

A Raspberry Pi Based Assistive Nursing Robot for Remote Patient Care

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Abstract—This paper presents a design for an assistive nursing robot utilizing a Raspberry Pi for processing data from various sensors. The robot is designed for autonomous movement using a line-following system and DC motor-powered wheels. It features a servo-controlled medicine delivery system that activates upon reaching a specified patient. For remote diagnosis, a camera and microphone enable contact-less communication between the doctor and patient. Real-time heart rate, blood oxygen level (SpO₂), and temperature are monitored using dedicated sensors. The robot is intended for regular patient check-ups and provides emergency alerts if an issue is detected. Given the current scenario of pandemics and the global need for assistive nursing robots, this technology aims to secure patients and ensure medication is administered at the correct time and dosage, addressing issues like irregular timing and forgotten or incorrect dosages. The design seeks to support nurses and improve patient care delivery, particularly in situations where highly contagious diseases necessitate social distancing between the patient and care provider.

Index Terms—Assistive robot, Line following, Nursing robot, Raspberry Pi, Remote patient monitoring, SpO₂ sensor.

I. INTRODUCTION

The demand for assistive nurse robots has surged due to global health crises and the need for contactless patient care. This paper introduces a Raspberry Pi-based autonomous nurse robot capable of real-time monitoring, medicine delivery, and remote communication. The robot navigates using a line-following system and delivers medication via a servo mechanism. It uses sensors to monitor vital signs and alerts medical staff during emergencies. The robot addresses traditional medication issues such as missed doses and incorrect timing, offering a reliable alternative in pandemic conditions

Here we are using raspberry pi for processing various information and data from all the sensors. The data is stored and processed by raspberry pi. Now for the autonomous movement of the robot the line following system is used. The robot moved on the DC motor powered wheels. Once the robot reaches the specified patient, a servo-controlled medicine delivery system activates and the medicine is delivered. For the remote diagnosis camera and microphone are used for contact less communication between doctor and patient. By making use of spo₂ and temperature sensor, real time heart rate, blood oxygen level and temperature can be monitored. This robot can be used for regular check-up of patients and if anything goes wrong it provides emergency alert. The history, as well as the future of this technology as an assistance to nurses, is uniquely positive. In the recent decades of world, medical and Hospital applications require huge need of an assistive nursing robot for serving patients in a pandemic situation like what happens in the current scenario. In some places autonomous robots are used to serve food and cloths. During this pandemic duration, these autonomous robots are modified into assistive nursing robots to secure patients in an eminent manner. And also, it ensures the medication is done at correct time and dosage. In traditional methods of medication have some problems of over dosage, forgetting to take the medication, and irregular timing. Majority of patients is only recommended to intake consider amount of medications in each day and some tedious cases created at forgetting to take medicine in a specific time interval.

According to the W.H.O's situational report 127 revealed on May 26, 2020, thus far, 5,404,512 confirmed cases are reportable worldwide with 343,514 casualties. The death rate is highest among older individuals compared to young ones, whereas male patients are a lot of at risk compared to feminine

patients within the same age group. Huge pandemic disease cases can be controlled by the usage of well-designed nursing robots. It controls the front line localization of the corona virus. The autonomous robots are widely used in food deliveries, quantity analyzer, delivering goods and agriculture harvesters. This is used for improving productivity and working hours. Autonomous robot system is used as well as automatic truck transportation with self-driving in a constructive area.

Viral Shah et al. (2016) revealed the process of technology in food industry; this paper discloses how supply chain decision-making. Their proposed work their research heightened of the upcoming track of the food industry among all the peoples. Harvesting is a process of important and concluding stage in agricultural production. In traditional approaches still fruit harvesting is carried out manually by the human beings. This paper exposed to make fruit picking robots in autonomously and it has been developed with the feature of vision processing capability and it is programmed by the various picking mechanisms. The researcher appraised all the techniques used to enhance future food processing industries towards autonomous food serving and cleaning attributes. These robots are programmed beyond with the route map of hospital and room locations and destinations of the corresponding patients. In some other autonomous robots are used in European countries, which is assist differently abled persons for their feedings and some numerous tasks. All over the developed countries have more number of elder peoples compare than younger peoples. So it needs some hygienic peculiarity for their individual grow. The author explored the importance of the Internet of Things in food industry and it makes how the food chain made emphasizing and promising area. It majorly revolves all the challenges in food industry and supply chain.

Humanoid robots are a recent technology in autonomy of robots and it how works in the various degree of human body postures. The Honda introduced first autonomous robot in 1996 and it is made by the feature of biped walking machine. It has one of the important feature is easily move upstairs and downstairs automatically with the help of biped walking program. It also reveals the Honda robot how adopting to various load changes. In the recent decades of the world, medical and Hospital applications is huge need of autonomous robots for serving in that pandemic

situation like what happens in the current scenario. In some places the autonomous robots are used to serving food and clothes. During this pandemic duration, the autonomous robots are modified into the nursing robots to secure the patients in a more eminent manner. In that corona affected patients needed more times of medications compared than others per day. In traditional method of medications have some estranges such as over dosage or insufficient dosage, forgetting medications and irregular timings. Some of the dosage accidents made when the co-occurrence of age factor as well as severity of disease will be high. The robots work in more processioned like human beings to serve the people to change clothes, food feeding and mobility of both wheelchair and physically. The normal physical robots can be converted into autonomous robots with the help of more number of sensors. Due to medical applications, the sensors need to be more precision and high ability to handle the patients. These sensors based autonomous robots have some good features like reliability, safety and easy adoptability. The nursing or autonomous robots are should be more user friendly, more compact and more précised manner. Using robots have the eminent feature like as a natural human care taker. Also, in certain circumstances, a highly contagious disease affects a person, and the patient is to be treated. Under such situations, the doctors are in need of maintaining proper distance from the patient so as to prevent the contagious disease affected the doctors themselves. The classification of EEG signal is discussed. Treating the patients under continuous observation becomes a very challenging task altogether. Human care assistive robots are in such cases where in the interaction between the doctor and the patient becomes very minimal and can also help to maintain social distancing.

II.LITERATURE SURVEY

Drug distribution in hospital: Real time nurses / Staff nurse development of robot: Patient health care, prevention of diseases and to prevent the disruption of their duties in the service areas of health workers in hospitals, in addition to real-time health monitoring system makes drug delivery nurse / staff nurse robot model was developed. These models study, using voice transmission made intelligent robot kit using Bluetooth module is running concurrently with the nurses made a robot design. This design will start to

work with the perception of the nurse's voice command. Task, after the command log data (for which patients, which room, which drug, which is an hour and so on.) Is held by reading the file will distribute medicines to patients. During drug delivery by the data specified by the audio message tells the patient taking the drug. Only if the patient does not receive the drug intelligent robot sends the report to the nurse with the help of Bluetooth module.

A staff nurse, who is involved directly in the patients care every day is a vital part of the healthcare system. Staff nurses are healthcare providers, who examine the patients for the right treatment. They are advocates for patients between the doctor and the patient's family. These professionals communicate with the family members and share the necessary information about the patient's medical conditions, plan of care, the physician's instructions etc. Staff nurses generally work in hospitals, outpatient clinics, nursing centres and medical centres. For a Staff nurse to become a successful professional, she/he is required to possess certain qualities and skills along with the required educational qualifications. These traits are either developed in the classroom or through clinical exposure.

Robotics in the patient care setting will transform and will very likely revolutionize the way we deliver care. The International Organization for Standardization (ISO) specifically defines nursing robots as "systems of mechanical, electrical, and control mechanisms used by trained operators in a professional health care setting that perform tasks in direct interaction with patients, nurses, doctors, and other health care professionals and which can modify their behaviour based on what they sense in their environment" (ISO/TC299 Robotics Technical Committee, 2012, p. 1). This definition contrasts with the application of service robots to support the work of nursing. Service robots assist human users in day-to-day tasks, for example, patient care delivery of daily routines as well as in monitoring patients. This paper will review the current state of the science in terms of robotics used to support nurses, particularly service robots, and examine the experiences of three pilot sites as a case study to inform the potential use of service robots for nursing. Finally, considerations will be provided for how organizations can prepare to embrace and capitalize on robots to support nursing care delivery.

One of the earliest nurse robotics studies involved a social robot named "Pearl" (Pollack et al., 2002). Pearl was developed out of a collaboration between the University of Michigan, the University of Pittsburgh, and Carnegie Mellon University with members from engineering, social sciences, and nursing (Pollack et al., 2002). This project, titled "Nurse robot," was aimed at developing mobile robotic assistants for the elderly with two primary functions: reminding people about routine activities such as eating, drinking, taking medicine, and using the bathroom, and guiding them through their environment. Although fairly successful, the project caused much discussion about robots replacing nursing. This is also reflected in a more recent 2017 study in which staff had ambivalence about sharing workspace with a robotic aid (Hebesberger et al., 2017). Others have indicated that the "robotic revolution happening in healthcare" is a threat to nursing practice.

Health care challenges facing the nation include rapidly expanding aging populations, nurses retiring at unprecedented numbers, and nurse and physician shortages at a time when health care reform is moving into alternative payment systems (Buerhaus et al., 2017). The shortages of nurses are not isolated to the United States, with forecasts globally exceeding 12 million by 2035 (European Commission, 2019). One answer to these challenges is to adopt new and innovative technology solutions. The use of robots in health care represents an opportunity to support those who are delivering health care. Robots can be used to enable people with cognitive, sensory, and motor impairments; help people who are ill or injured; support caregivers; and aid the clinical workforce (Riek, 2017). As noted, this paper will examine how robots can support nurses and examine three pilot sites that implemented a service robot to offload tasks commonly done by nurses. We emphasize that there are different types of robots available to support patient care delivery; however, for this paper, we are focused on the specific future opportunities for service robots.

Due to the predicted nursing shortages worldwide, Kangasniemi et al. (2019) conducted an extensive review of the literature to examine how robots and automated devices could potentially offload and alleviate the workloads of nurses. Their findings are compelling, indicating that there has been an increased focus on the use of robots and automated devices in

nursing care. The authors also identified areas of nursing care and tasks that could benefit from being reassigned to robots. These areas included medication delivery, automated patient monitoring, and a number of areas where robots could assist with nursing treatments. These areas involved auto-tracking systems to identify patients, automated devices to inject or infuse treatment, robots for patients' daily hygiene, and robots to help nurses manage physical tasks like turning patients. Outcomes in these studies included impact on working time and workload, measurement accuracy, safety for the nurse and the patient, as well as usability.

There is a distinction between robots that transport or deliver items within a hospital (medications, supplies, etc.) and robots that have an arm and thus can manipulate aspects of their environment. Some robots, including those with transport and manipulation capabilities, are also intended to be socially intelligent. The terms "robotics" and "automation" have precise technical meanings. According to the Robotics and Automation Society of the Institute of Electronics and Electrical Engineers, "Robotics focuses on systems incorporating sensors and actuators that operate autonomously or semi-autonomously in cooperation with humans. Robotics research emphasizes intelligence and adaptability to cope with unstructured environments. Automation research emphasizes efficiency, productivity, quality, and reliability, focusing on systems that operate autonomously, often in structured environments over extended periods, and on the explicit structuring of such environment". Note a fairly simplistic but useful definition of a service robot as robots that are "devices that interact with people and assist them in day-to-day tasks". They further differentiate service robots as unique in their approach to the steps of a task as a classical type of planning problem. The classical approach requires adopting a "closed-world assumption," presupposing that everything the robot could possibly need to reason about is already represented for the robot to perform. Note that, in most real-world service robot scenarios, like those that arise when interacting with people in offices or homes, such a complete list of options for the robot's performance is not likely (Jiang et al., 2019).

According to Riek (2017), one of the key insights learned about the use of robots in health care delivery (relevant to their use in nursing) are that robots help

caregivers and the clinical workforce who are currently overloaded with high rates of work-related injuries. also found that in health care, most problems are complex, and there is no "one-size-fits-all" solution, meaning that every person, task, and care setting is different. As such, there is a benefit from robots that are capable of robustly learning and adapting on the fly. To be successful with the use of service robots, nursing teams of technologists, researchers, providers, and users must closely collaborate to ensure successful robotic adoption and implementation into practice and workflow.

Hospitals have two type of drug distribution system:

- Distribution of drugs to indoor patients (patients in wards, operation theaters, X-ray, and other specified departments).
- Distribution of drugs to outdoor patients (patients not admitted and not occupying bed).

The pharmacy sector is important in any country because it consumes a high proportion of health system expenditures. Therefore, it is a challenge for governments to ensure easy access to a safe and stable supply of pharmaceuticals at the lowest possible cost. A high expenditure on drugs is notable in many health systems especially those in the developing countries where it may reach a high percentage (25%) of the running costs of their ministries of health. Hospital pharmacies are the largest consumers in the pharmacy sector, so it is important for policy-makers to be aware of the importance of providing effective pharmacy services with rational and safe use of medications. Clinical pharmacy services are the building blocks of modern hospital pharmacy, and hospital pharmacists are a vital part of the clinical team, helping to ensure that drugs are used in the best way from the safety, efficacy and economic points of view. Adoption of a proper drug dispensing system (DDS) is a top priority for any hospital to ensure cost-effective drug management process in that hospital. There are many types of drug dispensing systems, including ward stock and unit dose systems, that could be adopted to achieve this goal. In a ward-stock DDS, drugs are dispensed from the pharmacy to the hospital departments and stored in the departments' stocks and then used by nurses according to physicians' orders. In a unit-dose DDS, drugs are dispensed in amounts that fulfill the needs of each individual patient for only 24 hours. The unit-dose DDS was developed in the 1960s

to support nurses in administration of medication, to provide nurses and pharmacists with more time for patient care and to reduce wastage of increasingly expensive medications. Now unit-dose dispensing of medications is standard practice in many hospitals around the world. The study was aiming to assess which DDS was more appropriate based on a comparison between a hospital using the unit- dose DDS and another using a ward-stock DDS.

III.SYSTEM ARCHITECTURE

The proposed assistive nurse robot integrates multiple subsystems to enable autonomous operation and effective patient interaction within clinical environments. The architecture comprises the following key components:

- **Processing Unit:** A Raspberry Pi microcontroller serves as the central processing unit, responsible for acquiring sensor data, executing control algorithms, storing patient information, and managing decision-making processes.
- **Mobility Subsystem:** The robot is equipped with DC motor-driven wheels and a line-following mechanism, enabling autonomous navigation along predefined paths within hospital premises.
- **Medicine Delivery Mechanism:** A servo motor-based actuator system ensures precise delivery of medication to patients. The dosage and timing are controlled programmatically to minimize human error and enhance treatment accuracy.
- **Remote Diagnosis Interface:** Integrated camera and microphone modules facilitate contactless communication between patients and healthcare professionals, supporting remote diagnosis and reducing exposure risks during contagious outbreaks.
- **Vital Sign Monitoring:** The robot incorporates SPO2 and temperature sensors to continuously monitor patient vitals, including heart rate, blood oxygen saturation, and body temperature. These readings are processed and logged for real-time alerts and clinical assessment.

This modular architecture supports scalable deployment and can be adapted to various healthcare settings, enhancing both operational efficiency and patient safety.

IV.SCHEMATIC BLOCK DIAGRAM

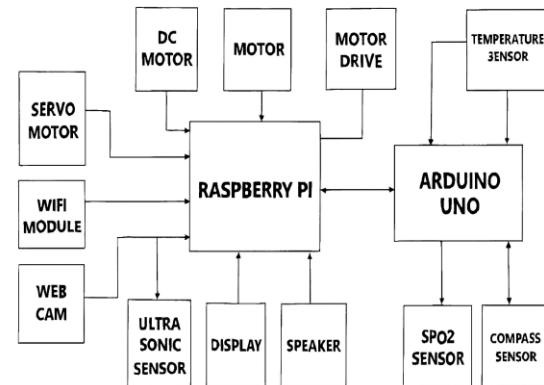


Figure 1: Block diagram of proposed system

The proposed nurse robot system integrates multiple hardware and software components to enable autonomous patient care, real-time health monitoring, and remote interaction. The block diagram of the system comprises the following key modules:

A. Raspberry Pi Controller

At the core of the system lies the Raspberry Pi, which functions as the central processing unit. It receives input from various sensors, processes the data, and coordinates the robot's actions. The Raspberry Pi is responsible for:

- Sensor data acquisition and storage
- Decision-making for autonomous navigation
- Activation of medicine delivery mechanisms
- Communication with remote devices (camera, microphone)

B. Sensor Suite

The robot is equipped with a comprehensive sensor suite to monitor patient vitals and environmental conditions:

- **Temperature Sensor:** Measures body temperature in real-time.
- **SpO₂ Sensor:** Monitors blood oxygen saturation and heart rate.
- **Ultrasonic Sensors:** Used for obstacle detection and avoidance during navigation.
- **Ring Sensor (optional):** A wearable device for continuous cardiovascular monitoring, transmitting data wirelessly to the robot.

C. Autonomous Navigation System

The robot employs a line-following mechanism for autonomous movement within hospital premises. This system includes:

- Infrared sensors for path detection
- DC motors for wheel actuation
- Motor driver circuits controlled by the Raspberry Pi

D. Medicine Delivery Unit

A servo motor-based medicine dispensing system is integrated to ensure accurate and timely delivery of medication. Upon reaching the designated patient location, the Raspberry Pi triggers the servo mechanism to release the prescribed dosage.

E. Remote Diagnosis Interface

To facilitate contactless communication between doctors and patients, the robot includes:

- Camera Module: Captures live video feed for remote consultation.
- Microphone and Speaker: Enables two-way audio communication.
- Bluetooth Module: Transmits alerts and patient data to nursing staff when required.

F. Emergency Alert System

In case of abnormal health readings or patient distress, the robot generates emergency alerts. These alerts are communicated to the medical staff via:

- Audio messages
- Bluetooth notifications
- Visual indicators (e.g., LED signals)

G. Power Supply and Battery Management

The system is powered by a rechargeable battery pack. Efficient power management is crucial to support continuous operation of sensors, motors, and communication modules.

V. WORKING METHODOLOGY

A. Line Following System

The line-following system is the primary navigation mechanism that enables the robot to traverse predefined paths within hospital corridors. It is based on the principle of differential reflectivity of surfaces when exposed to infrared (IR) radiation.

1) Infrared Sensing Principle

The robot employs an array of four IR sensors, each consisting of an IR LED (transmitter) and a photodiode (receiver). These sensors are mounted on the underside of the robot and are calibrated to detect the contrast between a black line and a white background:

White Surface: Reflects IR radiation, which is detected by the photodiode, generating a high output voltage.

Black Surface: Absorbs IR radiation, resulting in minimal or no signal at the receiver, producing a low output voltage.

This binary response allows the robot to distinguish the line from the surrounding surface and make real-time navigation decisions.

2) Sensor Configuration and Data Flow

The IR sensor array is interfaced directly with the Raspberry Pi via GPIO pins. The sensor outputs are continuously polled to determine the robot's position relative to the line. The data flow is as follows:

- Sensor readings are acquired and digitized.
- The Raspberry Pi executes a line-following algorithm that interprets the sensor data.
- Based on the logic, motor control signals are generated and sent to the motor driver circuit.

3) Control Logic and Actuation

The robot is driven by two DC gear motors connected to a dual H-bridge motor driver (L298N). The Raspberry Pi generates PWM signals to control motor speed and direction. The control logic includes:

- **Straight Movement:** When the center sensors detect the line.
- **Left/Right Correction:** When side sensors detect deviation.
- **Stop Condition:** When no sensor detects the line, indicating a possible end or error.

A digital compass sensor (e.g., HMC5883L), interfaced via Arduino Uno, provides heading information to assist in directional stability, especially at junctions or turns. The Arduino transmits compass data to the Raspberry Pi via serial communication (UART).

4) Path Planning and Junction Handling

The robot is capable of handling 90-degree turns and junctions by implementing a junction-counting algorithm. This is achieved by:

- Monitoring sensor patterns to detect intersections.
- Using compass data to determine the correct turn direction.
- Updating internal counters to track progress along the route.

This enables the robot to autonomously navigate complex hospital layouts with minimal human intervention

.B. Image Sensing and Remote Diagnosis

To enhance its diagnostic capabilities and enable contactless interaction between patients and healthcare providers, the robot integrates a camera module and audio interface.

1) Camera Integration

A high-resolution camera module (e.g., Raspberry Pi Camera v2) is mounted on the robot and interfaced with the Raspberry Pi via the CSI interface. The camera serves multiple purposes:

- Obstacle Detection: Identifies static or dynamic obstacles in the robot's path.
- Patient Identification: Captures facial images for recognition and verification.
- Remote Consultation: Streams live video to remote medical personnel for diagnosis.

2) Image Processing and Communication

The captured video feed is processed using OpenCV libraries running on the Raspberry Pi. Key functionalities include:

- Motion detection and object tracking.
- QR code or marker recognition for room identification.
- Integration with video conferencing platforms (e.g., Zoom, Skype) for real-time communication.

The camera is complemented by a microphone and speaker module to facilitate two-way audio communication, enabling doctors to interact with patients remotely.

3) System Integration

The image sensing subsystem operates concurrently with the navigation and monitoring modules. The Raspberry Pi manages task scheduling and resource allocation to ensure real-time performance. The integration of visual and sensor data enhances the robot's situational awareness and operational safety.

VI. RESULT AND DISCUSSIONS



Figure 2: Base figure

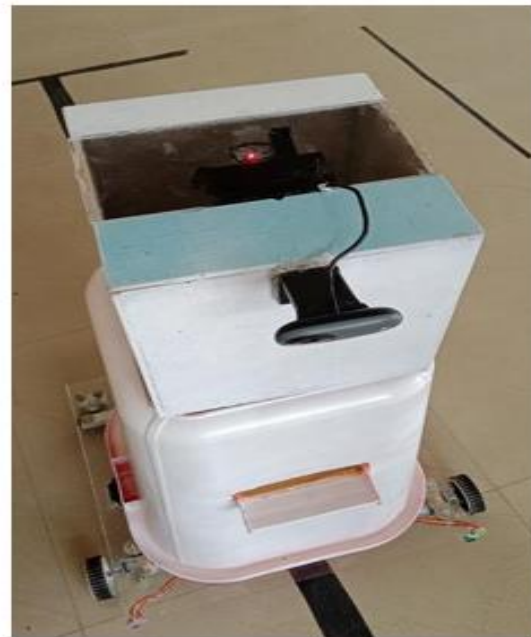


Figure 3: Overall view

The medicine delivery by the robot is completely working. The movement is done using line follower technology, that the path is black and is detected by using IR sensor and compass sensor. The obstacle throughout the way is detected by the ultrasonic sensor.

The pulse oximeter sensor and temperature is working and gives precise outputs. But it taking some time to give the outputs. Remote diagnosis like temperature measurement, blood oxygen level and heartbeat are taken and sends to the doctor through telegram port. A smart mobile is settled as a display and the communication between doctor and patients is done with the help of google meet application. The entertainments purpose like news reading is working properly. The medicine delivery is doing properly with the help of servo mechanism. Dc motor and motor drive are also doing their functions properly without any overheating. A 12v battery is giving the supply to the entire system.

VII. CONCLUSION

Assistive nurse robots signify a paradigm shift in modern healthcare delivery, offering a compelling blend of automation, precision, and patient-centric care. By integrating autonomous navigation, real-time physiological monitoring, and remote communication capabilities, these robotic systems address critical challenges in clinical environments—particularly during pandemics and in elder care settings where minimizing human contact is essential.

The deployment of such robots not only enhances operational efficiency but also ensures timely medication administration, continuous health surveillance, and improved patient engagement. Their ability to reduce the burden on healthcare professionals, especially nurses, allows for better allocation of human resources toward complex and empathetic care tasks that machines cannot replicate. However, to fully realize their potential, future research and development must prioritize several key areas:

- **Adaptability:** Robots should be capable of dynamic learning and contextual decision-making to function effectively in diverse and unpredictable healthcare environments.
- **Affordability:** Cost-effective design and scalable manufacturing are essential to ensure widespread adoption, especially in resource-constrained healthcare systems.
- **Infrastructure Integration:** Seamless interoperability with hospital information systems, electronic health records, and existing

medical workflows is crucial for maximizing utility and minimizing disruption.

Moreover, ethical considerations, user acceptance, and regulatory compliance must be addressed to foster trust and ensure safe deployment. As healthcare continues to evolve, assistive nurse robots will play an increasingly vital role in shaping resilient, responsive, and patient-friendly medical ecosystems.

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