



南京航空航天大学  
NANJING UNIVERSITY OF AERONAUTICS AND ASTRONAUTICS

# Enabling Edge Computing for Human Digital Twin: Experimental Testbed and Case Studies

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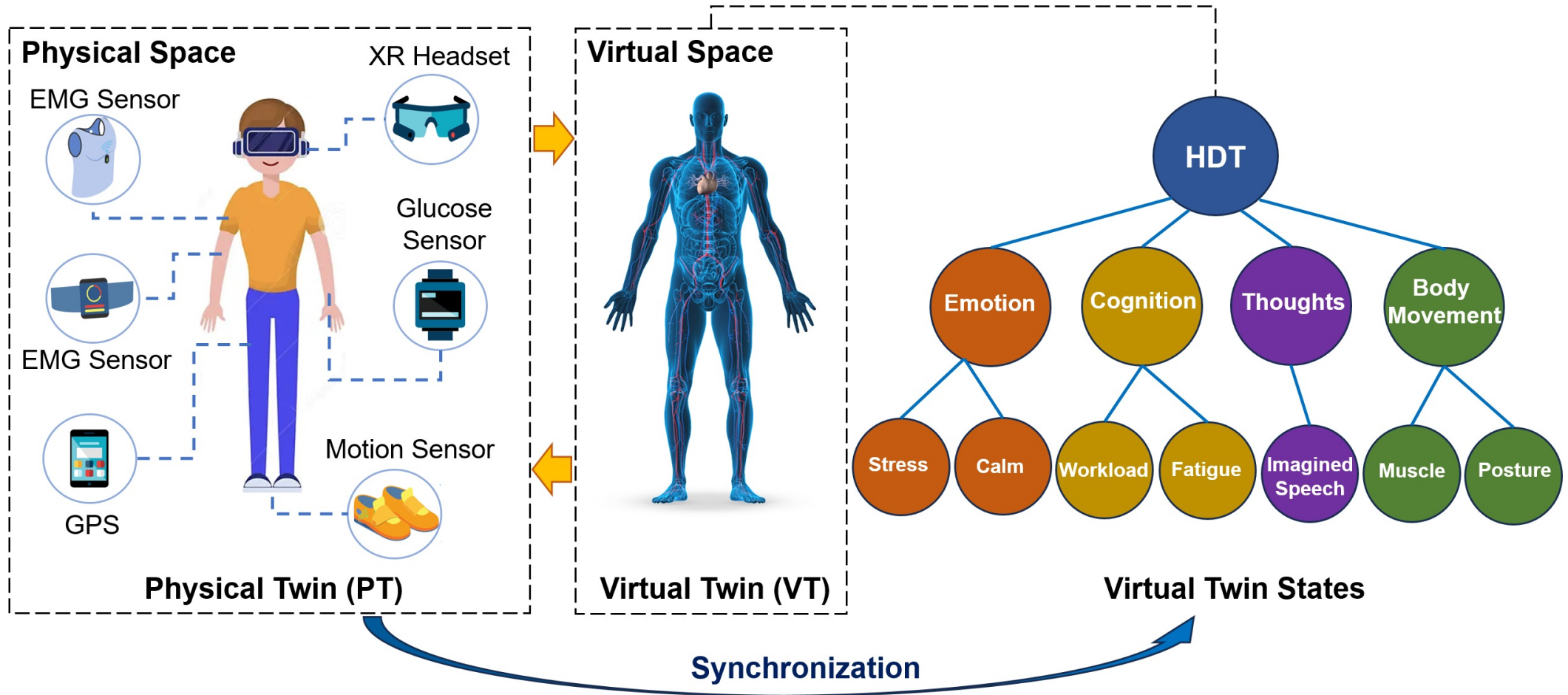
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# Outline



- Human Digital Twin (HDT): Concept
- Edge Empowered TI (ECoTI) for HDT
- System Architecture of ECoTI for HDT
- Key Steps and Core Guidelines
- Experimental Testbed
- Preliminary Results
- Conclusion

# Human Digital Twin (HDT): Concept



**Human Digital Twin (HDT):** HDT characterizes **the replication of individual human body in the virtual/digital space** while **reflecting its physical status both psychologically and physiologically in real time**

- **Jiayuan Chen**, Changyan Yi, Samuel D. Okegbile, Jun Cai and Xuemin Shen, "Networking Architecture and Key Supporting Technologies for Human Digital Twin in Personalized Healthcare: A Comprehensive Survey," *IEEE Communications Surveys and Tutorials*, 2023.

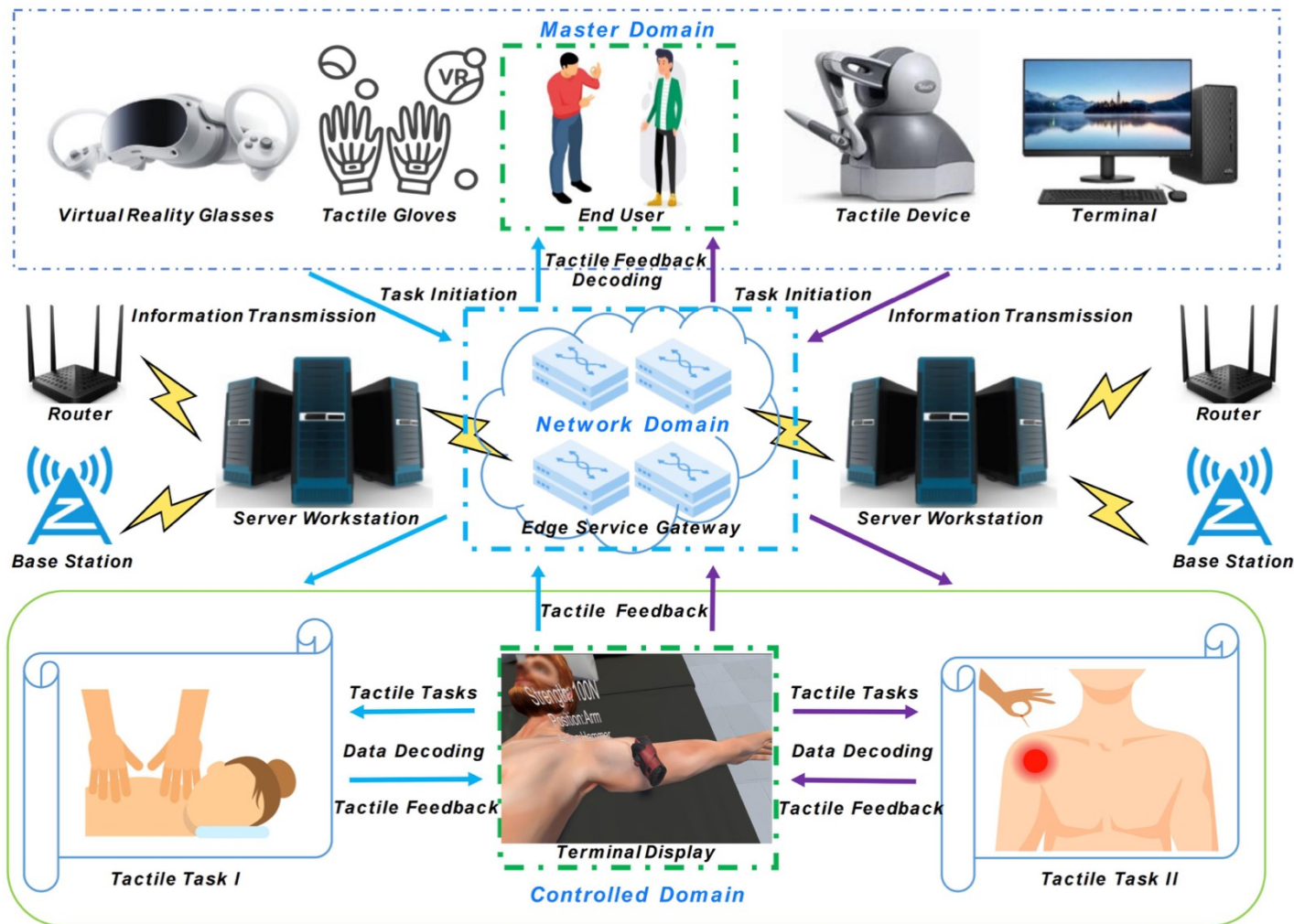


# Edge Empowered TI (ECoTI) for HDT

**Tactile Internet (TI):** TI can transmit **human skills** through networks and provide **multisensory haptic feedbacks**, enabling users to interact with objects more intuitively

Challenges of TI for HDT	ECoTI Solution
<p><b>Frequent service interruptions</b> due to limited network resources</p>	<ul style="list-style-type: none"><li>• Support <b>large-scale data collections, real-time processing and analysis</b> for TI;</li><li>• Employ <b>distributed and collaborative</b> approaches to optimize resources allocations</li></ul>
<p><b>Inefficiency and vulnerability</b> when facing with heavy traffics, inducing delays and inconsistencies in feedbacks across different data modalities</p>	<ul style="list-style-type: none"><li>• Analyze and process data <b>near the data sources and terminals</b></li></ul>
<p>Cannot support physical and virtual entities' <b>seamlessly data exchange and synchronization</b></p>	<ul style="list-style-type: none"><li>• <b>Modelling dimension: Manage, analyze, mine and integrate</b> collected multi-source data;</li><li>• <b>Service dimension: Utilize lightweight AI</b> to provide desired functions and services</li></ul>

# System Architecture of ECoTI for HDT



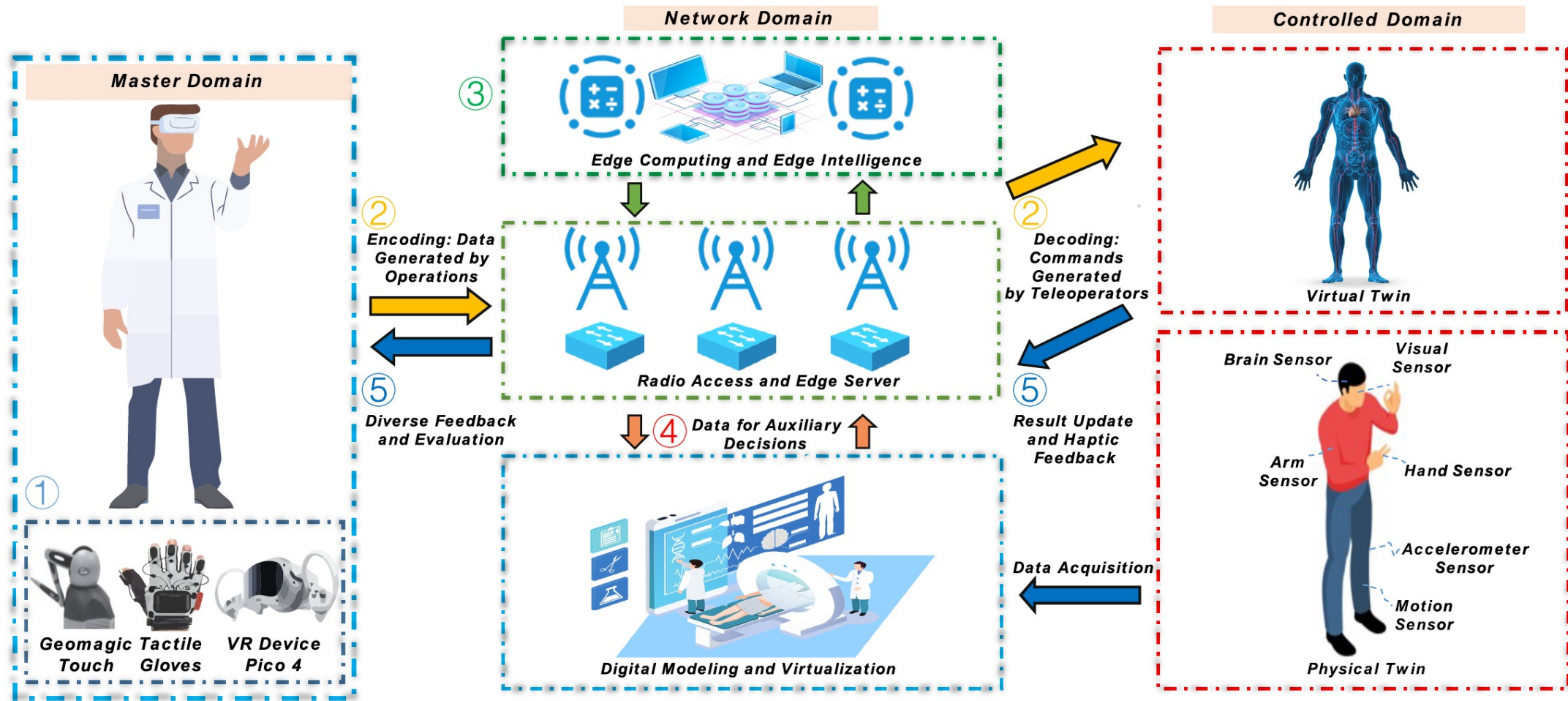
**Master Domain:** PTs with various haptic sensors, display devices and terminals, etc. **initiating human skills**

**Network Domain:** Support **bi-directional communications** between the master and controlled domains

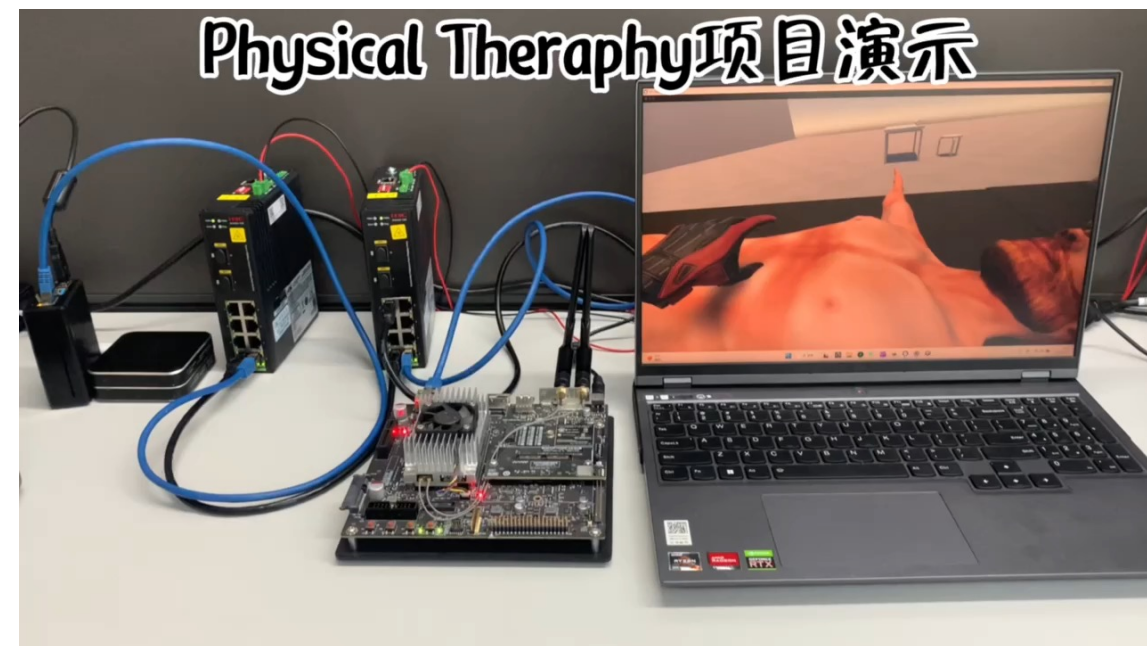
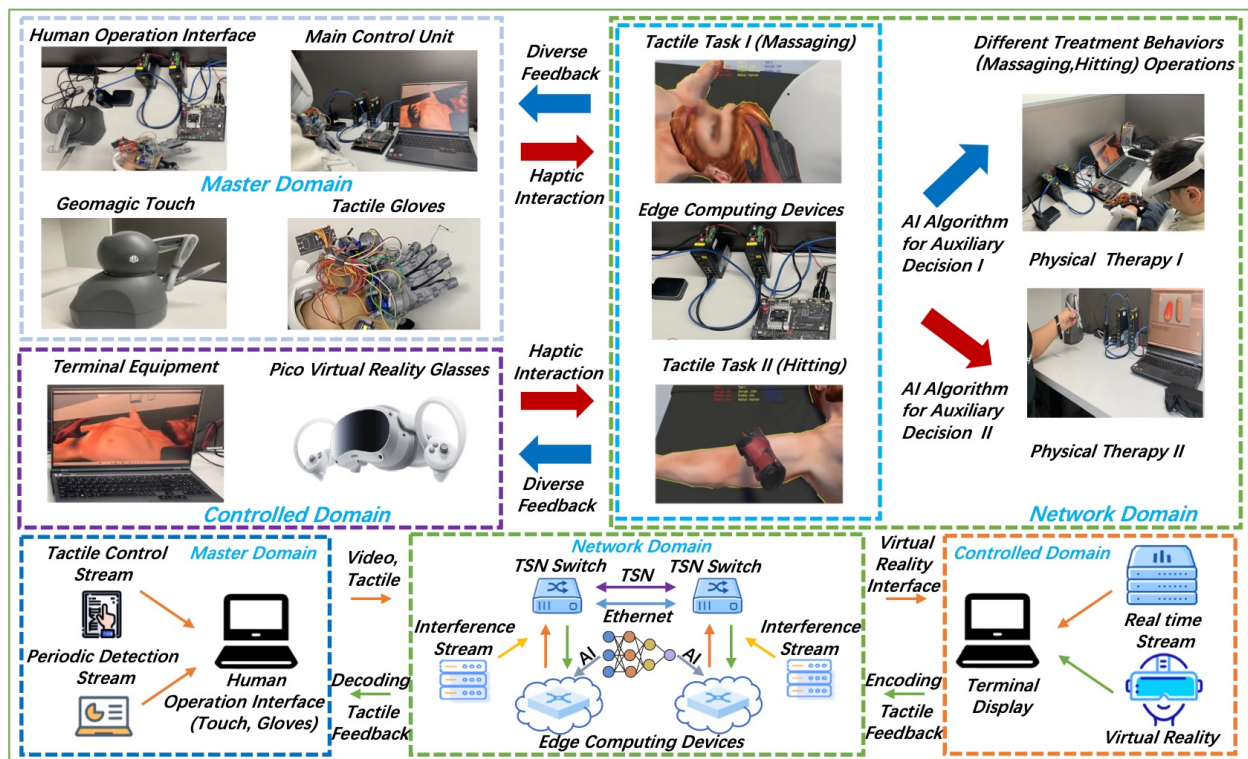
**Controlled Domain:** **Execute actions** from the master domain, and the VTs **generate the feedbacks**



# Key Steps and Core Guidelines



# Experimental Testbed

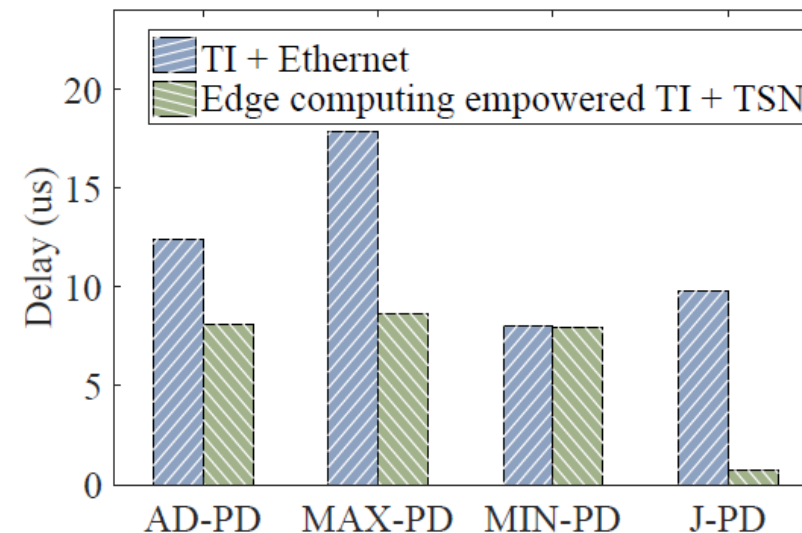
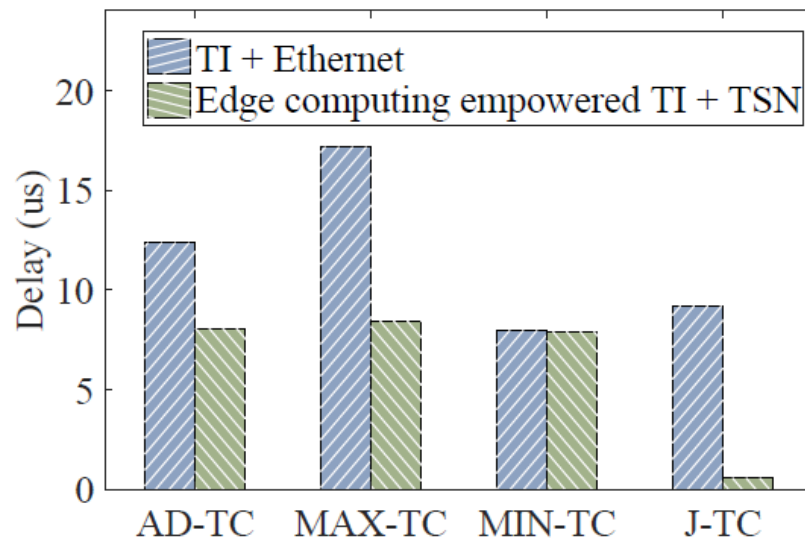


## ECoTI for HDT in Physical Therapy:

- Master domain is an agent therapist, the controlled domain is a patient, and the network domain provides both transmission and computing services.
- A virtual body is digitally constructed for mapping the patient (i.e., a PT) based on the perceived user data. TI enables the therapist to provide tactile therapy actions and videos to the patient, allowing him/her to conduct high-density and highly interactive physical operations (such as hitting and massaging) according to different situations.
- The platform also feeds back treatment operations to the patient, letting them to experience immersive and vivid therapies.

# Preliminary Results

**Objective Evaluation**  
(Delay)



**Subjective Evaluation**  
(User QoE)

Framework	Video stream	Tactile feedback	Sync.
TI + Ethernet	Choppy	Inaccurate	Jitter
Edge computing empowered TI + TSN	Fluent	Responsive	Efficient



# Conclusion



- We have proposed the design of edge computing empowered Tactile Internet (ECoTI) for human digital twin (HDT);
- We have presented detail steps and core guidelines for implementing this system;
- We have conducted a case study demonstrating ECoTI for HDT in physical therapy.



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# Thank you!

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