A Revolution of Personalized Healthcare: Enabling Human Digital Twin with Mobile AIGC

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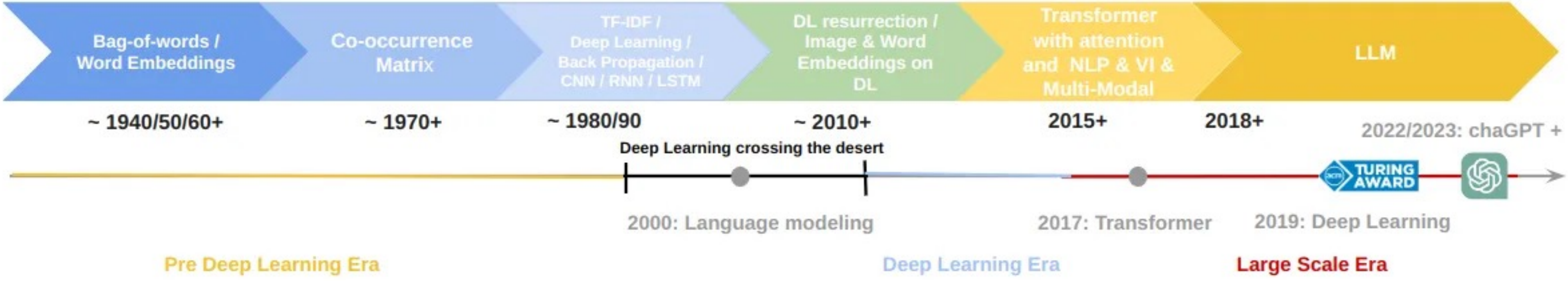
https://arxiv.org/abs/2307.12115

Enabling HDT with Mobile AIGC

Motivations:

- The successful implementation of HDT in personalized healthcare needs **large amounts of individual–level multi-modal data**.
- However, traditional data collection methods are **difficult to be personalized and scaled**, due to the **high privacy** in the healthcare realm.

Artificial Intelligence-Generated Content (AIGC): AIGC over mobile networks has the abilities of creatively generating, manipulating, and modifying valuable and diverse data by using advanced AI algorithms, can be a promising solution for powering up HDT in personalized healthcare.



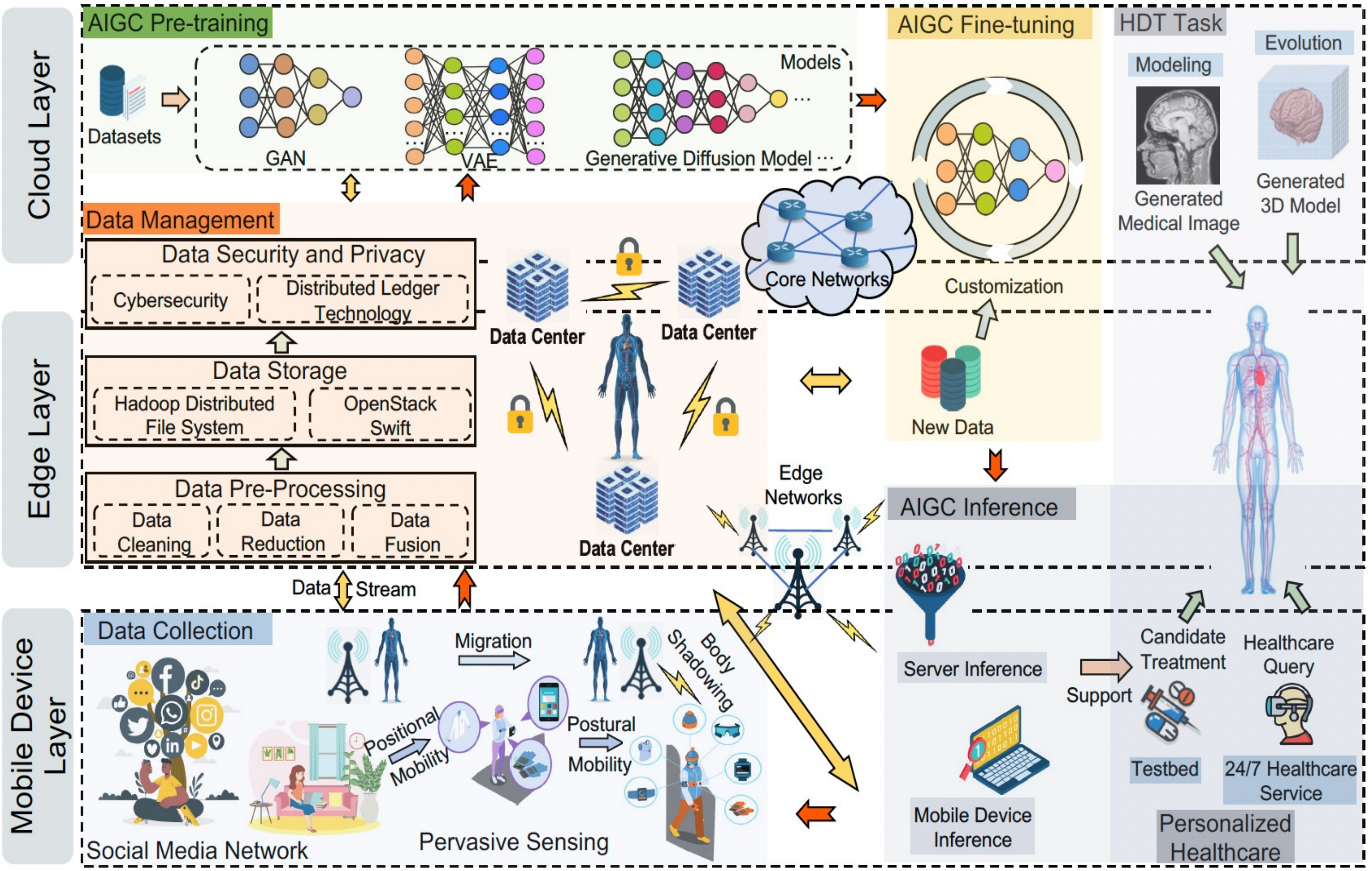
- **Jiayuan Chen**, Changyan Yi, Hongyang Du, Dusit Niyato, Jiawen Kang, Jun Cai and Xuemin Shen, "A Revolution of Personalized Healthcare: Enabling Human Digital Twin with Mobile AIGC," *https://arxiv.org/abs/2307.12115*

Mobile AIGC Enabled HDT: Potentials

Deploying AIGC at **mobile edge networks** for HDT, referred to as **mobile AIGC-driven HDT**, to provide **low-latency and interaction-intensive** personalized healthcare services.

Potential Benefits	Preliminary Attempts
Generating Rare Data for HDT	**RadImageGAN:** Developed by NVIDIA, can generate multi-modal data (such as CT/MR/ultrasound) with considerably small amounts of real ones. (https://www.nvidia.com/en-us/on-demand/session/gtcspring23-s51264/)
Modeling High-Fidelity HDT	**BioMap:** BioMap recently launched an AI generated protein platform to produce customized protein by exploiting biological operation mechanisms. (https://www.biomap.com/en/)
Assisting Personalized Versatile Testbed	**ProtTVAE:** Developed by Evozyne, can predict and simulate the interactions of drugs in the human body using AIGC. (https://www.nvidia.com/en-us/on-demand/session/gtcspring23-S51713/)
Assisting 24/7 Customized Services	**Med-PaLM :** Developed by Google, can utilizes expert-level medical large language models to accurately and safely answer medical questions. (https://sites.research.google/med-palm/)

System Architecture of Mobile AIGC-HDT



Data Collection: obtained from public datasets, pervasive sensing, and individual social network

Data Management: data pre-processing, data storage, and data security and privacy

AIGC Pre-training: automatically learn features of the collected data using generative models

AIGC Fine-tuning: adjust a pre-trained model to new tasks by utilizing a modest amount of data

AIGC Inference: generate desired contents according to the input, providing low-latency and privacy

Design Requirements of Mobile AIGC-HDT

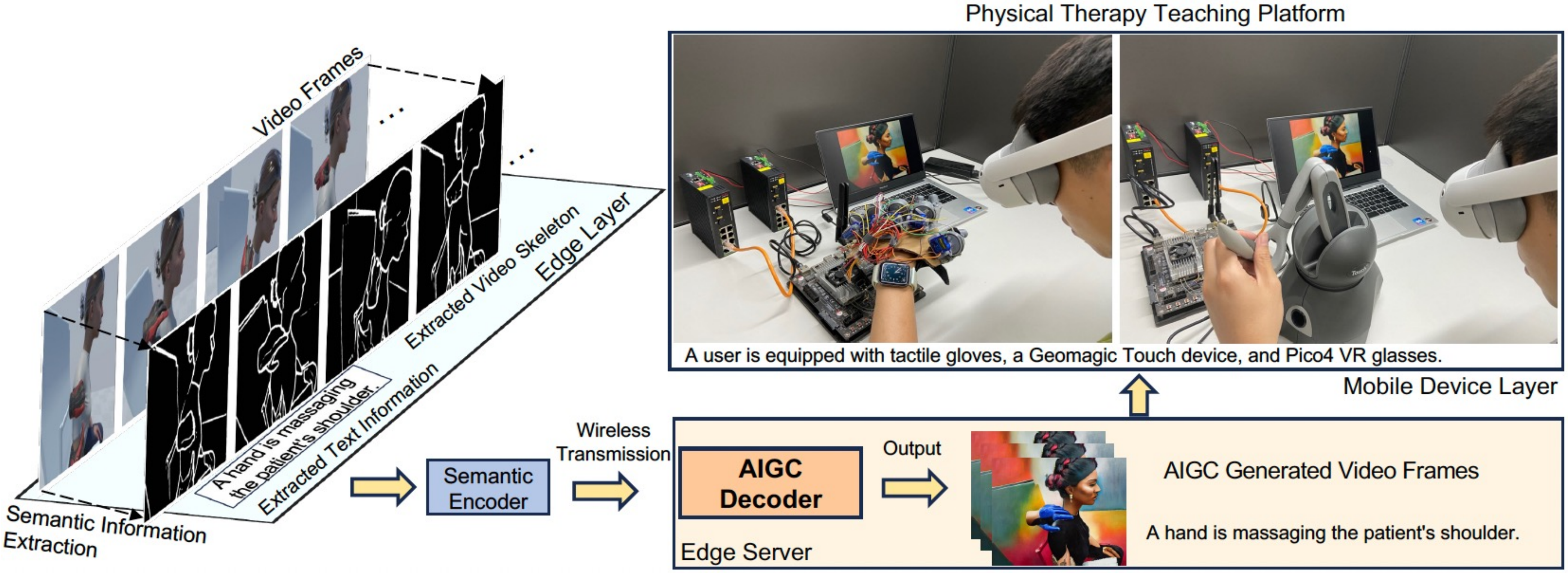
- **Personalized and Adaptive Self-evolution of Mobile AIGC-driven HDT**

Features	Requirements
Heterogeneous QoS requirements and **highly sophisticated AIGC models**	Adaptive computing and networking resource orchestration
Human condition variations generate new data	Timely data collection, generation and integration
Complex **human positional and postural mobility**	Pervasive connectivity for ubiquitous mobility

- **Customized and Multi-modal Intelligent-interaction of Mobile AIGC-driven HDT**

Features	Requirements
Multi-modal encoding schemes and data transmissions are hard to be **synchronized**	Multi-modal data processing and transmission
Individual-level data are **highly privacy-sensitive**	Data privacy, security and integrity with ethics and morality
Contents generated by AIGC models may be **unreliable in terms of factuality**	Integration of subjective and objective evaluations in personalized healthcare application

Experimental Setup



Virtual Physical Therapy Teaching Platform based on Mobile AIGC-driven HDT:

- The platform is deployed on an edge server, where trainers and trainees, can access the server for participating the virtual class.
- The hand represents a hand of a trainer or trainee VT, and the woman represents a patient VT. The trainer or trainee PT controls his/her VT to massage the shoulder of the patient VT, and then the platform provides all PTs with immersive experience by feeding back haptic signals and VR video streams, among other feedback signals.
- Semantic communication is used to transmit the video stream for reducing data size, overhead and latency.
- The AIGC decoder/model at the user’s side is used to generate a resembled video stream according the received information.

Preliminary Results

This mobile AIGC-driven paradigm may suffer from a degradation of QoE, i.e., **the linear combination of the bitrate of video and the similarity between the generated and actual ones**, thus motivating the need to balance the trade-off between QoE and the network overhead.

Optimization Problem

- ***Objective***: Maximizing the total users' QoE
- ***Variable***: Resolution ratio and the diffusion step of the AIGC decoder/model
- ***Constraints***: Bandwidth resource, computation resource and users' QoE thresholds

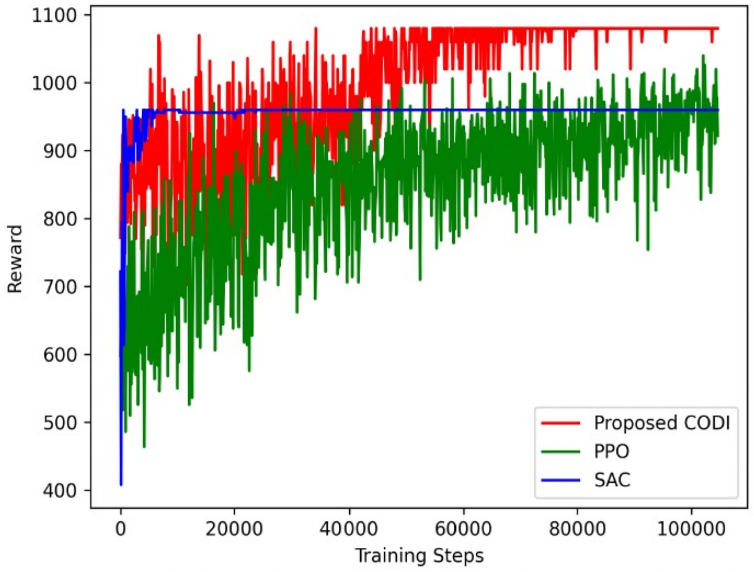
Solution and Results

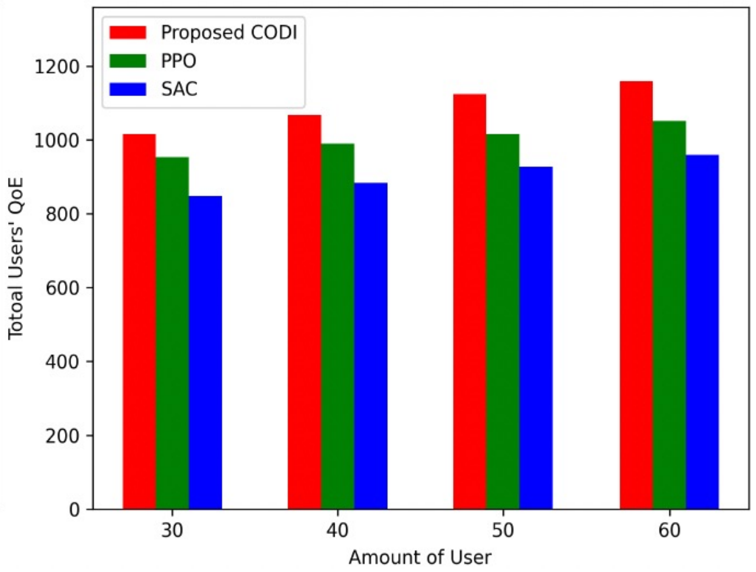
- **Proposed Method**:

Conditional diffusion model-based approach (CODI)

- **Benchmarks**:

PPO and SAC (Conventional DRL algorithms)





Future Research Directions

- How to break down data silos
- How to achieve cross-modal content generation
- How to balance tradeoff among high fidelity, accuracy