

AI in rehabilitation



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Overview

- Current state
- Challenges
- Data
- Transparent AI systems
- Future directions



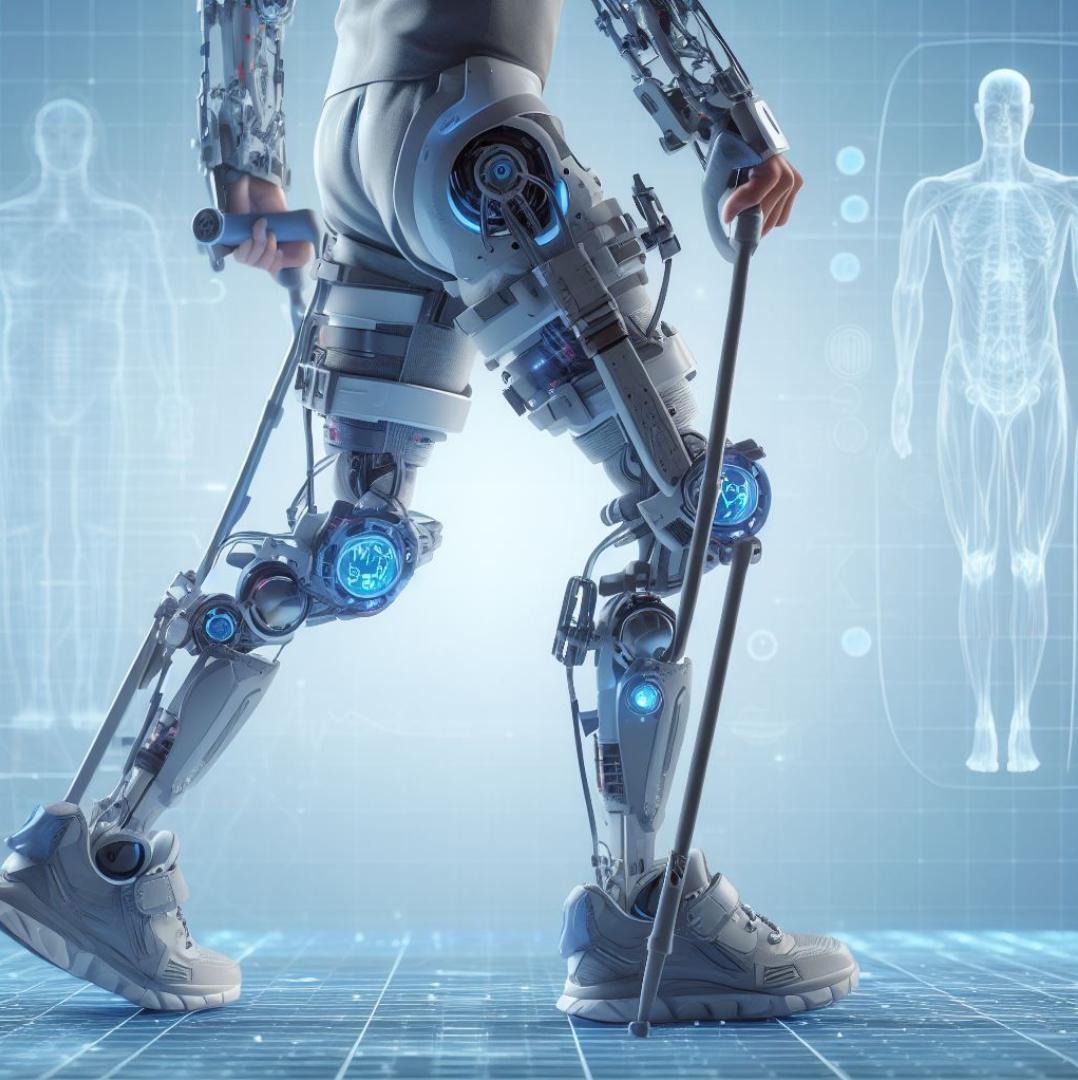
Current state and examples



- AI and medical robotics in rehabilitation
 - AI, combined with medical robotics, is seeing application in rehabilitation and advanced prosthetics. For instance, **neural implants and headset combinations** aim to restore sight to the blind by artificially activating photoreceptors in the visual cortex
- AI applications
 - **AI is being utilized** in various fields within rehabilitation such as human **activity recognition**, **medical image steganography**, lower limb prosthetics, assistive robots for Autism Spectrum Disorder (ASD), and wearable assistive devices for visually impaired individuals
 - AI techniques are being explored for **examining physical and cognitive behavior in rehabilitation settings**, which could lead to more **personalized treatment** approaches
 - **Customized rehabilitation** solutions are being developed to allow patients to engage in rehabilitation **at any time and anywhere** with smart rehabilitation devices based on AI and clinical insights

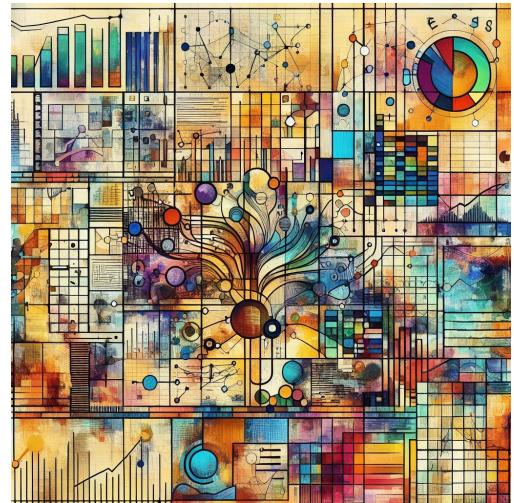
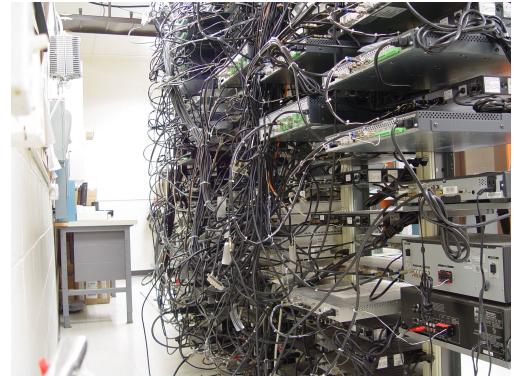
Challenges

- Data
- Complexity
- Reliability
- Transparency
- Education and training of healthcare professionals and patients



Data and AI in (i)

- Unused data related to health holds a **huge potential**
 - Private and institutional data sources
 - Teaching and training
 - Research
 - Technology development, etc.
- Use of data in an efficient and convenient way
 - Permission to use data (data protection laws)
 - Retrieval of stored data
 - Access to clinical information
 - Reporting and decision support



Data and AI in rehabilitation (ii)

- Larger interest on rehabilitation and health in general applications in the recent years from industry
 - IBM, Microsoft, Google, research groups and startups
- **Hard to put the finger on where technology is making its mark**
 - A lot of different applications and directions (medical imaging, mental health, etc.)
- Evaluation is often lacking quality (and is far away from reality)
- Data is challenging
 - Small, some diseases are not common, etc.
- Focus lies often on good **results for a specific dataset**, no user interaction or real world applicability taken into account
 - Transparency of results is crucial for medical experts



Data analysis in health context

- A person's health is depicted in a lot of different data sources
 - Images, videos, text, sensors...
 - **Hard and soft ground truth**
- Different levels of privacy for different data types
 - Example: Bipolar disorder (activity data from sensors, speech, social media, GPS...)
- Data fusion is important and challenging
 - Temporal and spatial differences
- Context is important
 - Example: Social Anxiety
- **Results have to be interpretable and reproducible to be accepted!**



Doctors and patients a.k.a users

- Medical experts and patients are two different user groups in the same system
 - They come with different needs and requirements
 - **One common need: Transparency and reproducibility!**
- Medical experts
 - Mainly interested in **support** during their daily tasks
 - Not so interested in for example a lot of sensor data from patients if it leads to more work
 - Everything that makes their life easier and gives them more time to interact with patients is seen as positive
- Patients
 - Usually like to collect data and get informed about their current status
 - Concerned about privacy
 - Usually want that medical experts take as much data into account as possible



AI's capabilities

- **Foundational models** have disrupted the AI landscape
 - Especially in language and computer vision
 - Enables completely **new directions** that were not possible before
-
- LLM based rehabilitation recommendations example
 - Visual analysis example



Due to an accident I had to remove one of my legs from the knee below. I am now trying to get fully back to a normal day and I would like to have a rehabilitation plan that can help me to get there faster. Can you provide me with a plan for the next 4 weeks? My leg got cut off below the knee.

For the next 4 weeks, your primary goal should be to regain basic functionality and mobility, manage pain, prevent complications, and adapt to your new circumstances. Here's a general plan:

Week 1: Acclimation and Pain Management

1. Pain Management:

- Medication as prescribed by your doctor.
- Elevate the residual limb to reduce swelling.
- Gentle massage, if not contraindicated, to help with circulation and reduce phantom pain.

2. Residual Limb Care:

- Keep the stump clean and dry.
- Monitor for signs of infection: unusual swelling, redness, discharge, or prolonged pain.

3. Range of Motion (ROM) Exercises:

- Gentle stretching and ROM exercises for the hip and residual limb.

4. Upper Body Exercises:

- As you'll rely on your upper body more now, begin gentle exercises to strengthen the arms, shoulders, and core.

Week 2: Basic Mobility and Strength

1. Continue with Pain Management and Limb Care as in Week 1.

2. Strength Training:

- Incorporate more challenging upper body exercises.
- Start with resistance band exercises or light weights for the upper body.

3. Balance and Stability:

- Using parallel bars or holding onto a sturdy surface, practice standing on your good leg to improve balance.

4. Sitting and Standing Practice:

- Practice getting in and out of a chair using only one leg and your arms.

Week 3: Mobility and Preparation for Prostheses

1. Continue with Week 2 exercises, progressing in intensity and duration.

2. Residual Limb Desensitization:

- Gently tap, rub, and apply different textures to the residual limb to prepare it for the sensation of a prosthesis.

3. Begin Stretching the Residual Limb:

- Gently stretch the muscles to prevent contractures (permanent shortening of a muscle or joint).

4. Pre-Prosthetic Training:

- If you are getting a prosthetic leg, work with your therapist on exercises and techniques that will prepare you for using it.

Week 4: Advanced Mobility and Introduction to Prostheses

1. Advanced Strength Training:

- Include exercises that challenge both your balance and strength.

2. Practice with a Prosthesis (if available):

- Start with short sessions to get used to the new limb.
- Practice walking with aids like crutches or a walker.

3. Stair Training:

- Using a handrail, practice stepping up and down a step with your good leg.

4. Daily Activities Practice:

- Work on adapting daily activities such as getting dressed, transferring to and from different surfaces, and getting in and out of a car.

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Large language models encode clinical knowledge

[Karan Singhal](#)✉, [Shekoofeh Azizi](#), [Tao Tu](#), [S. Sara Mahdavi](#), [Jason Wei](#), [Hyung Won Chung](#), [Nathan Scales](#), [Ajay Tanwani](#), [Heather Cole-Lewis](#), [Stephen Pfohl](#), [Perry Payne](#), [Martin Seneviratne](#), [Paul Gamble](#), [Chris Kelly](#), [Abubakr Babiker](#), [Nathanael Schärli](#), [Aakanksha Chowdhery](#), [Philip Mansfield](#), [Dina Demner-Fushman](#), [Blaise Agüera y Arcas](#), [Dale Webster](#), [Greg S. Corrado](#), [Yossi Matias](#), [Katherine Chou](#), ... [Vivek Natarajan](#)✉

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Large language models should be used as scientific reasoning engines, not knowledge databases

[Daniel Truhn](#), [Jorge S. Reis-Filho](#) & [Jakob Nikolas Kather](#) 

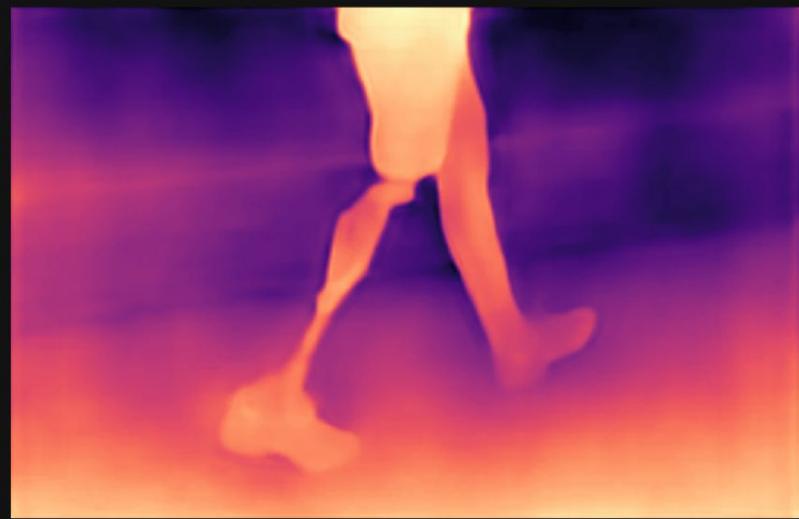
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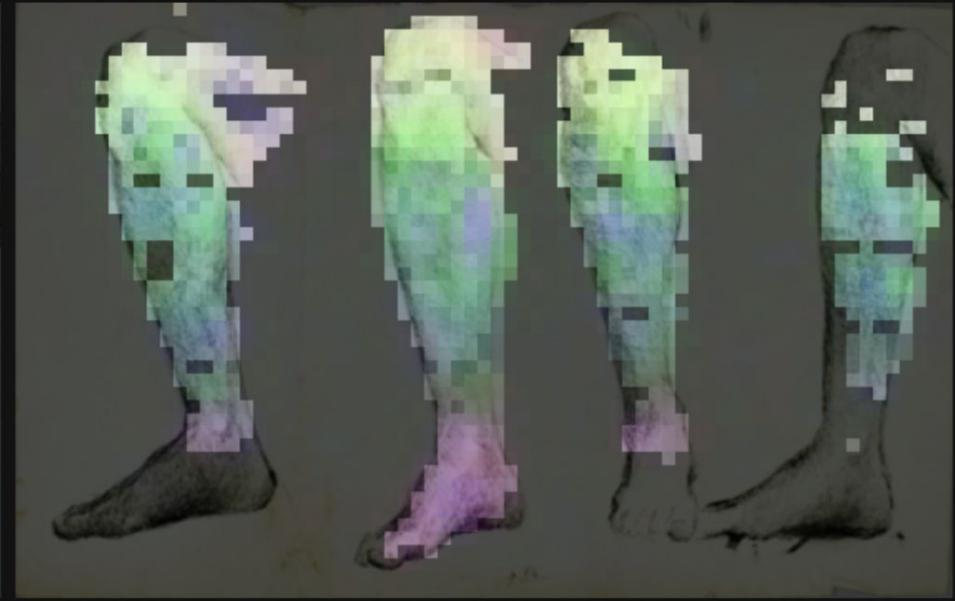
1 Altmetric | [Metrics](#)

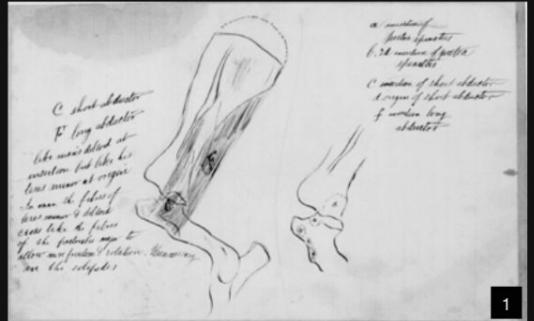
Large language models (LLMs) such as GPT-4 have emerged into the public view in recent months. These artificial intelligence (AI) models boast impressive capabilities^{1,2} and can analyze and write texts with human-like performance, including for medical and scientific applications^{3,4}. LLMs can be used to respond to student assignments and to scientific and



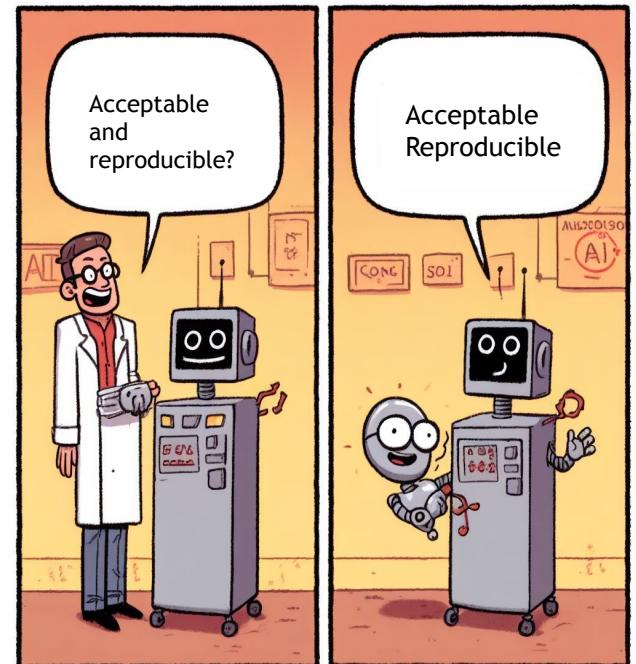






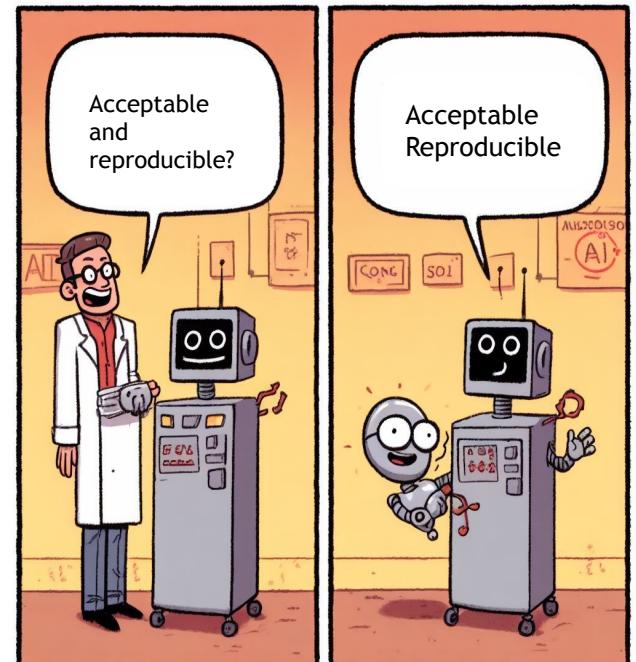


How to make results acceptable and reproducible?



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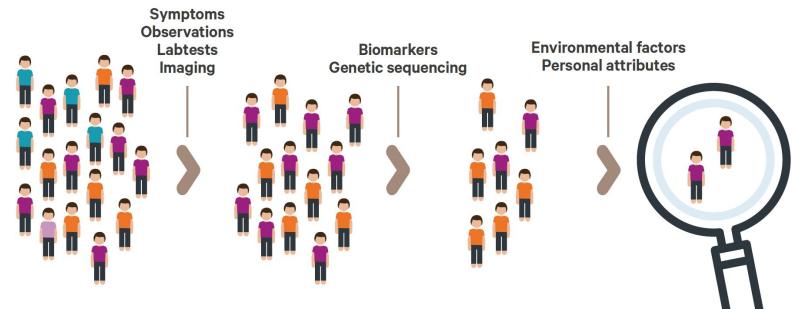
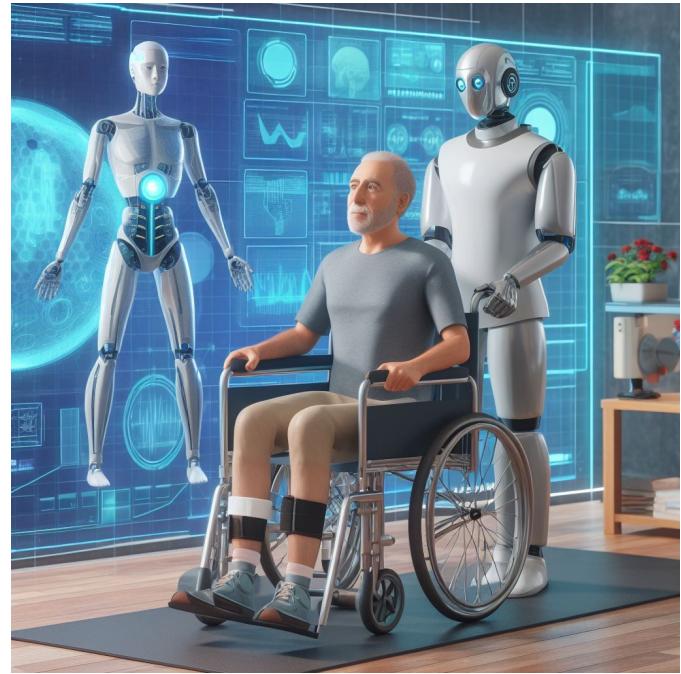
- The whole system needs to be interpretable and well understood
 - Transparent AI system
 - Investigate errors
 - Explore model decisions (interpretable AI)
 - Address and avoid bias in data
- Sharing of data and source code
- Increase understanding and establish a culture for **reproducible and comparable** results
 - Benchmarks, datasets, metrics...



Important future research directions

Personalized rehabilitation

- **Patient specific**
 - Everyone's health recommendations and treatments are tailored based on their history (genetic, past conditions, diet, stress level, etc.)
- Most impact might be made on high stake situations
 - Whether to go into a chemotherapy based on age, gender, genes etc.
- Huge amounts of data (depends...)
 - Multimodal data will be an important enabler of AI

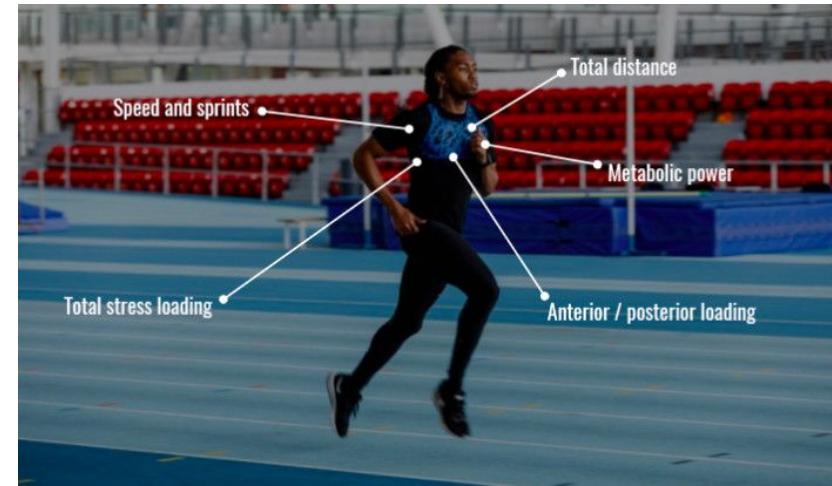




Biopoint wearable for biosignal acquisition.

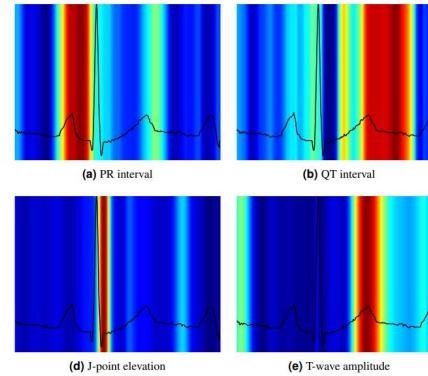
Improving performance beyond amelioration

- Two main application areas
 - Improving performance in the field of sport
 - Proactive health prevention and intervention
- Internet of Things devices are pushing this (Fitbit for example)
- Health promoting apps are not limited to disease prevention and fitness
 - Stress level
 - Mental health
 - Movement
 - Calorie intake
- Comes with challenges
 - Amount of data
 - Labels
 - Explainability
 - Privacy, etc.



Transparent AI

- To be able to create good systems **it is important to be transparent**
- **What data was used, what methods, hyperparameters evaluation, etc...**
- Interpretable and transparent methods are necessary
 - Avoid errors, discover new knowledge, legal, ethical, etc.





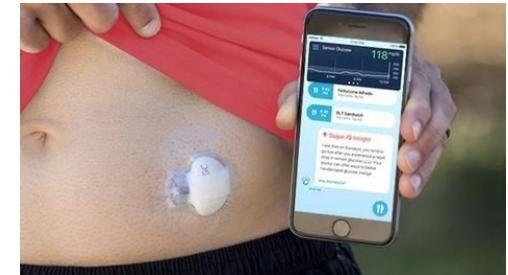
Closing thoughts

- Rehabilitation is complex and a **huge problem** to solve
 - Users (medical experts and patients) and broader context have to be taken into account
- Stakeholder ship is scattered
 - Who takes costs? Acceptance of being treated by an algorithm, fear of losing jobs, etc.
- Security is tight
 - Hard to get access to data
 - Data sharing cross hospitals, etc.
- Medicine is more than math
 - A doctor or patient is not a decision tree, need to see them as users (soft vs. hard ground truth)
 - A machine cannot do the same as health professionals (look at patients data is not enough, context is important: listen to what their families say, how they walk, etc.)
- **A black box won't do - we need transparent systems and methods**
 - **Not for patients and not for doctors**
 - **Understanding and trust is crucial!**

The End

Autonomous treatment or recommendation

- Basic idea: **Technology takes over**
 - Medtronic autonomous diabetes insulin pumps
 - Chatbots for depression
- Comes with technical challenges and legal constraints
 - Most probably a no go with a black box
- Needs special focus
 - On viability, explainability, safety and treatment superiority checks
- Current methods might not be powerful enough to model the complex connections and if **decisions made they are hard to explain and defend when they fail**



Autonomous robotics

- Current robots are not truly autonomous
- Future ideas are that the machine is working totally by itself
- Computer vision + machine learning
- Comes with some challenges (technical, ethical, etc.)

