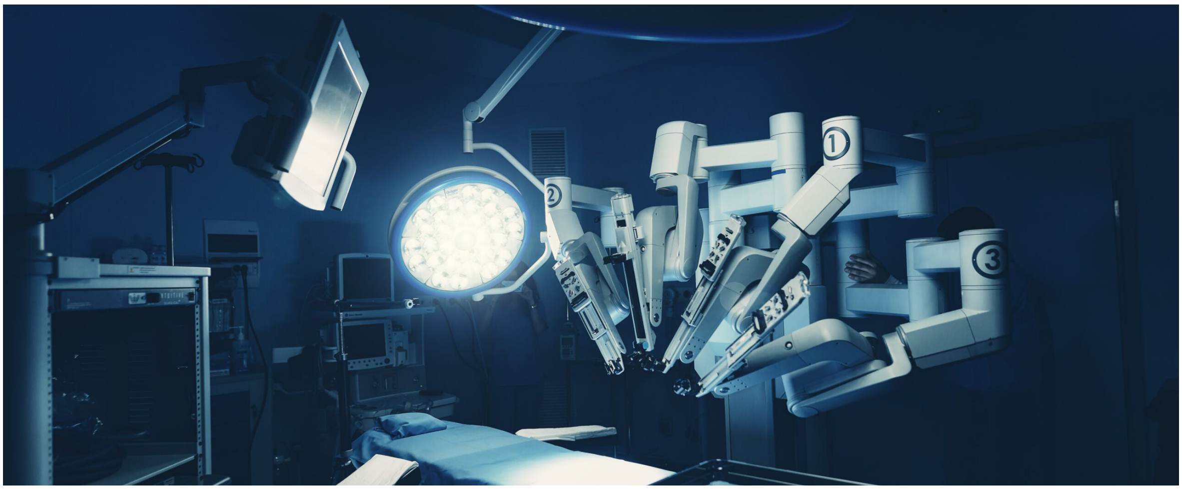
https://doi.org/10.31705/BPRM.v5(2).2025.4



Shaping the Future of Surgical Assistance with IoT Robotics: *Bot Nurse 1.0*

A New Dawn in Surgical Treatment

Surgical procedures are essential to healthcare and require high levels of precision, concentration, and stamina from medical personnel. Extended operations may result in fatigue and raise the risk of human error. The need for dependable assistive technologies is further highlighted by the global shortage of skilled surgical personnel. One crucial technological advancement intended to counteract these challenges is robotic assistance in surgical settings.

Despite their advantages, contemporary robotic solutions can occasionally increase the cognitive load on surgeons by requiring them to use modified surgical instruments or remember specific gestures. Tackling these pivotal challenges holistically, Bot Nurse 1.0 unveils a novel methodology that fuses cutting-edge robotics, Internet of Things (IoT) technologies, speech recognition, and computer vision. This system markedly elevates surgeon-robot engagement by employing instinctive voice commands and accurate palm recognition, seeking to diminish operational intricacy, boost surgical efficiency, and reinforce safety outcomes, thus establishing a fresh standard in assistive surgical innovation.

Why Do We Need Intelligent Robotic Assistants in Surgery?

Scrub nurses have a common but essential duty in traditional surgical settings: handling and obtaining surgical instruments. However, human limitations like chronic fatigue and short attentional gaps still affect these manual methods. As procedures occasionally stretch for numerous hours, fatigue can amplify the likelihood of procedural mistakes and jeopardize patient safety. Additionally, the deficit of skilled surgical nurses magnifies these concerns, underscoring the need for reliable and enduring resolutions.

Earlier robotic offerings, such as Penelope [1] and Gestonurse [2], endeavored to ease these burdens but encountered limitations. For example, Penelope needed specific metallic instruments, which restricted their applicability in a range of surgical scenarios. By requiring surgeons to learn special hand signals for tool retrieval, Gestonurse increased mental strain rather than reducing it.

To tackle these persistent problems, Bot Nurse 1.0 creates a more natural and intuitive method. The robot employs speech recognition systems that are combined with accurate visual palm tracking to lessen cognitive load and operational complexity. Through the simplification of communication between surgeons and robotic aids, Bot Nurse seeks to transform the delivery of surgical care by enhancing overall patient outcomes, lowering procedural risks, and significantly increasing surgical precision.

Other	**Bot Nurse**
Penelope: Can only handle special tools with metal holder	Uses a simple gripper which can grasp wide range of rigid tools.
Gestonurse: Commands are given through the hand gestures. Surgeons/operator has to remember the hand signals	Activated though Voice command, Pick the tool from the predefined position and place it on the surgeon's palm.

Fig. 1. Bot Nurse 1.0 – A Surgery Assistive Robot Prototype

The Breakthrough Underpinning Bot Nurse 1.0

Bot Nurse 1.0 rests on two main subsystems: a mechanical framework encompassing a robotic manipulator and mobile platform, and a progressive IoT-based control system. A 4-degree-of-freedom (4-DOF) Robotic arm, positioned on a mobile platform, it ensures the maneuverability throughout the surgical theater. The integrated tool table provides smooth accessibility to vital instruments, additionally refining surgical processes.

What notably differentiates Bot Nurse is its seamless synthesis of voice recognition and computer vision, facilitating seamless surgeon-robot engagement. Verbal directives initiate the robot's reaction, removing the requirement for tangible instructions. After the directive is logged, the robot discerns the surgeon's palm coordinates via 3D visual detection algorithms, precisely conveying the designated surgical instrument right onto the surgeon's palm.

How It Works

The operating foundation of Bot Nurse 1.0 merges control algorithms with mechanical activation. When a verbal instruction is received, the system deploys speech recognition algorithms that decode the required instrument's name. Using a single camera setup, a computer vision algorithm simultaneously locates and pinpoints the surgeon's palm position. This visual recognition accurately locates the palm in three dimensions by utilizing depth estimation techniques that translate pixel values into tangible coordinates.

The coordinates derived from this visual process are then used by the robot's intricate inverse kinematics algorithm. The joint angles required for the robotic arm to arrive at the assigned location are calculated by this mathematical framework. After they are finalized, a high-level controller, such as a microprocessor or personal computer, wirelessly transmits these coordinates and angles to the low-level ESP32 microcontroller via Wi-Fi (using TCP/IP protocols). The ESP32 manages the servo motors via the Pololu motor controller, ensuring precise, smooth, and dependable movements. When the robotic arm retrieves the proper surgical instrument from its assigned location and places it directly in the surgeon's hand, a swift and accurate cycle of assistance is finally finished.

Experimental Validation and Potential

Multiple surgeons participated in a series of rigorous experiments that confirmed Bot Nurse 1.0's effectiveness. Over the course of multiple trials, participants gave voice commands, offering a thorough assessment of the system's functionality. The results showed great promise, with error margins kept below 1.5 cm and a good voice recognition accuracy rate and consistently accurate positioning.

Furthermore, testing also focused on the practical efficiency of Bot Nurse 1.0, measuring average delivery times for surgical tools. The robot consistently completed tool retrieval and delivery tasks in approximately 25 seconds from the moment of command initiation to successful tool transfer to the surgeon. These performance indicators highlight the robot's dependability and efficiency, demonstrating its capacity to significantly expedite surgical procedures and shorten their durations, ultimately improving surgical results and patient safety.

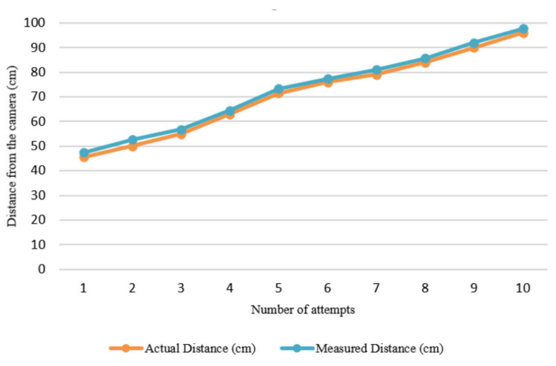


Fig.4. Actual Depth vs Measured Depth of the Hand from the Camera

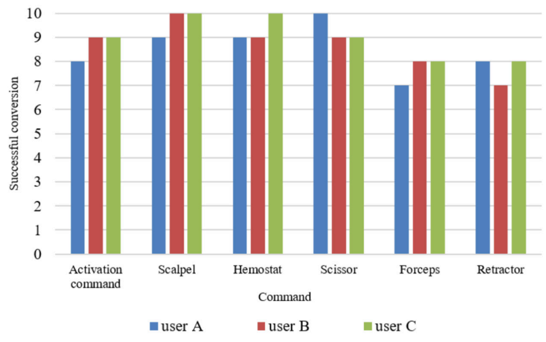


Fig.5. Speech Recognition Success rates

Looking Ahead

By successfully resolving important problems in surgical settings, Bot Nurse 1.0 represents an exciting development in medical robotics. Even with this success, improvements are already planned for the future. Plans call for replacing the manipulator with a 6-DOF system, adding stereo cameras to improve 3D vision, putting sophisticated AI-driven prediction algorithms into practice, and switching from open-loop to closed-loop control for increased accuracy, adding path planning for safer tool delivery. With further development, Bot Nurse 1.0 represents a major advancement in robotically assisted healthcare, showing promise not only for abscess drainage procedures but also for wider applications in different surgical contexts.

Reference

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[2] M. G. Jacob, Y.-T. Li, and J. P. Wachs, "Gestonurse," in Proc. Seventh Annual ACM/IEEE Int. Conf. Human-Robot Interaction (HRI), 2012, pp. 139-140.

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