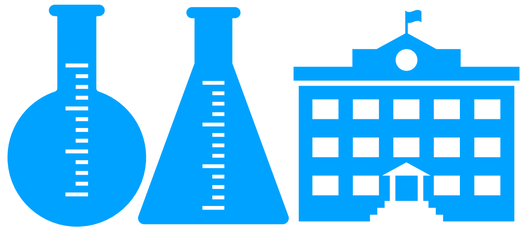
Concept

P2
BioInfo

What is currently being done?

Medicine

- Quantitative Analysis
  - Patient Records comes in natural language (human language)
  - Information Extraction
  - **Data analysis**



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Knowledge Oriented

100 patients with knee injury
- **Location: "knee"**
- **Degree: "substantial" -> "major"**
- **Condition: external injury**
- **Patient feeling: pain, level 0.5-0.7**

- **Age 30 and under:**
  - **Treatment A: recovery in 30 days**
  - **Treatment B: recovery in 15 days**
- **Age 50 and over:**
  - **Treatment A: recovery in 45 days**
  - **Treatment B: recovery in 30 days**

Concept

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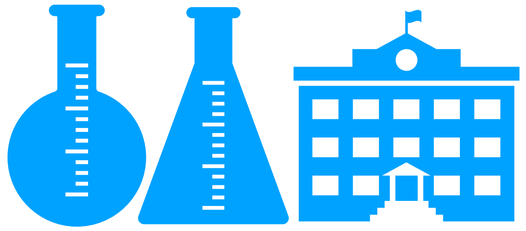
BioInfo

What is currently being done?

Medicine

- Quantitative Analysis
  - Patient Records comes in natural language (human language)
  - Information Extraction
  - **Data analysis**



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Knowledge Oriented

100 patients with knee injury
- **Location: "knee"**
- **Degree: "substantial" -> "major"**
- **Condition: external injury**
- **Patient feeling: pain, level 0.5-0.7**

→

- **Age, Occupation, Gender, ...:**
  - **Treatment A: recovery in ... days**
  - **Treatment B: recovery in ... days**
  - **...**
  - **Treatment Z: recovery in ... days**

→ **...**

Concept

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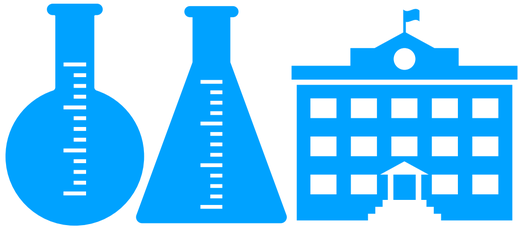
BioInfo

What is currently being done?

Medicine

- Data analysis: Intelligent Diagnostic System
  - IBM Watson
    - Input: patient info and examination records
    - Output: treatment options
    - This is a failed project



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Concept

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Medicine

Concept

1. https://www.youtube.com/watch?v=lRhg6yxenY4

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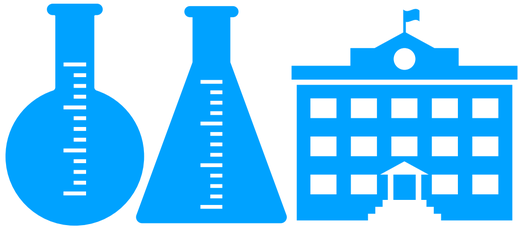
What is currently being done?

Medicine

- Data analysis: Disease Prevention Systems
  - Given patient records and life style, can we predict what likely disease this patient can contract?
  - Given above predictions, can we give recommendations that will lower the chance of actual contraction?



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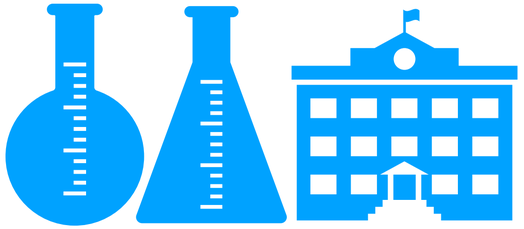
What is currently being done?

Medicine

- Data analysis: Contact Tracing for Covid-19
  - How does it work?
  - Uses bluetooth technology



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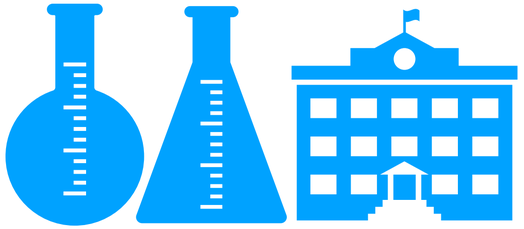
What is currently being done?

Medicine

- Study biology, develop new treatments
  - Prosthetic Arms and BCI
  - Human Genome Project



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Concept

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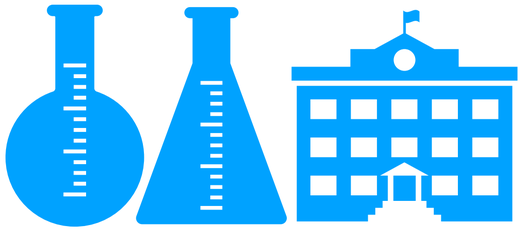
What is currently being done?

Medicine

- Study biology, develop new treatments
  - Prosthetic Arms and BCI
    - Human bodies are filled with neurones
    - Neurones produce electric signals to each other
      - Motor control: controlled through neurones
      - Sensing: optical neurones, etc.
      - Thinking: Wernicke’s’ region for language etc.



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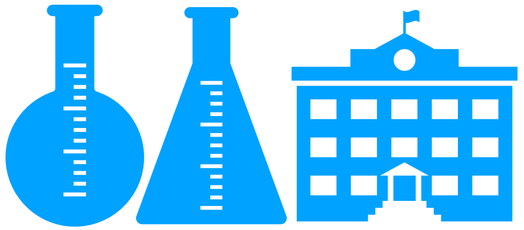

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1. https://www.youtube.com/watch?v=rSQNi5sAwuc

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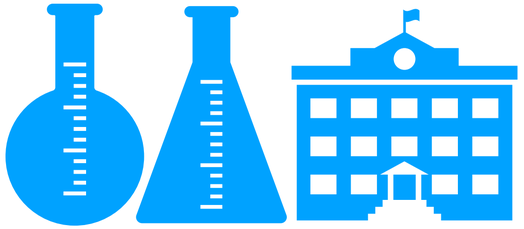
What is currently being done?

Medicine

- Study biology, develop new treatments
  - Prosthetic Body Parts
    - Detect motor control signals (muscle controlling electric signals)
  - BCI: Brain Computer Interface
    - Interpret human brain signals



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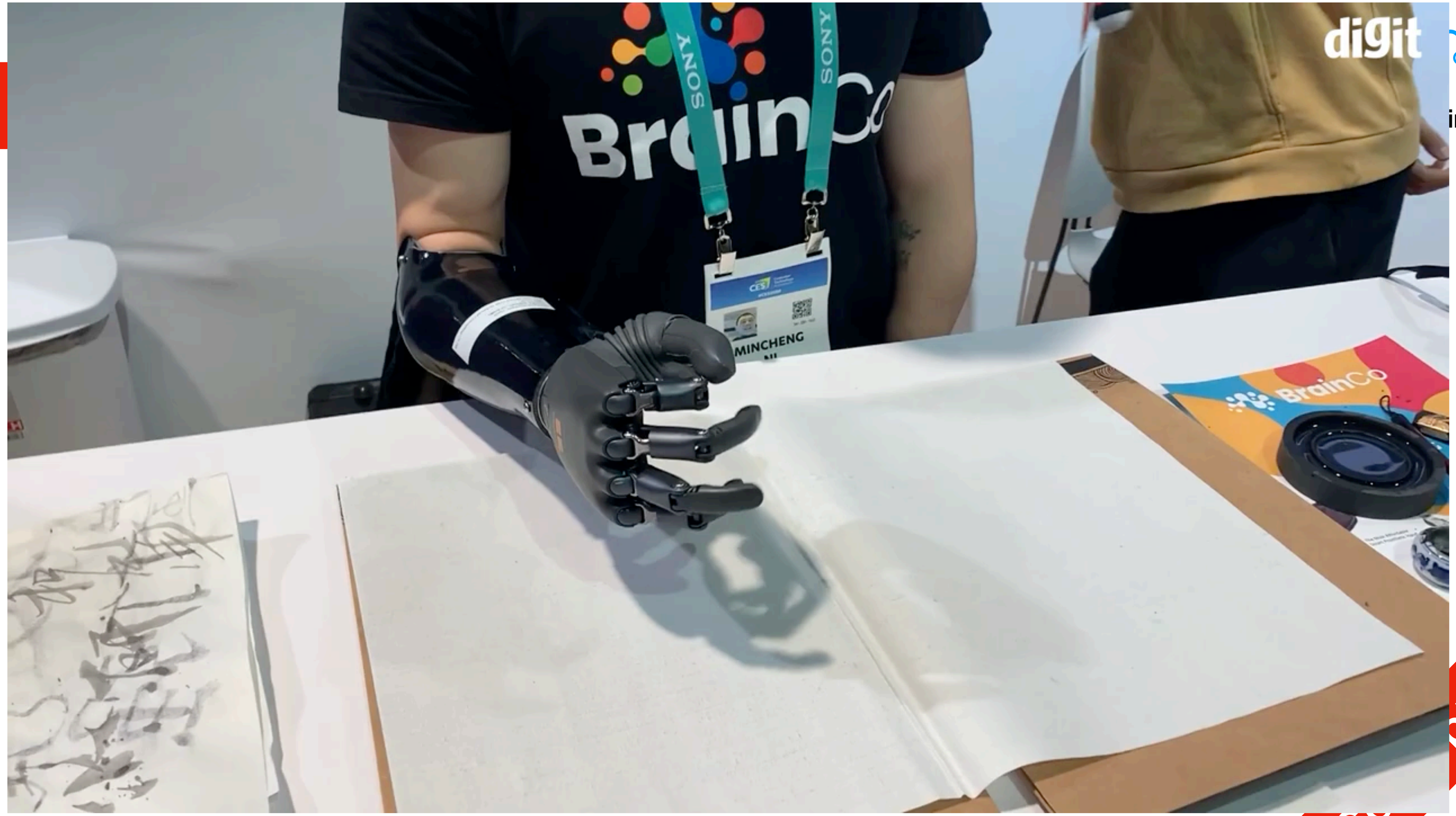

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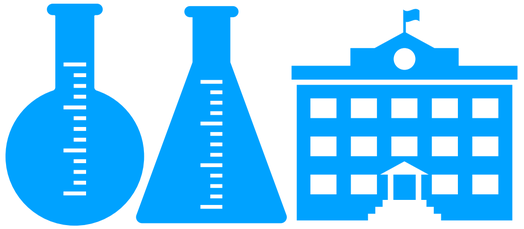
BioInfo

What is currently being done?

Medicine

- Current Advancement in BCI
  - Binary Sentiment Analysis from EEG
  - Reconstruct (some) Acoustics from EEG/ECogG
  - Controlling robotic arms using Brain signals



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Research Topics

Technical