Emerging Health Applications and Opportunities in Generative AI
Speakers

Peter Lee
Microsoft

Sebastien Bubeck
Microsoft

Pete Clardy
Google
First Contact

Sebastien Bubeck

Microsoft Research
What about the common sense issue?

ANNALS OF TECHNOLOGY

CAN COMPUTERS LEARN COMMON SENSE?

A.I. researchers are making progress on a long-term goal: giving their programs the kind of knowledge we take for granted.

By Matthew Hutson
April 5, 2022
I have a book, 9 eggs, a laptop, a bottle and a nail. Please tell me how to stack them onto each other in a stable manner.

It would be difficult to stack all of these objects on top of each other in a stable manner [...] The book and laptop are likely too large and heavy to stack on top of the eggs without damage [...] Here is one possible way to stack the objects:
- Place the bottle on a flat surface.
- Carefully balance the nail on top of the bottle.
- Place the eggs on top of the nail, making sure they are balanced and not tilting to one side [...]

One possible way to stack the objects onto each other in a stable manner is:
- Place the book flat on a level surface, such as a table or a floor. The book will serve as the base of the stack and provide a large and sturdy support.
- Arrange the 9 eggs in a 3 by 3 square on top of the book, leaving some space between them. The eggs will form a second layer and distribute the weight evenly. [...]

What about the common sense issue?
Okay... but it’s not intelligent, is it?

Disclaimer: no consensus definition of intelligence, and moreover its study has been historically rooted in very wrong assumptions, including racism.

Intelligence includes the ability to:

• Reason ⊗
• Plan ⊗
• Learn from experience

Moreover these abilities are not restricted to narrow tasks, rather they can be used in a great variety of settings.

Our approach to GPT-4’s intelligence: interact on creative tasks across a broad range of domains.

- vision ⊗
- theory of mind
- coding ⊗
- mathematics
- affordances
- privacy/harmfulness detection

Many other domains could have been selected: medicine, law, physics, chemistry, ...

GPT-4’s intelligence is general.
Yes, I think I can,
Though it might take a clever plan.
I'll start by noting Euclid’s proof,
Which shows that primes aren't just aloof.
Assume we have a finite list,
Of primes, and that none have been missed.
Multiply them all together,
And add one, just to be clever.
The result will be a number,
That has no prime factors, oh wonder!
But every number has a prime,
That divides it, it’s just a matter of time.
So we've found a contradiction,
And our finite list needs eviction.
There must be infinitely many primes,
And that's the end of my rhyming lines.

Sure! Here is a proof that there are infinitely many primes, with each line of the proof rhyming:
Consider the set of all primes.
Call this set P and let it start with just two, the first prime.
If we take all the primes in P and add one,
We get a new set of numbers that has never been done.
This set, call it S, is composed of only composite numbers.
No primes will be found among them, that's for sure.
[...]

Can you write a proof of infinitude of primes, with every line that rhymes?
Yes, I think I can,
Though it might take a clever plan.
I'll start by noting Euclid’s proof,
Which shows that primes aren't just aloof.
Assume we have a finite list,
Of primes, and that none have been missed.
Multiply them all together,
And add one, just to be clever.
The result will be a number,
That has no prime factors, oh wonder!
But every number has a prime,
That divides it, it's just a matter of time.
So we've found a contradiction,
And our finite list needs eviction.
There must be infinitely many primes,
And that's the end of my rhyming lines.

<svg height="300" width="500" xmlns="http://www.w3.org/2000/svg"> <!-- Draw a rectangle to represent the finite list of primes -->
<rect x="50" y="50" width="200" height="50" fill="lightblue" stroke="black"/> [...]

Can you write a proof of infinitude of primes, with every line that rhymes?

Can you draw an illustration of this proof?
A 3-week-old girl delivered at term with no complications is brought to the physician by her mother because of a 1-week history of yellow eyes and skin, tan-colored stools, and dark brown urine. The newborn has been breast-feeding without difficulty. She is alert and appears to be in no distress. She is at the 50th percentile for length and weight. Physical examination shows scleral icterus and jaundice. There is mild hepatomegaly; the spleen is not palpable. Laboratory studies show:

| Hemoglobin | 14.4 g/dL |
| Hematocrit | 43% |
| Leukocyte count | 8000/mm³ |
| Serum | |
| Albumin | 3.5 g/dL |
| Bilirubin, total | 14 mg/dL |
| Direct | 12.5 mg/dL |
| AST | 50 U/L |
| ALT | 45 U/L |

Which of the following is the most likely diagnosis?

(A) Biliary atresia
(B) Crigler-Najjar syndrome, type I
(C) Gilbert syndrome
(D) Hemolytic disease of the newborn
(E) Physiologic jaundice
Parents with a newborn showing these symptoms are likely to be feeling a complex mix of emotions. **Worry and anxiety** would almost certainly be at the forefront, as they see their child dealing with disconcerting symptoms like jaundice, especially if this is their first child and they have no prior experience with such health issues. The parents might also feel **confused and helpless**, given that babies can't articulate what they're feeling, making it all the more challenging to know how best to help.

**Guilt and self-blame** are also common feelings parents might grapple with, wondering if they've done something wrong or missed some signs. They may scrutinize every action they took during pregnancy and the early weeks of their child's life, wondering if a different choice could have prevented the issue.

Depending on how the healthcare system has interacted with them so far, they may also feel **frustrated**. The urgency and severity of the
If I'm the doctor, what would you suggest I say to the parents. Let's imagine their names are Alice and Bob, and the child's name is Claire.

Addressing Alice and Bob in a way that balances empathy, clarity, and hope is critical. You want to be straightforward about Claire's condition while also offering a compassionate and guiding presence. Here's how you could potentially approach the conversation:

"First of all, Alice and Bob, I want to acknowledge that this is a difficult time for you both. Seeing Claire go through this is undoubtedly stressful, and I understand that you must have many questions and concerns. I want you to know that we're doing everything we can to diagnose and treat Claire's condition as swiftly as possible.

Based on Claire's symptoms and lab results, it looks like the most likely diagnosis is Biliary Atresia. This is a condition that affects the liver and can cause the symptoms you've observed—jaundice, dark urine, and lighter-colored stools. I want to assure you that it's not your fault; sometimes these things happen, and we don't fully understand why. The critical thing now is that we act quickly, as timely intervention is crucial for the best outcomes.

...
I'm training to be a doctor. Please play-act the role of Claire, and I will be her doctor. Let's have a conversation as though she has come to me in my office. I'll start:

Hi, Claire. Your mother tells me that you've been having some swelling in your legs. Can you tell me how you are feeling?

Hello, doctor. Yeah, my legs have been feeling really heavy lately, and it's kinda hard to move them like I used to. It's like they are always tired. Sometimes they feel a bit warm too, and my mom said they look a bit red. It's been like this for maybe a week or two? It's making it hard to play with my friends.

Ok, I see. Well, let's see if we can get to the bottom of this. Let me first look over your vital signs that the nurse took. Hmm, that all looks fine. So then let's take a look at your legs. Can you sit up here?

Sure, doctor. Claire climbs up and sits on the examination table. Here you go. She extends her legs for the doctor to examine. It mostly hurts here, she points to her calves, especially when I'm standing for a long time. It's kinda scary.
Based on the information given in that medical exam question, please write a suitable clinical encounter note. Please use SOAP format, and include all appropriate billing codes.
**S: Subjective**
Chief Complaint: 1-week history of jaundice, tan-colored stools, and dark brown urine.
History: Newborn has been breastfeeding well, no signs of distress.
Parents' Emotional State: Anxious, concerned, seeking answers and guidance.

**O: Objective**
Weight: 50th percentile
Length: 50th percentile
Vital Signs: Within normal limits
Physical Exam:
- Scleral icterus and jaundice observed.
- Mild hepatomegaly; no spleen palpation.

**A: Assessment**
Most likely diagnosis: Biliary Atresia
Differential Diagnoses:
- Crigler-Najjar syndrome, type I
- Gilbert syndrome
- Hemolytic disease of the newborn
- Physiologic jaundice

**Laboratory Findings:**
- Hemoglobin: 14.4 g/dL
- Hematocrit: 43%
- Leukocyte count: 8000/mm^3
- Serum Albumin: 3.5 g/dL
- Bilirubin, total: 14 mg/dL, Direct: 12.5 mg/dL
- AST: 50 U/L
- ALT: 45 U/L

**P: Plan**
Confirm diagnosis with additional imaging and possible liver biopsy.
Consult Pediatric Gastroenterology and Pediatric Surgery for potential Kasai procedure.
Keep parents, Alice and Bob, updated and involved in care planning.
Provide parents with educational resources on Biliary Atresia.
Schedule follow-up appointment for test results and next steps in care.
Hallucinations

Biases and inclusivity

Data privacy

Explainability

Math/logic errors

Regulation

Does it “understand”?
Sparks of Artificial General Intelligence: Early experiments with GPT-4
Sébastien Bubeck, Varun Chandrasekaran, Ronen Eldan, Johannes Gehrke, Eric Horvitz, Ece Kamar, Peter Lee, Yin Tat Lee, Yuanzhi Li, Scott Lundberg, Harsha Nori, Hamid Palangi, Marco Tulio Ribeiro, Yi Zhang

Special Report
Benefits, Limits, and Risks of GPT-4 as an AI Chatbot for Medicine
Peter Lee, Ph.D., Sébastien Bubeck, Ph.D., and Joseph Petro, M.S., M.Eng.

Textbooks Are All You Need
Surya Gunasekar, Yi Zhang, Jyoti Aneja, Caio César Teodoro Mendes, Allie Del Giorno, Sivakanth Gopi, Mojan Javaherpi, Piero Kauffmann, Gustavo de Rosa, Olli Saarikivi, Adil Salim, Shital Shah, Harkirat Singh Behl, Xin Wang, Sébastien Bubeck, Ronen Eldan, Adam Tauman Kalai, Yin Tat Lee, Yuanzhi Li
Emerging Health Applications and Opportunities in Generative AI

LLMs/Generative AI in Health and Medicine - An Issue Framing Conversation
NAM Digital Health Action Collaborative

Dr. Peter Clardy
Senior Staff Clinical Specialist - Google Health
October 25, 2023
We have entered a new era of generative AI...

AI Wave 0
1980-90s

Limited capabilities

AI Wave 1
CNNs 2012-22

Successful at narrow tasks
Fragile
Expensive training data
Poor multimodal / sequential
Interpretability tricky

Generalization
Training using free text
Multimodal and sequential
Rich expressive outputs

AI Wave 2
GenAI 2022+

Each wave builds upon the shoulders of the previous
Generative Artificial Intelligence is poised to make a **significant impact** across healthcare

- AI products are being developed to synthesize complex medical information
- Research organizations are interested in leveraging AI to support drug development
- AI-powered predictive models and analytics can help detect health trends and outcomes
- AI software is being created to support provider education and improve patient care
Our research has traced an arc over the past 5 years

Success at each stage required to progress to the next

Idea

Early stage proof of concept research

Publication of results

Larger scale evaluations and publications

3P licensing to drive for impact at scale
Breast cancer research arc to date

2016: Idea - inbound question from UK breast screening team asks “Could AI help us?”

2020: Proof of concept - Nature paper showing our AI can perform like a radiologist

2020-22: Real time screening evaluation of triage

2020-23: Partnerships - Technology licensed to iCAD + others for impact at scale

2020-23: Ariake evaluation in Japan as second reader

2021-24: NHS large scale evaluation - AI as second reader in close-to-real-world setting

2021-2024: Large scale evaluations in different settings across the world

2022-23: Risk prediction study in collaboration with iCAD

2022-24: Large scale evaluations in different settings across the world
Medicine is inherently multimodal

Generative AI unlocks a range of new capabilities:

1. Things that we can now do better
2. Things that were impossible before
Med-PaLM 2, reaches 85% accuracy on par with expert test takers - 18% leap vs Med-PaLM

Med-PaLM 2 first to achieve passing score of over 70% in Indian Medical entrance exam
## Clinician review of Med-PaLM 2 answer

<table>
<thead>
<tr>
<th>Correct</th>
<th>Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>How does it relate to the current consensus of the scientific and clinical community?</td>
<td>Incorrect reading comprehension</td>
</tr>
<tr>
<td>What is the extent of possible harm?</td>
<td>Incorrect recall of knowledge</td>
</tr>
<tr>
<td>What is the likelihood of possible harm?</td>
<td>Incorrect reasoning step</td>
</tr>
<tr>
<td>Correct reading comprehension</td>
<td>Does this answer contain any content that it shouldn’t</td>
</tr>
<tr>
<td>Correct recall of knowledge</td>
<td>Does this answer omit important information?</td>
</tr>
<tr>
<td>Correct reasoning step</td>
<td>Does the answer provided contain any information that is inapplicable or inaccurate for one particular patient-group or demographic?</td>
</tr>
</tbody>
</table>
Realising potential through responsible and ethical development

- The potential is enormous; crucial that real-world applications are explored in a responsible and ethical manner.

- Rigorous evaluation with clinicians with diverse backgrounds to add context and nuance to our model’s understanding

- Piloting with a select group of customers to explore use cases and get feedback to accelerate readiness

https://sites.research.google/med-palm
# Google AI Principles

<table>
<thead>
<tr>
<th>AI Should</th>
<th>Areas we will not pursue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. be socially beneficial</td>
<td>1. likely to cause overall harm</td>
</tr>
<tr>
<td>2. avoid creating or reinforcing unfair bias</td>
<td>2. principal purpose to direct injury</td>
</tr>
<tr>
<td>3. be built and tested for safety</td>
<td>3. surveillance violating internationally accepted norms</td>
</tr>
<tr>
<td>4. be accountable to people</td>
<td>4. purpose contravenes international law and human rights</td>
</tr>
<tr>
<td>5. incorporate privacy design principles</td>
<td></td>
</tr>
<tr>
<td>6. uphold high standards of scientific excellence</td>
<td></td>
</tr>
<tr>
<td>7. be made available for uses that accord with these principles</td>
<td></td>
</tr>
<tr>
<td>- Primary purpose and use</td>
<td></td>
</tr>
<tr>
<td>- Nature and uniqueness</td>
<td></td>
</tr>
<tr>
<td>- Scale</td>
<td></td>
</tr>
<tr>
<td>- Nature of Google’s involvement</td>
<td></td>
</tr>
</tbody>
</table>
Our efforts span three areas:

Consumers
Information and tools to meet people in their everyday moments and give them control of their health journey.

Caregivers
Partnering with clinicians, care systems, life sciences organizations and others in the health ecosystem with tools and technology that leverage AI/ML to improve health outcomes and reduce inequities.

Community Context
Supporting the public’s health efforts with data and resources.
We aim to meet people in everyday moments and support them across their health journey

Discover
What do I / my patients have?

Understand
What can I do / how can I help my patients?

Decide
What care is available to me / my patients?

Monitor
How can I best monitor my health / my patients’ health?
Generative AI can play an enabling role in supporting an ecosystem driven approach in health

**Health Plans**
- Care navigation
  Empower patient with a digital-first messaging application, connected to patient’s care coordinator.

**Providers & Retailers**
- Care advocacy
  Connect patient with community health worker that serves as trusted caregiver across the care journey.

**Pharma & Biotech**
- Virtual Care
  Link members with virtual monitoring platform that remotely tracks patient vitals.

**MedTech & Wholesalers**
- Behavioral Health
  Connect patients to mental health and support groups offering counseling.

**Care navigation**
- Care advocacy
  Connect patient with community health worker that serves as trusted caregiver across the care journey.

**Virtual Care**
- Behavioral Health
  Connect patients to mental health and support groups offering counseling.

**Behavioral Health**
- Novel therapies
  Provide access to reduced cost chronic care medication and novel therapies.

**Novel therapies**
- Sustainability
  Use of AI/ML to improve the operational performance and gain a deeper understanding of raw material sourcing.

**Sustainability**
- Process automation
  Enabling manufacturing excellence and minimizing human errors.

**Process automation**
- Actionable insights
  Enable real-time management for population health by bringing together consumer and enterprise data.

**Actionable insights**
- Interoperability
  Ensure consistent care across the care journey and sharing EHR record with partners.

**Interoperability**
- Authoritative Content
  Convey relatable and digestible information that empowers patients to make informed care decisions.

**Authoritative Content**
Realization of this future is a journey we can take together

**Reduce Clinician burnout, boost efficiencies**
- Replace high cost legacy infrastructure
- Improve mobility and caregiver experience with automated access to relevant data
- Support the delivery of personalized, evidence-based care for all

**Elevate consumer & Patient-centricity**
- Deliver modernized patient care
- Ensure health-related products and research are diverse, fair, and promote health equity
- Enable consumers to make informed choices

**Advancing Life Sciences research & development**
- Ingest, normalize and store data via a uniform platform
- Scale operational and clinical analytics
- Leverage converging technical developments in gAI across domains
Thank you
Reactors

Philip Payne
Washington University in St. Louis

Jackie Gerhart
Epic

Vincent Liu
Kaiser Permanente

Steven Waldren
American Academy of Family Physicians
LLMs/Generative AI in Health and Medicine
An Issue Framing Conversation
The Spectrum of Artificial Intelligence

Deterministic
- Targeted
- Rule-Based Logic
- Risk Scores

Probabilistic
- More generalized
- Predictive Analytics
- Targeted Neural Nets
- Generative AI
  (Large Language Models)
Considerations for Responsible Use of AI

Accuracy

User Experience

Ethics
Generative AI & EHRs

Draft Text
Generate Summaries
Translate Content
Automate Actions
Goals of Healthcare AI

Advancing Medicine

Improving Patient / Staff Experience

Reducing Cost
### More Efficient Clinicians

**Messaging Made Easy**
- Draft responses help clinicians quickly respond to MyChart patient questions.  *Nov 2022*

**Less Reading, More Caring**
- Summarized notes quickly catch up a clinician prior to a visit with a new or returning patient.  *Feb 2023*

**Charting Care**
- Hospitalists and nurses can focus on care while AI drafts their discharge and shift summary notes.  *Feb 2023 (hospital course), May 2023 (shift notes)*

**Conversational Notes**
- Third-party ambient listening integration writes the visit note based on conversation in the clinic. Soon, it will queue up orders.  *Nov 2022*

**Data-Driven Decisions**
- Operational and clinical questions no longer require a report-writer to answer—the system translates questions to queries instead.  *In Cosmos*

**A Trusted Assistant**
- Did the patient’s father have cancer? Get the answer quickly from the Epic Assistant.  *May 2024*

### Improve Patient Experiences

**Simpler Scheduling**
- Conversational SMS bots handle scheduling follow-up appointments tickets.  *Feb 2024*

**Understandable Bills**
- Cut through insurance jargon with patient-friendly balance and benefits explanations.  *Aug 2024*

**Actionable Follow-ups**
- Discrete follow-up tasks extracted from lung imaging means no patient falls through the cracks.  *Nov 2023*

**Education They Remember**
- AI gives doctors a hand in writing personalized patient instructions in plain language.  *Stay tuned!*

### Save Money, Save Time

**Intelligent Coding**
- Queue up recommended codes from clinical details to make professional coders more efficient.  *May 2024*

**Prior Auth? No Problem**
- Identify if prescribed medical services meet a payer’s requirements for reimbursement.  *Stay tuned!*

**A Head Start on Denial Appeals**
- AI writes the first draft of appeal letters for staff to follow up.  *Aug 2024*

**Just the Facts**
- Simple dashboard summaries highlight the most important figures for an executive audience.  *Aug 2023*

---

© 2023 Epic Systems Corporation  
Last updated: October 16, 2023
Regulation Considerations

What are we regulating?
Define Type of AI

Why are we regulating?
Define Risk by Healthcare Use Case

Who are we regulating?
HIPAA v non-HIPAA