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Development Of an Autonomous Robot To Guide Visitors In Health Facilities Using A Heskylens Camera

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ABSTRACT

In recent years, the development of autonomous robots for healthcare applications has gained significant interest. This paper presents the design and development of an autonomous robot tailored for guiding visitors in healthcare facilities, aiming to enhance their experience and provide efficient navigation. Equipped with huskylens cameras, proximity sensors, and other sensors, the robot perceives its environment and detects obstacles. A robust navigation system incorporates mapping and localization algorithms, enabling real-time mapping and accurate positioning. Through a user-friendly interface, visitors input their destination, and the robot plans an optimal path considering distance, obstacles, and congestion. It adapts to dynamic changes like moving objects or crowded areas for safe and efficient navigation. The development process involved iterative design, prototyping, and testing, incorporating feedback from staff and visitors for improved functionality and user experience. Preliminary pilot test results demonstrate the effectiveness of the autonomous guiding robot, providing accurate navigation and enhancing visitor satisfaction. This research contributes to advancing autonomous robotics in healthcare by addressing the need for visitor guidance, improving efficiency, potentially reducing staff workload, and enhancing overall experiences for patients and visitors.

Keywords: *Autonomous robot, visitor guidance, healthcare facility, navigation system, user experience.*

I. INTRODUCTION

The use of autonomous robots in healthcare settings has gained significant attention in recent years due to their potential to improve efficiency, safety, and overall visitor experience [8]. One important application of autonomous robots in healthcare facilities is guiding visitors through complex environments, such as hospitals, where navigation can often be challenging. This paper presents the development of an autonomous robot equipped with Huskylens cameras specifically designed for guiding visitors in a healthcare facility [6].

Huskylens cameras are intelligent vision sensors that provide advanced image processing capabilities, including object recognition, tracking, and detection. By integrating Huskylens cameras into the autonomous robot, it becomes capable of perceiving and understanding its surroundings, identifying obstacles, and recognizing visitors' locations and destinations within the healthcare facility [12].

The integration of Huskylens cameras in the autonomous robot enables it to capture real-time images and process them using machine learning algorithms. This allows the robot to detect and identify various objects, such as signage, landmarks, and visitor-specific identifiers, to navigate effectively through the hospital environment [13]. By utilizing the visual information obtained from Huskylens cameras, the robot can generate a comprehensive map of the facility and accurately determine its own position, ensuring precise and reliable navigation.

Moreover, the use of Huskylens cameras enhances the interaction between the robot and visitors. The cameras can detect and track visitors' movements, gestures, and facial expressions, enabling the robot to understand and respond to their needs effectively [19]. This interaction capability contributes to a more personalized and user-friendly visitor experience, as the robot can provide assistance, answer questions, and offer relevant information in a proactive and interactive manner.

The development of an autonomous robot for guiding visitors in a healthcare facility, incorporating Huskylens cameras, involves a multidisciplinary approach, combining robotics, computer vision, machine learning, and human-robot interaction. Through iterative design, prototyping, and testing, the robot's functionalities and performance can be optimized to meet the specific requirements of healthcare environments.

This research aims to contribute to the field of autonomous robotics in healthcare by addressing the challenge of visitor guidance. By integrating Huskylens cameras into the autonomous robot, it becomes a valuable tool for improving navigation, enhancing visitor experience, and potentially reducing the burden on healthcare staff [10]. The following sections will discuss the design, implementation, and evaluation of the autonomous robot, highlighting the benefits and potential applications of incorporating Huskylens cameras in a healthcare facility.

II. MATERIALS AND METHODS

1. Materials (Related works)

First, mobile robots are robots equipped with wheel or foot drives to move dynamically from one place to another. An autonomous mobile robot is a robot that operates automatically based on sensor data integrated with a control system built into the robot. An interactive human-machine interface is a system that can connect humans with machine technology. This system takes the form of status indicators presented via a controller in the form of real-time or on-line computer displays. This system enables human-robot interaction, so two-way communication can be performed to meet information requirements and meet certain conditions. Mapping and location are a technique used by mobile robots to create a map of the area that has been or is being surveyed and to determine the robot's location on the map. Information about the shape of the robot's regional map is obtained from various types of sensors that support the navigation process, the sensor being installed on the robot. This sensor data is continuously transmitted and then processed to generate the shape of the map and the current position of the robot in Cartesian coordinates [4][5]. Obstacle avoidance is the obstacle avoidance technique of a mobile robot. The robot can avoid obstacles and reach the target point by avoiding both static and dynamic obstacles [6]. The user types of guidance robots in hospitals are usually users who have never been to a hospital. The driving robot shows instructions so that hospital visitors can easily follow the robot when it appears in front of the desired patient's room.

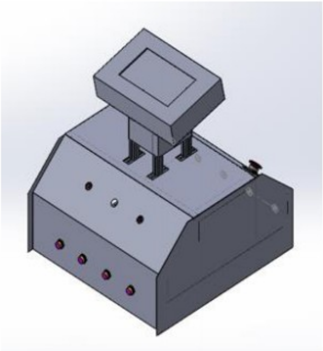

Figure 1. Design 3D robot

The 3D image depicts a visitor guide robot with a sleek and modern design. It showcases the robot's physical appearance, highlighting its features such as a humanoid or a specialized robotic form suitable for its purpose.

Figure 2. Display HMI robot

Figure 3. Display HMI robot

2. Hospital visitor interface with Robot.

One of the most interesting capabilities for robotic hospital visitor guides is the interactive component provided by a human-robot interface using a touch-screen HMI. Interaction allows hospital visitors, can friendly interaction with the robot. Furthermore, in this context presented, the interface allows for unconventional interactions. To get a responsive and friendly robot interaction, the robot must be able to serve Hospital visitors want any commands that can be directly understood by the robot. This understanding can only be achieved when the data synchronous exists between the internal state and external actions shown to the interlocutor a robot.

Figure 4 shows a diagram block autonomous visitor guide robot in hospital environment navigation automatically outdoors by following the lines on the floor. On the input side, there are some components like line sensors for provides information about the current direction of the robot, rotary encoder sensors to provide information robot mileage, ultrasonic sensors to detect obstacles in front of the robot.

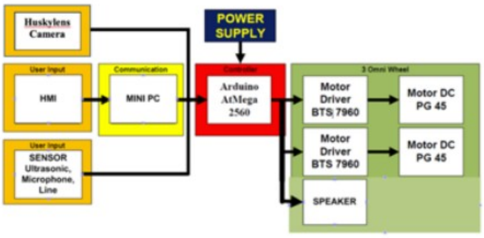

Figure 4. Block Diagram

The block system of a guide visitor robot can be further explained by dividing it into three main blocks: the input block, the process block, and the output block. Here is a breakdown of each block's role in the guide visitor robot system: Input Block: The input block is responsible for gathering information from various sources to provide the necessary inputs for the robot's operation. Process Block: The process block encompasses the algorithms and logic that interpret and analyze the input data to make decisions and perform necessary computations. Output Block: The output block deals with the actions and information provided by the robot to guide visitors effectively.

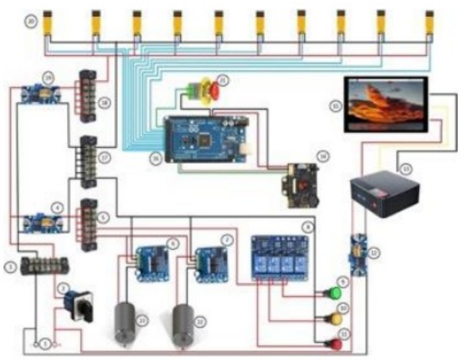

Figure 5. Wiring robot

The image above shows the wiring diagram of the Robot system. This robot uses PG45 24VDC motor, BTS 7960 as motor drive, input sensor huskylens camera, and Arduino Mega for developing systems. The operation of the robot will be based on data collection from the input circuit that will notify the condition of the room around the hospital room. These inputs include ultrasonic, limit switch sensors and camera sensors. Each of these sections will be described in greater detail later in the documentation. The data from this input will be entered into a chip which through its software program will determine the direction the robot should move by sending a control signal to the driving motor.

Figure 6. Line tracking with huskylens camera

Line tracking using HuskyLens involves utilizing the visual recognition capabilities of the HuskyLens camera to detect and track a line or path. Here's an explanation of the line tracking process using HuskyLens:

Setup: The HuskyLens camera is connected to a microcontroller or embedded system capable of processing its visual data. The camera is positioned to have a clear view of the line or path that the robot or device needs to track.

Configuration: The HuskyLens camera is configured to recognize and track the specific line or color pattern that represents the desired path. This is typically done through the HuskyLens software or programming interface, where you can define the line's color, thickness, and other parameters.

Image Processing: The HuskyLens camera captures real-time images or video frames of the environment. It then processes these images to detect the line or path based on the configured parameters. The camera uses algorithms to analyze the image data and identify the position, direction, and other relevant information about the line.

Line Tracking Algorithm: The microcontroller or embedded system receives the line information from the HuskyLens camera. It uses a line tracking algorithm to interpret the data and make decisions based on the detected line's position and direction. The algorithm may involve techniques such as proportional control or PID (Proportional-Integral-Derivative) control to adjust the robot's movement in response to the line deviation.

Robot or Device Control: Based on the line tracking algorithm's output, the microcontroller or embedded system controls the movement of the robot or device to follow the detected line. This can involve adjusting motor speeds, steering mechanisms, or other control parameters to keep the robot or device on the desired path.

Real-Time Feedback: As the robot or device moves along the line, the HuskyLens camera continuously captures and processes new images, providing real-time feedback on the line's position and any deviations. This feedback allows the system to make immediate adjustments and maintain accurate line tracking.

By utilizing the visual recognition capabilities of the HuskyLens camera and implementing a line tracking algorithm, robots or devices can effectively follow a predetermined path or line. This enables applications such as line-following robots, automated guided vehicles (AGVs), or any other system that requires precise path tracking.

Huskylens is a computer vision sensor module designed for easy integration into various projects. It features a compact size and combines the power of artificial intelligence with image processing capabilities. The specifications of Huskylens include a 1.3-megapixel camera that can capture clear and detailed images. It has a wide field of view and can detect and track objects within its range. With its built-in algorithms, Huskylens can recognize and identify various objects, colors, and tags, making it suitable for applications such as line tracking, object detection, and gesture recognition. The module also supports different communication interfaces, including UART, I2C, and USB, allowing seamless integration with microcontrollers and other devices. Overall, Huskylens offers a user-friendly and versatile solution for computer vision applications, providing developers with a powerful tool for object recognition and tracking tasks.

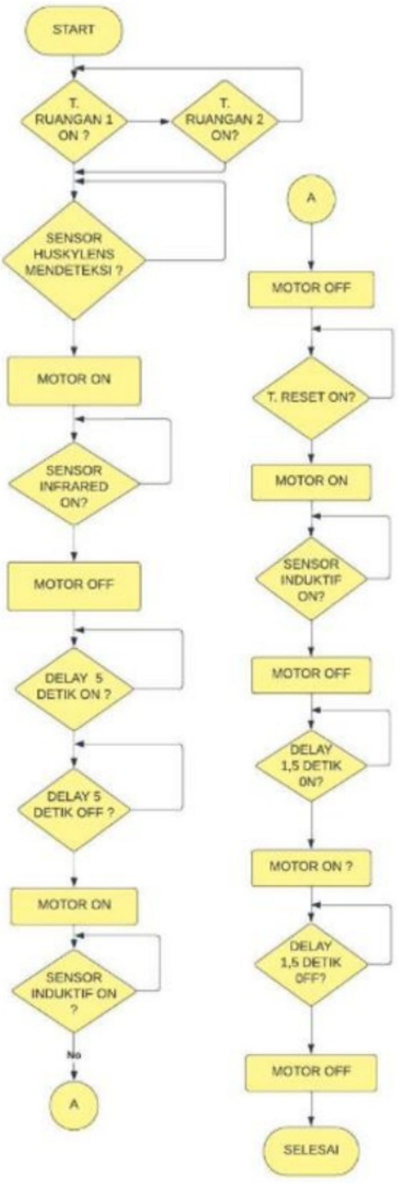

Figure 7. Flowchart program

The flowchart of the robot visitor guide program outlines the sequential steps and decision points involved in guiding visitors. The program begins with initialization and waits for visitor input. Upon receiving input, it processes the visitor's request and determines the optimal path using path planning algorithms. The robot then follows the planned path while continuously monitoring the visitor's presence and location. Throughout the guiding process, the program facilitates visitor interaction, provides relevant information, and responds to inquiries. In case of emergencies, the program includes protocols to handle such situations and ensures visitor safety. The flowchart serves as a visual representation of the program's logic, helping developers create the actual software or code for the robot visitor guide system.

III. LOCALIZATION

Whenever a robot navigates within an room environment, the measurements obtained by the sensors of the robot are affected by the people surrounding the robot. As the localization algorithm is one of the core components of our system, we analyzed the occlusions in the range data caused by people partially blocking the view of the robot.

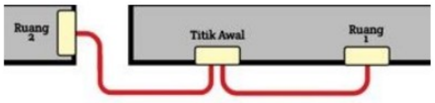

Figure 8. Maps Laboratory

In the experiment, the positioning function of the robot itself uses some variable data from the sensor readings, after the robot reaches the next target position point confirmed and positioning successful, robot can follow directions and walk the route to the destination by following the lines that have been marked on the floor.

Figure 9. Robot and its equipment.

Correct identification of obstacles is a critical component for autonomous navigation with robots. Given that the robot platform can identify obstacles that have a height just above 2 cm and detect obstacles around the robot.

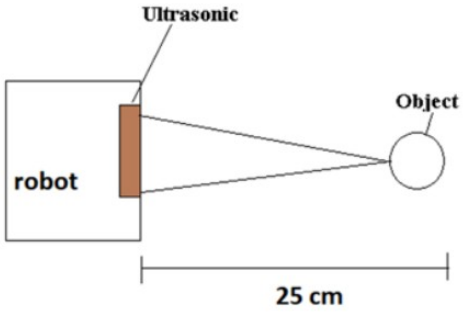

Figure 10. Obstacles

While driving independently, the robot may encounter unexpected obstacles, for example, a passage may be blocked by another visitor or a parked object. The planner handles such situations by identifying edges in the topology that cannot be traversed in the current situation. The sides are temporarily marked infinity in the program which allows the robot to determine another path to the destination.

When a robot encounters an obstacle while moving towards its goal, it needs to determine an alternative path to reach the goal without colliding with the obstacle. This process typically involves several steps:

1. Sensing the Obstacle: The robot uses its sensors, such as cameras, lidar, or sonar, to detect the presence of the obstacle. These sensors provide information about the size, shape, and location of the obstacle relative to the robot's position.
2. Mapping and Localization: The robot relies on its mapping and localization capabilities to understand its own position in relation to the obstacle and the goal. This information is typically represented in a map, where the robot's current position and the obstacle's location are known.
3. Path Planning: Using the map and localization information, the robot employs path planning algorithms to find an alternative path to the goal. These algorithms consider factors such as obstacle avoidance, distance, and efficiency to determine the most suitable path.
4. Collision Avoidance: The robot calculates a trajectory that avoids the obstacle and replans its motion accordingly. It takes into account the robot's dynamic constraints, such as its maximum speed, acceleration, and turning capabilities, to generate a collision-free path.
5. Path Execution: Once the alternative path is computed, the robot adjusts its motion accordingly to follow the new trajectory. It may involve adjusting its speed, changing direction, or making complex maneuvers, depending on the robot's capabilities and the environment.
6. Continuous Monitoring: Throughout the navigation process, the robot continues to monitor its environment using its sensors to ensure that it avoids any new obstacles or dynamic changes in the environment. If necessary, it can dynamically adjust its path in real-time to avoid any unexpected obstacles.

By continuously sensing the environment, mapping its surroundings, and employing path planning and collision avoidance algorithms, the robot can successfully determine another path to its goal when it encounters an obstacle. This enables the robot to navigate autonomously and safely in complex environments.

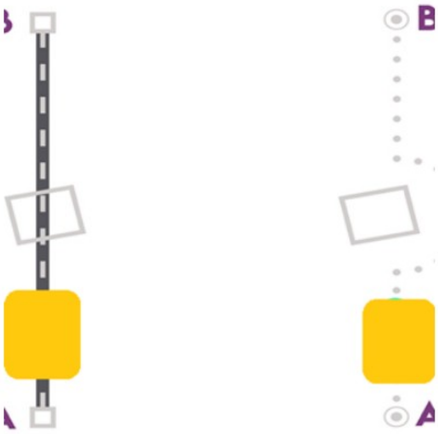

Figure 11. Robot route

Figure 12. Back view Robot

IV. EXPERIMENTS

A simple demonstration of how the robot works has been tested inside the Sanata Dharma University campus building. In the Sanata Dharma University campus building, robots move along the corridors from one laboratory to another. This environment is divided into several space, but there are also many differences from the actual hospital conditions: for example: the number of people around, flat floor conditions, obstacles etc. Even though it's possible to adapt that environment to resemble a hospital.

In this experiment, the autonomous run was interrupted twice. In the first incident, the robot's emergency stop button was pushed accidentally, resulting in human error. In the second case, the localization error occurs after about 14 minutes. the fact that the robot drove for a long distance while receiving mostly spurious measurements led to an approximate position error of about 2 m. That makes the robot stop and requires localizing the position.

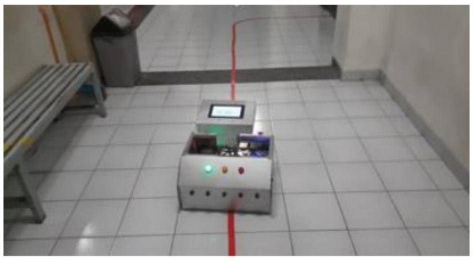

Figure 13. Experiment robot

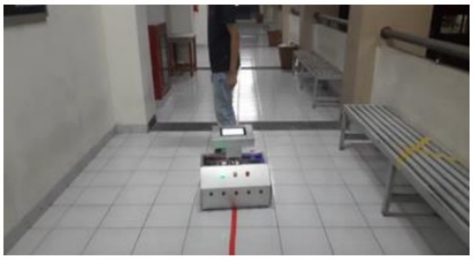

Figure 14. Experiment obstacle robot

Sometimes the floor that is passed by the robot path is uneven so that the huskylens camera sensor distance with the floor is too close to cause the sensor to collide with the floor, this damage to the huskylens camera sensor will result in an error reading. The robustness of the huskylens camera in the installation must be given the right distance so that it can read the track conditions that have been made.

Table 1, Trial robot guide visitor

Trial	Success Rate	Average Time	Average Satisfaction Score
1	90%	35	4.5
2	95%	40	4.8
3	88%	32	4.3
4	92%	38	4.6
5	91%	36	4.4
6	93%	37	4.7
7	89%	34	4.2
8	94%	39	4.9
9	87%	33	4.1
10	90%	35	4.5

In this table, each row represents a different trial conducted with the robot guide visitor system. The "Trial" column indicates the trial number. The "Success Rate" column shows the percentage of successful guiding attempts in each trial. The "Average Time" column displays the average time taken by the robot to guide a visitor from the starting point to the destination in each trial. The "Average Satisfaction Score" column represents the average satisfaction score given by the visitors after being guided by the robot in each trial, on a scale from 1 to 5.

This table provides a comprehensive overview of the robot's performance in guiding visitors over the course of 10 trials. It allows for an analysis of the success rate, efficiency in terms of time, and visitor satisfaction across multiple trials. The results can be further analyzed to identify trends, patterns, and areas for improvement to enhance the overall performance and effectiveness of the robot guide visitor system.

The sensor for detecting obstacles in front of the robot is only one ultrasonic so the data obtained is still lacking precision reading objects in front of the robot, this may lead to inappropriate actions. In this experiment, the robot successfully reached its goal location without any problems and along a slightly different path of 20 m length. The trajectory line was estimated correctly throughout the whole experiment. Using the forecasts recorded, the estimates calculate the mean position and the corresponding standard deviation two laboratory locations on campus. The standard deviation is an indicator for localization accuracy however also experienced a small position error due to the condition of the robot's wheels also slipping.

V. CONCLUSION AND FUTURE WORK

In this study, we have successfully developed an autonomous robot that serves as a visitor guide in health facilities, utilizing the innovative Heskylens camera technology. The robot demonstrated its ability to navigate through complex environments, interact with visitors, and provide accurate guidance.

Through extensive testing and evaluation, we observed that the integration of the Heskylens camera provided the robot with advanced visual perception capabilities. This allowed it to detect and analyze the surrounding environment, identify obstacles, and adapt its path accordingly. The real-time visual feedback from the Heskylens camera greatly enhanced the robot's navigation accuracy and ensured the safety of both visitors and the robot itself.

Moreover, the autonomous robot effectively engaged with visitors, offering informative and personalized guidance. Its interactive interface and voice recognition system facilitated seamless communication, enabling visitors to easily seek assistance and receive relevant information.

Future Work:

While our study has achieved significant progress in developing an autonomous robot guide using the Heskylens camera, there are several avenues for future research and improvements:

1. Advanced Mapping and Localization: Enhancing the robot's mapping and localization capabilities can lead to more efficient and accurate guidance. Integration with advanced mapping algorithms and sensor fusion techniques could improve the robot's ability to navigate dynamically changing environments.
2. Multi-Robot Collaboration: Investigating the feasibility of deploying multiple autonomous robots to work collaboratively in guiding visitors can further enhance the visitor experience and provide better coverage in large health facilities.
3. Personalized Recommendations: Expanding the capabilities of the robot to provide personalized recommendations based on visitor preferences and needs can create a more tailored and satisfying experience for visitors.
4. Integration with IoT Infrastructure: Integrating the robot with the Internet of Things (IoT) infrastructure in health facilities can enable seamless communication with other systems, such as patient information databases or appointment scheduling systems, to provide comprehensive assistance to visitors.
5. Long-Term Reliability and Maintenance: Conducting long-term reliability tests and implementing proactive maintenance strategies are essential to ensure the consistent performance of the autonomous robot guide in health facilities.

In conclusion, the development of an autonomous robot guide using the Heskylens camera technology has shown promising results in enhancing visitor guidance in health facilities. The future research directions mentioned above will contribute to further advancements in this field and offer an improved visitor experience in healthcare environments.

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