AI and cardiology

The heart has its reasons of which reason knows something

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About me

Louis Abraham

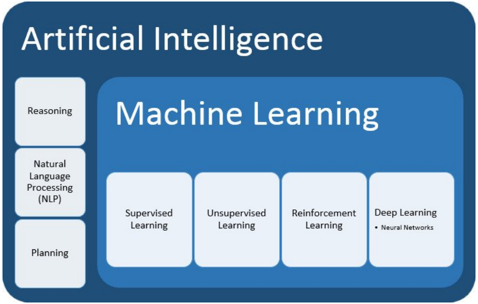
- Education: École polytechnique (Paris), ETH Zurich
- Experience:
  - Quant @ BNP Paribas
  - Deep learning @ EHESS / ENS Ulm
  - Data protection @ Qwant Care

Artificial Intelligence vs Machine Learning

One takeaway:

- AI is about cognition: creative thinking, critical reasoning, autonomous learning, self awareness, ...
- ML is about data: signal processing, image classification, assisted diagnosis, risk assessment, ...

In practice, tasks lie on a spectrum and it is not simple to decide if AI is attained.



Vocabulary checkpoint

- **Data**: digital information stored in a file
- **Format**: specification for encoding information in files
- **Algorithm**: specification for processing data
- **Model**: an algorithm that can be trained on data and make predictions
- **Program / Application**: what you run on a computer, often includes algorithms
- **Server**: a remote computer
- **Cloud**: servers in general

3 predicates of Machine Learning: a view on empiricism

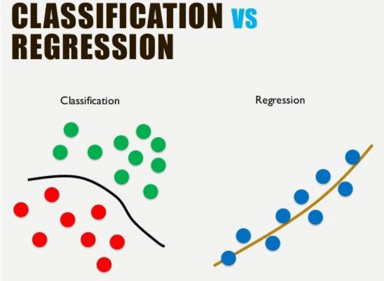
1. A machine can get measurements from the world and store them digitally
2. Patterns exist in the data collected by machines
3. Algorithms can infer and reproduce those patterns in a reasonable amount of time on existing computers

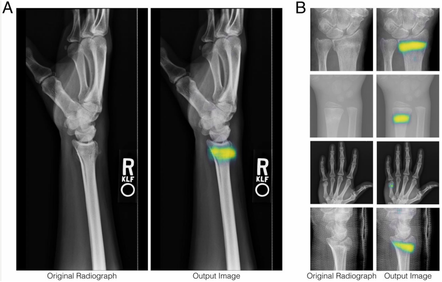
AI is already in our lives

- Google search
- Speech recognition
- Personal assistant (Google, Siri)
- Facebook face recognition
- Recommendations on YouTube, Netflix, Amazon. . .

ML tasks

- Classification
- Regression
- Detection





And many others. . .

ML isn't always complicated

- Constant model: (almost) everybody has 2 arms, 2 legs, 2 eyes, 1 head, etc...
- Threshold model
  - hemoglobin < 130 g/L $\rightarrow$ anemia
  - Body Mass Index $\geq 25 \rightarrow$ overweight

Note: $BMI = c\frac{weight}{height^2}$

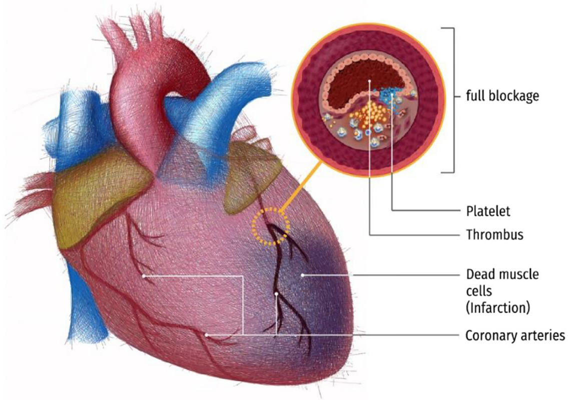
Most classification models are in fact threshold models with more complicated formulas.

Applications of AI in Healthcare

- Monitoring
- Computer-aided diagnosis
- Computer-assisted surgery
- Chatbots for patient care
- ...

An example of computer-aided diagnosis

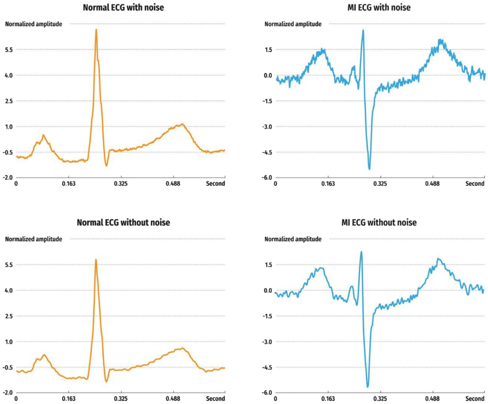
Application of deep convolutional neural network for automated detection of myocardial infarction using ECG signals (Acharya et al. 2017)



An illustration of myocardial infarction.

An example of computer-aided diagnosis

Application of deep convolutional neural network for automated detection of myocardial infarction using ECG signals (Acharya et al. 2017)



Sample normal and MI ECG beat with and without noise removal.

An example of computer-aided diagnosis

Application of deep convolutional neural network for automated detection of myocardial infarction using ECG signals (Acharya et al. 2017)

ECG data collected on 200 subjects (148 MI and 52 healthy subjects)

Data source: PTB Diagnostic ECG Database

Only used 1 lead out of 12 (lead II)

Total: 10,546 normal ECG beats and 40,182 MI ECG beats

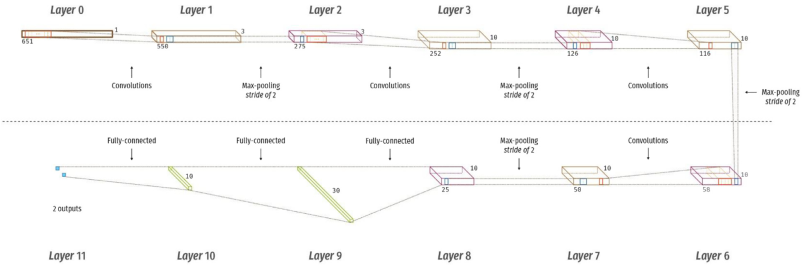
An example of computer-aided diagnosis

Application of deep convolutional neural network for automated detection of myocardial infarction using ECG signals (Acharya et al. 2017)

Accuracy: 93.53% with noise, 95.22% without noise

Sensitivity: 93.71%, 95.49%

Specificity: 92.83%, 94.19%



The architecture of the proposed CNN

Other examples in cardiology

- Mortality prognosis and risk stratification in heart failure (Ortiz et al. 1995; Atienza et al. 2000)
- Echocardiographic imaging analysis (Narula et al. 2017)
- Prediction on the development of atrial fibrillation (Kolek et al. 2016)
- Prediction of cardiovascular event risk (Pavlou et al. 2015)
- Prediction of in-stent restenosis from plasma metabolites (Cui et al. 2017)
- Real-time patient-specific ECG classification (Kiranyaz, Ince, and Gabbouj 2015)
- Automatic tissue classification of coronary artery (Abdolmanafi et al. 2017)
- Early detection of heart failure onset (Choi et al. 2016)

Conclusion

- Machine Learning can save lives
- The main challenges are data collection and technological integration
- Doctors will (probably) never be replaced by robots, but they can learn about them

Image sources

https://www.ibm.com/analytics/machine-learning

https://www.labmanager.com/leadership-and-staffing/2018/03/creating-a-successful-laboratory-training-program

https://www.ebuyer.com/blog/wp-content/uploads/2015/11/server_farm.jpg

https://www.usinenouvelle.com/article/les-gafa-dans-le-viseur-de-la-justice-americaine-pour-leurs-pratiques-concurrentielles.N869415

https://chatbotsmagazine.com/lets-know-supervised-and-unsupervised-in-an-easy-way-9168363e06ab

https://www.pnas.org/content/115/45/11591

References I

Abdolmanafi, Atefeh, Luc Duong, Nagib Dahdah, and Farida Cheriet. 2017. "Deep Feature Learning for Automatic Tissue Classification of Coronary Artery Using Optical Coherence Tomography." *Biomedical Optics Express* 8 (2). Optical Society of America: 1203–20.

Acharya, U Rajendra, Hamido Fujita, Shu Lih Oh, Yuki Hagiwara, Jen Hong Tan, and Muhammad Adam. 2017. "Application of Deep Convolutional Neural Network for Automated Detection of Myocardial Infarction Using Ecg Signals." *Information Sciences* 415. Elsevier: 190–98.

Atienza, Felipe, Nieves Martinez-Alzamora, Jose A De Velasco, Stephan Dreiseitl, and Lucila Ohno-Machado. 2000. "Risk Stratification in Heart Failure Using Artificial Neural Networks." In *Proceedings of the Amia Symposium*, 32. American Medical Informatics Association.

References II

Choi, Edward, Andy Schuetz, Walter F Stewart, and Jimeng Sun. 2016. "Using Recurrent Neural Network Models for Early Detection of Heart Failure Onset." *Journal of the American Medical Informatics Association* 24 (2). Oxford University Press: 361–70.

Cui, Song, Kefeng Li, Lawrence Ang, Jinghua Liu, Liqian Cui, Xiantao Song, Shuzheng Lv, and Ehtisham Mahmud. 2017. "Plasma Phospholipids and Sphingolipids Identify Stent Restenosis After Percutaneous Coronary Intervention." *JACC: Cardiovascular Interventions* 10 (13). JACC: Cardiovascular Interventions: 1307–16.

Johnson, Kipp W, Jessica Torres Soto, Benjamin S Glicksberg, Khader Shameer, Riccardo Miotto, Mohsin Ali, Euan Ashley, and Joel T Dudley. 2018. "Artificial Intelligence in Cardiology." *Journal of the American College of Cardiology* 71 (23). Journal of the American College of Cardiology: 2668–79.

Kiranyaz, Serkan, Turker Ince, and Moncef Gabbouj. 2015. "Real-Time Patient-Specific Ecg Classification by 1-d Convolutional Neural Networks." *IEEE Transactions on Biomedical Engineering* 63 (3). IEEE: 664–75.

References III

Kolek, Matthew J, Amy J Graves, Meng Xu, Aihua Bian, Pedro Luis Teixeira, M Benjamin Shoemaker, Babar Parvez, et al. 2016. "Evaluation of a Prediction Model for the Development of Atrial Fibrillation in a Repository of Electronic Medical Records." *JAMA Cardiology* 1 (9). American Medical Association: 1007–13.

Narula, Sukrit, Khader Shameer, Alaa Mabrouk Salem Omar, Joel T Dudley, and Partho P Sengupta. 2017. "Reply: Deep Learning with Unsupervised Feature in Echocardiographic Imaging." *Journal of the American College of Cardiology* 69 (16). Journal of the American College of Cardiology: 2101–2.

Ortiz, Juarez, Claudia GM Ghefter, Carlos ES Silva, and Renato ME Sabbatini. 1995. "One-Year Mortality Prognosis in Heart Failure: A Neural Network Approach Based on Echocardiographic Data." *Journal of the American College of Cardiology* 26 (7). Journal of the American College of Cardiology: 1586–93.

References IV

Pavlou, Menelaos, Gareth Ambler, Shaun R Seaman, Oliver Guttmann, Perry Elliott, Michael King, and Rumana Z Omar. 2015. "How to Develop a More Accurate Risk Prediction Model When There Are Few Events." *Bmj* 351. British Medical Journal Publishing Group: h3868.