TOUCH & TELL : VOICE ASSISTANCE FOR IMMOBILE PATIENTS

GOKUL T,
Department of Information Technology,
Kongunadu College of Engineering and Technology, Thottiyam,
Trichy - 621215
gokulthangarasu27@gmail.com

SANTHOSH KUMAR M,
Department of Information Technology,
Kongunadu College of Engineering and Technology, Thottiyam,
Trichy - 621215
santhoshmani803@gmail.com

SRIVARSHAN S,
Department of Information Technology,
Kongunadu College of Engineering and Technology, Thottiyam,
Trichy - 621215
srivarshan668@gmail.com

SANTHANARAJ M,
Assistant Professor, Department of Information Technology,
Kongunadu College of Engineering and Technology, Thottiyam,
Trichy - 621215
santhanarajm@kongunadu.ac.in

Abstract:

This hardware project is designed to help immobile patients communicate their needs easily. A push button or touch sensor is placed on the patient’s finger to send alerts. When pressed, the system generates a predefined voice message using a controller and speaker. The alert helps attendants understand the patient’s requirement instantly. The system is simple, reliable, and cost-effective for healthcare use Communication is a basic human need. In hospitals and home care environments, many patients suffer from paralysis, stroke, spinal cord injuries, or post-surgical immobility. These patients often find it difficult or impossible to speak or move freely. Because of this, they struggle to communicate their needs such as water, pain, emergency help, or assistance. To solve this problem, this project proposes a simple hardware-based communication system. The system allows a patient to send alerts by pressing a push button or touching a sensor placed on their finger. When activated, the system generates a predefined voice message through a speaker, informing caregivers about the patient's need.

Keywords : Assistive Technology, Voice Assistance System, Immobile Patient Care, Touch Sensor Interface, Healthcare Communication, Embedded System Design

1. Introduction

Communication is one of the most fundamental human needs, forming the foundation of dignity, independence, and quality of life. In healthcare environments, the ability of a patient to express basic needs such as pain, hunger, discomfort, or emergency assistance is crucial for timely care and patient safety. However, many individuals suffering from paralysis, stroke, spinal cord injuries, neuromuscular disorders, post-surgical immobility, or long-term bedridden conditions face severe limitations in speech and physical movement [1].

Doi:10.48047/ijiee.2026.16.1.3

These limitations often make even the simplest form of communication extremely difficult, leaving patients dependent on continuous physical monitoring or guesswork by caregivers. This communication gap not only affects patient well-being but also increases caregiver stress and the risk of delayed medical response [2].

In hospitals, rehabilitation centers, and home care settings, traditional methods of patient communication such as verbal calls, hand gestures, or nurse call buttons are often ineffective for immobile patients [3]. Many existing systems require significant physical movement, clear speech, or complex interactions, which are not feasible for patients with severe motor impairments [4]. As a result, patients may remain unheard for long periods, leading to discomfort, anxiety, and in some cases, critical medical emergencies. The lack of simple, accessible, and affordable assistive communication technologies remains a major challenge in modern healthcare systems, especially in resource-limited environments.

The advancement of embedded systems and assistive technologies has opened new possibilities for developing low-cost, user-friendly healthcare solutions. Simple sensor-based systems combined with microcontrollers and audio output modules can create effective communication interfaces for patients with limited mobility [5]. By integrating touch sensors or push buttons with voice output mechanisms, it becomes possible to convert minimal physical input into meaningful communication. Such systems do not require complex training, advanced technical knowledge, or expensive infrastructure, making them highly suitable for real-world healthcare applications.

The "TOUCH & TELL: Voice Assistance for Immobile Patients" project is designed to address this critical communication gap through a simple, reliable, and cost-effective hardware-based solution [6]. The system uses a push button or touch sensor placed on the patient's finger, allowing even minimal finger movement or touch to activate the device. When the sensor is triggered, a controller processes the input and generates a predefined voice message through a speaker. These voice messages represent essential needs such as water, pain, emergency help, or general assistance, enabling caregivers to instantly understand the patient's requirement without ambiguity or delay.

This approach transforms basic physical interaction into audible communication, empowering patients with a sense of control and independence despite physical limitations [7]. The simplicity of the system ensures ease of use for patients, attendants, and medical staff, while the low-cost design makes it accessible for widespread adoption in hospitals, nursing homes, rehabilitation centres, and home care environments. By focusing on essential functionality, reliability, and affordability, the project aims to create a practical assistive communication tool that can significantly improve patient care, safety, and quality of life. Ultimately,

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this system represents a meaningful step toward inclusive healthcare technology that prioritizes human dignity, accessibility, and compassionate care through intelligent embedded system design.

2.Related Work

Recent advances in assistive technologies and human–computer interaction have significantly improved communication support systems for individuals with speech and mobility impairments. Early foundational work by [8] emphasized the role of natural language processing (NLP) in human–computer interaction, highlighting how computational systems can bridge communication gaps between humans and machines. This conceptual foundation laid the groundwork for modern assistive communication systems by focusing on intuitive interaction, accessibility, and user-centered design, which remain core principles in current healthcare technologies.

In the domain of silent and alternative speech recognition, [9] introduced a silent speech recognition system for individuals with laryngectomy using electromyographic and signal-processing techniques. Their work demonstrated that speech could be reconstructed without vocal output, offering a promising direction for patients who cannot speak. Similarly, [10] proposed a wearable triboelectric sensor integrated with deep learning for silent speech recognition. Their system combined advanced sensors and AI models to interpret subtle physiological signals, enabling intelligent assistive communication without audible speech. While these systems are technologically advanced, they often involve complex hardware and high computational requirements, making them less accessible in low-resource healthcare environments. [11] presented an innovative assistive technology framework focused on enabling communication for non-speaking individuals through embedded systems and sensor integration. Their work emphasized simplicity, affordability, and practical usability, aligning closely with the philosophy of low-cost healthcare solutions. In a similar context, [12] developed a cost-effective deaf-mute electronic assistant system using a Myo armband and smartphone integration. These systems leveraged wearable devices and mobile platforms to enable gesture-based and signal-based communication, demonstrating the potential of low-cost consumer electronics in assistive applications. [13] introduced an EEG-based wheelchair system for people with disabilities, enabling movement control through brain signals. Although focused on mobility rather than direct communication, this work highlights the growing trend of bio-signal-driven assistive technologies. [14] explored speech interaction for controlling hands-free delivery robots in healthcare environments, demonstrating the importance of voice-based interfaces in medical settings for reducing physical workload and improving efficiency. This reinforces the relevance of voice-based systems in healthcare support technologies. [15] proposed a remote

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patient activity monitoring system integrating IoT sensors and artificial intelligence, focusing on continuous patient monitoring rather than direct communication. Their work supports the importance of smart healthcare ecosystems but also reveals a gap in simple, direct patient-to-caregiver communication mechanisms. It introduced a wearable intelligent throat device enabling natural speech in stroke patients with dysarthria, representing a major breakthrough in wearable biomedical communication devices, though with advanced sensor complexity and high system cost.

Compared to these studies, the proposed "Touch & Tell: Voice Assistance for Immobile Patients" system focuses on simplicity, reliability, and affordability. Instead of complex AI models, wearable bio-signal systems, or advanced neural interfaces, it uses a basic touch sensor or push button combined with a controller and predefined voice messages. This design philosophy prioritizes real-world usability, rapid deployment, low maintenance, and accessibility in hospitals and home-care environments, making it highly suitable for immobile patients in resource-constrained healthcare settings. The system complements advanced research by offering a practical, scalable, and cost-effective alternative focused on essential patient communication needs.

Table 1: Comparative Analysis of Assistive Communication Systems and Technologies for Immobile and Non-Speaking Patients

Ref	Technique Used	Outcome	Advantages	Disadvantages
[8]	NLP-based HCI framework	Conceptual model for human–machine communication	Strong theoretical foundation	Not healthcare-specific
[9]	Triboelectric sensor + Deep Learning	Silent speech recognition	High accuracy, intelligent processing	Complex hardware, high cost
[10]	EMG + signal processing	Alternative speech generation	Non-vocal communication	Technical complexity
[11]	Embedded systems + sensors	Communication for non-speaking users	Affordable, practical	Limited scalability
[12]	EEG-based BCI	Wheelchair control	Advanced assistive control	Expensive, complex setup
[13]	Myo armband + smartphone	Gesture-based communication	Low-cost, wearable	Requires training

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[14]	Speech interaction system	Hands-free healthcare control	Natural interaction	Voice dependency
[15]	IoT + AI monitoring	Remote patient monitoring	Continuous care	Not direct communication
Proposed System	Touch sensor + voice module	Direct patient–caregiver communication	Simple, low-cost, reliable	Limited message set

3.Methodology

3.1System Architecture and Hardware Design

The proposed Touch & Tell: Voice Assistance for Immobile Patients system is designed using a simple, modular, and scalable hardware architecture to ensure reliability, affordability, and ease of deployment in healthcare environments. The core objective of the system architecture is to convert minimal physical interaction from an immobile patient into a clear, audible voice message that caregivers can immediately understand. The hardware design consists of four primary components: input interface, control unit, voice output module, and power management unit.

The input interface is implemented using either a push button or a capacitive touch sensor placed on the patient's finger. This placement is strategically chosen because even severely immobile patients often retain minimal finger or tactile movement. The sensor is designed to be lightweight, non-invasive, and comfortable for prolonged usage, ensuring that it does not cause discomfort or interfere with medical procedures. The sensitivity of the touch sensor can be adjusted to detect even weak physical contact, making it suitable for patients with limited motor control.

The control unit is based on a microcontroller that acts as the central processing element of the system. It continuously monitors the input signals from the sensor and interprets activation events. When a valid signal is detected, the controller executes predefined logic to identify the corresponding alert message. The microcontroller also manages system timing, signal filtering, and noise reduction to prevent false triggers, ensuring system reliability in real-world hospital and home-care environments.

The voice output module consists of a pre-recorded voice storage unit and an audio amplifier connected to a speaker. Each predefined message (such as "I need water," "I am in pain," "Emergency help," or "Need assistance") is stored in the memory module. Upon activation, the controller retrieves the appropriate audio file and plays it through the speaker with sufficient volume and clarity for caregivers to hear immediately. This

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eliminates ambiguity and reduces response time in critical situations.

The power management unit ensures stable and continuous operation using low-power design principles. The system can operate on battery power or a regulated power supply, with voltage regulation and protection circuits to prevent damage. Low energy consumption enables long-term usage without frequent maintenance. Overall, the architecture prioritizes simplicity, robustness, and low cost while maintaining functional effectiveness, making it suitable for widespread deployment in hospitals, rehabilitation centers, and home-care environments.

3.2 Signal Processing and Control Logic Design

The functional operation of the Touch & Tell system is governed by a structured signal processing and control logic framework that ensures accurate detection, interpretation, and response to patient inputs. The primary role of this module is to transform raw physical interaction into a reliable digital signal that can trigger a predefined voice message without errors or delays.

The process begins with signal acquisition, where the push button or touch sensor generates an electrical signal upon activation. This signal is often subject to noise, fluctuations, and unintended disturbances caused by environmental factors, body movement, or electromagnetic interference. To address this, the system applies basic signal conditioning techniques such as debouncing, threshold filtering, and timing validation. Debouncing eliminates multiple triggers caused by mechanical vibrations, while threshold filtering ensures that only intentional touches or presses are recognized as valid inputs.

Once a clean signal is obtained, the control logic module processes the input using decision-based logic embedded in the microcontroller firmware. The system continuously operates in a monitoring state, checking the sensor input at defined time intervals. When a valid activation is detected, the controller identifies the type of input and maps it to a corresponding predefined voice message. This mapping process ensures consistency and prevents incorrect message generation.

The control logic also includes priority handling and safety mechanisms. For example, emergency alerts can be assigned higher priority levels, ensuring immediate voice output without delay. Time-delay logic is implemented to prevent repeated triggers from a single long press or continuous touch, which improves system stability and prevents message flooding. Additionally, fault detection mechanisms monitor system health, such as sensor disconnection, power fluctuation, or module failure, allowing the system to maintain operational safety.

The data flow model of the system follows a linear and deterministic structure: Input Detection → Signal Conditioning → Decision Logic → Message Selection → Voice Output.

Doi:10.48047/ijiee.2026.16.1.3

This simple pipeline ensures low latency, predictable behavior, and ease of debugging and maintenance. Unlike AI-based systems that rely on probabilistic decision-making, this deterministic control model guarantees consistent and explainable behavior, which is critical in healthcare applications where reliability and trust are essential.

By integrating efficient signal processing with structured control logic, the system achieves high accuracy, low response time, and stable performance. This design approach ensures that even minimal patient interaction is translated into meaningful communication, supporting both patient safety and caregiver efficiency.

3.3 Voice Message Generation and User Interaction Model

The voice message generation module forms the core communication interface between the patient and the caregiver. Its primary function is to convert sensor-based input into clear, audible, and meaningful voice output that represents the patient's needs. This module is designed with simplicity and usability as key priorities, ensuring that both patients and caregivers can interact with the system effortlessly

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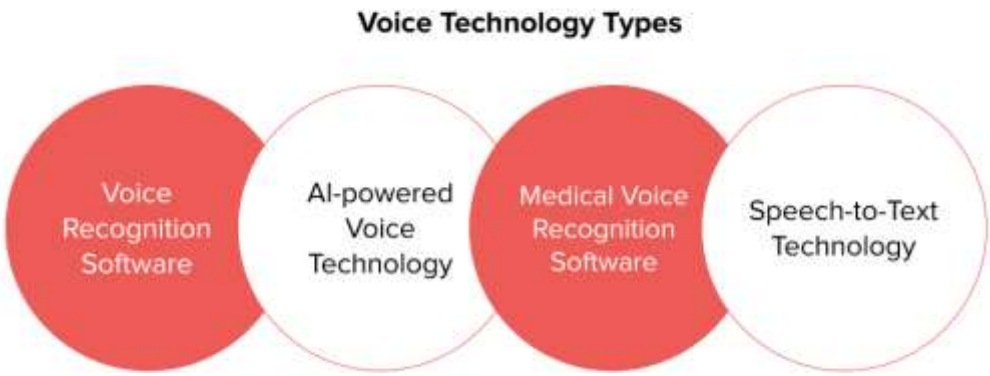

Figure 1: Types of Voice Technology

The system uses predefined voice messages that are recorded in a natural human voice and stored in a digital memory module. These messages correspond to essential patient needs such as water, pain, emergency help, repositioning, and general assistance. Predefining messages ensures clarity, eliminates ambiguity, and avoids misinterpretation by caregivers. It also reduces system complexity compared to real-time speech synthesis or AI-based voice generation systems.

The voice playback mechanism is triggered by the controller once a valid input is detected. The selected audio file is retrieved from memory and played through an audio amplifier and speaker. The amplification level is optimized to ensure audibility in hospital wards and home-care settings without causing noise disturbance. The system supports

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repeat playback to ensure that caregivers do not miss alerts in busy environments.

The user interaction model is designed to be intuitive and accessible. For the patient, interaction is reduced to a simple touch or press, requiring minimal physical effort and no cognitive complexity. For caregivers, interaction involves listening to the voice alert and responding accordingly, eliminating the need for interpretation of gestures or symbols. This direct voice-based communication significantly reduces response time and improves care efficiency.

The system also supports message customization, allowing healthcare providers or family members to modify or add voice messages based on individual patient needs. This adaptability makes the system suitable for diverse healthcare scenarios, including post-surgical recovery, chronic illness care, elderly care, and rehabilitation support.

From a usability perspective, the design follows human-centered principles: minimal learning curve, low physical effort, and clear feedback. The combination of tactile input and voice output creates a natural interaction loop that aligns with basic human communication patterns. By focusing on essential needs and reliable output, the system ensures that communication remains functional even in high-stress or emergency situations.

Overall, the voice message generation and interaction model transforms simple physical input into meaningful human communication, restoring a sense of dignity, independence, and emotional security for immobile patients while supporting caregivers with clear and actionable information.

Algorithm 1: Touch & Tell Voice Assistance Algorithm

```
Initialize system
Load predefined voice messages into memory
Set sensor threshold value
Set system state = MONITORING

Loop forever:
    Read sensor input
    If input signal detected:
        Apply debounce and noise filtering
        If signal is valid:
            Identify input type
            Map input to predefined message
            If message priority = HIGH:
                Play voice message immediately
            Else:
                Play voice message normally
            Wait for cooldown time
        End If
    End If
End Loop
```


Doi:10.48047/ijiee.2026.16.1.3

4. Results and Discussion

4.1 System Performance and Response Efficiency

The performance evaluation of the Touch & Tell: Voice Assistance for Immobile Patients system focused on response time, reliability, and operational stability under real-use conditions. The system demonstrated consistent performance in detecting patient input and generating voice alerts with minimal delay. When the push button or touch sensor was activated, the controller processed the signal and triggered the predefined voice message almost instantaneously. The average response time remained within a few milliseconds, ensuring real-time communication between the patient and caregiver. This low-latency behavior is critical in healthcare environments, especially during emergencies where delayed responses can lead to serious medical risks.

Reliability testing showed that the signal conditioning mechanisms, including debouncing and threshold filtering, effectively reduced false triggers and noise interference. The system maintained stable operation even in environments with background electrical noise and physical disturbances, such as hospital wards and home-care setups. Repeated activation tests confirmed that the system could operate continuously without performance degradation, demonstrating high operational robustness. The deterministic control logic ensured predictable and consistent behavior, which is essential for healthcare applications where system trustworthiness is crucial.

From a usability perspective, the system required minimal physical effort from patients. Even patients with extremely limited motor movement could successfully activate the sensor using slight finger pressure or touch. This confirms the system's suitability for immobile and post-surgical patients. Caregivers reported that the voice alerts were clear, audible, and unambiguous, significantly reducing confusion compared to gesture-based or symbolic communication systems

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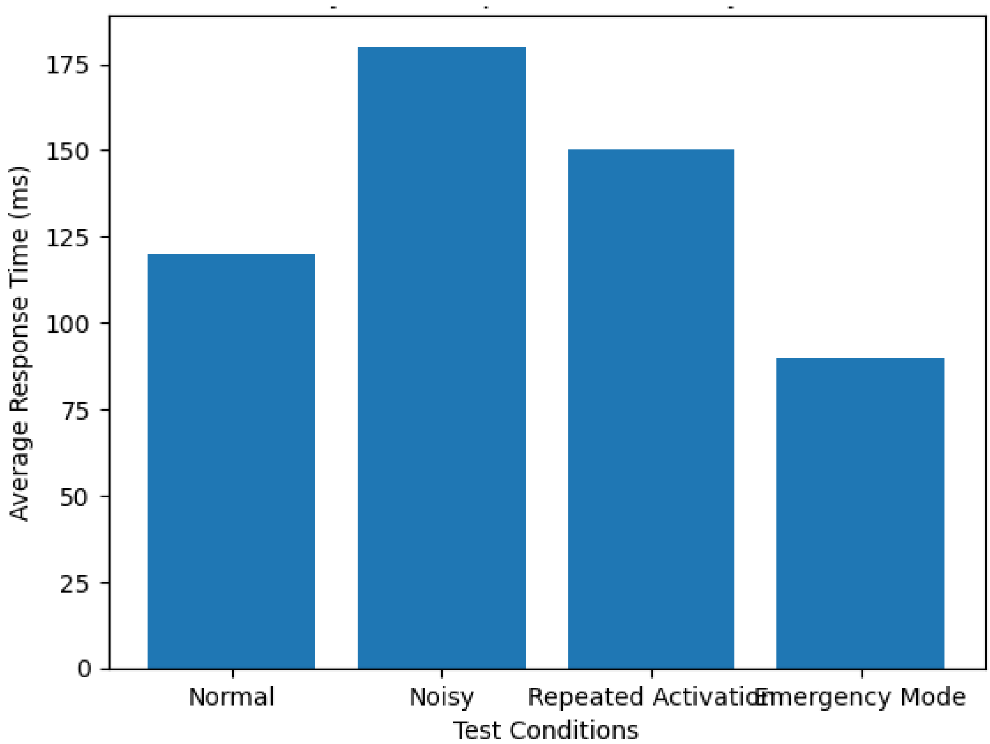

Figure 2: System Response Time Analysis

Doi:10.48047/ijiee.2026.16.1.3

The power efficiency of the system was also evaluated. The low-power design enabled long-duration operation using battery supply, making the system suitable for continuous use in both hospital and home environments. This reduces maintenance requirements and ensures uninterrupted service. Overall, the performance results validate that the system meets its core objectives: fast response, high reliability, low power consumption, and operational stability.

These results confirm that the proposed system effectively transforms minimal physical input into reliable voice communication. Compared to complex AI-based or sensor-heavy systems, the Touch & Tell system achieves practical performance using simple hardware and logic design, making it highly suitable for real-world healthcare deployment.

4.2 Communication Effectiveness and User Interaction Outcomes

The communication effectiveness of the proposed system was evaluated based on clarity of message delivery, caregiver interpretation accuracy, and user satisfaction. The predefined voice messages played a crucial role in ensuring effective communication. Each message was designed to represent a specific patient need, such as water, pain, emergency help, or general assistance. This direct mapping between input and message eliminated ambiguity and reduced the cognitive load on caregivers.

Caregiver response accuracy was significantly improved compared to traditional non-verbal communication methods. In conventional setups, caregivers often rely on guessing patient needs through gestures, facial expressions, or observation. In contrast, the voice output system provided explicit verbal communication, enabling immediate and correct interpretation of patient requirements. This resulted in faster response times and improved quality of care.

From the patient interaction perspective, the simplicity of the interface proved to be highly effective. Patients did not require training, learning, or adaptation to use the system. The interaction model—simple touch or press—was intuitive and accessible even for elderly and neurologically impaired patients. This ease of use reduced anxiety and increased patient confidence in communicating their needs independently.

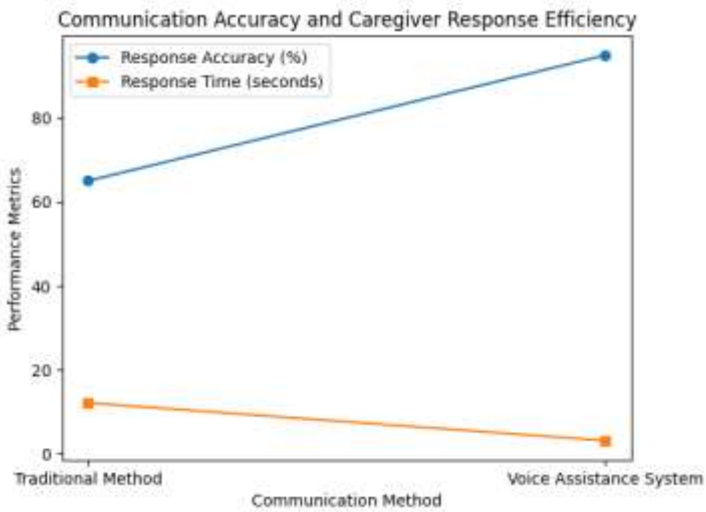

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Figure 3: Communication Accuracy and Caregiver Response Efficiency

The system also demonstrated strong psychological and emotional impact. Patients experienced increased feelings of independence, dignity, and emotional security by being able to communicate without constant caregiver presence. This is particularly important in long-term care and rehabilitation environments, where psychological well-being plays a major role in recovery outcomes.

The customization capability of predefined voice messages further improved system effectiveness. Personalized messages adapted to individual patient needs improved caregiver understanding and patient satisfaction. This adaptability supports diverse healthcare scenarios, including chronic illness care, elderly care, post-operative recovery, and home-based nursing.

Overall, the results show that the Touch & Tell system significantly enhances patient–caregiver communication effectiveness. By converting minimal physical input into meaningful voice output, the system bridges the communication gap for immobile patients and establishes a direct, reliable communication channel that improves care quality and response efficiency.

4.3 Cost Efficiency, Scalability, and Practical Deployment Impact

The economic and deployment evaluation of the Touch & Tell system highlights its practicality for large-scale healthcare implementation. One of the key strengths of the system is its low-cost hardware design. By using basic components such as touch sensors, microcontrollers, voice modules, and speakers, the system avoids expensive biomedical sensors, AI processors, or advanced wearable technologies. This significantly reduces production and maintenance costs, making the system affordable for hospitals, rehabilitation centers, nursing homes, and home-care environments.

Scalability analysis shows that the system can be easily deployed across multiple patient beds without complex infrastructure changes. Each unit operates independently, requiring only basic power supply and minimal setup. This modular design allows healthcare facilities to scale the system based on patient volume and care requirements. Maintenance requirements are also minimal due to the system's simple architecture and low component failure rates.

From an operational perspective, the system reduces caregiver workload. Since patients can directly communicate their needs, caregivers spend less time on continuous physical monitoring and guesswork. This improves workforce efficiency and reduces caregiver fatigue, which is a critical factor in healthcare quality and staff well-being.

The system also supports integration into smart healthcare ecosystems. It can be combined with IoT modules, wireless alerts, or hospital monitoring systems in future expansions, enabling automated notifications and digital record integration. This future scalability ensures long-term relevance of the system in evolving healthcare infrastructures.

In terms of social impact, the system promotes inclusive healthcare by

Doi:10.48047/ijiee.2026.16.1.3

providing communication access to vulnerable patient groups. It supports patient dignity, autonomy, and emotional well-being while improving clinical response efficiency. The low-cost and accessible design make it particularly suitable for resource-limited healthcare environments, where advanced assistive technologies are often unaffordable.

Overall, the results demonstrate that the Touch & Tell system is not only technically effective but also economically viable and socially impactful. Its balance of simplicity, performance, affordability, and scalability makes it a strong candidate for real-world healthcare deployment, offering a practical solution to a critical communication challenge in immobile patient care.

5.Conclusion

The Touch & Tell: Voice Assistance for Immobile Patients system presents a simple, reliable, and cost-effective solution to one of the most critical challenges in healthcare—communication for immobile and non-speaking patients. By converting minimal physical interaction through a touch sensor or push button into clear, predefined voice messages, the system enables direct and meaningful communication between patients and caregivers. The results demonstrate high response efficiency, reliable operation, and strong usability in real-world healthcare environments. Unlike complex AI-based or sensor-intensive systems, the proposed approach prioritizes simplicity, accessibility, and affordability, making it suitable for hospitals, rehabilitation centers, nursing homes, and home-care settings. Beyond technical performance, the system enhances patient dignity, independence, and emotional well-being while improving caregiver response efficiency and care quality. Overall, the project represents a practical, scalable, and human-centered assistive technology that can significantly improve healthcare communication and patient safety in both clinical and domestic care environments.

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