WORKING GROUP 1 – 6G & EHEALTH - USE CASES AND POTENTIAL SERVICE REQUIREMENTS

ONE6G OPEN LECTURE 9 – 6G FOR E-HEALTH

WI Rapporteur and Presenter: José Perdomo
Chair: Prof. Mohammad Shikh-Bahaei, King's College London
Vice-chair: Prof. Periklis Chatzimisio, International Hellenic University (IHU)

One6g Open Lecture 9 – October 17th, 2024

OVERALL VISION AND METHODOLOGY

WG1 - 6G use cases and requirements

1. Gather key players and needs from industries and academics institutions across all verticals

2. Discuss 6G-related use cases and derive system requirements

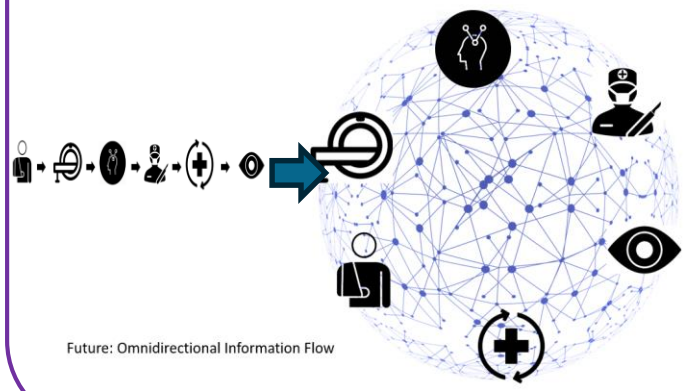
3. Vision: Provide an interface to academic institutions and verticals with SDOs to shape 6G vision and technology according to their needs

6GHealth WI – Scope and Objectives

Key Objective:

- Identify areas/use cases in healthcare sector where the 6G mobile radio system can play a significant role
- Develop use cases in identified areas and derive technical (e.g., KPIs and functional requirements) and non-technical considerations

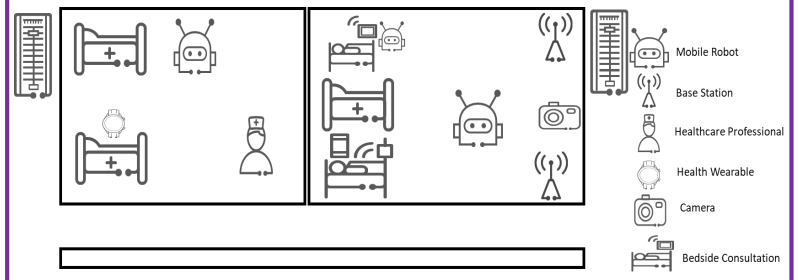
Model-based medicine vision



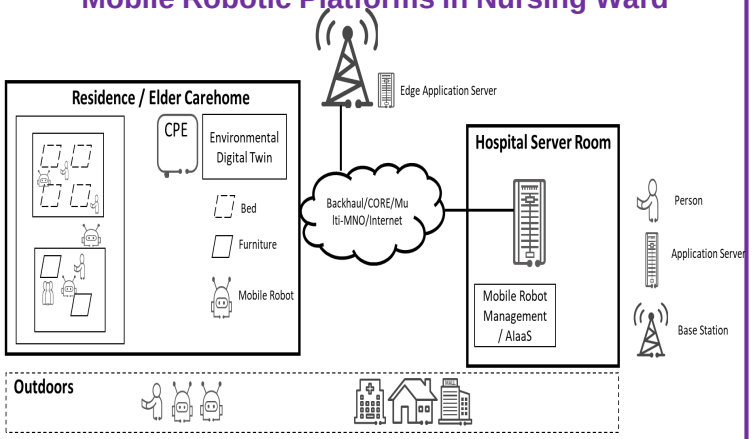
- The different identified UCs are independent in the sense that they could be realized without a model-based medicine vision.
- Altogether, the UCs provide different key components to realize the model-based medicine vision.

6GHealth WI - Identified Use Case Clusters and Use Case Examples

Medical Robotics Applications

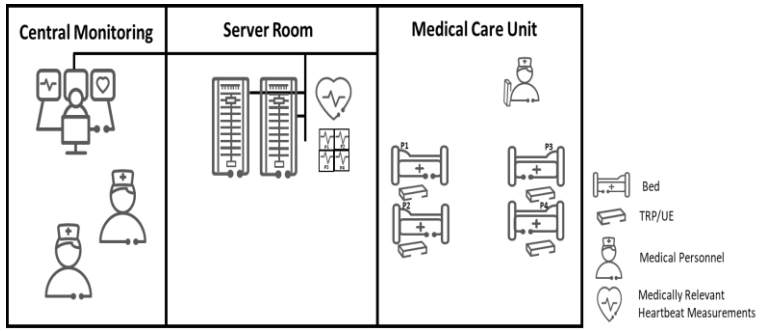


Mobile Robotic Platforms in Nursing Ward



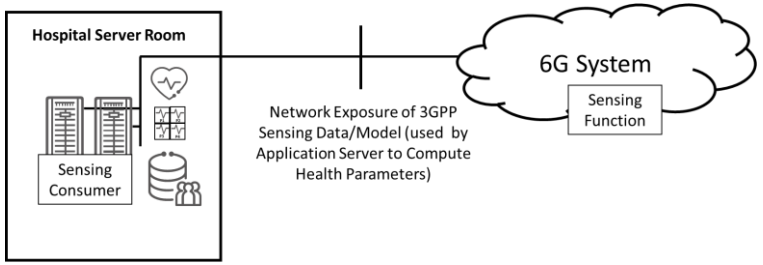
Assisted Living with Companion Mobile Robots

Vital Sign Wireless Sensing



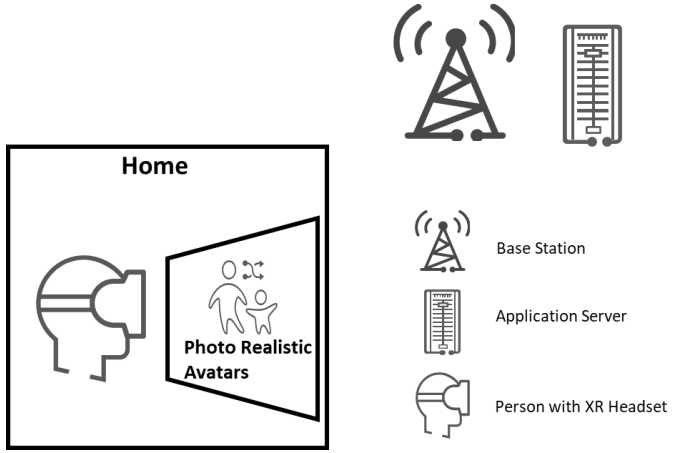
Vital Sign Sensing in Medical Care Unit

Medical Data and Model Sharing



Exchange of 3GPP sensing model/data associated with Medical Information

Immersive & Ubiquitous Treatment



Immersive XR-based Self Attachment Therapy

WG1 – 6GHEALTH WI

6GHealth WI – Medical Robotics Applications

Need

Increasing demand of healthcare services and increasing scarcity of healthcare personnel

Description

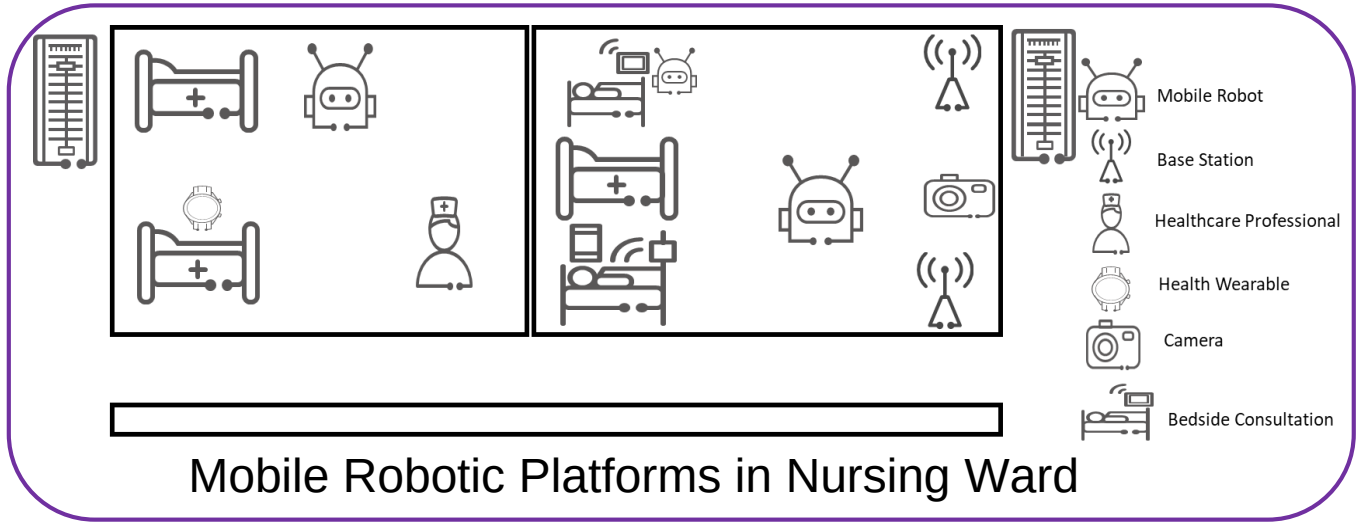
Mobile robots are expected to take over caregiving tasks [1]. To do so, they need context-awareness of the real-time health status of patients so that they can perform context-sensitive actions accordingly (e.g., sensitive to disease or distress of patient)

Assumptions

- Mobile robots have autonomous navigation and manipulation capabilities and 3GPP and non-3GPP infrastructure (e.g., cameras) sense vital signs of patients.

Outcome

Mobile robots by consuming context-awareness services perform context-sensitive actions to interact with patients



Mobile Robotic Platforms in Nursing Ward

Potential New Requirements:

- 3GPP system shall facilitate the secure and privacy-perserving sensor fusion of multi-modal health data (e.g., 3GPP sensing data, Electronic Health Records and wearable health information) to create a “context-aware” service for mobile robots.

- 3GPP system shall distribute 3GPP sensing data, “context-aware” service or results via unicast/multicast/broadcast in target sensing service area.

[1] B. L., P. Schwingenschlogl, J. Hofmann, D. Wilhelm and A. Knoll, “Boosting the hospital by integrating mobile robotic assistance systems: a comprehensive classification of the risks to be addressed,” in Autonomous Robots, 2024.

WG1 – 6GHEALTH WI

6GHealth WI – Medical Robotics Applications

Need

Wider adoption of rehabilitation robotics (e.g., at home) is constrained by the lack of reconfigurability and customisability of the exoskeletons

Description

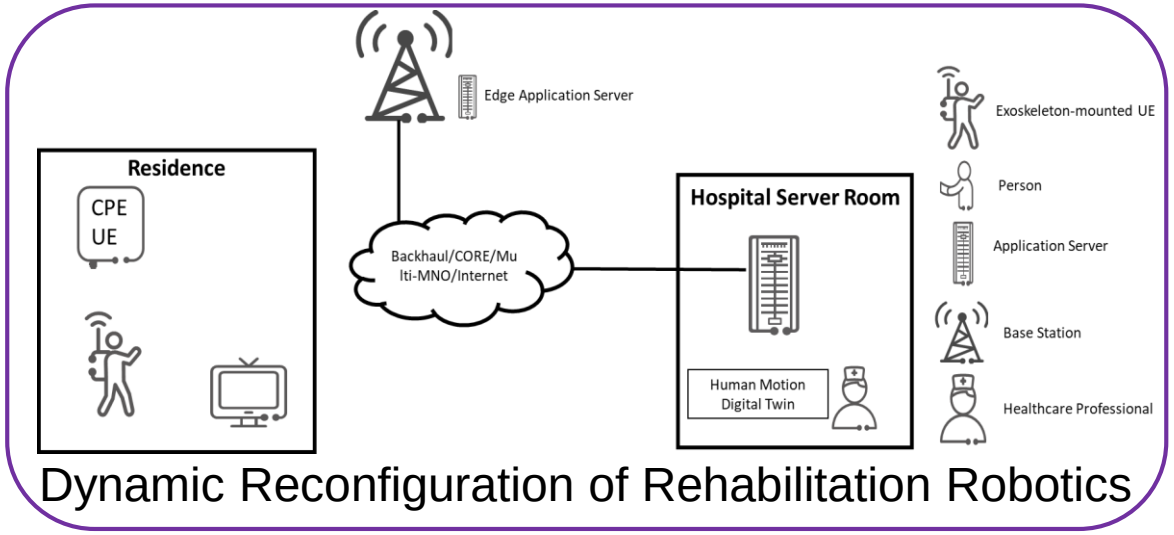
An ideal dynamic and reconfigurable exoskeleton is capable of being structurally/mechanically adjusted to the patient's needs to achieve versatility, mobility and safety [2].

Assumptions

- A real-time 'human-in-the-loop' (closed-loop) rehabilitation control system is closed over the 6G mobile radio system. CPE performs 3GPP sensing. Application Server hosts models of human gait motion .

Outcome

The networked control system closed over the 3GPP network facilitates the operation of an optimal, patient-specific reconfigurable exoskeleton for an effective rehabilitation therapy.



Dynamic Reconfiguration of Rehabilitation Robotics

Potential New Requirements:

Scenario	Availability: target value [%]	Reliability: Mean Time btw Failure	Direction	e2e latency	Bit rate	Message Size [byte]	Transfer Interval	UE speed	# of active UEs	Service Area
Sensor Feedback from Rehabilitation Robotics	> 99.999	>> 1 month (< 1 year)	Uplink	50 ms NOTE2	Up to 78.6 Mbits NOTE3	< 9830400 NOTE3	< 20 ms / 100 km²	< 12.8 km/h NOTE1	< 20 per 100 km²	regional

NOTE1: The average human running speed is approximately 12.8 km/h.

NOTE2: Determined by the "slowest" exteroreceptive feedback[5] hardware used in the control loop (e.g., 50 ms for depth cameras). Ideal and efficient, (hard) real-time control on a networked system is based on 1 ms control loops.

NOTE3: If point-cloud data (constructed from different sensors) is used, message size can be up to 9830400 bytes.

[2] G. Durandau et al., "Voluntary Control of wearable robotic exoskeletons by patients with paresis via neuromechanical modeling," Journal Neuroengineering Rehabilitation, vol. 16, p. 91, 2019.

WG1 – 6GHEALTH WI

6GHealth WI – Medical Robotics Applications

Need

Due to the current demographic change in terms of aging population, a significant portion of older adult population live in households or care homes [3]

Description

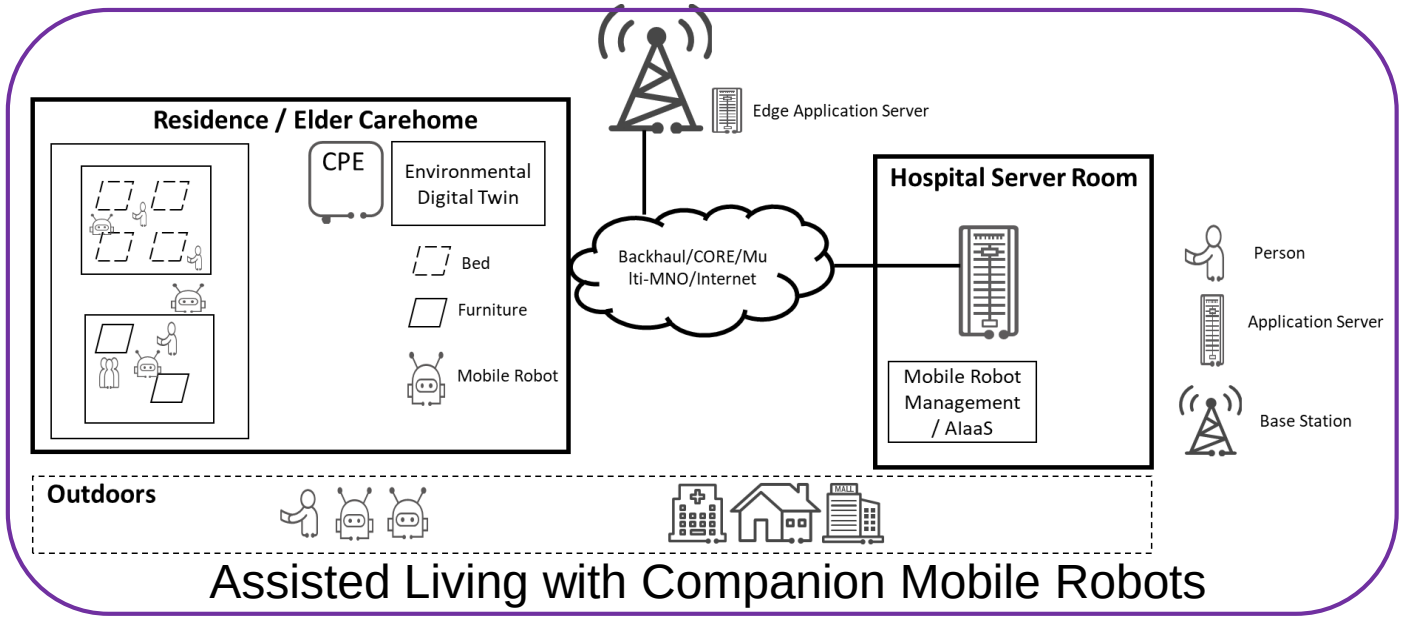
Mobile robots can perform essential companionship tasks such as exchange items with human (e.g., exchange groceries, furniture, cooking tools, etc…) as well as engaging in personalized dialogues in indoor and outdoor environments.

Assumptions

- Mobile robots have autonomous navigation and manipulation capabilities and perform 3GPP and non-3GPP sensing. Mobile robot management system located at hospital.

Outcome

- Bob is safely assisted and supported with tasks such as item exchange, carrying groceries as well as personalized conversational dialogues.



Assisted Living with Companion Mobile Robots

Potential New Requirements:

- To enable protective stop of mobile robot servant (according to DIN EN ISO 13482), 3GPP system shall have the capability to timely compute and deliver 3GPP sensing result to relevant robot application that triggers protective stop.
- Depending on the mobile robot tasks (e.g., dialogue), the 3GPP system timely communicate AI/ML split inference and/or AI/ML model to mobile robot servants in arbitrary outdoor environments

[3] U. Nations, “World Population Ageing 2020 Highlights - Living arrangements of older persons,” Social Affairs PD, 2020

WG1 – 6GHEALTH WI

6GHealth WI – Vital Sign Wireless Sensing

Need

Traditional wired sensors, such as the electrocardiograph (ECG), restrict movements, limiting a patient's ability to have walks and engage in activities. In these scenarios, contact-based monitoring should be avoided [4].

Description

Tracking medical relevant information (synchronous and continuous heart rate/respiration measurement) of vital signs with contactless sensing is crucial to monitor health status, assess the effectiveness of medications while supporting patient comfort.

Assumptions

- 3GPP infrastructure (TRP or UE) provide 3GPP sensing service to sense medical relevant data and support healthcare professionals

Outcome

Reliability of contactless system with 3GPP sensing avoids false alarms since there are no probes to manipulate by distressed patients. Distress of patients is significantly reduced by enabling mobility.

Vital Sign Sensing in Medical Care Unit

Potential New Requirements:

Scenario	Sensing service area	Confidence level [%]	Human motion rate accuracy [Hz]	Accuracy of positioning estimate by sensing (for a target confidence level)		Accuracy of velocity estimate by sensing (for a target confidence level)		Sensing resolution		Max sensing service latency[ms]	Refreshing rate [s]	Missed detection [%]	False alarm [%]
				Horizontal [m]	Vertical [m]	Horizontal [m/s]	Vertical [m/s]	Range resolution [m]	Velocity resolution (horizontal/ vertical) [m/s x m/s]				
Synchronous Heartbeat Measurements in Medical Care Units	Indoor	99.9	0.003 NOTE 1	N/A	N/A	N/A	N/A	N/A	N/A	100 ms	1 s	< 0.01 % NOTE 2	< 0.01 % NOTE 2

NOTE1: Norm DIN EN 60601 defines the requirement of the measurement of a heartbeat within +/- 75ms around the actual heartbeat (i.e., 0.0317 Hz considering heart rates as low as 40 bpm) [28] . To be competitive with ECG measurements, human motion rate accuracy should be significantly more precise in medical care units (assuming a factor of 10).

NOTE2: Minimum false alarms are required so that healthcare professionals trust the continuous contactless heart rate monitoring system in the palliative care unit, where patients may suddenly be in critical situation [3] .

[4] K. Shi, C. Will, T. Steigleder, F. Michler, R. Weigel, C. Ostgathe and A. Koelpin, “A Contactless System for Continuous Vital Sign Monitoring in Palliative and Intensive Care,” in Annual IEEE International Systems Conference (SysCon), 2018

WG1 – 6GHEALTH WI

6GHealth WI – Immersive & Ubiquitous Treatment

Need

Mental health diseases are main causes of burden globally and access to mental healthcare services should be improved [5]

Description

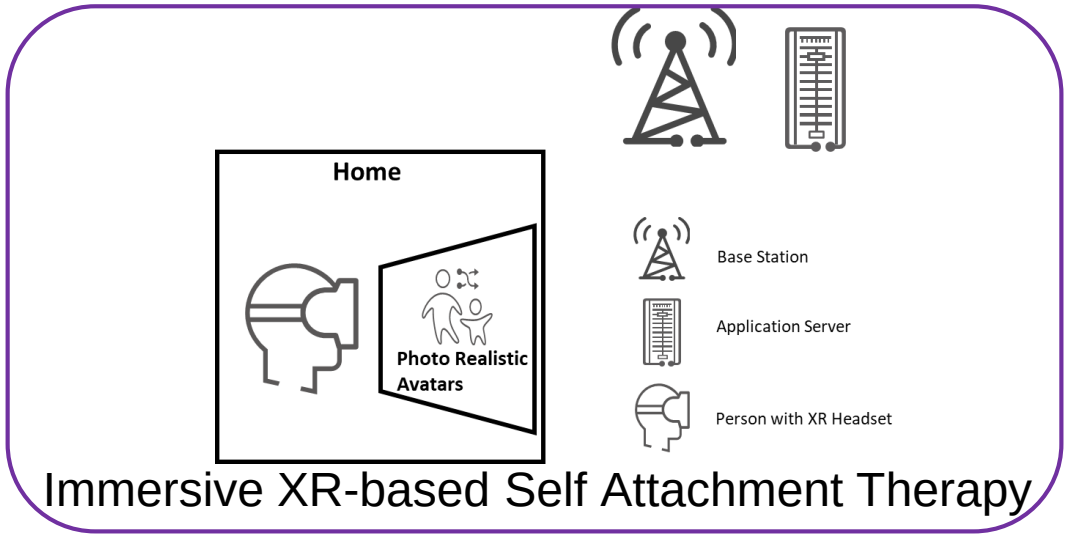
Immersive Virtual Reality has been explored to enhance the efficacy of psychotherapeutic treatments. In one such technique, Self-Attachment Therapy [6], XR user's capacity for self-regulation of emotion are enhanced by means of simulating a photo-realistic version of the user's childhood avatar and having rich interactions with said avatar

Assumptions

- XR Headset is a UE with 3GPP sensing capabilities without rendering capabilities. Rendering done at application server.

Outcome

XR user is involved in a protocol that describes patterns of interaction between adult-self (XR user) and inner-child (childhood avatar version of XR user) that foster secure attachment .



Immersive XR-based Self Attachment Therapy

Potential New Requirements:

Scenario	Availability: target value [%]	Reliability: Mean Time btw Failure	Direction	e2e latency	Bit rate (Uplink)	Bit rate (Downlink)	Message Size [byte]	Transfer Interval	UE speed	# of active UEs	Service Area
Immersive XR-based Self Attachment Therapy	99.9	>> 1 month (< 1 year)	Downlink	10 ms NOTE3	[500] Mbits/s NOTE1	[200-2000] Mbits/s NOTE1	FFS NOTE4	< 20 ms / 100 km^2	< 12.8 km/h NOTE2	< 100 per 1-10 km^2	Residential

NOTE1: KPIs extended from Mobile Metaverse Services (Viewports streaming from rendering device to AR glasses through direct device connection) in TS 22.156

[41]. For Uplink, >500 Mbits/s may be expected. The assumption is that XR device does not have rendering capabilities. Application server performs rendering and hosts personalized intelligence of user avatar.

NOTE2: The average human running speed is approximately 12.8 km/h.

NOTE3: Includes uplink and downlink delay between XR device and application.

NOTE4: Dependent on the video/audio resolution and 3GPP sensing representation

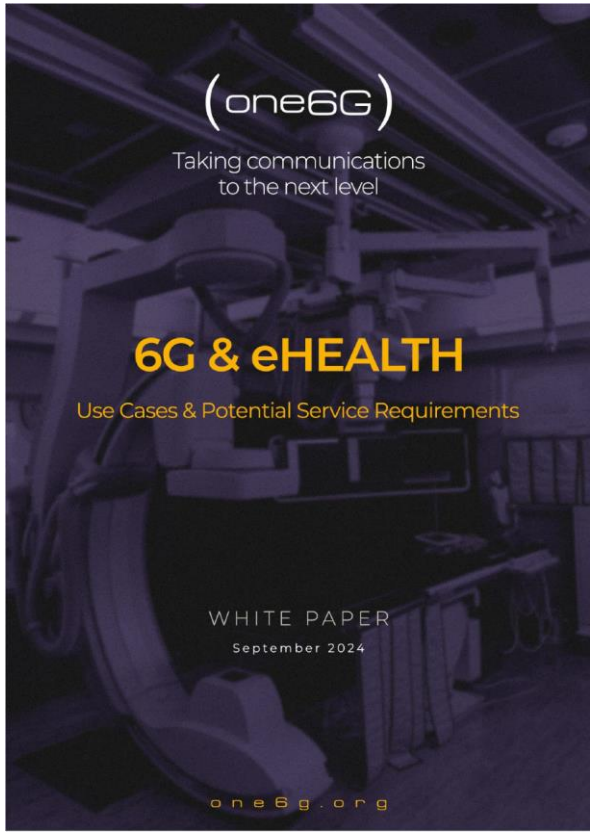
[5] "Global, regional, and national burden of 12 mental disorders in 204 countries and territories," The Lancet Psychiatry, vol. 9, no. (2), pp. 137-150, 2022.

[6] A. Edalat, "Computational Neurology and Psychiatry," Self-Attachment: A Holistic Approach to Computational Psychiatry, vol. 6, pp. 273-314, 2017.

WG1 – WI: 6G and eHealth – 6GHealth – White Paper Volume 1

White Paper Volume 1:

- Published September 2024
- Analysis of 6G communication, sensing, AI/ML support and functional requirements for eHealth domain
- A total of 11 use cases are presented across 4 identified use case clusters: Medical Robotics Applications, Vital Sign Wireless Sensing, Medical Data & Model Sharing, Immersive & Ubiquitous Treatment
- Considerations related to risk analysis, privacy, medical device regulation, ethics are elaborated



Contributors:

- Mohammad Shikh-Bahaei, Emmanouil Spyrakos , **King's College London**
- Dirk Wilhelm, **Klinikum Rechts der Isar Technische Universität München**
- Fabian Michler, **Sykno GmbH**
- Thomas Neumuth, Tobias Pabst, **Innovation Center Computer Assisted Surgery, Universität Leipzig**
- Fatih Cogen, **Turkcell 6GEN. Lab**
- Jesús Fernández Lozano, **University of Malaga**
- Ali Hessami Vega, **Vega Global Systems**
- Jose Mauricio Perdomo, Mona Ghassemian, Daniel Gordon, **Huawei Technologies Duesseldorf GmbH**
- Others…

WG1 – WI: 6G and eHealth – 6GHealth – Summary & Next Steps

Outcomes from 6GHealth white paper volume 1:

- 6G system functional requirements and KPI as baseline were identified across the eHealth-related use case clusters: Medical Robotics Applications, Vital Sign Wireless Sensing, Medical Data & Model Sharing, Immersive & Ubiquituous Treatment
- Analysis based on medical device regulation, ethics and sustainability are elaborated per use case
- Relevant stakeholders from the medical domain, industry and academia shall further collaborate to determine the depth of ethics, sustainability and safety considerations for 6G and eHealth.
- Interested parties are invited to join the one6G WG1 discussions for future treatment of eHealth use cases (including use cases from other verticals)

https://one6g.org/working-groups/

THANK YOU FOR YOUR ATTENTION!

WI Rapporteur/Presenter: José Perdomo; Contact: jose.mauricio.zelaya@huawei.com
Chair: Prof. Mohammad Shikh-Bahaei, King's College London
Vice-chair: Prof. Periklis Chatzimisio, International Hellenic University (IHU)

One6g Open Lecture 9 – October 17th, 2024