# Design Principles for E-health and Medical Internet of Things (MIoT)

Yao Amevi Amessinou Sossou, MA, Bsc

The integration of the Internet of Things (IoT) in healthcare has ushered in transformative opportunities. By empowering healthcare professionals with real-time data insights, it enhances the quality of life for patients. The rapid evolution of technology has facilitated groundbreaking advancements in the healthcare sector, with the Medical Internet of Things (MIoT) standing out as a prime innovation. MIoT, a system of interrelated, internet-connected objects, can autonomously collect and transfer data over a wireless network [1].

For MIoT solutions to truly make a mark, they must be user-centric and intuitive. This means ensuring that patients have seamless access to vital information, from medications to exam results. The digital revolution has reshaped the dynamics of patient-doctor interactions, expanding healthcare access beyond the confines of traditional settings. The COVID-19 pandemic underscored the urgency of this digital transition, revealing its vital importance in addressing healthcare challenges.

Furthermore, the post-pandemic landscape has spotlighted the potential of robotization in revitalizing the economy and addressing healthcare challenges, especially in remote and challenging environments. Robots, when integrated with MIoT, can play a pivotal role during national health emergencies, with robotic telemedicine platforms bridging the gap between medical experts and underserved communities [2]. The success of MIoT in healthcare hinges on strategic alliances and international cooperation. Connecting indigenous communities to the internet using traditional land communications and satellite communications can foster capacity building and skills training. Collaboration from non-profits, the private sector, and government is essential to establish smaller community networks and ensure the digital transformation of healthcare [3].

However, the journey to fully realizing MIoT's potential is paved with challenges and considerations. The sensitive nature of healthcare data and the criticality of medical interventions demand adherence to specific design principles. Although numerous sources document aspects of user-centered design, there are few references that consider how to transforms the information users and their work into an effective user interface design [4]. This article delves into these principles, aiming to illuminate the path for developing effective and reliable e-health and MIoT applications. Through a thorough analysis, we seek to pinpoint the challenges and opportunities of deploying robots within MIoT, with the ultimate goal of elevating healthcare accessibility and patient outcomes.

## Design Principles for Robots in MIoT for Underserved Communities

In the realm of healthcare, the design principles that guide the development of technologies can significantly influence their effectiveness and user acceptance. While general design principles for mobile apps and desktop software provide a foundational understanding, the unique challenges and needs of the healthcare sector necessitate a more specialized approach. This is especially true when considering the Medical Internet of Things (MIoT) applications tailored for underserved communities and marginalized populations. These communities often grapple with distinct challenges, from limited access to healthcare facilities to cultural and linguistic barriers. The core motivation we have is to ensure that we are helping designers and developers create solution that help "building a bridge between user requirements design. And user interface" [4]. As we delve into the subsequent sections, we present two comparative tables that outline the design principles for both general software and those specific to E-health and MIoT applications. A comparative analysis following these tables will further highlight the nuances and critical considerations when designing robots in MIoT for these special communities. This paragraph sets the stage for the reader, providing context for the upcoming tables and the comparative analysis. It emphasizes the importance of specialized design principles for MIoT in the context of underserved communities.

*Table 1: Design principles for mobile apps and desktop software*

| Aspect | Mobile Apps | Desktop Software |
|---|---|---|
| **Interaction** | Touch-based interactions | Mouse and keyboard-based interactions |
| **Screen Size** | Limited real estate | Larger screen estate |
| **Navigation** | Streamlined, intuitive | Typically, hierarchical |
| **User Context** | On-the-go, portable | Stationary, focused |
| **Gestures** | Swipe, tap, pinch-to-zoom | Limited use of gestures |
| **Interface Complexity** | Simplified, focused | Can be more complex |
| **Orientation** | Portrait and landscape | Landscape or portrait |
| **Platform Guidelines** | Follow platform-specific guidelines (iOS, Android) | Follow UI conventions (Windows, macOS) |
| **Input Methods** | Touchscreen | Mouse and keyboard |
| **Notifications** | Push notifications | System tray notifications |
| **Screen Transitions** | Animated, fluid | Can be more abrupt |
| **Performance Consideration** | Optimized for lower hardware resources | More freedom in resource usage |
| **Context Switching** | Frequent, quick | Less frequent, deliberate |
| **Offline Capability** | Emphasized, if applicable | Less critical |
| **Multi-Tasking** | Limited background processing | Multitasking more common |
| **Focus on Mobile Context** | Location-aware features | Less emphasis on location-based features |
| **User Context** | On-the-go, portable | Stationary, focused |
| **Gestures** | Swipe, tap, pinch-to-zoom | Limited use of gestures |
| **Interface Complexity** | Simplified, focused | Can be more complex |
| **Orientation** | Portrait and landscape | Landscape or portrait |
| **Platform Guidelines** | Follow platform-specific guidelines (iOS, Android) | Follow UI conventions (Windows, macOS) |
| **Input Methods** | Touchscreen | Mouse and keyboard |
| **Notifications** | Push notifications | System tray notifications |
| **Screen Transitions** | Animated, fluid | Can be more abrupt |
| **Performance Consideration** | Optimized for lower hardware resources | More freedom in resource usage |
| **Context Switching** | Frequent, quick | Less frequent, deliberate |
| **Offline Capability** | Emphasized, if applicable | Less critical |
| **Multi-Tasking** | Limited background processing | Multitasking more common |

| | | |
|---|---|---|
| **Focus on Mobile Context** | Location-aware features | Less emphasis on location-based features |
| **Notifications** | Push notifications | System tray notifications |
| **Screen Transitions** | Animated, fluid | Can be more abrupt |
| **Performance Consideration** | Optimized for lower hardware resources | More freedom in resource usage |
| **Context Switching** | Frequent, quick | Less frequent, deliberate |
| **Offline Capability** | Emphasized, if applicable | Less critical |

*Table 2: A comparison table of design principles for E-health and Medical Internet of Things (MIoT) applications, with a specific focus on underserved communities and marginalized peoples*

| Aspect | E-health Applications for Underserved Communities | MIoT for Underserved Communities |
|---|---|---|
| **Accessibility** | Designed for low-literacy and diverse cultural backgrounds | Intuitive interfaces for ease of use by all demographics |
| **Affordability** | Low-cost or subsidized solutions for economic accessibility | Cost-effective and scalable hardware and connectivity |
| **Language Localization** | Multilingual support to accommodate regional languages | Language options for wider usability |
| **Internet Connectivity** | Offline functionality or support for low-bandwidth areas | Low-power communication technologies for remote regions |
| **Health Literacy** | Simplified health information and educational resources | Audiovisual content for enhanced understanding |
| **Privacy Concerns** | Enhanced data security and consent for sensitive data | Informed consent and transparency in data collection |
| **Localized Solutions** | Contextualized for specific healthcare needs of the region | Tailored for local healthcare infrastructure and practices |
| **Collaboration with Local Stakeholders** | Involvement of local healthcare providers and communities | Community engagement and feedback for relevant solutions |
| **Power and Energy Considerations** | Battery-saving modes and efficient energy consumption | Energy-efficient MIoT devices for prolonged usage |
| **Infrastructure and Technical Limitations** | Compatibility with older devices and low-resource settings | Adaptation to limited technical infrastructure |
| **Cultural Sensitivity** | Respectful design that considers cultural beliefs and norms | Avoidance of cultural bias and inclusive representation |

**Comparative Analysis**:

Both the design principles for mobile apps and desktop software, as well as for e-health and MIoT applications for underserved communities, share some common themes. Usability and accessibility remain crucial in both cases, as underserved communities often have diverse cultural backgrounds and may have limited access to resources. In both scenarios, designers should consider language localization, making the interfaces accessible to users in their native languages.

Affordability is another shared concern, whether it is about providing low-cost e-health solutions or cost-effective MIoT devices for underserved communities. For both mobile apps and MIoT, there is a need for localized solutions that address the specific healthcare needs of the region and align with the local infrastructure and practices.

Security and privacy are paramount in both cases, especially in medical applications where sensitive data is involved. Designers must ensure robust data security and obtain informed consent for data collection to build trust with the user base.

However, there are also unique challenges and considerations for e-health and MIoT applications for underserved communities. The lack of consistent internet connectivity and limited access to electricity in remote regions necessitates offline functionality for e-health apps and low-power communication technologies for MIoT devices. Additionally, health literacy is an essential factor, and designers need to focus on delivering simplified health information and educational resources, particularly through audiovisual content.

Cultural sensitivity plays a significant role in both cases, but it becomes even more critical when designing for marginalized communities. Ensuring that the design respects cultural beliefs, norms, and diverse perspectives is essential to create inclusive solutions.

To maximize the positive impact of robotic technologies integrated with the Medical Internet of Things in underserved communities, the following design principles should be meticulously followed:

**1. Usability and Accessibility:**

Design robots with intuitive interfaces and communication mechanisms that can be easily understood and used by individuals with varying levels of technical proficiency. Accessibility features, such as multilingual support and voice-guided instructions, ensure inclusivity for all members of the community. The user experience of e-health and MIoT applications should be intuitive and accessible to individuals of varying technical proficiencies. Clear and concise interfaces, easy navigation, and visual cues play a vital role in making these solutions user-friendly for both patients and healthcare professionals.

**2. Affordability and Cost-effectiveness:**

Robotic solutions must be cost-effective and accessible to communities with limited financial resources. Utilizing off-the-shelf components, embracing open-source software, and exploring local manufacturing options can help reduce costs without compromising quality.

**3. Energy Efficiency:**

Optimize power consumption to ensure robots can operate efficiently with minimal energy resources. Utilize low-power components, implement energy-saving modes, and explore renewable energy sources to extend operational durations in regions with unreliable power supply.

**4. Cultural Sensitivity:**

Incorporate cultural sensitivity into the design of robots to avoid biases and promote respect for local customs and traditions. Designers should collaborate with cultural experts and community representatives to ensure robots are inclusive and respectful in their interactions.

**5. Contextual Relevance:**

Tailor robotic solutions to address the specific healthcare needs and challenges of the local community. Consider the prevalent health conditions, medical practices, and infrastructure limitations to ensure the robots' effectiveness and relevance.

**6. Collaboration with Local Stakeholders:**

Involve local healthcare providers, community leaders, and end-users in the design and development process. Collaborating with the community ensures that the robotic solutions align with the local healthcare ecosystem and are readily accepted and integrated into healthcare practices.

**7. Scalability and Sustainability:**

Design robotic systems with scalability in mind to accommodate the growing needs of the community. Implement maintenance and repair protocols that are feasible and accessible locally, ensuring the long-term sustainability of the robotic solutions.

**8. Security and Privacy First:**

E-health and MIoT applications collect and transmit sensitive patient information. Robust security measures, data encryption, and secure authentication protocols are imperative to safeguard this data from unauthorized access and breaches. Compliance with industry standards such as HIPAA and GDPR is vital to ensure patient privacy and maintain trust in the system.

**9. Interoperability and Standards:**

Healthcare is a multidisciplinary domain with a multitude of devices and systems. Ensuring interoperability between various e-health and MIoT devices is crucial for seamless data exchange and enhanced care coordination. Adherence to established standards, such as HL7 and FHIR, promotes a cohesive ecosystem and efficient data exchange.

**10. Reliability and Redundancy:**

In medical applications, reliability is of utmost importance. Systems must be designed with built-in redundancies and fail-safes to ensure continuous operation, especially in life-critical scenarios. Regular maintenance and testing of the devices are essential to guarantee accuracy and dependability.

**Key Takeaways**:

- Usability and accessibility are fundamental principles across all application domains, but specific attention must be given to cultural backgrounds and diverse literacy levels in underserved communities.
- Affordability and cost-effectiveness are vital factors to consider, aiming to provide accessible healthcare solutions to marginalized peoples.
- Privacy and data security are non-negotiable aspects in medical applications, regardless of the user base.
- Tailoring solutions to local infrastructure and practices enhances the relevance and effectiveness of e-health and MIoT applications.

- Involving local stakeholders and engaging with the community throughout the design process leads to more contextually appropriate solutions.
- Energy efficiency and offline functionality are essential in resource-constrained environments, addressing infrastructure limitations.
- Cultural sensitivity and inclusive representation foster acceptance and adoption of healthcare technologies among underserved communities.

**Conclusion:**

Designing e-health and Medical Internet of Things applications necessitates a meticulous approach, considering the sensitive nature of healthcare and the criticality of medical interventions. The realm of e-health and the Medical Internet of Things (MIoT) stands at the intersection of technology and human well-being. As we venture deeper into this fusion, the stakes become higher. Every application or device we introduce into the healthcare ecosystem doesn't just represent a piece of technology; it embodies the trust patients place in modern medicine and the hope for better, more efficient care.

Crafting solutions in this space demands more than just technical prowess. It requires a deep understanding of the human elements of healthcare: the vulnerabilities of patients, the dedication of healthcare professionals, and the intricacies of medical procedures. Given the delicate nature of healthcare data and the paramount importance of medical interventions, a rigorous and thoughtful approach becomes indispensable.

By emphasizing principles such as security, we ensure that patient data remains sacrosanct, protected from breaches and unauthorized access. Usability ensures that these advanced tools are accessible to all, from tech-savvy individuals to those less familiar with digital interfaces. Interoperability is the bridge that allows different systems to communicate seamlessly, ensuring that no piece of critical information is lost in translation. Reliability ensures that these systems perform consistently, even in the face of unforeseen challenges. Lastly, remote monitoring extends the reach of healthcare, ensuring that even those in the most remote locations are not left behind.

In essence, the responsibility is on designers(mainly), developers, and innovators in the MIoT space to forge solutions that not only leverage the best of technology but also resonate with the core values of healthcare. These solutions should empower both patients and healthcare practitioners, upholding the pinnacle of data protection and striving for excellence in patient care, ensuring a brighter, healthier future for all.

**References:**


1. Ramos, Herman. "Health Data: Exploring the adoption of Internet of Things in Healthcare.", DC DDHT Report book on Health matters, Technologies driving change in healthcare, A Community of Thought, (2021).https://intgovforum.org/en/content/dynamic-coalition-on-data-driven-health-technologies-dc-ddht
2. Amali De Silva-Mitchell. "Opportunities For The Internet Under The UN Rights of Indigenous Peoples.", DC DDHT Report book on Health matters, Technologies driving change in healthcare, A Community of Thought,(2021).https://intgovforum.org/en/content/dynamic-coalition-on-data-driven-health-technologies-dc-ddht
3. Dr. Christine P. Tan. "Digital Technologies for New Healthcare Applications Under the COVID-19 Pandemic.", DC DDHT Report book on Health matters, Technologies driving change in healthcare, A Community of Thought, (2021), https://intgovforum.org/en/content/dynamic-coalition-on-data-driven-health-technologies-dc-ddht
4. User Interface Design: Bridging the Gap from User Requirements to Design. (1998). United Kingdom: CRC-Press.
5. World Health Organization, ( 2020). EHealth, https://www.who.int/ehealth/en/
6. Druce, K. L., Li, Y., Sullivan, T., Rosen, A., Theurer, L., & Vetter, B. (2020). An IoT-Based Remote Cardiac Monitoring System. IEEE Internet of Things Journal, 7(12), 12408-12419.
7. Fast Healthcare Interoperability Resources (FHIR), https://www.hl7.org/fhir/overview.html