GRIGORE T. POPA UNIVERSITY OF MEDICINE AND PHARMACY IASI

ARTIFICIAL INTELLIGENCE IN MEDICINE

Our Academic Experience

Associate Professor Alexandru BURLACU
MD, PhD, FESC

MEDICAL EDUCATION TODAY

Worldwide, little time is spent on familiarizing medical students or residents with new technologies such as AI, mobile healthcare applications, and telemedicine

Medical students

With an overfull curriculum, there is limited interest in adopting new topics, although a 2016 survey by AMA [1] shows that 85% of physicians perceive benefits from new digital tools.

Curriculum

In the 2018 annual meeting, the American Medical Association (AMA) adopted its first policy on augmented intelligence, encouraging research into how AI should be addressed in medical education [2]

New policies

1. American Medical Association. 2016. Digital Health Study Physicians' motivations and requirements for adopting digital clinical tools: https://www.ama-assn.org/practice-management/digital
2. https://www.ama-assn.org/press-center/press-releases/ama-passes-first-policy-recommendations-augmented-intelligence

Several initiatives for incorporating AI in medical education:

Duke Institute for Health Innovation	University of Florida	Carle Illinois College of Medicine	Sharon Lund Medical Intelligence and Innovation Institute	Stanford University Center for Artificial Intelligence in Medicine and Imaging	University of Virginia Center for Engineering in Medicine
Medical students work together with data experts to develop care-enhanced technologies made for physicians	Radiology residents work with a technology-based company to develop computer-aided detection for mammography	Offers a course by a scientist, clinical scientist, and engineer to learn about new technologies	Organizes a summer course on all new technologies in health care, open to medical students	Involves graduate and postgraduate students in solving healthcare problems with the use of machine learning	Involves medical students in the engineering labs to create innovative ideas in health care

MEDICAL EDUCATION TODAY

- Another important technology-related aspect that is often overlooked in medical training is working with electronic health records (EHRs).
- EHRs have many benefits, such as improved patient safety, but also assist the implementation of AI in health care.
- AI algorithms use information from the EHR, and therefore, the knowledge on how to input unbiased data into the EHR is essential
  - ✓ → Otherwise, the AI algorithm will likely be biased as well.

CHANGES IN CLINICAL PRACTICE

- With the rapid digitization of healthcare, EHRs facilitate new ways to acquire and process information.
- The transitioning from an information age to the age of AI changes clinical practice and patient outcomes for the better.
- Physicians will have a crucial role in deciding which of the AI tools is best for their patients.

CHANGES IN CLINICAL PRACTICE

Besides understanding the principles of medicine, physicians of the future will need to acquire satisfactory knowledge of mathematical concepts, AI fundamentals, data science, and corresponding ethical and legal issues.

These skills will help them to use data from a broad array of sources, supervise AI tools, use AI applications to make informed decisions and recognize cases where algorithms might not be as accurate as expected.

CHANGES IN CLINICAL PRACTICE

Communication, leadership skills and emotional intelligence will be more important than ever as AI-based systems will not be able to consider all the physical and emotional states of the patient.

These traits are hard to master for computers and will characterize a great physician in the age of AI

The system has to change in such a way that competence will no longer be judged based on factual knowledge but rather on communication skills, emotional intelligence, and knowledge on how to use computers.

CHANGES IN CLINICAL PRACTICE

Attendance of conferences on health care AI could be incentivized, so that health care professionals stay up-to-date with the latest developments.

A small subset of rapidly evolving AI in healthcare conferences that physicians and trainees can attend to learn more about this technology and its applications in health care:

Ai4 AI Healthcare Conference	AI in Healthcare	Machine Learning and AI forum (Healthcare Information and Management Systems Society—HIMSS)	AI in Healthcare @ JP Morgan Healthcare Conference https://www.mitcnc.org/events/ai-in-healthcare/	Radiology in the age of AI	American Medical Informatics Association Clinical Informatics Conference
Exploring top use cases of AI and MLb in health care https://ai4.io/healthcare/	Business value outcomes of AI and experience in clinical care and hospital operations https://aiworld.com/Healthcare-AI	Data, analytics, and real-world applications of ML and AI https://www.himsconference.org/education/specialty-programs/machine-learning-ai-healthcare	AI applications—drug discovery, secure data exchange, insurer coordination, medical imaging, risk prediction, at-home patient care, and medical billing	AI in medical imaging https://www.rsna.org/spotlight/ai-san-francisco	AI in medical informatics https://www.amia.org/cic2019/topics-keywords

PHYSICIAN-PATIENT RELATIONSHIP

When information processing will be done mainly by computers, this highlights one of the major benefits of AI in medicine:

- ✓ It allows the physician to focus more on caring for and communicating with patients.

FIRST STEPS

- To enable clinicians to think innovatively and create technology-enabled care models, multidisciplinary training is needed in implementation science, operations, and clinical informatics.

- Next worlwide projects are new developments and are the first steps taken to introduce AI in medical education.

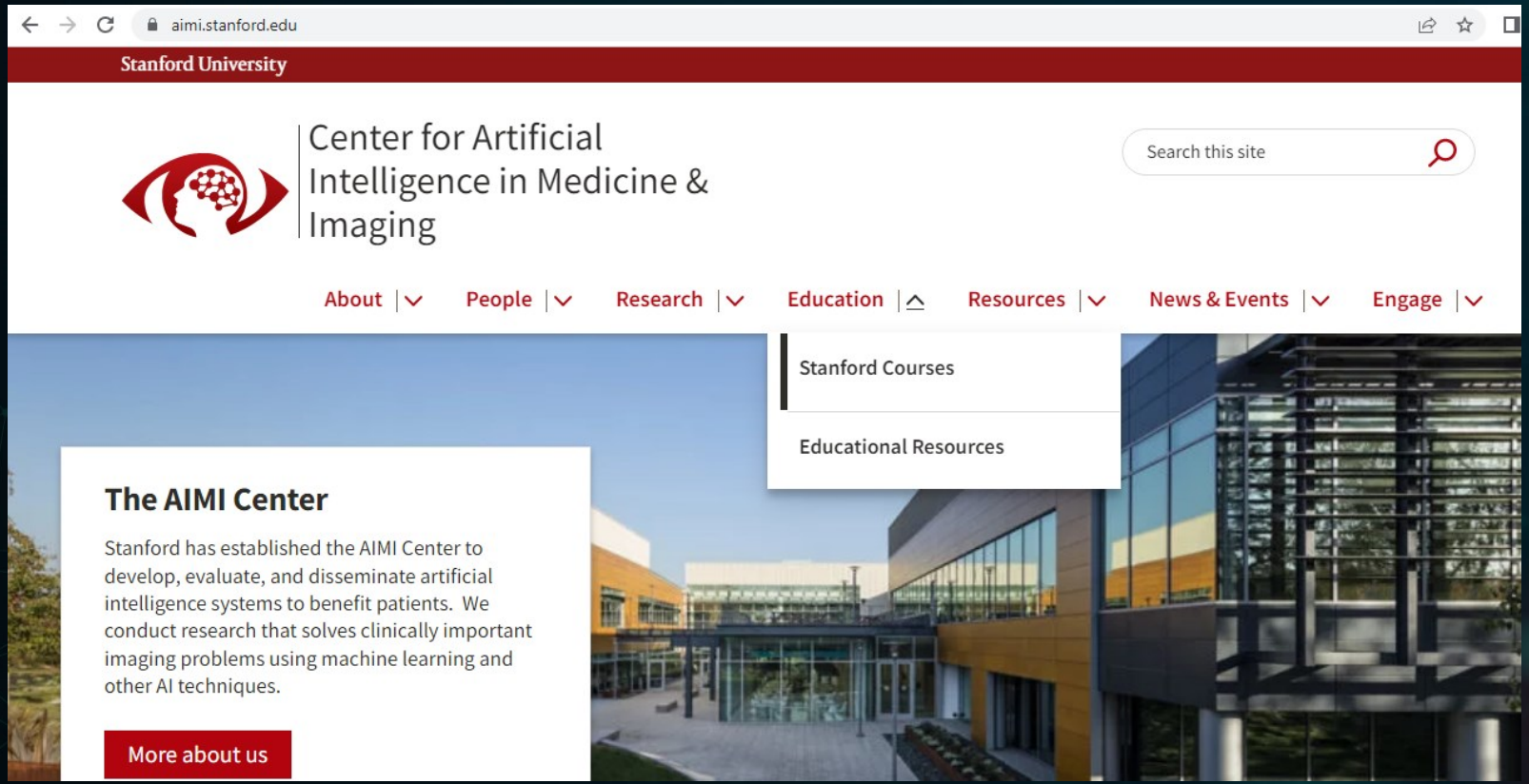
STANFORD MEDICAL SCHOOL

- The Stanford Center for Artificial Intelligence in Medicine and Imaging (AIMI Center) was established in 2018 with the primary mission to solve clinically important problems in medicine using AI.

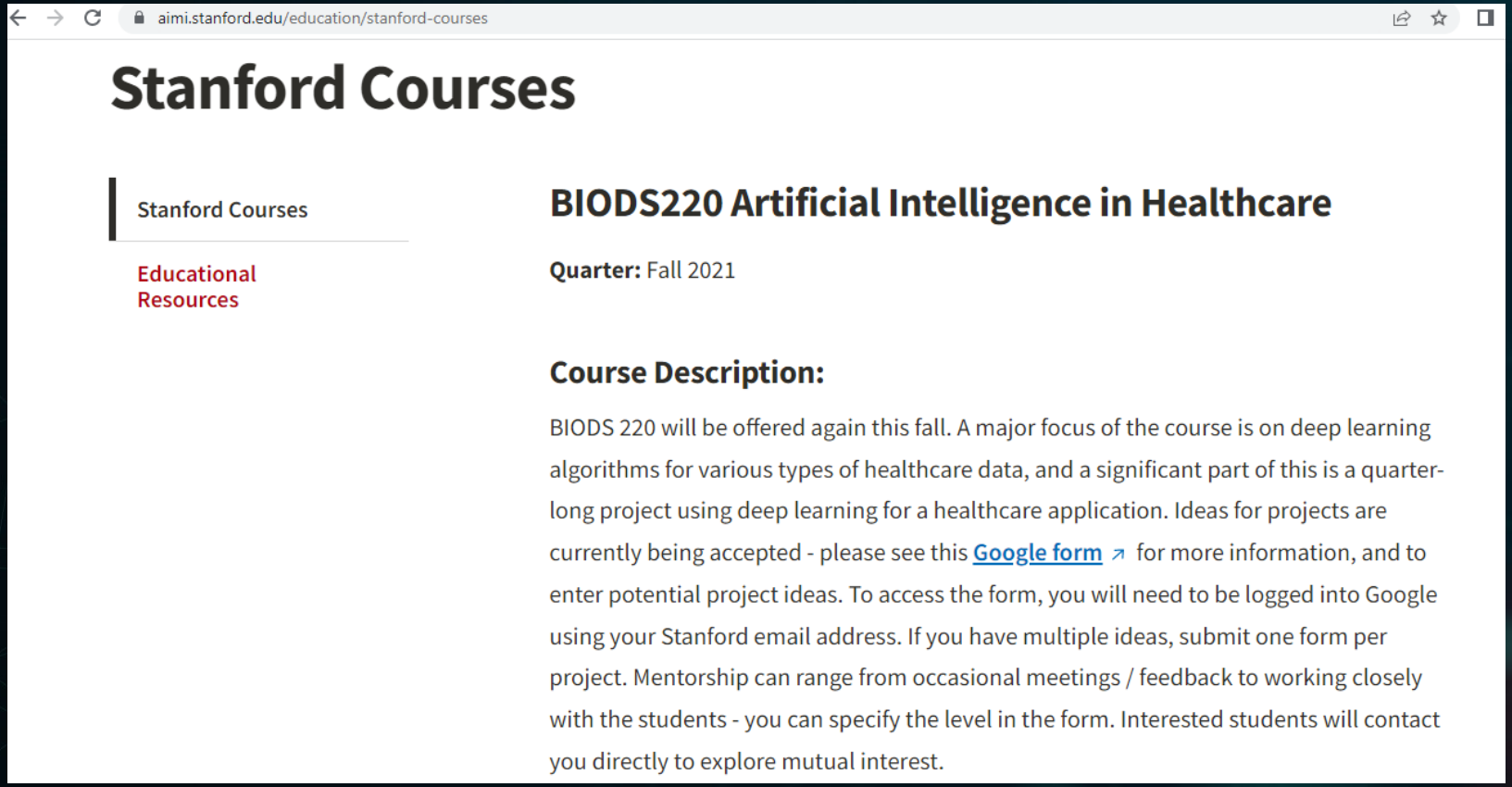
- Drawing on Stanford's interdisciplinary expertise in clinical medical imaging, bioinformatics, statistics, electrical engineering, and computer science, the AIMI Center supports the development, evaluation and dissemination of new AI methods applied across the medical imaging life cycle.

- Its mission is to develop and support transformative medical AI applications and the latest in applied computational and biomedical imaging research to advance patient health.

STANFORD MEDICAL SCHOOL



STANFORD MEDICAL SCHOOL



STANFORD MEDICAL SCHOOL

aimi.stanford.edu/education/stanford-courses

MED 18SI Artificial Intelligence in Medicine and Healthcare Ventures

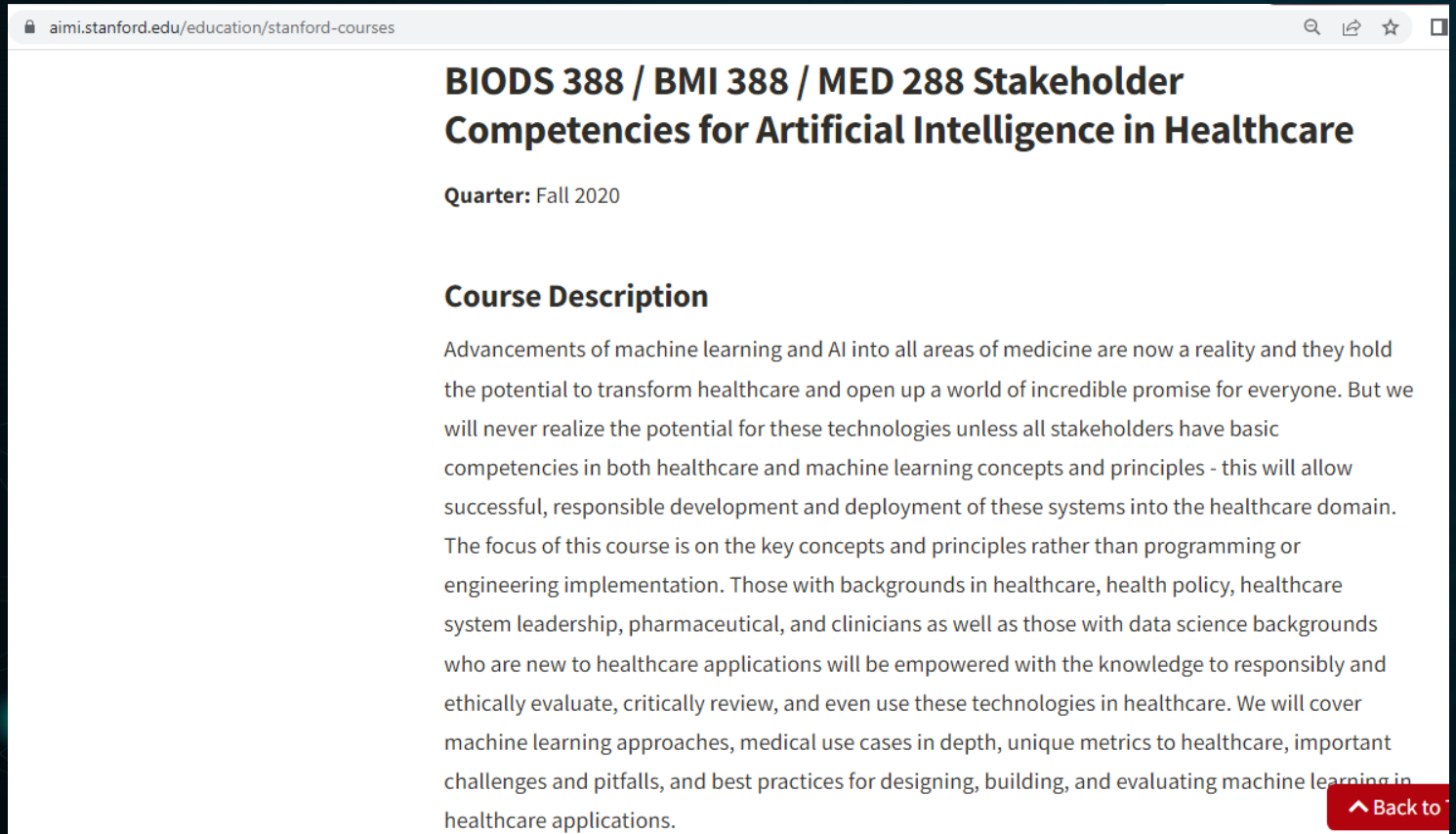
Quarter: Spring 2021

Course Description

The face of healthcare is changing - innovative technologies, based on recent advances in artificial intelligence, are radically altering how care is delivered. Startups are offering entirely new ways to diagnose, manage, treat, and operate. Few ever reach the patient - those that do have much more than an idea and an algorithm; they have an intimate understanding of the healthcare landscape and the technical knowhow to successfully integrate AI solutions into the medical system. In this course, we tackle the central question: How can young students find feasible and impactful medical problems, and build, scale, and translate technology solutions into the clinic. Together, we will discover the transformative technologies of tomorrow that we can build today. Please see the syllabus for more information. We encourage students of all backgrounds to enroll- the only prerequisite is a strong passion for technology in healthcare.

Back

STANFORD MEDICAL SCHOOL



STANFORD MEDICAL SCHOOL

aimi.stanford.edu/education/stanford-courses

CS 522 Seminar in Artificial Intelligence in Healthcare

Quarter: Fall 2020

Course Description:

Artificial intelligence is poised to make radical changes in healthcare, transforming areas such as diagnosis, genomics, surgical robotics, and drug discovery. In the coming years, artificial intelligence has the potential to lower healthcare costs, identify more effective treatments, and facilitate prevention and early detection of diseases. This class is a seminar series featuring prominent researchers, physicians, entrepreneurs, and venture capitalists, all sharing their thoughts on the future of healthcare. We highly encourage students of all backgrounds to enroll (no AI/healthcare background necessary). Speakers and more at CS522 Seminar in AI in Healthcare ↗ .

STANFORD MEDICAL SCHOOL

aimi.stanford.edu/education/educational-resources

AI in Healthcare Specialization

Dates: Begins March 22

Cost: Free

Artificial intelligence (AI) has transformed industries around the world, and has the potential to radically alter the field of healthcare. Imagine being able to analyze data on patient visits to the clinic, medications prescribed, lab tests, and procedures performed, as well as data outside the health system -- such as social media, purchases made using credit cards, census records, Internet search activity logs that contain valuable health information, and you'll get a sense of how AI could transform patient care and diagnoses.

In this specialization, we'll discuss the current and future applications of AI in healthcare with the goal of learning to bring AI technologies into the clinic safely and ethically.

This specialization is designed for both healthcare providers and computer science professionals, offering insights to facilitate collaboration between the disciplines.

STANFORD MEDICAL SCHOOL

aimi.stanford.edu/education/educational-resources

Data Science and Using Image Processing for Healthcare Professionals

Dates: Thu Aug 27, 9:00 am to 4:00 pm & Fri Aug 28, 9:00 am to 4:00 pm

Cost: $800

Data science and digital image processing are becoming an increasingly integral part of health care. This course exposes you to ways data science is used to extract innovative and actionable insights from healthcare-related datasets and medical imaging.

In this course, we will examine how predictive modeling is used to assess outcomes, needs, and potential interventions. We will also explore medical image analysis which has become an inherent part of medical technology. Participants will have the opportunity to:

- Install Anaconda on a personal computer.
- Prepare and explore healthcare-related datasets using the primary tools for data science in Python (e.g., NumPy, Pandas, Matplotlib, Scikit-learn).
- Examine many of the unique qualities and challenges of healthcare data.
- Understand how data science is impacting medical diagnosis, prognosis, and treatment.
- Use a data-science approach to evaluate and learn from healthcare data (e.g., behavioral, genomic, pharmacological).
- Use deep learning and TensorFlow to interpret and classify medical images.
- Perform feature extraction, segmentation, and quantitative measurements of medical images.
- Understand the increasing importance of data science and image processing in healthcare.

STANFORD MEDICAL SCHOOL

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CANADA

Comment | Open Access | Published: 03 June 2022

Insights from teaching artificial intelligence to medical students in Canada

Ricky Hu ✉, Kevin Y. Fan, Prashant Pandey, Zoe Hu, Olivia Yau, Minnie Teng, Patrick Wang, Anthony Li, Mishal Ashraf & Rohit Singla

Communications Medicine **2**, Article number: 63 (2022) | Cite this article

Clinical artificial intelligence (AI) applications are rapidly developing but existing medical school curricula provide limited teaching covering this area. Here we describe an AI training curriculum we developed and delivered to Canadian medical undergraduates and provide recommendations for future training.

CANADA

Objectives, timeline, and methodology

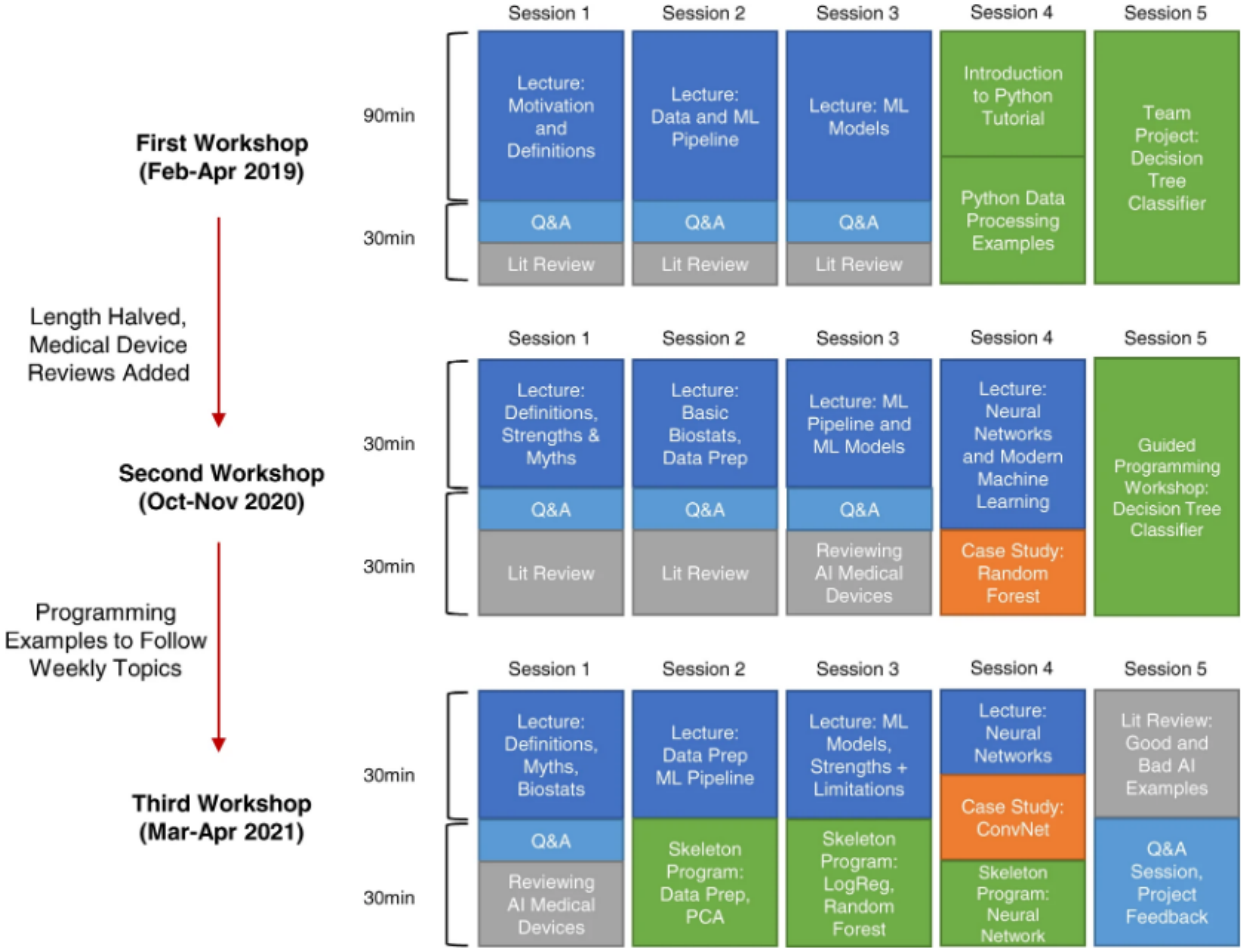
Our five week "Introduction to Medical AI" workshop for medical students was delivered three times between February 2019 and April 2021. A timeline of each workshop summarizing curricular changes is shown in Fig. 1. We had three major learning objectives motivating our curriculum: For learners to understand how data is processed in an AI application, analyze clinical implications of AI literature, and apply opportunities to collaborate with engineers in developing AI.

The first workshop ran from February to April 2019 at the University of British Columbia and all 8 participants provided positive feedback[4]. Due to COVID-19, the second workshop was offered virtually from October to November 2020, with 222 medical students and 3 resident physicians from 8 Canadian medical schools registered. Presentation slides and code were uploaded to an open-access website (http://ubcaimed.github.io). Major feedback from the first iteration included lectures being dense and material being overly theoretical. There was the additional challenge to serve 6 different time zones in Canada. Hence, the second workshop reduced sessions to 1 h each, condensed didactic material, added more case studies, and

C A N A D A I

Fig. 1: A visualization of the timeline for the three iterations of our workshop.

From: Insights from teaching artificial intelligence to medical students in Canada



CANADA

Challenges	Succeses
1.*Heterogeneity of Prior Knowledge*: Our participants varied in mathematical proficiency. 2.*Attendance Attrition*: There was reduced attendance in subsequent sessions, particularly with the online format. A solution could be to track attendance and provide a certificate of completion. 3.*Curricular Design*: As AI spans numerous subfields, selecting core concepts at an appropriate depth and breadth was challenging. 4.*Knowledge Retention*: It remains to be seen how well participants retain knowledge as there are limited opportunities to apply AI.	1. *Proficiency was targeted over literacy:* The depth of material was designed without rigorous mathematics, which has been a perceived challenge in launching clinical AI curricula 2.*Concerns about AI were addressed*: There is a common concern that AI might replace certain clinical duties. To address this, we explained the limitations of AI, including that nearly all AI technologies approved by regulatory bodies require physician supervision. We also emphasized the importance of bias, where algorithms are susceptible to systematic error, especially if the dataset is not diverse. 3.*Resources were open-access:* We generated publicly available resources, including lecture slides and code. 4.*Multidisciplinary Collaboration*: The workshop was a joint venture initiated by medical students to plan curricula alongside engineers.

MASSACHUSETTS, BOSTON

- At the Healthcare Transformation Laboratory (HTL) at Massachusetts General Hospital (MGH) in Boston, a 1-year fellowship is offered in health care innovation exposing resident trainees to topics in data sciences, machine learning, health care operations, services, design thinking, intellectual property, and entrepreneurship

MASSACHUSETTS, BOSTON

GEORGIA

augusta.edu/mcg/medicine/ai/#

Artificial Intelligence in Medicine

Preview medicine's data-augmented future with physician-level data science skills and machine intelligence literacy.

This course has been co-developed by experts in AI from the **College of Computer & Cyber Sciences**, and experts in healthcare and medical education from the **Medical College of Georgia**.

By incorporating multi-media teaching methods with small group and asynchronous learning opportunities we equip learners with the AI literacy requisite to answer these and other questions:

- What will AI technology mean to the next era of medicine and practice?
- Will AI help doctors to take better care of patients with complex illnesses?
- What must medical learners understand to effectively & ethically practice Alaugmented medicine?

Learners will engage in scholarly discourse focused on key theoretical and applied AI references, and all will use the IBM Watson Studio platform to run datasets through various AI algorithms.

Learning Objectives

At the end of this course overview module, you will be able to:

define data science concepts.	define principles of Machine Learning (ML) for data analysis and visualization.
apply data science and ML to real-life applications in medicine and healthcare.	discuss ethical and other emerging issues with AI integration in clinical practice.

LOCAL INITIATIVE

The University of Medicine from Iasi integrated in its curricula in 2020 an „AI in Medicine” optional course for the 5th year students.

GRIGORE T. POPA UNIVERSITY OF MEDICINE AND PHARMACY IASI

LOCAL INITIATIVE

Programarea cursului optional Inteligenta Artificiala in Medicina (anul 5 Medicina Generala)
Introductory talk: Present and future in AI
AI algorithms & strategies and their usefulness in Medicine / Science
Data Science in medicine: Machine Learning techniques & tools for non-programmers, with application in medicine
Local projects using AI in medicine
AI in cardiology
AI in pneumology
AI & artificial pancreas
NLP (Natural language processing): theory and application
Digital Health & Telemedicine - concepts and examples from an industry point of view
The start-up phenomenon in MedTech: opportunities for entrepreneurship in medicine
Final talk & assessment

LECTURE ON: AI ALGORITHMS

- Topics covered:
  - ✓ ML paradigms: Supervised / Unsupervised / Reinforcement learning
  - ✓ Terminology (observation, labels, features, training / test dataset, prediction)
  - ✓ Classification versus regression
  - ✓ Presentation of the mechanism of AI algorithms appealing to clinical applications and evidence based medicine in order to conveniently familiarize students with the AI technology:
    i. Decision trees / Random forrest / Support vector machine / Artificial neural networks / Convolutional neural networks / Natural Language Processing / Recurrent Neural Networks / Deep learning

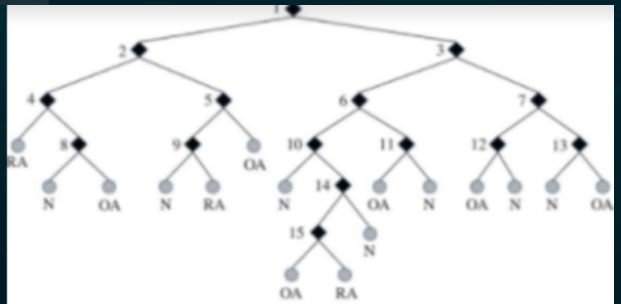
CLINICAL QUESTION

How to differentiate normal individuals, osteoarthritis and rheumatoid arthritis patients using serum biomarkers?

DECISION TREES - EXAMPLE

The objective of this study was to develop a method for categorizing normal individuals (normal, n = 100) as well as patients with osteoarthritis (OA, n = 100), and rheumatoid arthritis (RA, n = 100) based on a panel of inflammatory cytokines expressed in serum samples using AI algorithms (among which decision trees).

https://doi.org/10.1098/rsif.2014.0428



node	cytokine	value (X)	<X; move to node:	>X; move to node:
1	TGFalpha	4.025	2	3
2	EGF	20.085	4	5
3	CD40L	2558.36	6	7
4	CD40L	196.94	RA	8
5	CD40L	4010.68	9	OA
6	IFNgamma	60.94	10	11
7	MIP-1beta	159.01	12	13
8	eotaxin	30.05	N	OA
9	eotaxin	2340.24	N	RA
10	TNFalpha	1.06	N	14
11	IL-1alpha	76.59	OA	N
12	GRO	1455.42	OA	N
13	eotaxin	110.97	N	OA
14	G-CSF	28.1	15	N
15	fractalkine	18.76	OA	RA

LECTURE ON: AI ALGORITHMS

- Topics covered:
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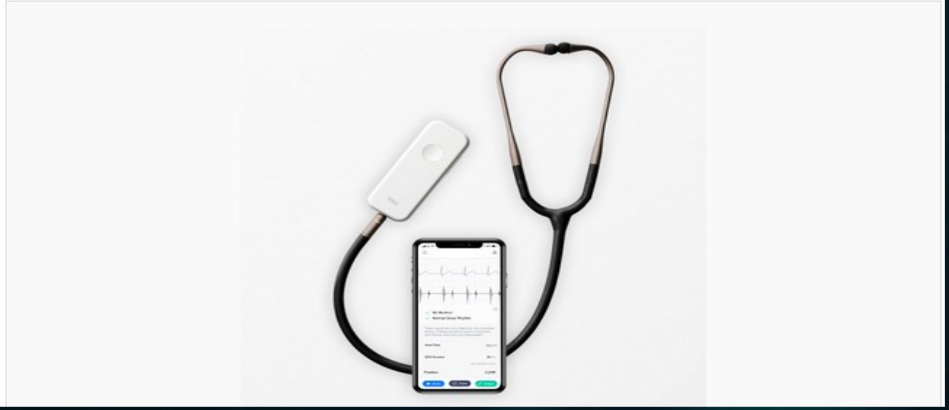
ARTIFICIAL NEURAL NETWORKS (ANN) FDA APPROVED

Name of device or algorithm	Name of parent company	Short description	FDA approval number	Mention of A.I. in announcement	Date	Medical specialty	Secondary medical specialty
Eko Analysis Software	Eko Devices Inc.	Cardiac Monitor	K192004	artificial neural network	2020 01	Cardiology	
PAPNET Testing System	Neurome dical Systems Inc.	Semi-automated device indicated to aid in the rescreening of negative Pap test	P940029	neural networks	1995 08	Pathology	Gynecology

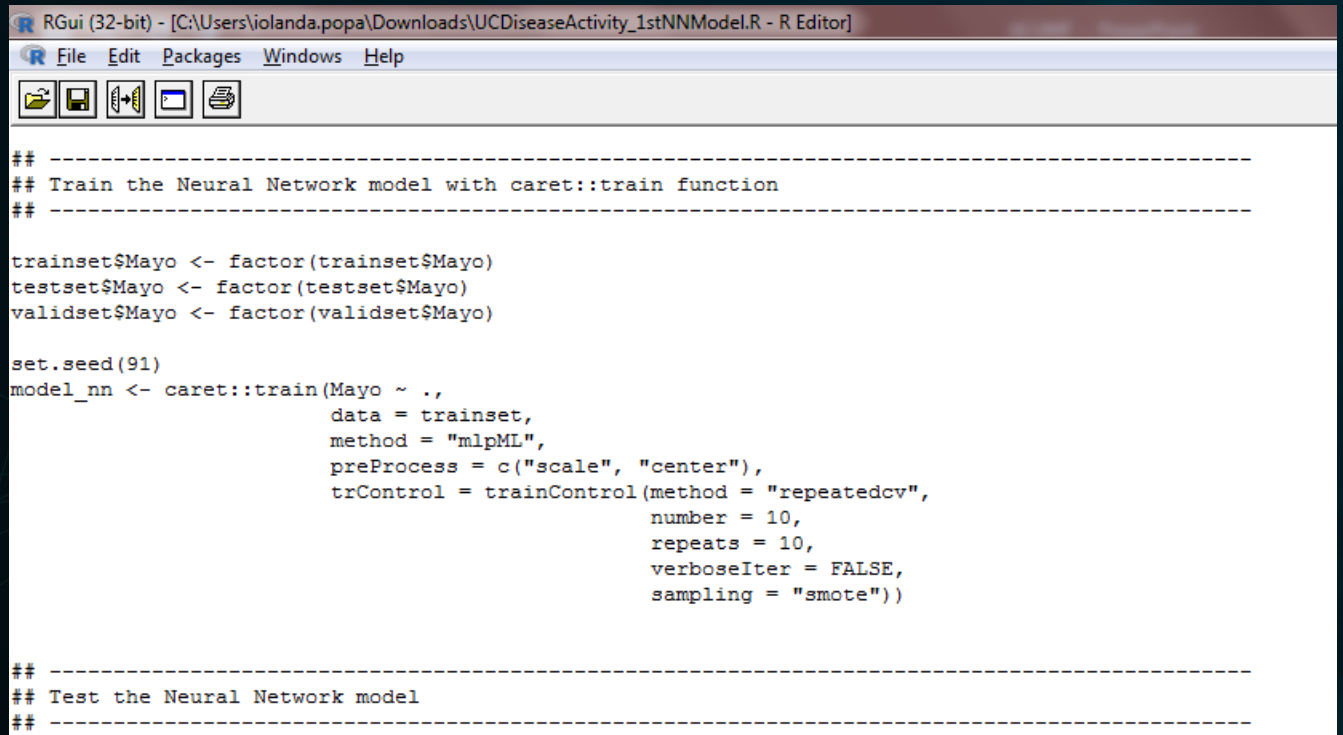
FDA Clears Eko's AFib and Heart Murmur Detection Algorithms, Making It the First AI-Powered Stethoscope to Screen for Serious Heart Conditions

Eko's algorithms alert clinicians to the presence of heart murmurs and atrial fibrillation (AFib) during the physical exam, converting the classic stethoscope into a powerful early detection tool



LECTURE ON: DATA SCIENCE IN MEDICINE - ML TOOLS

Step by step example of a medical AI application in R - step by step




```
## ------------------------------------------------------------------------------------------------
## Train the Neural Network model with caret::train function
## ------------------------------------------------------------------------------------------------

trainset$Mayo <- factor(trainset$Mayo)
testset$Mayo <- factor(testset$Mayo)
validset$Mayo <- factor(validset$Mayo)

set.seed(91)
model_nn <- caret::train(Mayo ~ .,
                         data = trainset,
                         method = "mlpML",
                         preProcess = c("scale", "center"),
                         trControl = trainControl(method = "repeatedcv",
                                                  number = 10,
                                                  repeats = 10,
                                                  verboseIter = FALSE,
                                                  sampling = "smote"))


## ------------------------------------------------------------------------------------------------
## Test the Neural Network model
## ------------------------------------------------------------------------------------------------
```

LECTURE ON: LOCAL PROJECTS USING AI IN MEDICINE

GRIGORE T. POPA UNIVERSITY OF MEDICINE AND PHARMACY IASI

AI IN MEDICINE

3RD WEEK

AGENDA

- *Local projects using AI in medicine;*
- *Working with inteligent machines (explore the concept of inteligence in machines)*

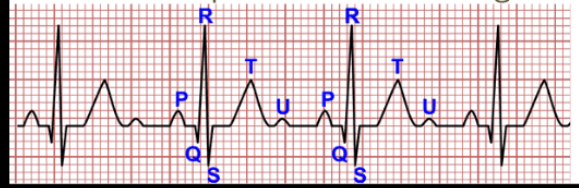
ADRIAN IFTENE
UAIC
DECAN FACULTATEA DE INFORMATICA
PROFESOR UNIV.

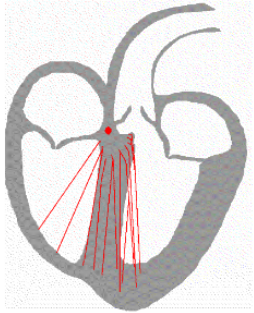
4 DEC 2020 | FROM 18:30 | ONLINE ON TEAMS

ECG Biometrics

A way to identify persons by the morphology of the electrocardiogram, identification based on differentiated characteristics

Features: points P and T along with the QRS complex





LECTURE ON: LOCAL PROJECTS USING AI IN MEDICINE

ImageCLEFmed Tuberculosis - Data

Dataset contains chest CT scans of 403 (283 for train and 120 for test) TB patients. For all patients organizers provide 3D CT images with an image siz per slice of 512*512 pixels and number of slices being around 100

Table 1. Patients Affected in the Training Set

Columns	Patients Affected in the Training Set (out of 283)
LeftLungAfftected	211
RightLungAffected	233
CavernsLeft	66
CavernsRight	79
PleurisyLeft	7
PleurisyRight	14

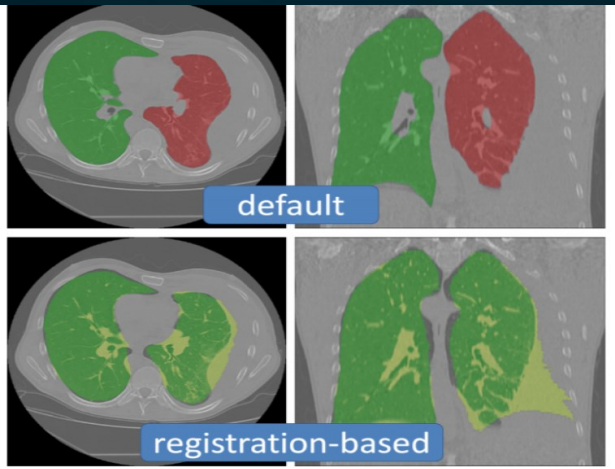
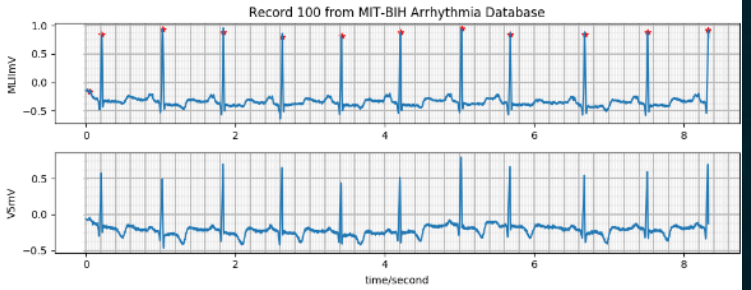


Fig. 1. CT image of a TB patient having pleurisy with the default lung masks (top) and the lung masks obtained via registration-based approach (bottom).

LECTURE ON: LOCAL PROJECTS USING AI IN MEDICINE

Atrial Fibrillation

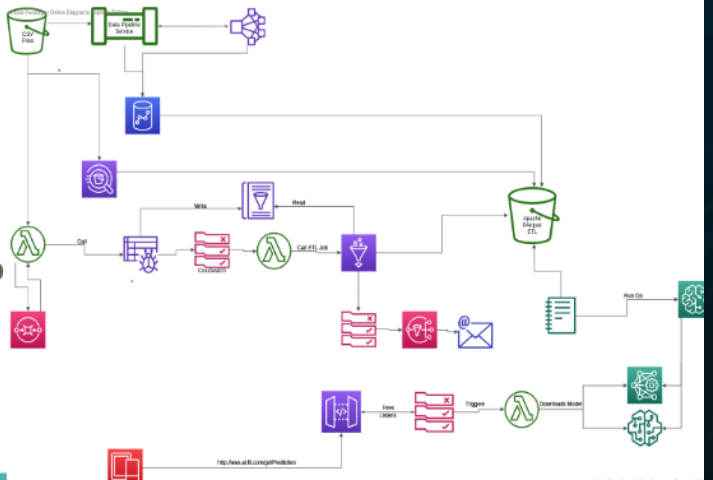


In collaboration with **Alexandru Burlacu**

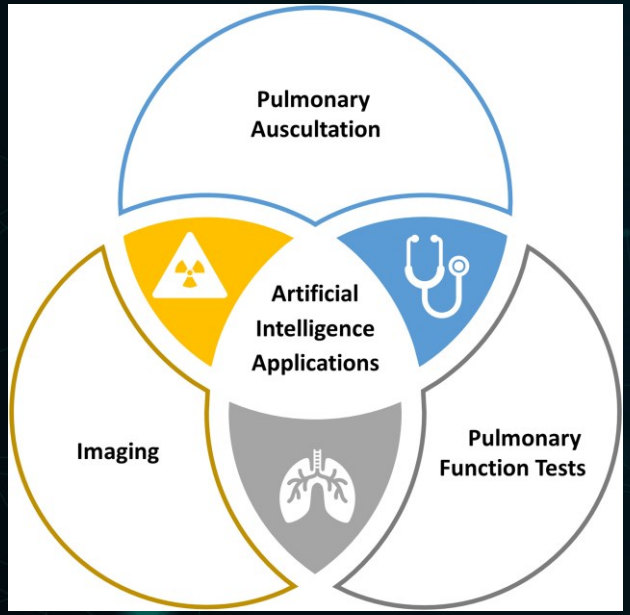
Data 87,554 train individuals and around 21,892 test individuals from the PTB and MIT DB datasets available open-source

- BNN (Bayesian Neural Network) ~ 90%
- CNN Conv 1D ~ 95%
- RNN Model ~ 88%
- CNN Conv 1D with preprocessing ~ **98%**

Other solutions ~ 97.5



LECTURE ON: AI IN PNEUMOLOGY



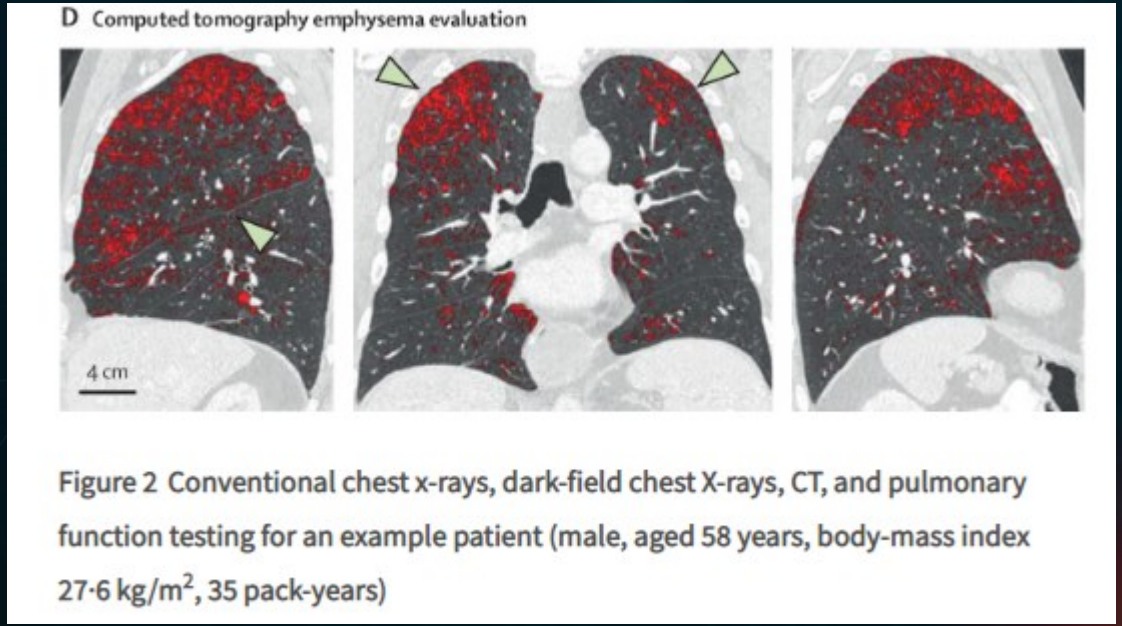
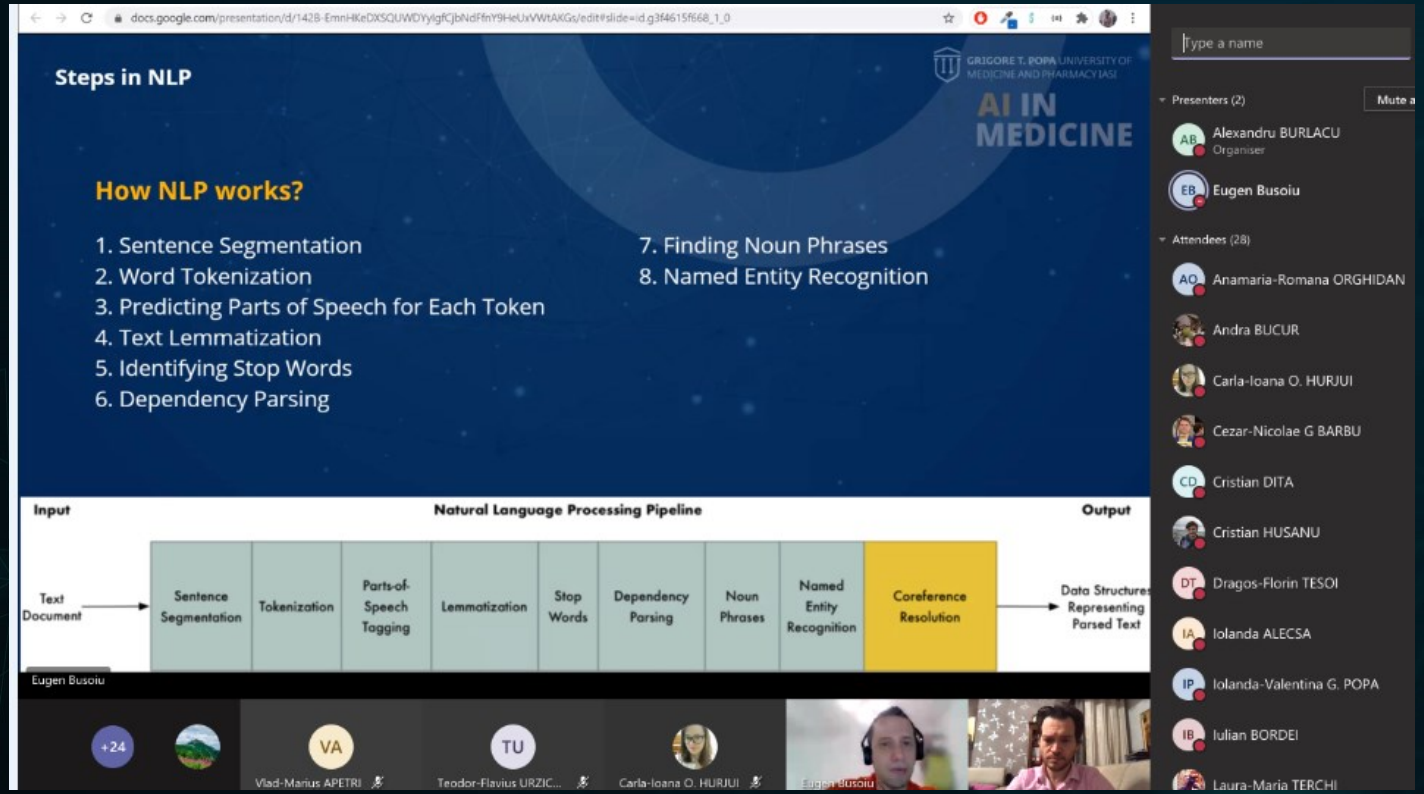


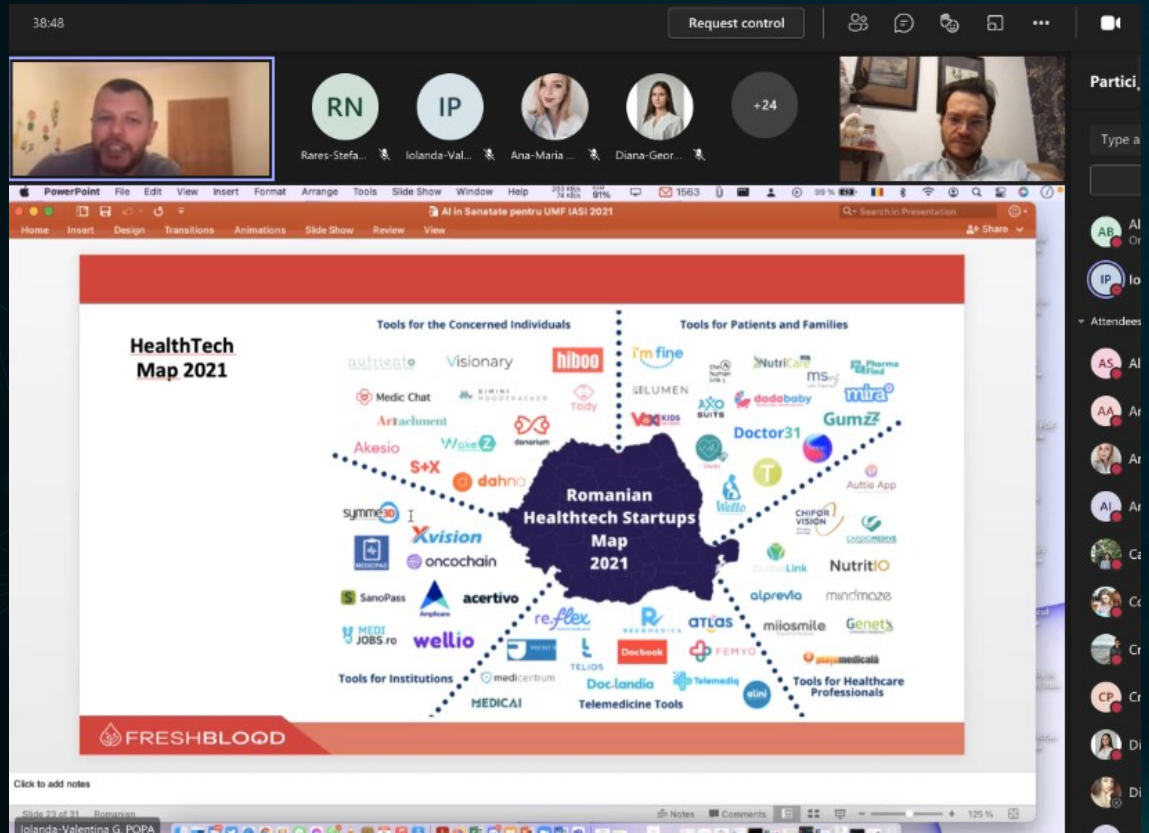
Figure 2 Conventional chest x-rays, dark-field chest X-rays, CT, and pulmonary function testing for an example patient (male, aged 58 years, body-mass index 27·6 kg/m^2, 35 pack-years)

LECTURE ON: AI & ARTIFICIAL PANCREAS

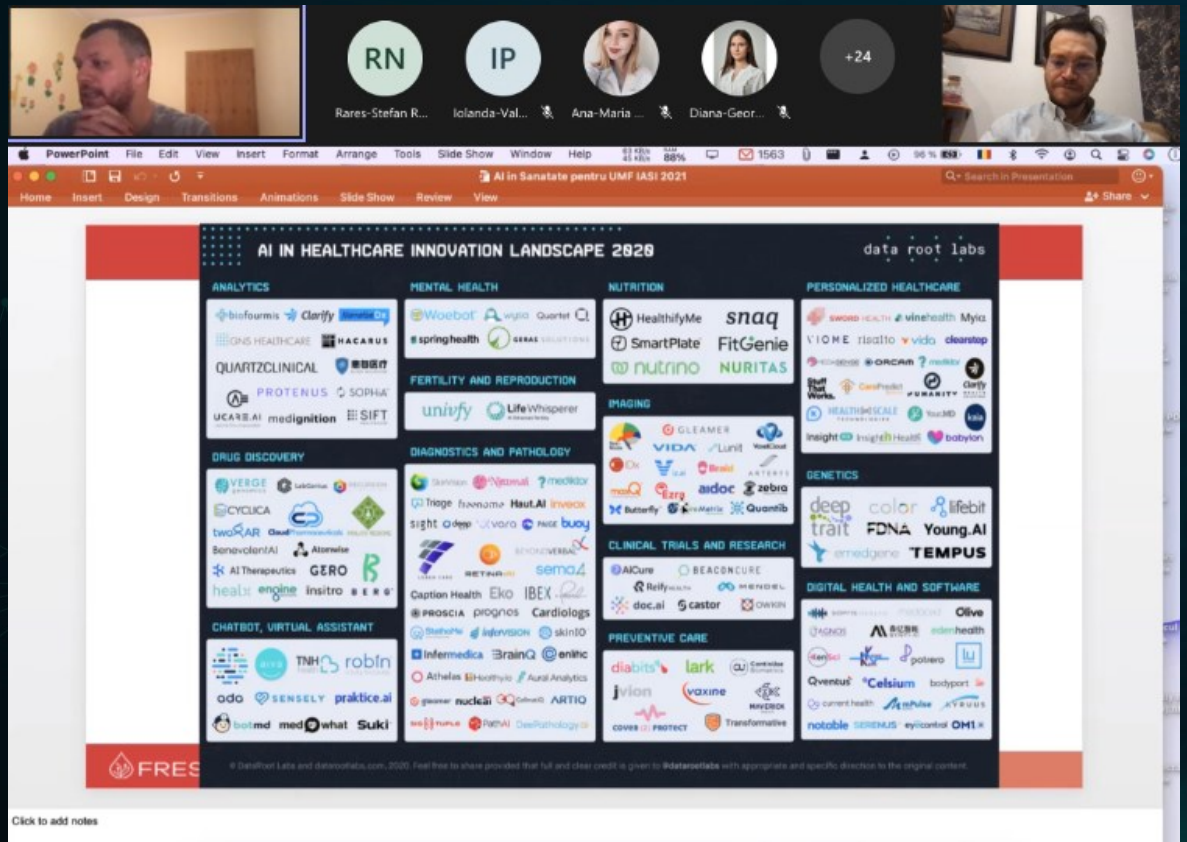
LECTURE ON: NATURAL LANGUAGE PROCESSING



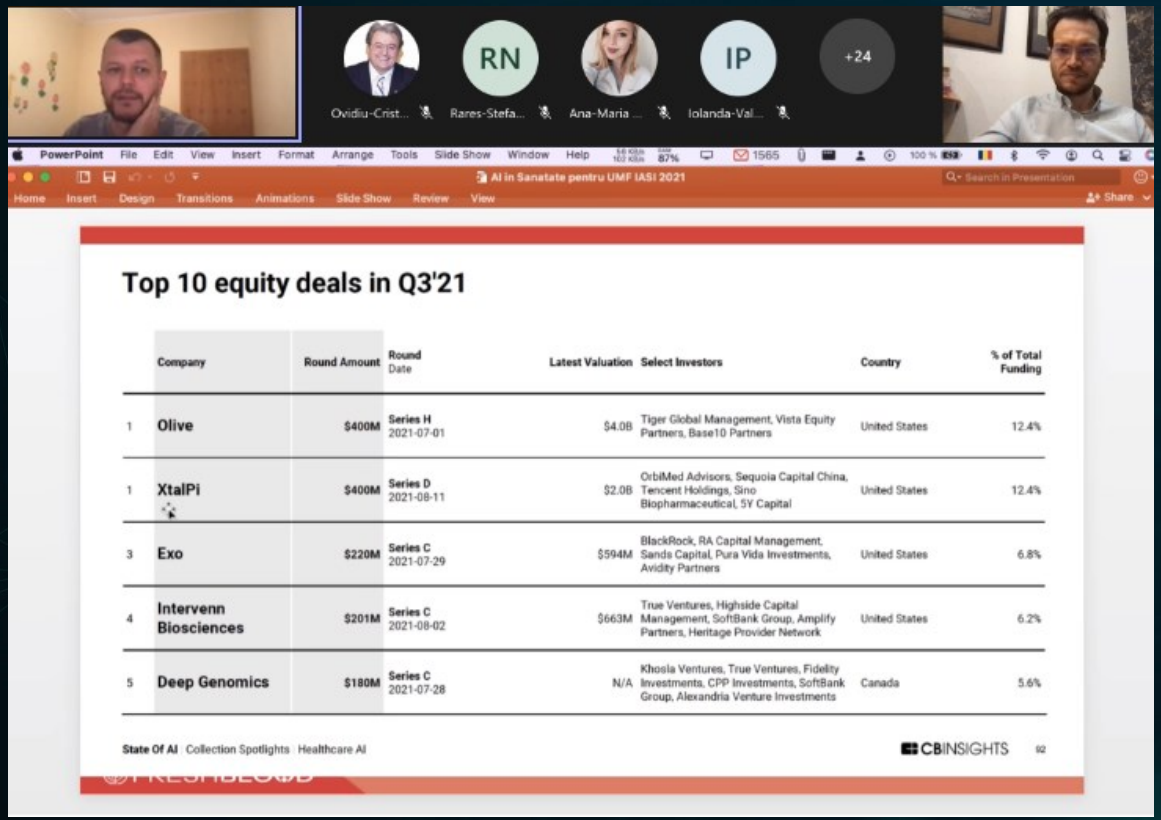
LECTURE ON: THE START-UP PHENOMENON IN MEDTECH



LECTURE ON: THE START-UP PHENOMENON IN MEDTECH

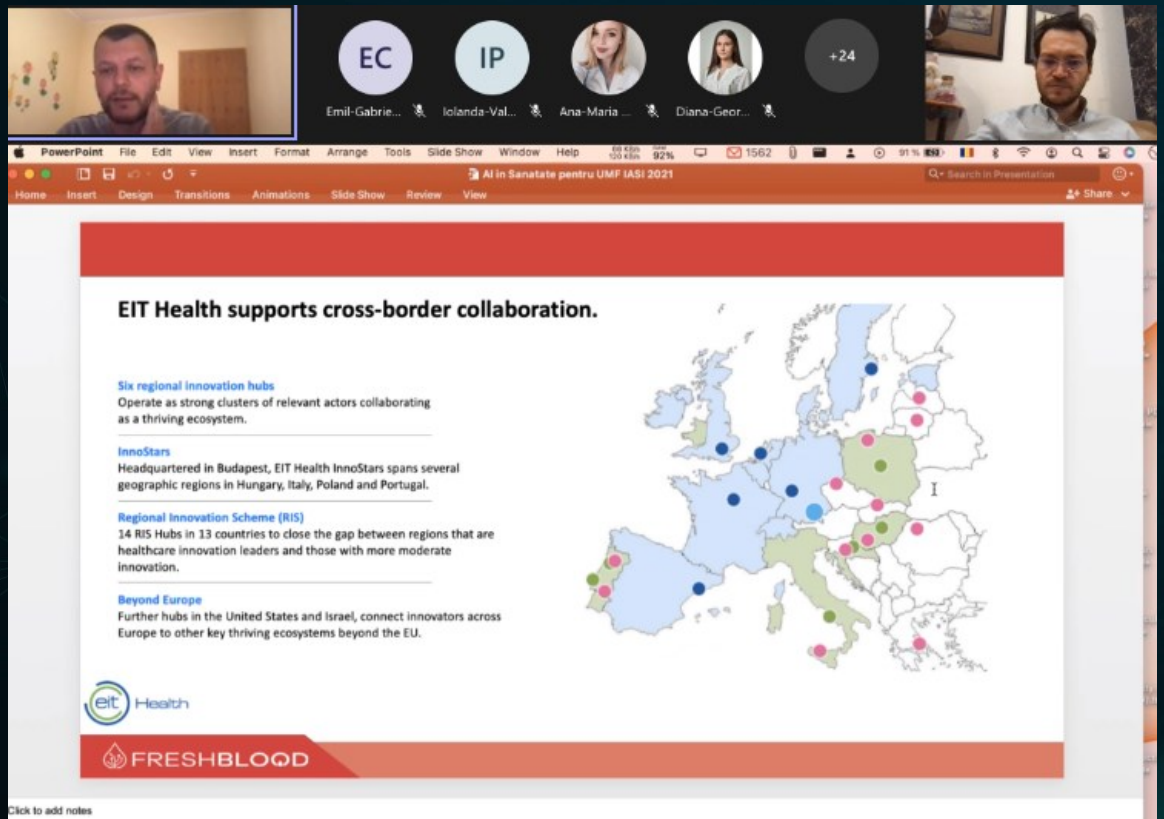


LECTURE ON: THE START-UP PHENOMENON IN MEDTECH



	Company	Round Amount	Round Date	Latest Valuation	Select Investors	Country	% of Total Funding
1	Olive	$400M	Series H 2021-07-01	$4.0B	Tiger Global Management, Vista Equity Partners, Base10 Partners	United States	12.4%
1	XtalPi	$400M	Series D 2021-08-11	$2.0B	OrbiMed Advisors, Sequoia Capital China, Tencent Holdings, Sino Biopharmaceutical, 5Y Capital	United States	12.4%
3	Exo	$220M	Series C 2021-07-29	$594M	BlackRock, RA Capital Management, Sands Capital, Pura Vida Investments, Avidity Partners	United States	6.8%
4	Intervenn Biosciences	$201M	Series C 2021-08-02	$663M	True Ventures, Highside Capital Management, SoftBank Group, Amplify Partners, Heritage Provider Network	United States	6.2%
5	Deep Genomics	$180M	Series C 2021-07-28	N/A	Khosla Ventures, True Ventures, Fidelity Investments, CPP Investments, SoftBank Group, Alexandria Venture Investments	Canada	5.6%

LECTURE ON: THE START-UP PHENOMENON IN MEDTECH



CONCLUSIONS

- Physicians and machines working in combination have the greatest potential to improve clinical decision making and patient health outcomes
- AI can curate and process more data such as medical records, genetic reports, pharmacy notes, and environment data and in turn retain, access, and analyze more medical information.
- However, it cannot replace the art of caring.
- As AI and its application become mainstream in healthcare, medical students, residents, fellows, and practicing physicians need to have knowledge of AI, data sciences, EHR fundamentals, and ethics and legal issues concerning AI.

CONCLUSIONS

- Medical schools will need to include them as part of the curriculum
- AI will enable faster and accurate diagnosis, augment radiology, reduce errors due to human fatigue, decrease medical costs, assist and replace dull, repetitive, and labor-intensive tasks, minimally invasive surgery, and reduce mortality rates.
- With the global health care expenditure projected to reach US $10 trillion by 2022, AI has the invaluable potential to advance the quadruple aim in healthcare - enhance the patient experience, improve population health, reduce costs, and improve the provider experience.

THANK YOU!

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