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Augmented Medicine

The way AI is reshaping clinical practice

Giovanni Briganti, MD

Unit of epidemiology, biostatistics and clinical research

Université libre de Bruxelles

Giovanni.Briganti@ulb.be

Twitter: @giovbriganti

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Frontiers in Medicine

Artificial Intelligence in Medicine: Today and Tomorrow

Giovanni Briganti*
Unit of Epidemiology, Biostatistics and Clinical Research
Université libre de Bruxelles
giovanni.briganti@hotmail.com

Olivier Le Moine
Hopital Erasme
Université libre de Bruxelles
olivier.lemoine@erasme.ulb.ac.be

Abstract

Artificial intelligence-powered medical technologies are rapidly evolving into applicable solutions for clinical practice. Deep learning algorithms can deal with increasing amounts of data provided by wearables, smartphones and other mobile monitoring sensors in different areas of medicine.

Currently, only very specific settings in clinical practice benefit from the application of artificial intelligence, such as the detection of atrial fibrillation, epilepsy seizures, and hypoglycemia, or the diagnosis of disease based on histopathological examination or medical imaging. The implementation of augmented medicine is long-awaited by patients because it allows for a greater autonomy and a more personalized treatment, however, it is met with resistance from physicians which were not prepared for such an evolution of clinical practice.

This phenomenon also creates the need to validate these modern tools with traditional clinical trials, debate the educational upgrade of the medical curriculum in light of digital medicine as well as ethical consideration of the ongoing connected monitoring. The aim of this paper is to discuss recent scientific literature and provide a perspective on the benefits, future opportunities and risks of established artificial intelligence applications in clinical practice on physicians, healthcare institutions, medical education and bioethics.

Keywords digital medicine · mobile health · medical technologies · artificial intelligence · monitoring

From tongue depressors to wearables
What happened to medical technologies?

- Medical technologies
  - Early diagnosis
  - Fewer complications
  - Optimize treatment
  - Reduce hospital stay length
- Smart medical technologies
  - High computational power on the go
  - Artificial Intelligence (AI) powered applications

Explaining “techthusiasm”
Why patients easily adopt medtech

- 4P medicine is enabled
- Increased autonomy in various contexts
  - Keep electronic personal health records
  - Monitor vital functions with biosensors
  - Reach optimal therapeutic compliance

→ The empowered “patient-partner”

Rise of medical AI
Back to basics

- AI: *perceiving*, *reasoning*, and *acting* computation
- Machine learning: improving from experience
  - Supervised learning: data is labeled → prediction
  - Unsupervised learning: data is unlabeled → prediction
  - Random forest (decision trees)
  - Artificial Neural Networks (hidden layers and n neurons per layer)
- Deep learning: decreasing number of n neurons per layer
  - Low computational resources → big/temporal data

Rise of medical AI
Statistics v Machine Learning

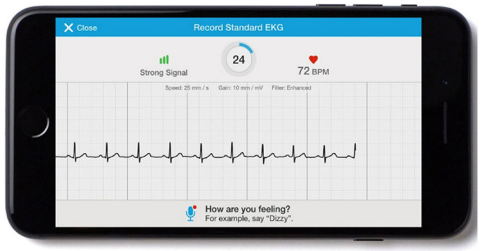
Statistics	Machine Learning
Theory	Data
Hypothesis testing	Predictability
Low dimensional	High dimensional
Reasonable n	Very high n (big data)

Origins of Augmented Medicine

- FDA approval of several AI-based algorithms
- Bridging the gap with other digital tools:
  - Surgical navigation systems/computer-assisted surgery
  - Virtuality-Reality continuum tools
- The war on AI: physician resistance
  - Unpreparedness due to lack of background knowledge
  - Failures of the early digitization processes $<$ physician burnout
  - "Will AI steal my job?"
  - World-wide lack of legal framework (What if?)

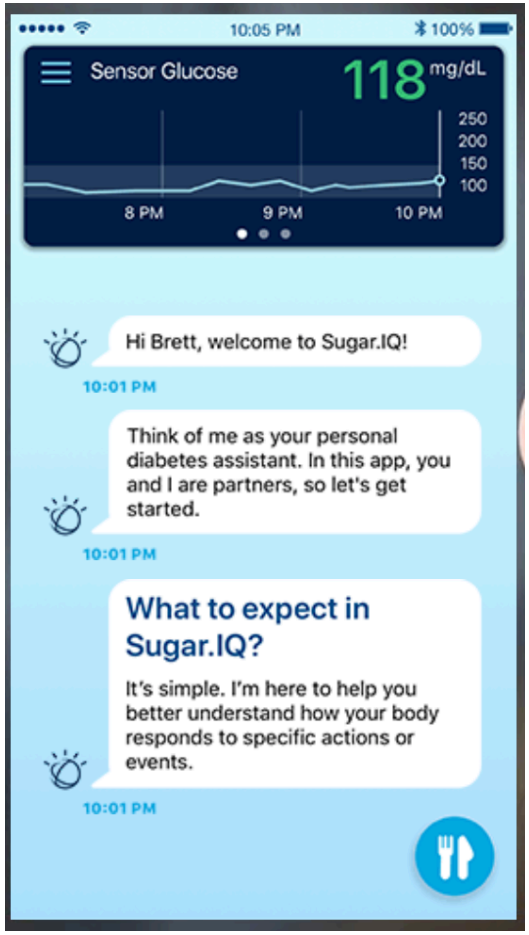
Applications of AI in medicine
Cardiology and Pulmonology

- Atrial fibrillation, the first use-case
  - AliveCor (2014) > Kardia
  - Apple Watch 4 (2018)
- Prediction of cardiovascular risk
  - From electronic health records
- Pulmonary functions tests
  - Decision support



Applications of AI in medicine
Endocrinology and Nephrology

- Continuous glucose monitoring
  - Medtronic > Guardian
  - Medtronic + IBM > prediction
  - Reduce stigma
  - Confidence >< failure to regulate
- Decline in GFR
- Progressive IgA nephropathy
  - Risk assessment

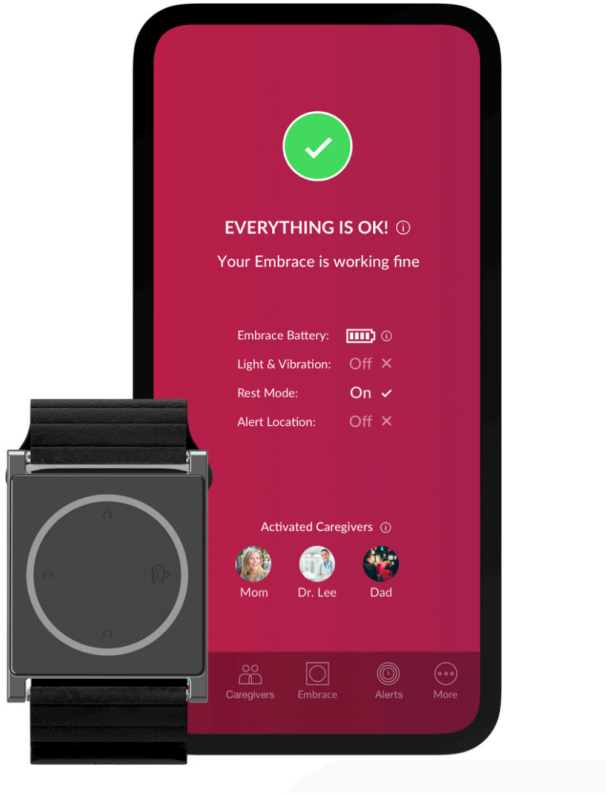


Applications of AI in medicine
Gastroenterology

- Wide range of AI applications
- Deep learning
  - process images in endoscopy & ultrasound > detect abnormal structures
- Machine learning
  - Predict outcomes, survival, risk of metastasis

Applications of AI in medicine
Neurology

- Epilepsy
  - Empatica > Embrace
  - Dermic captors to detect seizure
  - Alert family & physicians
  - Soon: prediction?
- Gait, posture and tremor
  - Quantitative assessment
  - Multiple sclerosis
  - Parkinson
  - Huntington



Applications of AI in medicine
Pathology and imaging

- Paige.ai < breakthrough status FDA
  - Memorian Sloan Kettering < 1 million images
  - Diagnose cancer in computational histology
- Radiologists vs AI
  - Meta-analysis: deep learning as efficient radiologists
  - BUT
    - 99% of studies with NO reliable design
    - 1/1000 of studies compared with other source populations
    - Need of extensive validation through clinical trials

Validation of AI-based technologies
Towards a replication crisis?

- Challenge 1: clinical validation of core concepts and tools
  - Lack of primary replication (no other source than training and testing set)
  - Solution: open data and open science
- Challenge 2: the problem of overfitting
  - Models optimally fit training data set but do not replicate
  - Solution: reevaluation and recalibration after adoption
  - Solution: development of algorithms to fit larger communities and subgroups
- Challenge 3: the study of AI vs physicians
  - Not the best way to tackle the issue of performance
  - Solution: study the combined force of AI and physicians

Ethical implications
The issue of ongoing monitoring

- Medtech: 1000 billion $ 2019
  - Increasing % due to retail to younger populations
- Redefining the concept of "healthy individual"
  - Young individual: not the primary target consumer profile?
  - The concern of the quantified self
- Tech + government deals > large scale distribution to induce lifestyle change
  - Risk of increasing stigma on disadvantaged citizens
  - Reduce access to health benefits
  - Ex: Deep Mind, Nightingale, Singapore

Ethical implications
Data ownership

- Two-decade old debate
- Option 1: common ownership of data
  - Profit to development of personalized medicine
- Option 2: patient ownership of data
  - Improvement of information sharing
  - 1 on 1 data use agreements
- Consensus from recent epistemological works is shifting towards Option 2

Reshaping education
On the need to educate augmented doctors

- The rise of hybrid curricula Medicine-Engineering
  - Humanitas – double bachelor's degree
  - Kaiser Permanente – whole new med school
  - Rest > ongoing education
- Possible structures of augmented curricula
  - Bachelor: hard sciences, IT, statistics, mechatronics and AI
  - Clinical rotations stay unchanged

The difference lies in a novel approach of the bachelor's degree !

Reshaping education
On the need to educate augmented doctors

- To enlighten and manage the digital transition in healthcare and public institutions
- To educate patients and peers
- To be a safety net in complex medical and bioethical issues
- To drive innovative research projects and policies

Reshaping education
On the need to educate augmented doctors

- Retraining our existing doctors
  - Crucial to make the digital transition **accessible** to all doctors
  - University certificates
  - Ongoing education (ex. webinars, podcasts)

Experienced healthcare professionals have much to say in the digital transition!

Reshaping education
On the need to educate augmented doctors

More and more healthcare institutions are including CMIOs in the medical leadership.

- The war on AI?
- Or war between AI-powered doctors and regular ones?
- The turning point on legal, bioethical, clinical and social standard
- The competency shifts initiated by tech giants will isolate European healthcare institutions if no wake-up call
- Re-placing academia as the heart of scientific developments in the AI field

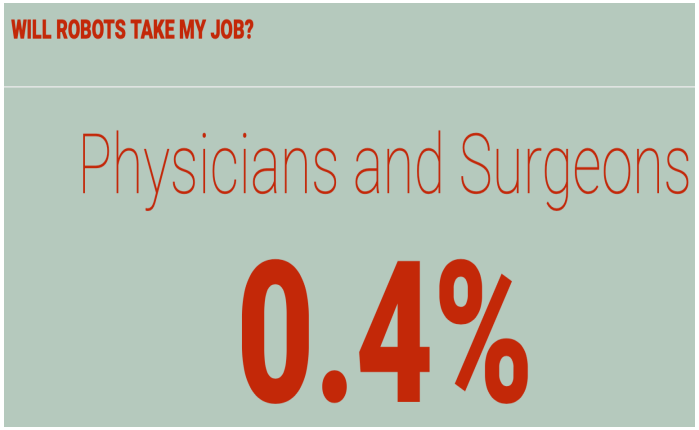
We need European-made experts to deal with these challenges by our standards of care.

Moving forward with AI
The promise of ambient clinical intelligence (ACI)

- Administrative burden is a major issue in healthcare
  - Indirect patient care time $> 80\%$
  - Main source of burnout
  - Natural Language Processing is part of the solution
- ACI: *sensitive*, *adaptive* and *responsive* digital environment around the physician and the patient
  - Analyzing and writing interview report
  - Fill electronic health record
  - Decision support

Conclusions
AI will not change what it means to be a doctor

- MedTech as support
- An agenda for 2030
  - Study physician + AI
  - Translational clinical trials
- A position of privilege
  - But education needed to provide future leaders with competencies to lead innovation



Thank you!

@giovbriganti

Giovanni.Briganti@ulb.be