Overview

- Computational medical XR (CMXR)
- Generative AI
- Our approach

Midjourney prompt:
"a there and back again hobbit house looking from inside towards outside through the open door, cinematic, atmospheric lighting"
My Career arcs
XR and Spatial computing for medical training?

XR and Spatial computing for education?


People lack access to affordable surgical and anesthesia care according to WHO.

150+
Years outdated medical educational residency model: master - apprentice

18M
Medical professionals' shortage by 20230

5B
People lack access to affordable surgical and anesthesia care according to WHO.

The Anatomy Lesson of Dr. Nicolaes Tulp, 1632, Rembrandt, Mauritshuis museum, The Hague, Netherlands
Spatial Computing, Medical Metaverse\(^1\) and Digital Twins are revolutionizing healthcare and education

\(81\%\)^2

Of healthcare executives say the metaverse will have a positive impact on their organizations

\(5B\)^3

By 2030, the healthcare metaverse market will grow by 48.3% CAGR and be worth $5.37 billion

\(570\%\)^4

Reduction in learning time by using immersive medical VR training

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Computational medical XR is a new interdisciplinary field, bridging life sciences, with mathematics, engineering and computer science. It unifies computational science (scientific computing) with intelligent extended reality and spatial computing for the medical field.

It integrates computational methods from computer graphics, computational geometry, vision and deep learning to solve hard problems in medicine and neuroscience:

- low-code/no-code authoring XR platforms
- XR medical training
- XR surgical planning
- XR operative navigation
- XR for rehabilitation and therapeutics

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Computational Medical XR

Overview

Frontiers SIGGRAPH 2023 talk¹
Frontiers SIGGRAPH 2023 workshop²

¹ https://s2023.siggraph.org/presentation/?id=ftalk_101&sess=sess408
² https://s2023.siggraph.org/presentation/?id=fwork_109&sess=sess287, 2023
Why now for computational medical XR?

“After years of validation and use by early adopters – XR medical technology is poised to move to the mainstream; recent changes in access and cost make XR quite affordable”

Dr. Walter Greenleaf, Stanford Health Care & Virtual Human Interaction Lab

“The biggest challenges in healthcare are (1) access—there aren’t enough enough good doctors to provide timely care to all who need it (and clinicians are leaving the field in droves due to burn out), and (2) cost—the cost of healthcare has skyrocketed, largely because of increasing labor costs.

AI will solve both of these issues.”

Metaverse* = Internet\(^{(3D)} \text{AI} \leftrightarrow \text{XR}

The Rules

Rule #1. There is only one Metaverse.

Rule #2: The Metaverse is for everyone.

Rule #3: Nobody controls the Metaverse.

Rule #4: The Metaverse is open.

Rule #5: The Metaverse is hardware-independent.

Rule #6: The Metaverse is a Network.

Rule #7: The Metaverse is the Internet.

* Source: A. Graylin, HarvardXR, April 2023
** https://medium.com/meta-verses/the-seven-rules-of-the-metaverse-7d4e06fa864c

Stable Diffusion prompt:
“a girl in VR glasses experiencing metaverse worlds”
Virtual Worlds and Web 4.0 *

Virtual Worlds:
Persistent, immersive environments based on 3D and extended reality (XR) technologies

Web 4.0:
Digital and real objects and environments integrated and communicating between each other, enabling immersive experiences

* Source:
Initial search identified 1,394 articles,

- Of which 61 were included in the final qualitative synthesis.
- The majority (54%) were published in 2019–2021, 49% in Europe.
- The majority of studies (70%) focused on simulator validation.

Current literature pertaining to VR training for orthopaedic residents is focused on establishing validity and rarely forms part of a curriculum. Where the focus is education, the majority are discrete educational modules and do not teach a comprehensive amalgam of orthopedic skills. This suggests focus is needed to embed VR simulation training within formal curricula.
Heads-up computing*

Do our tools really complement us, or are we adjusting our natural behavior to accommodate our tools?

METAVERSE GENERATION (VIRTUAL WORLDS):
CODE -> LOW-CODE -> NO-CODE (GENERATIVE AI)
XR draws on AI

“In order to get to ultrarealistic and useful 3D, there’s a need to step beyond hardware and incorporate AI.

Even the most powerful GPU wouldn’t be able to generate high-quality ray-traced 3D models in real time.

Just when Moore’s Law is expiring and graphics as usual has run into a roadblock, AI has appeared as a valuable tool.

It provides us with new and powerful methods to push graphics forward, by being smarter about the rendering process.

We are at the cusp of enormous innovation in the 3D rendering space”

Deep learning and generative AI

“Deep learning takes data points and turns them into a query-able structure that enables retrieval and interpolation between the points.

You could think of it as a continuous generalization of database technology.”

“It is categorically different from even the simplest of embodied biological agents. As in, it's an entirely different category, with no shared characteristics.

Analogies to the brain are just as misleading as when people used the same analogies to describe computers in the 1950s.”

F. Chollet, Google AI
What is Generative AI?

AI models capable of generating new, open-ended and creative content:
- Text
- Images
- videos
- music
- 3D models
- 3D animations
- ....

Based on Foundational Models (Large Language models) and variations of the Transformer AI model
Generative AI tools are increasing productivity today

Generative AI exists because of the transformer

This is how it works

By Visual Storytelling Team and Madhumita Murgia in London SEPTEMBER 12 2023
First a block of words is broken into **tokens** — basic units that can be encoded. Tokens often represent fractions of words, but we’ll turn each full word into a token.

We go to work by train
In order to grasp a word’s meaning, in our example, LLMs first observe it in context using enormous sets of training data, taking note of nearby words. These datasets are based on collating text published on the internet, with new LLMs trained using billions of words.
Eventually, we end up with a huge set of the words found alongside work in the training data, as well as those that weren't found near it.
As the model processes this set of words, it produces a vector — or list of values — and adjusts it based on each word's proximity to: work: in the training data. This vector is known as a word embedding.
A word embedding can have hundreds of values, each representing a different aspect of a word’s meaning. Just as you might describe a house by its characteristics — type, location, bedrooms, bathrooms, storeys — the values in an embedding quantify a word’s linguistic features.

The way these characteristics are derived means we don’t know exactly what each value represents, but words we expect to be used in comparable ways often have similar-looking embeddings.
By reducing the hundreds of values each embedding represents to just two, we can see the distances between these words more clearly.
We might spot clusters of **pronouns**, or modes of **transportation**, and being able to quantify words in this way is the first step in a model generating text.

https://ig.ft.com/generative-ai/
A key concept of the transformer architecture is self-attention. This is what allows LLMs to understand relationships between words.

I have no interest in politics
Self-attention looks at each token in a body of text and decides which others are most important to understanding its meaning.

Before transformers, the state of the art AI translation methods were recurrent neural networks (RNNs), which scanned each word in a sentence and processed it sequentially.

With self-attention, the transformer computes all the words in a sentence at the same time. Capturing this context gives LLMs far more sophisticated capabilities to parse language.

In this example, assessing the whole sentence at once means the transformer is able to understand that interest is being used as a noun to explain an individual's take on politics.
The dog chewed the bone because it was delicious.

- had a red collar
- was his owner's best friend
- loved playing fetch
- ate dinner at 6 pm

The benefits of self-attention for language processing increase the more you scale things up. It allows LLMs to take context from beyond sentence boundaries, giving the model a greater understanding of how and when a word is used.
Generative AI in Medicine

1. **AI for Healthcare**
   AI can revolutionize medical research and improve patient outcomes.

2. **Generative Models**
   Generative AI models can generate synthetic medical data and enhance diagnostic accuracy.

3. **Deep Learning**
   Deep learning algorithms are used to train generative models and generate medical insights.

Midjourney prompt:
“a combination of brain MRI, a neural network graphic and an AR headset, cinematic, 3D”
Gen AI applications in Medicine

Virtual Drug Trials

Accelerate drug development by simulating and predicting drug efficacy and side effects.

Medical Imaging Analysis

Improve accuracy and efficiency in radiology with generative models for image reconstruction and segmentation.

Disease Modeling

Create realistic disease models to study disease progression and develop personalized treatment strategies.

Clinical diagnosis

Develop personalized diagnostic and treatment strategies.


Glass AI combines a large language model (LLM) with a clinical knowledge database, created and maintained by clinicians, to create DDx and Clinical Plan outputs.

71 year old male with a history of MI presents with subacute progressive dyspnea on exertion and is found to have bilateral lower extremity edema, an S3 heart sound, and JVD on physical exam, EF newly revealed to be 30%.

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Ethical Considerations and Challenges

- Privacy and security concerns in handling sensitive medical data
- Ensuring fairness and avoiding bias in AI-based medical decision making
- Transparency and explainability of generative AI models for regulatory compliance
Future Trends and Implications of Gen AI in Medicine

1. Personalized Medicine
   - Generative AI to develop tailored treatments based on individual patient data.

2. Remote Patient Monitoring
   - Generative AI can enable remote monitoring and telemedicine for better healthcare accessibility.

3. Collaborative AI-Doctor Partnership
   - Harmonious collaboration between AI algorithms and medical professionals.
THE PROBLEM

XR training improves learning outcomes\(^1\), XR content creation cannot keep up with demand:

- **LENGTHY CREATION TIMES:** \(2 - 8\) MONTHS

- **HIGH AUTHORING COSTS\(^2\):** 
  MIN $20K PER MINUTE

- **INFINITE NUMBER OF TRAINING EXPERIENCES TO BE SIMULATED AS DIGITAL TWINS**

- **LACK OF LOW/NO-CODE, CONTENT AUTHORING TOOLS**

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and more than 55 published clinical trials since 2020 verify this fact

MAGES XR training low-code/no-code authoring platform*:

- SKILLS TRANSFER, COMPETENCY ASSESSMENT
- SCALING TRAINING LOW-COST AND ON-DEMAND
- LOW-CODE XR TRAINING AUTHORING FASTER (8X), AT LOWER COST (8X)
- NO-CODE XR TRAINING AUTHORING IN FEW HOURS BY NON-DEVELOPERS (FORTHCOMING)

*https://ieeexplore.ieee.org/document/10038619
We have created the best low-code, Medical XR Authoring Platform SDK:

**THE PRODUCT**
MAGES SDK

**MAGES SDK**

**PROPRIETARY IP WITH 5 KEY MED-XR ALGORITHMS (PATENTABLE):**
- Multiplayer soft / hard tissues
- DL-based unlimited Analytics
- Gamified VR design patterns
- Educational visual Editor
- Medical Semantic representation

**XR HARDWARE AGNOSTIC & CROSS-ENGINE (UNITY, UE)**

**SDK-AUTHORED MED-XR APPS PROVEN IN 7 PUBLISHED CLINICAL TRIALS**
- Statistically significant improvement on sensorimotor performance of the trainees of the VR group
- Higher satisfaction and user acceptance

**VIDEO →**

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*https://www.sciencedirect.com/science/article/pii/S0883540319303341
https://games.jmir.org/2021/1/e24170
https://games.jmir.org/2021/4/e29586/
https://doi.org/10.3389/frvir.2021.740197*
METAVERSE LOW-CODE AUTHORING FRAMEWORKS

Numerous **authoring frameworks** have emerged to sustain the creation of VR/AR applications

Main characteristics of virtual reality authoring tools: [1]

- Virtual environment **creation**
- Manipulating and importing **3D** objects
- Interactive **human characters** development
- Artificial intelligence **automation**

"Our medical virtual-worlds (or digital twins) will seem fundamentally different in the future due to the incorporation of developing technology" [3]

"The most evaluated metrics were **usability**, **effectiveness**, **efficiency**, and **satisfaction.**" [2]

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METAVERSE AUTHORING FRAMEWORKS: MAGES 4.0

MAGES 4.0 introduces

- Automations in VR design-patterns for interaction-design Actions development
- VR recorder to capture and replay VR sessions
- Realistic real-time cut, tear and drill algorithms
- AR and mobile (iOS/Android) support
- Dissected edge physics engine
- Edge-cloud remote visual rendering
- Optimized networking layer with collaboration of AR/VR devices
- Convolutional neural network automatic assessment
- New template applications (open source)

MAGES 4.0: Accelerating the world's transition to medical VR training
One more thing

What about no-code generative-AI for medical XR training?
OMEN-E: Open MEdical Neural metaversE

MAGES OMEN-E No-code platform (Generative-AI based, no developer needed)

MAGES SDK NXT Low-code platform* (support all VR/AR/mobile h/w devices, 1 developer needed)

MAGES SIM template Library (reach 100 sims as medical VR apps)

*https://ieeexplore.ieee.org/document/10038619
JARIA – MAGES SDK NXT (5.0)
One really last thing
Ladies and gentlemen, welcome to the 5th Annual Virtual Reality and Healthcare Europe Symposium.

Today, we delve into the exciting realm of generative AI in medicine.

Imagine a world where computers aid in medical diagnosis, drug discovery, medical training and personalized treatment plans.

With generative AI, we can unlock endless possibilities. By combining the power of virtual reality and healthcare, we can revolutionize patient care and improve outcomes.

Let us embrace this technology, harness its potential, and together, shape a future where generative AI drives us towards a healthier, more compassionate world!
Let’s accelerate world’s transition to computational medical XR and Gen AI!