An Introduction to Artificial Intelligence and Machine Learning with Applications in Healthcare

Homayoun Valafar
Chairman, Department of Computer Science and Engineering
Director, SC INBRE Bioinformatics Core
Director, Big Data Health Science Center Genomic Core

Outline

1)Discuss the role of Artificial Intelligence (AI) and Machine Learning (ML) in scientific discovery

2)Define the relationship between AI and ML

3)Abstracted training of ML models

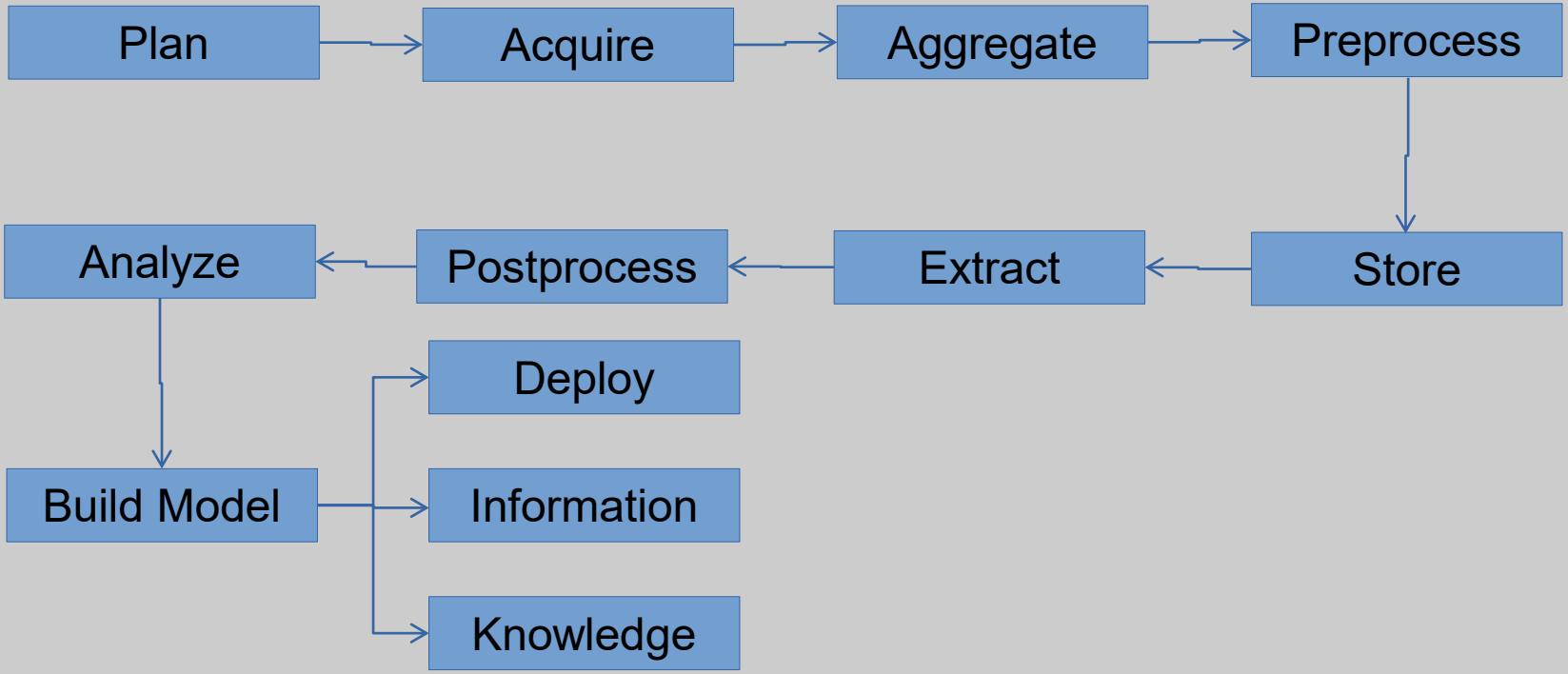
4)Examples of AI & ML techniques

5)Example applications of AI & ML in healthcare

6)Conclusion and acknowledgments

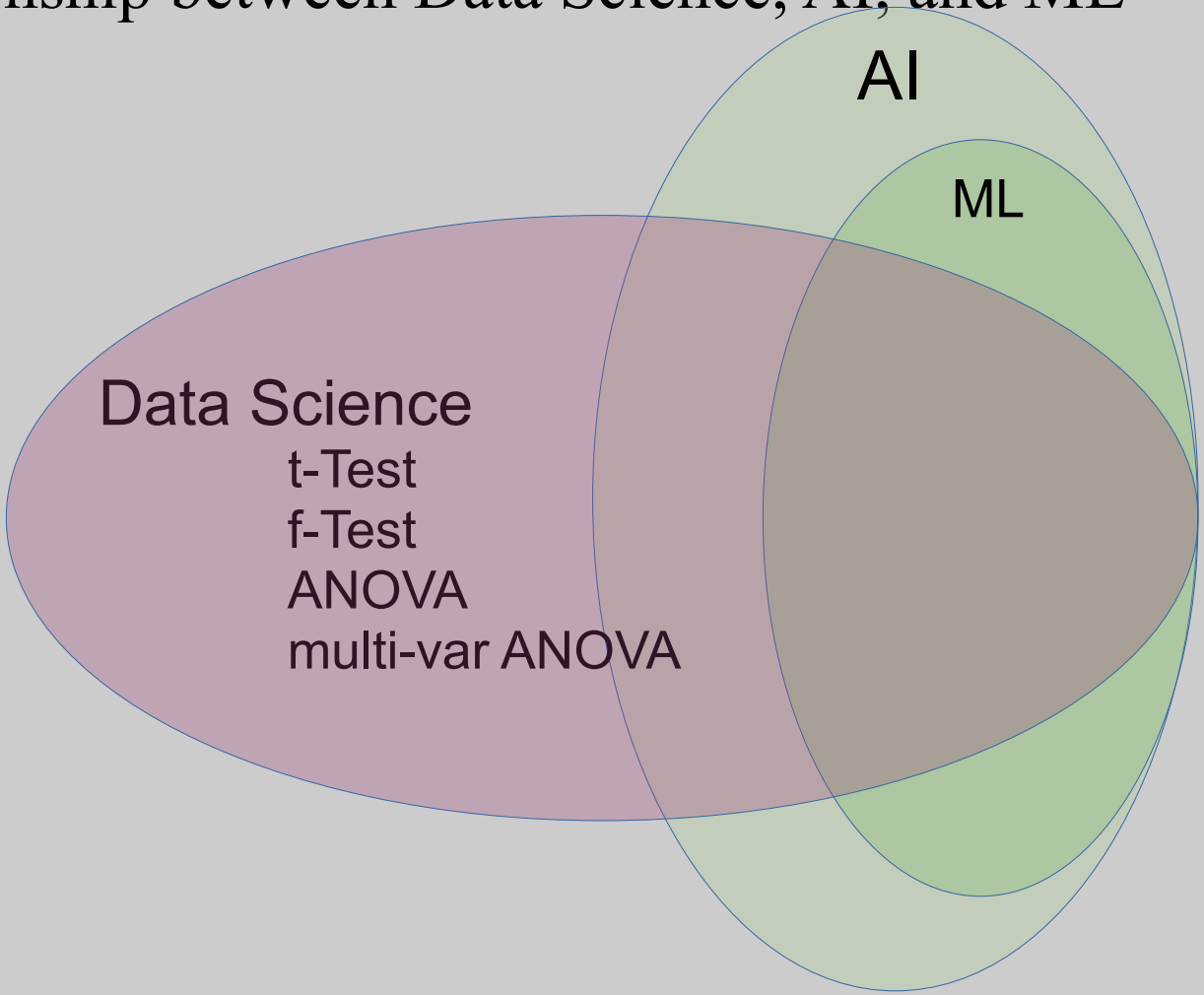
Data Life Cycle/Path

- One example view of data path
- Data scientist play a role at each step to various degrees
- AI/ML play a critical role in application of data processing



Data Science, AI, and ML

- The relationship between Data Science, AI, and ML



AI versus ML

- Incorrectly, they are used interchangeably
  - But they are distinctly different
- AI: when machines act intelligently
  - Has been around since 1956
  - A technique is AI and not ML if intelligence is programmed by humans
- ML: when machines learn on their own
  - Machine will know but we (humans) may or may not know what the machine is doing!
  - Black-box versus white-box is based on
    - Explainability and reliability AI

AI versus ML

- Examples of AI but not ML

–Rule based systems

- Example: if after 7 PM then turn on the living room lights

- Examples of AI that are ML

–Given the data, find patterns that determine responders to a drug

–Given the data, find the distinguishing attributes of smoking

–Given the data, find the common characteristics of patients with vascular disease

–Given the images, find the perpetrators in a crowd

Abstracted training of ML models

Two Main Branches of ML

- ML itself can be divided into two distinct categories

–Supervised Learning

- The outcome for each observation is known or expert evaluations are included
- More reliable and common practice
- More time and resource consuming

–Requires human expert evaluation of the data

- Will incorporate human errors

–Unsupervised Learning

- Machine will determine the natural clustering of the data
- Less prevalent and more academic in nature
- Clustering of the data may be meaningful or not

Abstraction of Supervised Learning

1)Collect and aggregate relevant data

2)Scrutinize the data for accuracy and bias

–Sex or race-based biases

3)Remove biases (balance the data)

–90% of the data from males and 10% females

- Repeat each female 8 times to arrive at equal proportions

–Some biases are unintended and unknown

- AI-based tools should be extensively tested before full utility

4)Divide the data into the Training and Testing sets

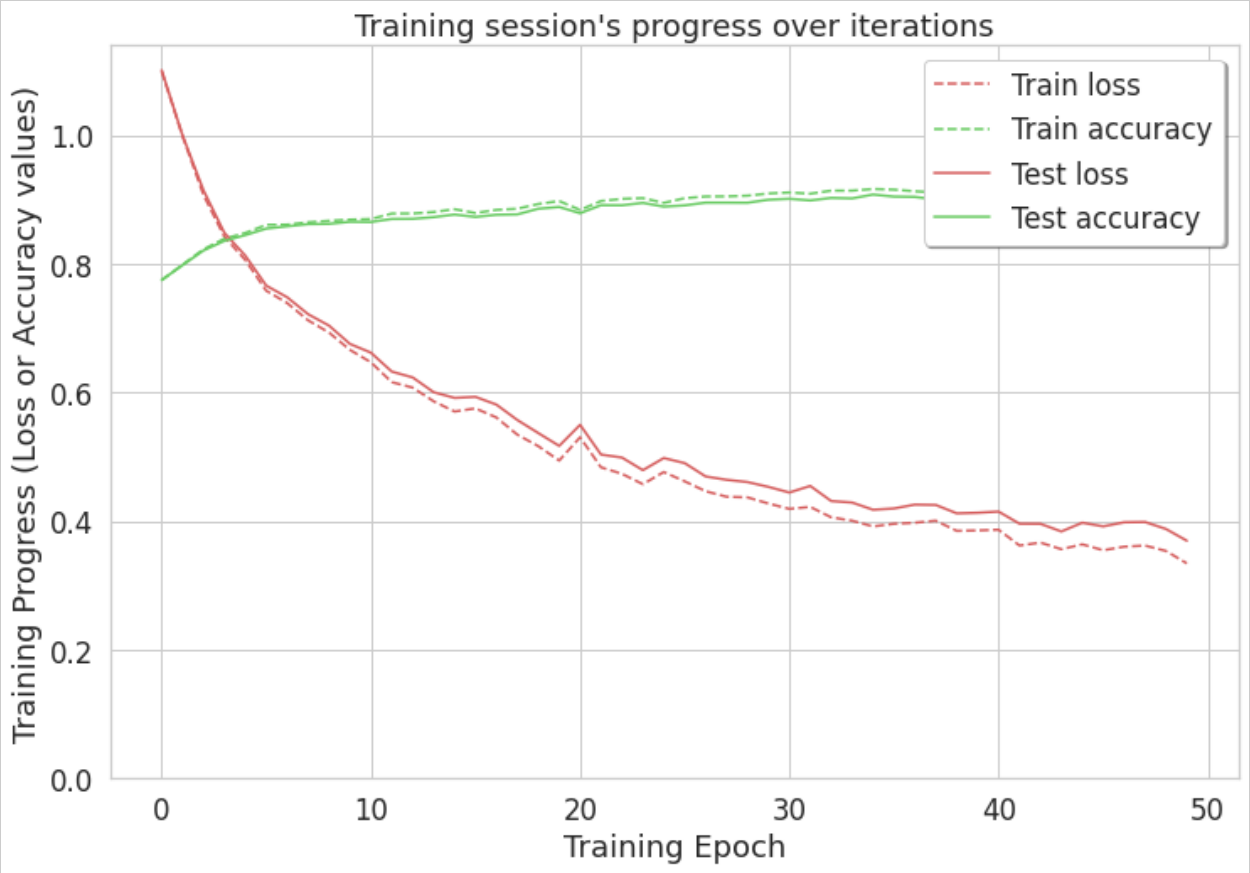
–Training-set is used to train the model

–Testing-set is used (at the end) to evaluate the trained model

–Memorization versus Generalization

Training of a Model

- Training consists of adjusting the internal parameters of the model until the correct input-output association is achieved
- Should observe increasing accuracy in performance and decreasing error during training



Examples of AI & ML techniques

Examples of ML Techniques

- Linear Regression
- Logistic Regression
- Bayesian Classifiers
- Support Vector Machine
- Decision Tree (DT)
- Random Forest
- Artificial Neural Networks (ANN)
  - Multi Layer Perceptrons (MLP)
  - Deep Neural Networks (DNN)

DNN versus Decision Tree

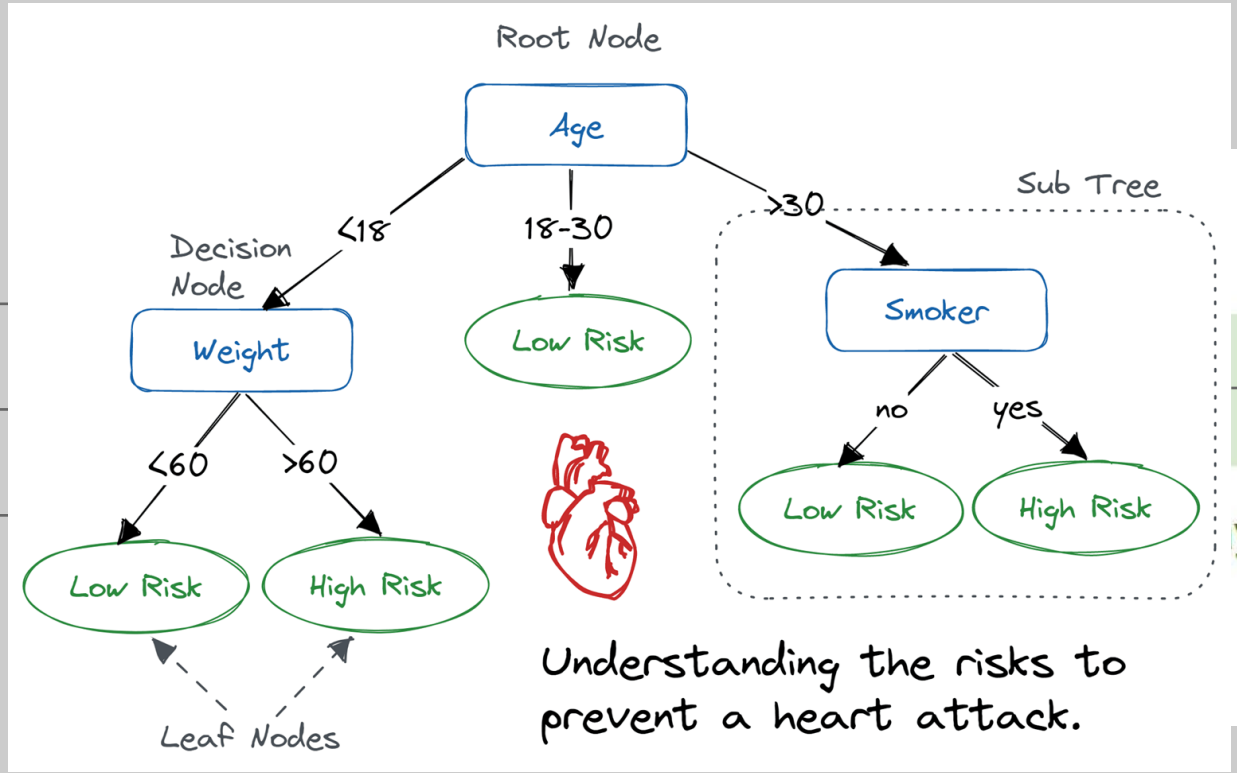
- DNNs
  - Inspired by biological brain
  - Generally outperform all other methods
  - Can achieve great performances
    - Autonomous driving
    - Computer vision
  - Black-box
    - Lack explainability

- Decision Trees
  - Inspired by graph theory
  - White-box
    - Explainable
  - Generally do not perform as well as DNN

DNN versus Decision Tree

Problem: Given age, weight, and smoking habits, determine the cardiovascular risk factor.

Decision Tree



Age

Weight

Smoke

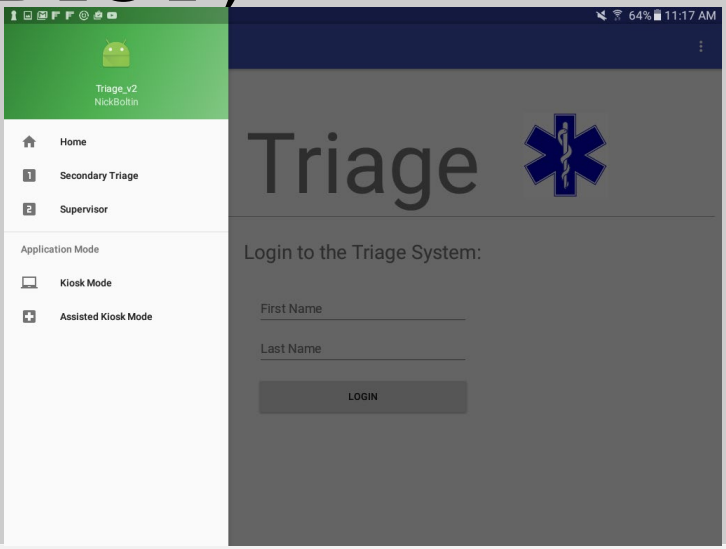
High

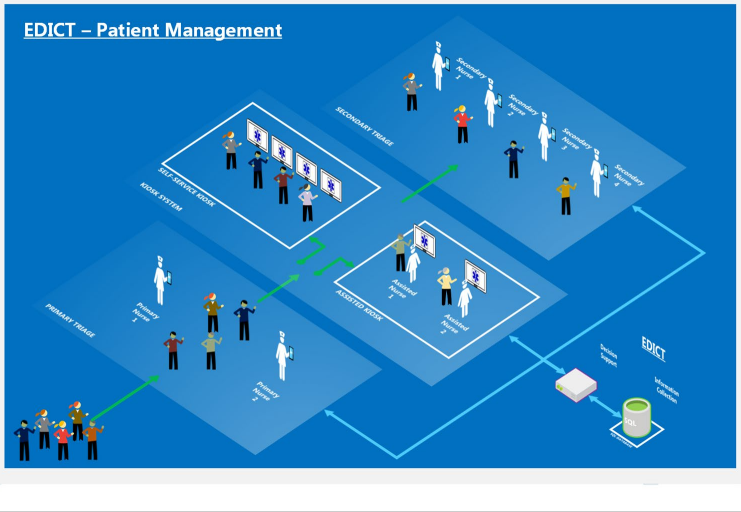
Low

Example applications of AI & ML in healthcare

Emergency Department Informatics Computational Tool (EDICT)

- EDICT: a patient management system
  - Uses Mobile devices (phones, tablets, etc.)
  - Rapid data collection from patients
  - Aggregation and distribution of information.
  - Used by patients, nurses, supervisors, etc.
- EDICT: a clinical decision system
  - Uses AI to detect the chemical exposure
  - Determines the severity of exposure for each individual
  - Recommends course of action per person



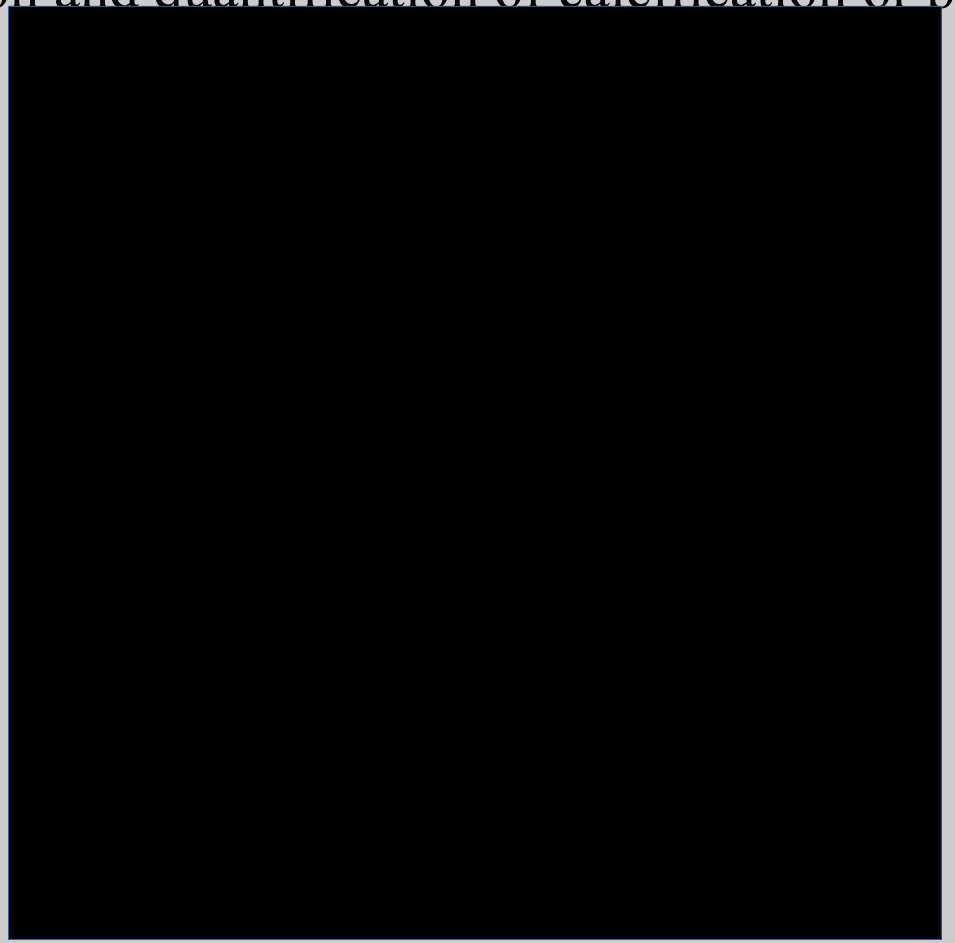


Performance Benchmark

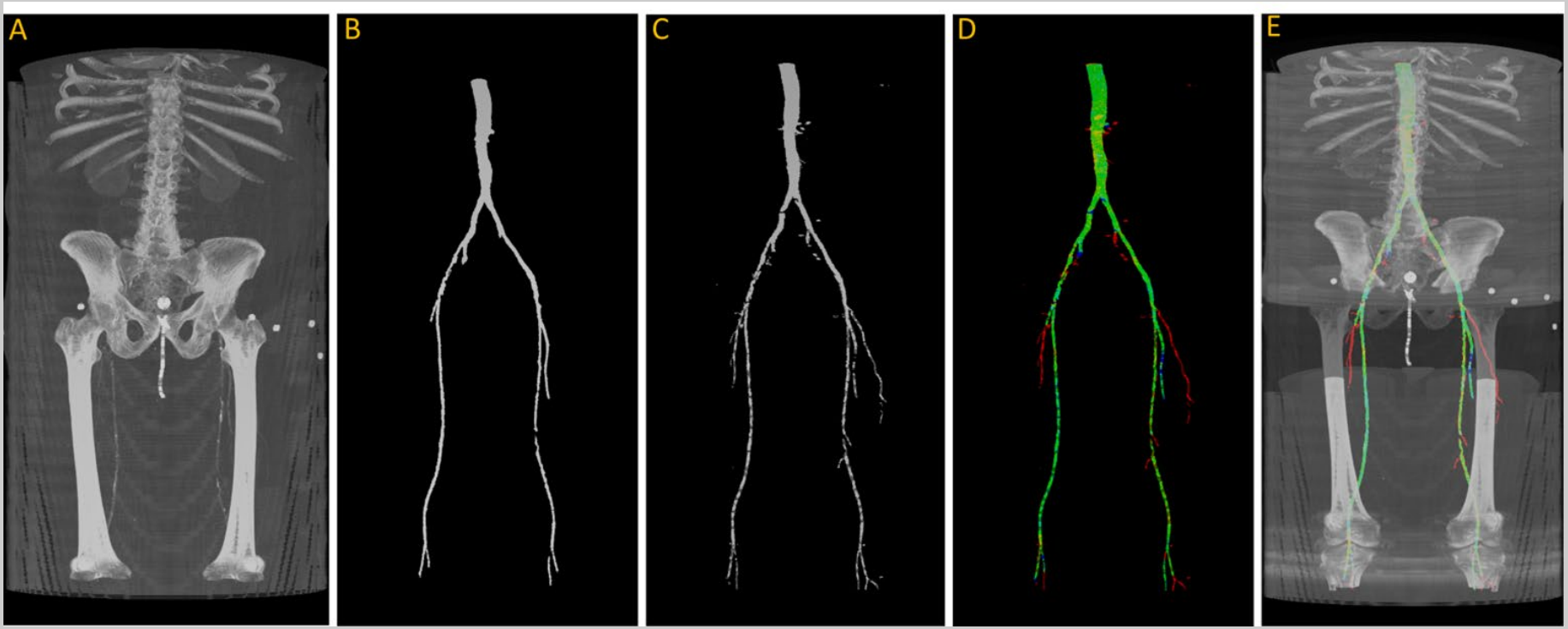
- Deployed EDICT during a mock MCI exercise
  - Simulated Graniteville chlorine incident (2005) with 500 volunteers
  - More than 95% accuracy diagnosis and recommendation
  - Processed 300 patients in 3 hours (30 sec/patient compared to >12 hours)

Machine Learning in Vascular Surgery

- Automated identification and tracking of aorta and the peripheral arteries
- Automated detection and quantification of calcification or plaques

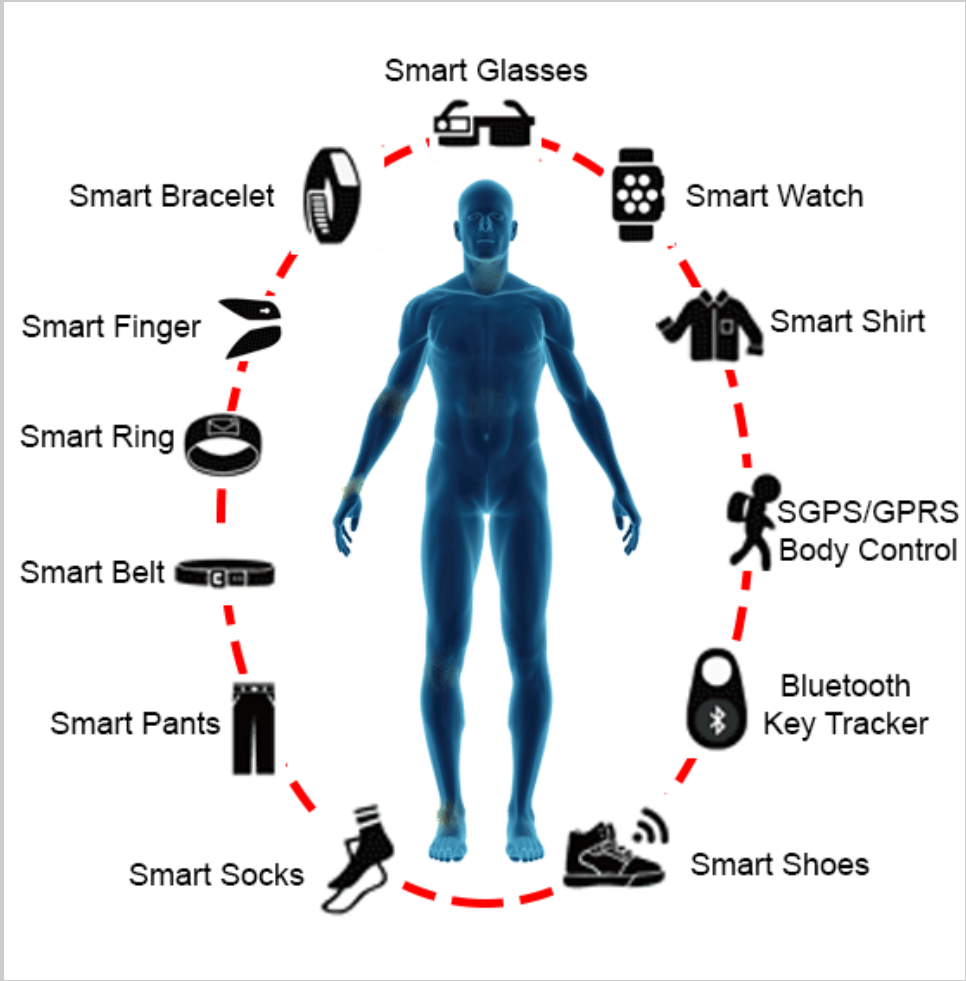


Medical Image Segmentation



Human Activity Monitoring with Modern Wearable Devices

- A variety of devices
  - Watches
  - Rings
  - Wrist/ankle bands
  - Necklace
- A range of prices
  - $30 to over $1000
- A variety of applications
  - Steps
  - Sleep
  - Sport activity
  - Etc.



Rich Array of Sensors

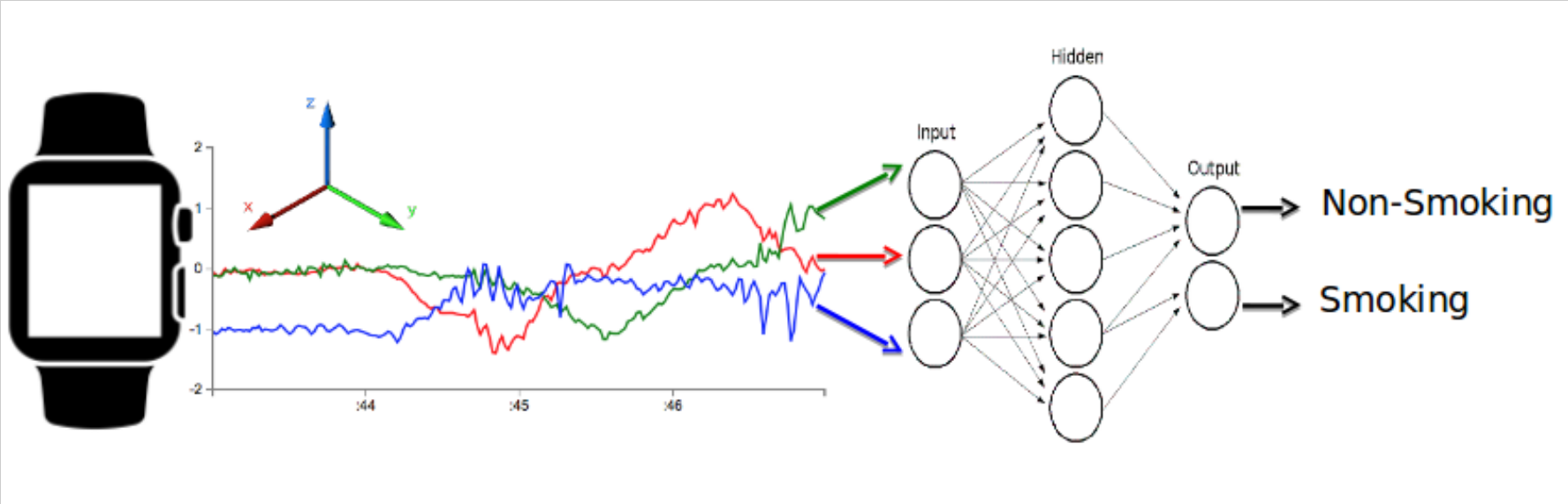
- Ambient light sensor
- Microphone
- 3-axis accelerometer
- Altimeter
- Optical heart rate sensor
- SpO2 monitor
- Bioimpedance sensor

–heart rate, respiration rate, water level and more

- Proximity sensor
- Compass
- ECG
- GPS
- Gyroscope
- Magnetometer
- Electrodermal activity sensor
- Skin temperature sensor

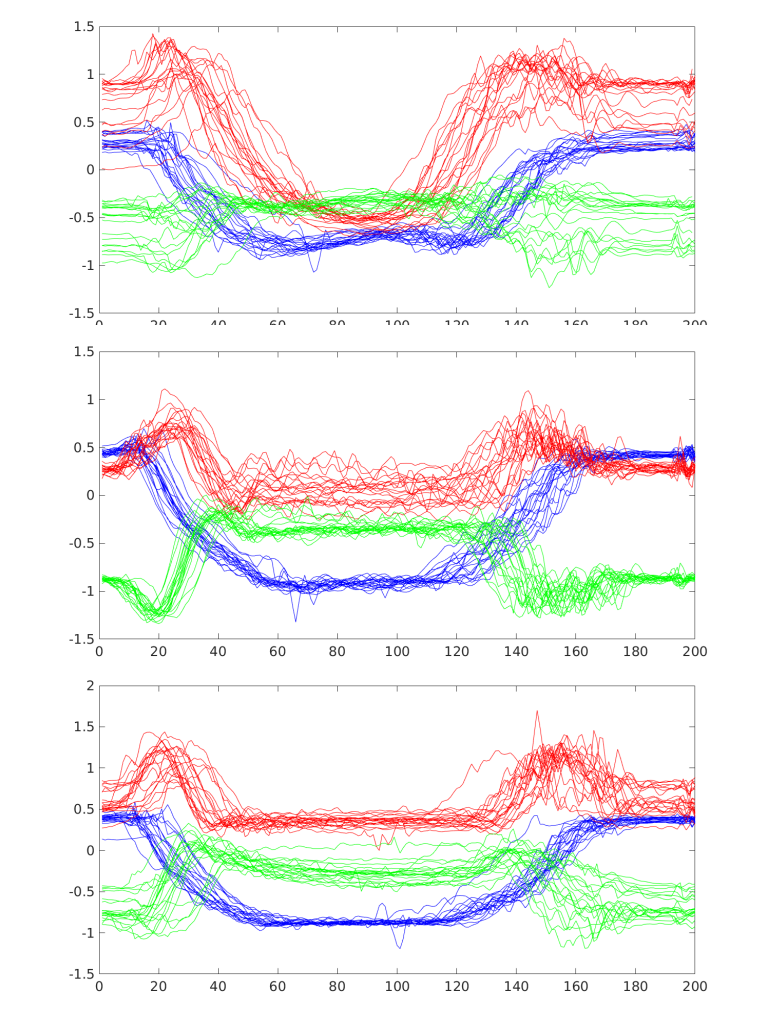
Human Activity Recognition

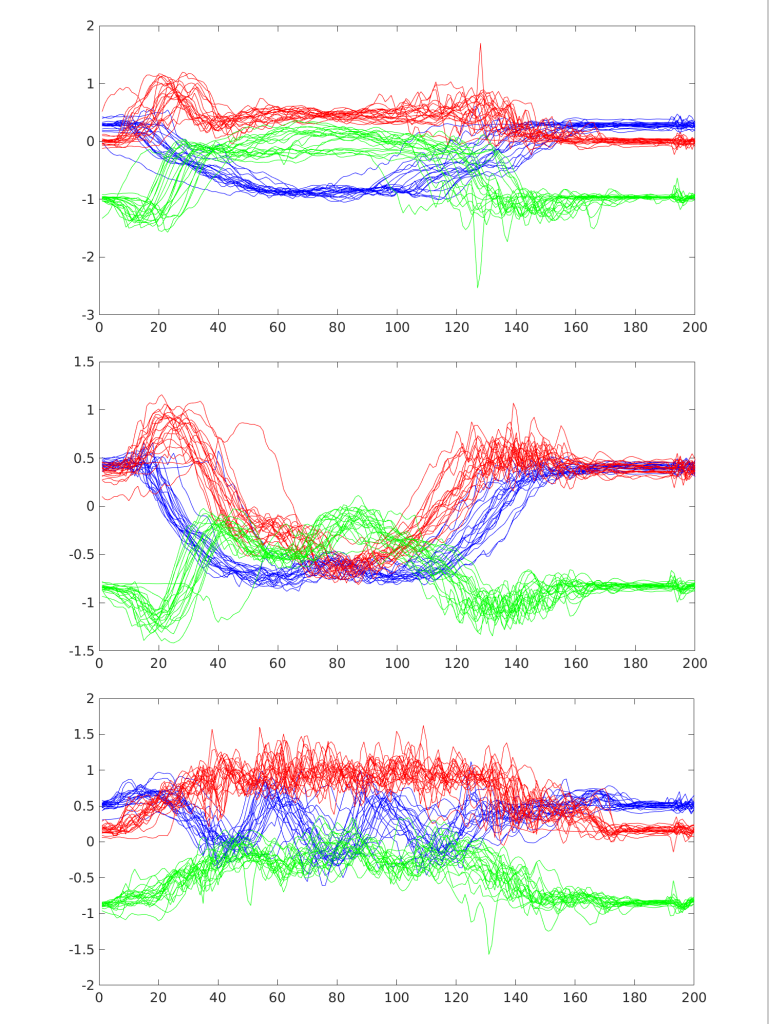
Detection of Smoking Using Wearables



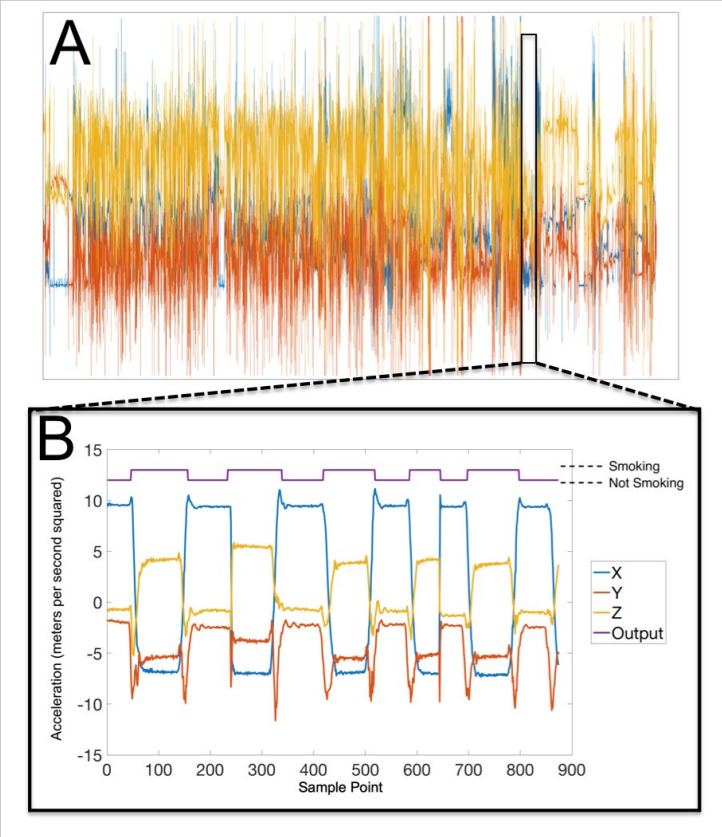
- Current research relies on self reporting
  - Subjective
  - Accuracy of less than 80%
  - Imposes additional burden on human subjects
  - Not amenable for certain population (elderly, children)

Human Activity Recognition





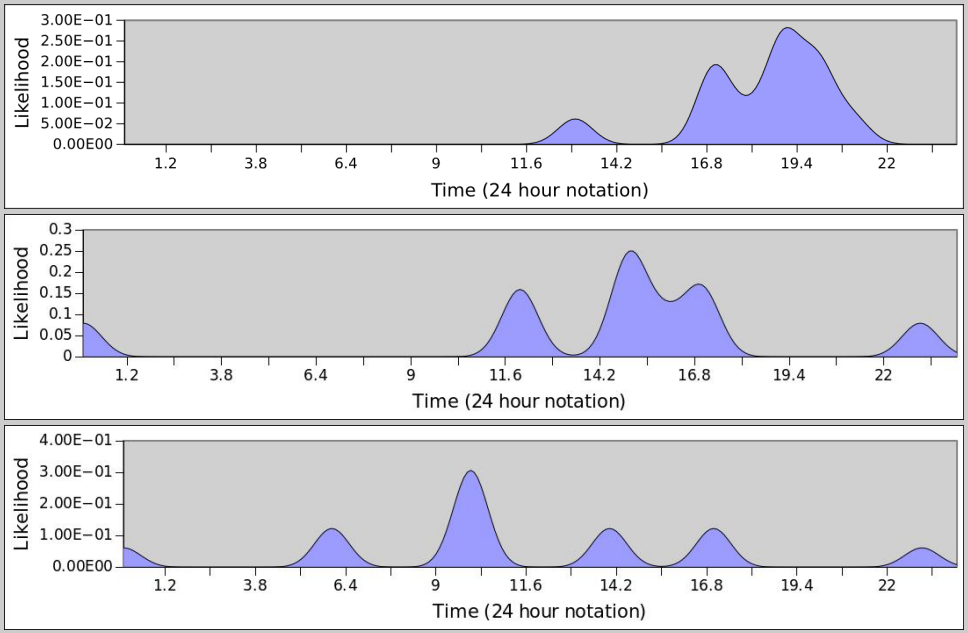
Finding Needle in a Haystack

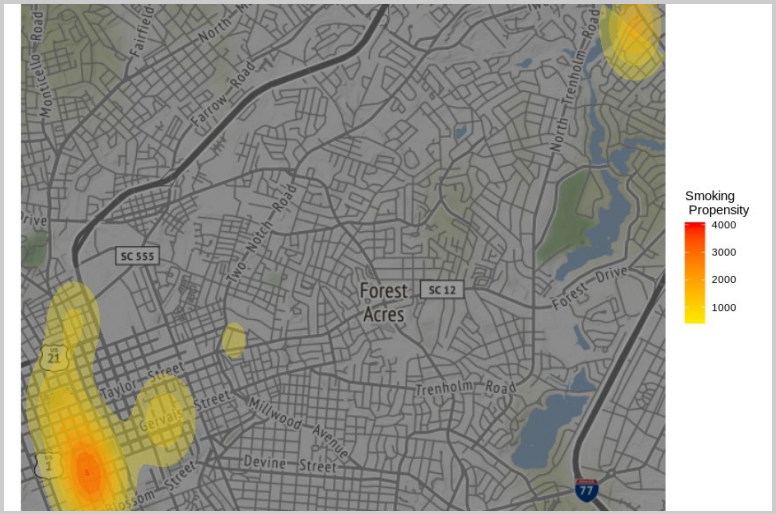


- Accuracy of recognition:
  - Over 96% in lab
  - About 90% in situ
- Allows anonymous study of addiction
  - Cannabis or other illegal drugs

Personalized Smoke Cessation

1)Develop a personal smoking profile.

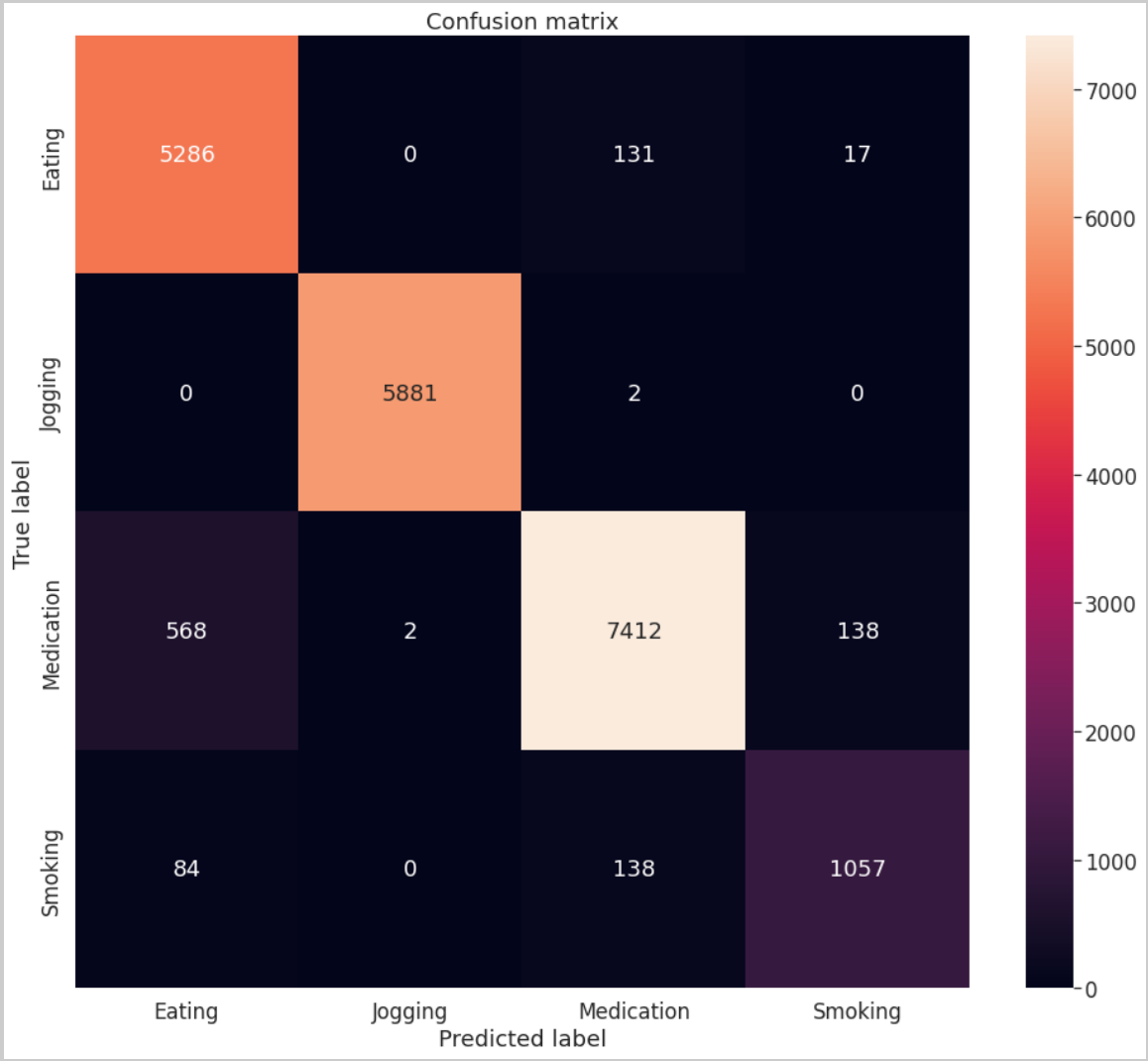




1)Using this model predict smoking and craving ahead of time.

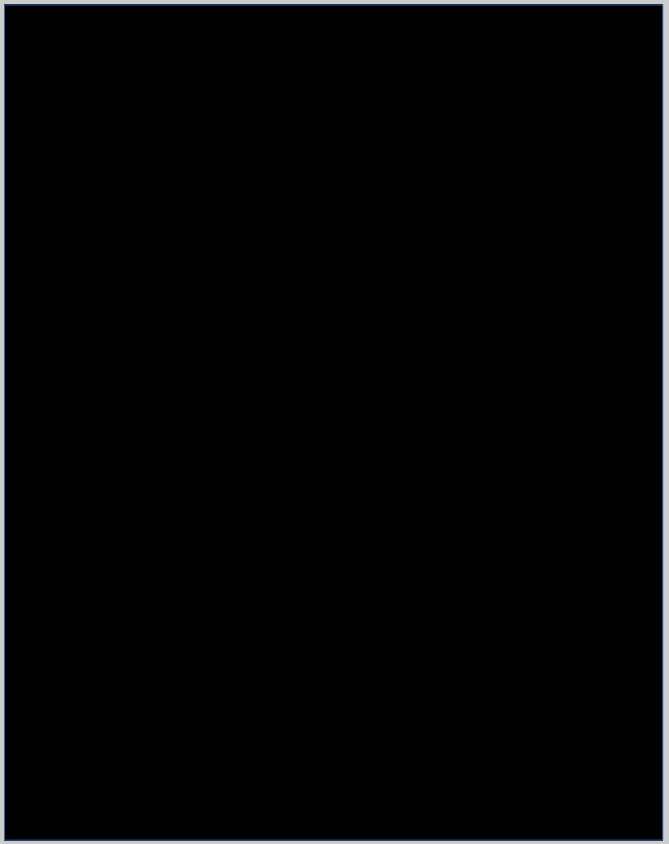
- Achieve more than 80% prediction of craving for smoking
- Females are less predictable than males

Human Activity Tracking



Structural Biology

- AI has revolutionized structure prediction of proteins
  - AlphaFold2
- AI has opened the door to investigation of protein dynamics
- AI has reignited protein engineering and intelligent drug design



Conclusions

- AI has the potential to revolutionize healthcare and medical sciences
  - Optimize patient outcome while developing personalized care
  - ML tools can be assistants to practitioners and tutors to apprentices (JEDI)
- Two major impediments stand in the way of realizing the full potential of AI in healthcare
  - Data sharing barriers need to be removed
  - Better collaborations between healthcare providers and data scientists
- Incorporation of AI in our critical daily practices must be better examined and regulated