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# RoboDoc: An Autonomous Medical Robot for Primary Health Assessment in Villages

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***Abstract-*** In rural areas, limited access to a primary healthcare facility is still a significant barrier to care, due to a lack of doctors or healthcare facilities. This paper describes an autonomous medical robot that provides primary healthcare service to communities at the village level. The system features IoT-ready sensors which enable data capture of vital signs including, but not limited to, blood pressure, body temperature, heart rate, oxygen saturation, and ECG. The robot allows patients to upload any external medical reports, e.g. blood tests, USGs, or other scans. An embedded AI/ML engine processes the data and generates a preliminary health assessment, health report, health advice, and self-limiting cases a provision. In communicating with and engaging patients, the robot engages the user with speech-to-text and text-to-speech, dialog to allow natural conversation in the local vernacular language to enable usability by any member of that community. To ensure privacy, all data is stored and processed locally, and all data is deleted at the end of the session. In adverse and crisis situations, the robot is able to elevate care by suggesting hospital visits, and/or beginning secure videoconferencing.

***Keywords***- IoT, Autonomous Medical Robot, AI/ML in Healthcare, Rural Healthcare

## I. INTRODUCTION

Healthcare accessibility in rural and remote zones remains extremely problematic- especially with pockets of developing areas and limited facilities and qualified staff. Patients can face delays in treatment because of travel distances. Traditional approaches of periodic medical camps can provide intermittent care at best. Healthcare IoT and AI/ML have enhanced remote monitoring, predictive diagnostics, and teleconsultation but most solutions are either digital dependent, requiring some level of internet connectivity or are different apps that lack seamless data integration for patient contact with healthcare professional depending on data collection, analysis, patient contact, and doctor association. To solve these problems, we propose an autonomous medical robot for rural health care. The robot would have sensors for vital signs (temperature, $SpO_2$, pulse, blood pressure, EC) and for anthropometric

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measurements (height, weight, BMI). In addition, it would also have an electronic stethoscope for remote auscultation and allow for the upload of diagnostic reports (blood tests, ECG, ultrasounds), from which the AI and ML algorithms would analyze and provide first advice and lifestyle recommendations and possibly preliminary prescriptions. In serious cases, we envision a secure video connection to the oversight doctor. The robot would have a speech-to-text/text-to-speech interface for multi-lingual, natural conversation, as well as the capacity for speech recognition and synthesis, allowing simple and natural communication even with semi-literate people. No information will be transferred to the server without explicit user consent and all data processing will happen on the robot. We will retain nothing from the session and are designed to erase all traces unless specifically directed to keep some for later review by the medical provider. Ultimately, the combination of real time remote continuous health monitoring, AI and expert analysis of the data, interaction of human and machine and telemedicine should provide the affordable, reliable, and inclusive health identified in the smart rural village concept more broadly.

## II. LITERATURE REVIEW

Rural and underserved areas still have serious problems in healthcare delivery based on the limitations of workforce and structure, which causes delays in diagnostics and poor health outcomes. Recent work has shown the potential for IoT, ML and AI and robotics to close this gap. IoT has provided continuous monitoring of key vital parameters such as $SpO_2$, temperature, blood pressure, and heart rate, removing the need to attend hospitals frequently [1]. However, most platforms are device-specific and disconnected when it comes to diagnostic intelligence. AI/ML techniques have been shown to improve clinical decision-making and diagnostic accuracy [2], [3], but numerous models use previously recorded datasets, lacked real-time, patient-specific assessments. Robotics has been adapted to surgery, rehabilitation, and operations in hospitals [4], [5], potentially benefitting rural healthcare [6], but most of the publications regards the hospital. Human-robot interaction (HRI) is a vital component in patient trust too, and multilingual STT/TTS systems have been proven to provide better inclusivity for low literacy users [7], [8].

Ethical issues, particularly data privacy, continue to be a challenge, researchers point out session-based deletion and transparent AI as proactive ways to protect patient trust [9], [10]. The ISO 60601-1-2:2015 Standard determines safety and performance levels for electromagnetic railways [11]. Even so, there are still issues with all of these fragmented solutions: IoT solutions remain unintelligent, AI solutions are static, and most healthcare robots remain in hospitals and not used to deliver patient care. This paper describes an autonomous medical robot with IoT sensing, AI or ML diagnostic capability, multilingual Shared Medical Information (SMI) dialogue, privacy-preserving deletion of data, and telemedicine capabilities to create scalable Smart Healthcare Hubs for rural populations.

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*Table.1. Comparison Table of Existing Literature*

| *Ref.* | *Focus Area* | *Application* | *Key Contributions* | *Limitations / Gaps* |
|---|---|---|---|---|
| [1] Vasam et al. | IoT + AI | Remote vital sign monitoring | Continuous monitoring of $SpO_2$, BP, temperature, and heart rate | Device-specific, lacks integrated diagnostic intelligence |
| [2] Williams et al. | AI in diagnosis | Clinical decision-making | Highlights adoption challenges of AI in medical diagnosis | Relies on pre-collected data, limited real-time use |
| [3] Németh et al. | AI/ML | Disease detection from blood tests | Developed "smart medical report" system | Focused only on blood test data, not multimodal |
| [4] Morgan et al. | Robotics | Surgery, rehab, patient care | Scoping review of 10 roles for robots in healthcare | Hospital-centric, no rural applications |
| [5] Cruz et al. | Robotics | Hospital operations | Literature review on robotics in hospital workflows | Scope limited to hospital domain |
| [6] Deo & Anjankar | AI + Robotics | Rural healthcare (India) | Argues for feasibility of robotics to fill provider gaps | Conceptual, no technical system design |
| [7] Esterwood & Robert | HRI | Patient trust | Found robot personality affects trust and acceptance | Social focus, lacks technical health integration |
| [8] Animesh & Srikanth | HRI + AI | Conversational healthcare robots | Demonstrates use of AI/ML for multilingual interaction | Does not integrate diagnostics or sensing |
| [9] Elendu et al. | Ethics | Data privacy in AI/Robotics | Provides framework for ethical healthcare AI | Non-technical, lacks system implementation |

## III. PROPOSED SYSTEM

In order to reduce the gap of equitable access to healthcare between urban and rural settings across our country we propose the development of an IoT and AI-enabled Autonomous Medical Robot which will be able to serve as a point-of-care healthcare companion. The capability will merge vital signs tracking with anthropometric measurement with AI-based diagnosis and telemedicine wherever possible, within one single

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serviced platform. The Robot would include sensors to measure temperature, $SpO_2$, pulse, blood pressure, ECG, height, weight and BMI, an electronic stethoscope, microphone, speaker and camera to enable real-time auscultation and communication with remote doctors. The reports which are then uploaded (blood tests, ECGs, ultrasound scans etc.,) would be processed using tools that contain AI/ML algorithms that use the patient sensor data when signifying abnormal patient codes and/or giving predictions.

This includes AI-based diagnoses and generates first-line prescriptions. There is a conversational layer for the patient to communicate with in their language of choice (i.e. this has implications for linguistic illiteracy inclusivity). Equity, trust, and privacy will also be protected because all conversations will be part of an open encrypted platform, and all patient-related information will be permanently deleted during all future encounters. The system will initiate improved accessibility, early disease detection, and integration of fragmented technologies, and the creation of sustainable smart healthcare hubs for rural communities

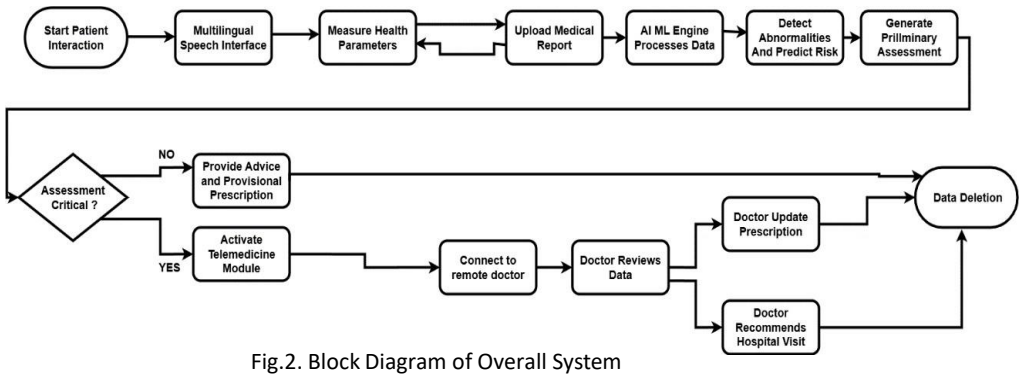



Fig.2. Block Diagram of Overall System

## IV. SYSTEM ARCHITECTURE

The proposed Autonomous Medical Robot (AMR) uses a modular design to integrate the hardware, software, A.I. telemedicine features of comprehensive, end-to-end healthcare provision.

I. *Sensor layer*: In the sensor layer, the autonomous robot will take vital signs (temperature, $SpO_2$, heart rate, blood pressure, ECG) and anthropometric measures (height, weight, BMI) data from embedded sensors.

II. *AI layer:* Data collection and uploaded laboratory reports (blood testing, ECGs, and ultrasounds) are used to process AI/ML algorithms. This layer identifies abnormalities, predicts health risks, and creates initial suggestions/recommendations and prescriptions.

III. *Interaction layer:* The multilingual interactive agent provides communication in a natural way (speech to text and text to speech), making it easy for semi-literate users.

IV. *Telemedicine Layer:* The layer establishes secure video consultations with remote doctors in an

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identified state of stress, as discussed above. These remote doctors can view the live vitals, the patient history (file with medical background) and listen to the audio of the e-stethoscope, allowing them to make a correct assessment and make recommendations or additional requests.

V. *Privacy and security layer:* All session data is removed immediately upon completing each patient interaction session, and anonymous communication with doctors is encrypted to comply with privacy and ethics laws in patient information and data management.

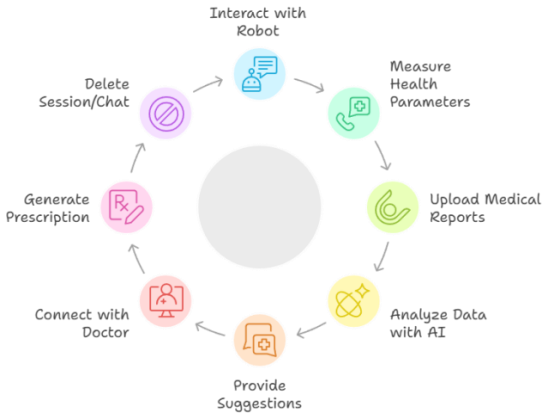



*Fig.2. Process Flow of the System*

## V. DISCUSSION

The proposed IoT and AI-enabled autonomous medical robot has considerable potential to address some of the challenges associated with rural health care. Its main advantages are accessibility (it takes key diagnostics to where the patient is in the village), clinical value in legitimizing early detection based on continuous monitoring, and integration of IoT sensors, AI-based analytics, robotics, and telemedicine in a single system. It also contains useful usability features such as multilingual conversational AI and safeguards like session-based data deletion that can help build patient trust. It is also scalable and can be deployed in several villages to become part of a smart healthcare hub.

However, there are some challenges. Technology dependent May contribute limitations to the overall reliability of our system. For instance, we are critically aware of technical considerations related to AI bias, sensor accuracy, and calibration that could potentially minimize reliability. Additionally, there may be practical infrastructure impediments to our teleconsultations, such as adequate internet connectivity. We must be aware that patient acceptance of robotic healthcare is a significant barrier to widespread adoption. We also recognize that rural patients may have limited trust (the clinical evidence and tech will ironically need to be effective before acceptance). The initial cost of the system presents a major obstacle for implementation, especially in rural and remote contexts. There are ethical issues around

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data privacy and if the clinician could be responsible for a misdiagnosis to consider, which may impact patient confidence in using our system. In conclusion, we believe the system proposed could help reduce the rural urban health care divide significantly. However, the above technical, economic, ethical and social challenges will need to be taken into consideration for successful uptake and integration in the real-world context.

## VI. CONCLUSION

The proposed IoT- and AI-enabled Autonomous Medical Robot offers an effective way to address the scarcity of healthcare services in rural regions. This's possible combining vital signs measurements, height and weight measurements, AI-supported interpretation of a medical report, and natural patient interaction using speech requests. Subsequently, it can provide reliable medical guidance for a patient within a small-time frame. Moreover, telemedicine components can connect critical cases to doctors for prompt assessment while retaining a human-in-the-loop for accurate diagnosis and treatment. In combination, these components enhance early access to and diagnosis of health care services as well as enhance trust and privacy of their patients through robust data security. Our modular design allows it to be scaled and to remotely link multiple villages to develop smart health care networks. Future expectations include transforming the robot into a more capable intelligent healthcare companion within rural communities with enhancements that allow it to perform simple automated medical interventions that do not require a medical practitioner (e.g., giving a patient an injection or dispensing medications) under controlled conditions, eventually diminishing the number of required medical practitioners on-site.

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