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Indoor Environment Surveillance via an Autonomous Mobile Robotic Device

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Research towards the building of intelligent surveillance systems is progressing. In this case, it is standard procedure to utilize mobile and multifunction robots as an attempt to reduce the sheer number of devices needed for a specific area and the length of environment structuring. Nevertheless, the conceptualization of the whole arrangement proves to be challenging due to the extensive number of sensors fitted on the robot and a great deal of elaborate jobs connected to monitoring, surveillance, and exploration. Our autonomous mobile robot for indoor environment surveillance is provided in the current investigation. We propose an intelligent robotic system that's capable of independently tackling highly complex surveillance concerns and autonomous general-purpose endeavors. It clearly shows that the recommended robotic surveillance scheme smoothly examines multiple states' essential problems with environment mapping, localization, and autonomous navigation, alongside other surveillance tasks like people finding and tracking and scene processing to determine removed or abandoned objects. The promising outcomes illustrate the usefulness of the proposed approaches for figuring out elements that have been introduced or eliminated from the inspected scene. Moreover, this system's YOLO model functions ten times sooner than two-stage procedures. Additionally, the conclusion of the experiment demonstrates that voice-controlled navigation can be accomplished by effectively integrating the advised mapping methodology with the voice recognition system. Another benefit is that it has been shown that the robotic surveillance system can effectively handle several specific issues concerning autonomous navigation, scene processing, and environment mapping, presenting it as an attractive choice for actual-life problem observation purposes. Results via lab tests have been carried out in numerous real-life circumstances, which include ones whenever an organization of people circulates across a hallway while no objects move inside a monitored scene.

Keywords: Autonomous robotic system, Intelligent surveillance, Face detection, Object

tracking.

1. Introduction

The rapid rate at which innovations have improved in recent decades has resulted in unique solutions that facilitate and enhance the lives of people. Especially, the robotics domain has a long-term goal to lower the sum of physical activity that humans perform at regular intervals and to augment any task that proposes human abilities like power, accuracy, and speed. The greatest advances in robotics have primarily arisen through various fields of robotic arms and miniature robotic vehicles, which are programmed, navigate on their own, and deliver data to a central control station through a local network or the Internet. The growing fields of remote control and monitoring have just recently come across an abrupt spike in the usage of robotic self-driving cars.

For purposes of helping users together with vehicle operation, the robotic vehicle industry comprises user mechatronics, artificial intelligence, and multi-agent (multi-agent Systems) systems.These are features that meet the criteria of the cars for the category of brilliant. A car will be deemed semi-automatic if it makes use of automation for difficult operations, such as navigating. An automobile can be regarded as semi-automatic if it depends upon automation for demanding duties with the value of navigating. On the opposing palm, vehicles that are programmed are referred to as robotic or self-driving. The technology of automation systems has progressively gotten greater in complexity mainly because the integrated circuit was created. Shortly after that, programmers and manufacturers proposed an extensive array of robotized functions, notably for cars and other automobiles [1].

The security robot can detect possible dangers and contact customers earlier than they arise. Employing the Internet, we can retain a watchful eye on potentially dangerous, public, and secret locations at any time and concerning any location. The working of autonomous robot flow chart is briefly explained in the Figure 1.1 shown below. Incorporating fire sensors and repelling intruders are common features of safety procedures. Private and protected matters are equally vital. Limitations and vulnerabilities of traditional security systems can be improved to propose a more untouchable home atmosphere service by mixing information and communication technology into robots. Through a multi-sensor system to provide intruder detection and service of insecure environment detection, real-time photo is used to monitor home conditions. The robot will use GSM to communicate with the public security unit of the government and send suggestions for precautions if unusual activities appear [2].

Different writers found various approaches for tackling such problems. This comprises the utilization of evolutionary techniques in tandem with automatic map-based localization, RFID-based protocols, and probabilistic localization techniques for enhancing robot spot predictions. However, the dynamics of the external environment can have an impact on each of those worries. The surrounding environment of the robot can be either dynamic or static. Considering that the robot is the only moving object in a static environment, localization is relatively easy. Localization turns much more complicated in a dynamic environment mainly because the mere existence of additional motion initiates the robot to seem unfocused. Perhaps the majority of problematic components of employing mobile robots in new environments is directing their own bodily motions. During navigation, the robot stirs up the map of the environments in new areas. Simultaneous localization and mapping is the name distributed to the strategy (SLAM) [3].

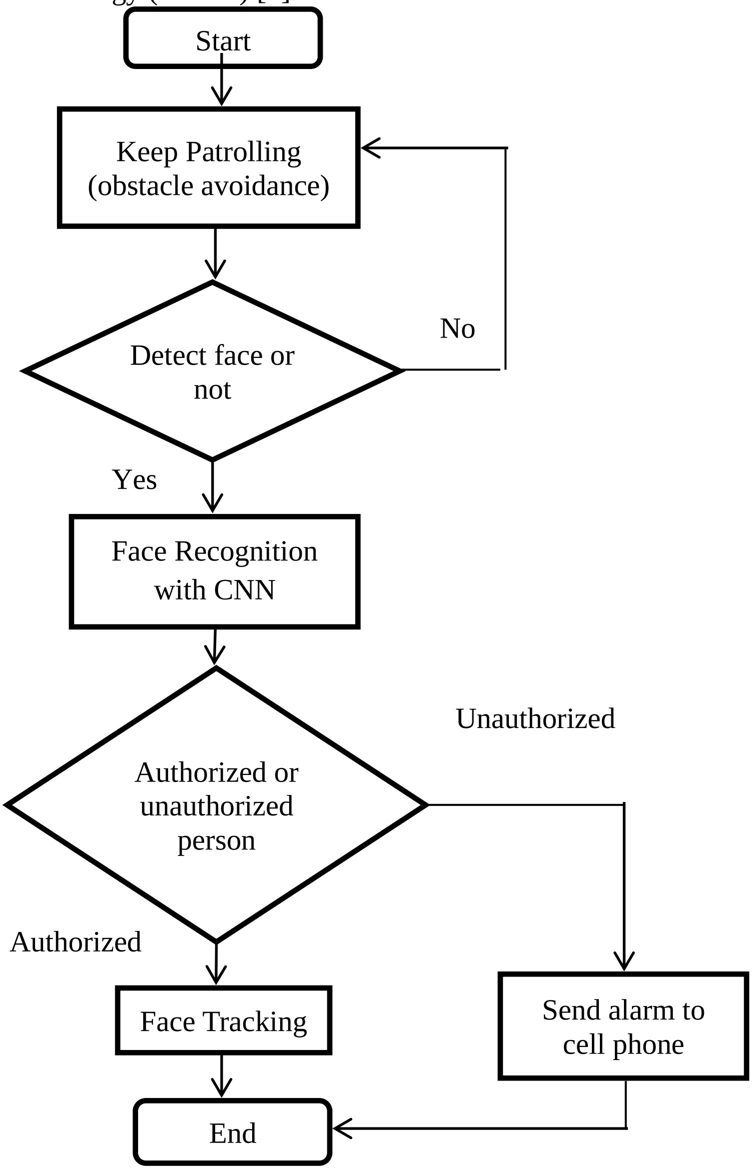

Fig. 1.1. Program Flow Chart

Leveraging chiefly open-source programming arising from the ROS robot operating system, a self-powered navigation framework for indoor handheld robots is demonstrated. A set of guidelines to nurture robot software entitled ROS demonstrates characteristics analogous to those employed by programs for robots. Many helpful characteristics, which comprise hardware inference, low-level device control, transmitted messages amongst processes, package management, and the implementation of commonly needed functionality, could be provided to visitors by it. These functions are generated for a heterogeneous computer cluster. Furthermore, it provides a wide selection of creation and debugging tools, it also serves as libraries essential to development environments [4].

The points that follow are the primary advantages of choosing surveillance robots over an immobile sensor network:

1. Extremely adaptable: The robots might have several types of sensors embedded in their ears, depending on the application.

2. Different assessment angles that would be problematic to monitor with a sensor network were rendered appropriate by robots.

3. It can be utilized in environments that could potentially consist of hazardous materials.

4. Easiest to make changes: Whenever sensor developments continue, it would be important to eliminate an important amount of sensors for the purpose of updating a wireless sensor network.

Various individuals and robots can join at any moment utilizing the facilities that has been shown here. An authentication and privileged entry mechanism is constructed for the reason that several people could track and work together with the robots.The system to figure out and replenishment low-level power sources was further developed because the robots have to work individually for a lengthy amount of time. An extremely fresh manuscript of this particular investigation, to concentrate on the utility of these apps, was presented. The specifics of this of the ultimate construction and the system's workings can be found in detail in this paper [5].

The article is broken down as follows: Section 3 will present an in-depth analysis of the robotic surveillance method; in Section 4, we observed our inquiries; in Section 5, we clearly explain and illustrate the robot's navigation, mapping, and scene processing; and in Section 5, we recommend an intelligent robotic system for indoor surveillance.

2. Related Works

[6] This article addresses the potential applications of a self-driving automobile, or ASV, for indoor environment monitoring and surveillance. The ASV's cause is to support an outsider by keeping a watchful eye on enormous rooms. It is suited to venturing underneath an organized indoor setting (such as a building) and accompanying moving personnel for these functions. If, in a rare instance a scenario unusual arises (such as anybody entering a permitted area), this ASV has a choice to follow a target object on its impulse or at the remote operator's suggestion. The ASV may be used to carry out additional surveillance operations encompassing facial identification and figuring out noteworthy prospects. Several investigations on indoor scenarios have proved that the recommended ASV accomplishes robust monitoring of the movement underneath the monitored scene. Subsequently, to accomplish a good identification of the movement entities and to detect them with enough perfection, the ASV manages the targets inside the pitch of vision. As a final point, the classification highlights a reasonable face-detection frequency for advance individual credentials.

[7] This analysis highlights the combined utilization of numerous individual disciplines targeted at the progress of an easily accessible, all-inclusive floor-cleaning robot. Robotics

design is evaluated and human compatibility with cleaning robots is studied, culminating in the decision that robot maneuver can—and quite definitely should—be differentiated from mankind. As an alternative, it might be suggested that cleaning robots adopt passive infrared sensors owing to safety risks. To lessen the user's engagement with the robot, a new battery recharge procedure is proposed in this design. An intriguing gain-controlled ultrasonic transducer is described to allow distance estimates preparatory at 15 cm. Trials establish an extremely high grade of precision while the spotting of small needles near the robot is also secured. Since merely a single demonstration robot was used to generate the odometry results published in this investigation, it is not conceivable to formulate any direct judgments concerning prospective industrial production. But leveraging purely the motor encoders in the user feedback loop, research results for this particular kind of acceleration highlight insufficient odometry errors; thankfully, the robot's twisting trajectory could cover up systematic odometry problems.

[8] In this investigation, we present an acceptable approach for recognizing objects and recognition based on real-time computer vision to perform well indoor navigation of an autonomous vehicle. When crucial action must be executed in real-time or in a split second, mobile robotic systems generally serve for surveillance, emergency services, and home encouragement. With reduced computing requirements and a slightly smaller weight size of the network structure, this proposed algorithm—which is based on a modified version of the You Look Only Once (YOLO) algorithm—improves object detection and recognition. Contrasting this recommended computer-vision-based conduct against different traditional object detection/recognition algorithms, multiple parameters have been reviewed, notably weight size, false positive %, mean inference time, and mean Average Precision (mAP) score. The pointed-out conduct has remained matched together with state-of-the-art approaches named Faster RCNN, RFCN, and YOLOv3. In contrast to other algorithms, the proposed method has the smallest weight size and a quick mean inference time. Additionally, its false positive percentage is equivalent to state-of-the-art algorithms. Our experiment's outputs suggest that the proposed approach effectively and reliably admits a significant number of the challenges. To enhance navigation reliability, we want to test the MAI in public locations with stronger proximity sensors in the future.

[9] The architecture and mental capabilities of an autonomous robotic system geared to operate in a deforestation location are discussed in this investigation. This development of robotic mechanisms that allow standalone movement and operation is an issue that requires to be explored in many professions, notably the forest industry. Solutions from an assortment of professions, comprising software engineering, mathematics modeling, sensors, mechanics, and AI algorithms, must be merged with all-around system construction. The primary advantages of the suggested method are that it can operate underneath both light and dark instances and in all weather conditions. It can be utilized as well to apply growth stimulants and fertilizers and accumulate systematic data on the condition of environments for animals and forests. The proposed algorithm's results are employed by the presented framework, which can be implemented in an extensive number of indoor navigation robot applications for multiple purposes. It also leverages the result of reliable object detection/recognition to benefit the mobile robot in operating in an indoor environment.

[10] An environment monitoring mobile robot featuring a remote control can be found in the present research. The buildup of the robot system has been illustrated and information

concerning the control hardware and mechanical system are additionally supplied. Through artificial control, this robot can relocate to the established geography. It may transfer realistic real-time environmental data, which can include pictures in tandem with other kinds of information including the robot's that exist location and destination or hazard distance. For our robot, wireless communication methods and WLAN were demonstrated to be a very reliable and successful selection. The robot can potentially be maneuvered and function remotely via the operator. This robot might provide an adequate foundation for making sure that the rescue operation is efficient. Furthermore, the PC utilized WiFi to retrieve the camera inspection images. Finally, the automation prototype was manufactured and trialed. Experiment conclusions of typical occasions approved its flexibility and reliability.

[11] In this paper, we analyzed the guide dog project's comprehension of moving object and traffic light recognizing. We put into a GoPro camera fitted to a mechanical dog to snap shots. The mainboard received the image data and scanned the object detection program employing Neural Compute Stick Movidius. We implemented a new method for estimating the direction of the moving object before utilizing MobileNet SSD to recognize the object that appeared in the image. Furthermore, the client processed commands generated by the mainboard via an Amazon Alexa voice technology. The specified framework's performance has been proved across experiments. Implementing your current implementation outside the property is essential. In the future, we seek to implement our strategy overseas to come up with more realistic conclusions for real-life situations. We will also test alternative recognizing objects methodologies that the Movidius platform is equipped with accommodating.

[12] Kopek is a potent mobile driverless robot for ground operations. Two speedy silver servo actuators have been utilized to drive this mobile robot. The bumblebee stereo vision sensor and Toshiba laser length finder are integrated for obstacle elimination. The platform is equipped with the same equipment and cameras as the outdoor ground vehicle. When the vehicle is in monitoring mode, a further monocular camera is mounted onboard to detect human faces and preserve them in a database. The obstacle avoidance technique and path planning are designed in object-oriented programming in C language. It integrates the PGR package and Intel open machine learning framework for stereo being processed, 3D point cloud synthesis, and face detection. The algorithm displayed outstanding productivity and real-time capability. It was able to spot and remain free of hurdles like furniture gemstones, etc. Employing a microcontroller to receive information or take control of a mobile robot's movement was one of the key requirements for automated machinery.

[13] This paper develops a ROS-based indoor robot VLP positioning package. The construction of the VLP component and the message transmission amongst different reasons ROS nodes will be described in detail. Apart from that, an excellent rolling shutter patterning LED-ID recognizer is brought forth. This scheme functions successfully for thresholding old-fashioned OCC as well in addition to remaining applicable for LED-ID recognition features. A Turtlebot 3 robot has been employed to evaluate a prototype system. The results indicate that the proposed method can provide robot indoor positioning exactness of fewer than one centimeter and a mean computation time of just 0.08 s. This study pushed advanced the development of VLP technology applications in machine learning and additionally developed a foundation for migrating to other ROS robot platforms, demonstrating the immense possibilities of VLC localization for indoor robot positioning.

3. Methods and Materials

The RGB steam data, Kinect RGB-D data, odometer data, and 2D laser data are the data feeds used by the robotic OS. Figure 3.1 demonstrates the construction of our chosen robot system structure. The robot is furnished with an advanced technology object observing module to recognize its natural setting. Aforward-looking offline speech acknowledgement and communicated diction system permits human-computer interaction. There are two reasons we implement the offline function. First of all, the robots could have trouble being permitted to make a connection to the Internet in different conditions. Besides, network quality usually has a significant effect on online service robots. A poor network quality will end up in an unpleasant experience for the user. As an additional feature, we developed a novel hybrid mapping strategy to yield a hybrid occupancy grid map and increase navigation function performance, built around a cloud-based speech recognition system API. Additionally, we implemented a novel strategy for path-planning and localization that's much improved than the default procedure parameter and is based on experience fine-tuning the robot. The local planner enhances the artificially created global path to ensure that the robot can comply with it. The Riviz tool can be leveraged to visualize the robot framework's output. Our outlined framework's additional information will be covered in the several sections immediately following.

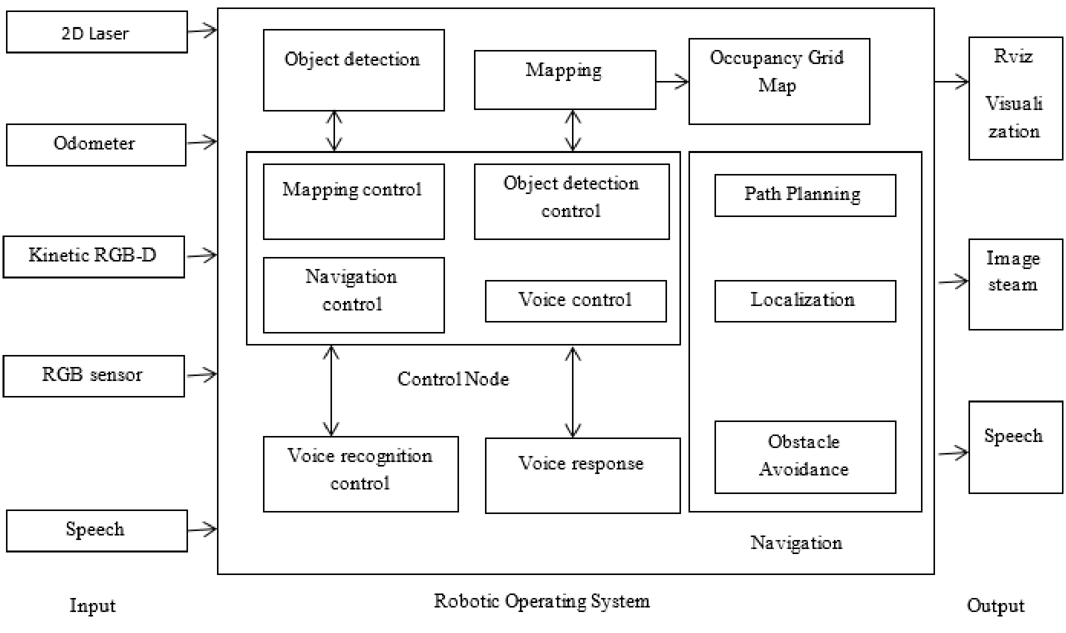

Fig. 3.1. Structure of the Suggested Robotic System

3.1 Recognition and sensitivity to voice

A great deal of mobile robots across operations features voice control. In noisy surroundings, a high-end voice recognition system will accurately recognize a user's voice. The speech systems that are nowadays in existence can be largely shared into dual primary categories: Online and Offline. The leading entrepreneurs of online speech systems are Microsoft Azure, Iflytek, Google Dialogflow, and Baidu. Often, an API is rendered readily accessible to use. When there is no connection and no network offered, an offline speech system is necessary. CMU Sphinx makes up one of the most respected offline speech systems. A phonetic dictionary, a mathematical model, and an acoustic model comprise several of the models in CMU Sphinx. Although robots only need to comprehend common phrases in just short batches, we expedited the experiment by utilizing dictionary files, language models, and pre-trained acoustic models.

We have to condition the models on our data for massive quantities of word appearances. Based on the established map, commonly referred to as the occupancy grid map, the robot is prepared to freely avoid obstacles. The best way to portray a map in 2D SLAM is to create a greyscale image with rectangles standing in for the location information. Grey pixels recommend unknown environment, black pixels indicate obstructions and white pixels symbolize free space. The normal planningtactic necessitates the use of a keyboard to teleoperate the robot, and collecting information with the Slam Gmap node to generate a map. To wrap up the navigation activity, the recordformerly stays in a file and reaches employing the AMCL firmware.

Ultimately, the organization accesses the odometer evidence held by the androidcorrupt and preserves it in a container. Nevertheless, it traditional method's disadvantages are that it demands a tedious procedure, and it struggles to greatest the markerargumentevidence whenever the drawing is being developed. It will necessitate greater duration for the user to put forth updating labeling information thereafter. Furthermore, the machine has to constantly start from the mapping starting point when it navigates to the target location to add labeling, which will end up in a certain degree of distance error in actual-world situations. In opposition to outdatedplotting strategies, we preserve that information in a MAP_{hybrid} container:

$$MAP_{hybrid} = \{< sem_j, topo_j, coor_j > | sem_j \in T, topo_j \in U, coor_j \in S^3\} \quad (1)$$

where T signifies the fixed of all topology nodes pertaining to the markerideas in the system, U refers to the implemented label name of all markerthemes in the system,$coor_j$ symbolizes the coordinate data at node j, and $\langle y, z, \vartheta \rangle$ represents the vector information of the grid points.

3.2 Localization

Our technique does not rely on any landmarks, in juxtaposition with robotic systems that do for self-localization and navigation. The procedure of navigation takes place by understanding the true circumstances. The Adaptive Monte Carlo Localization algorithm, an effective technique offered in the ROS AMCL platform for machine localization in a notoriousoccupancy grid map, is implemented for robot localization. Odometer and LIDAR scan data are analyzed by AMCL to decide on the robot's behavior. Integrating an IMU and a wheel odometer and obtain a more accurate odometer estimate for AMCL, an EKF/UKF can frequently referred to. The schematic diagram because of AMCL map localization is highlighted in Figure 3.2. This package functions best in tandem with SLAM gmapping.

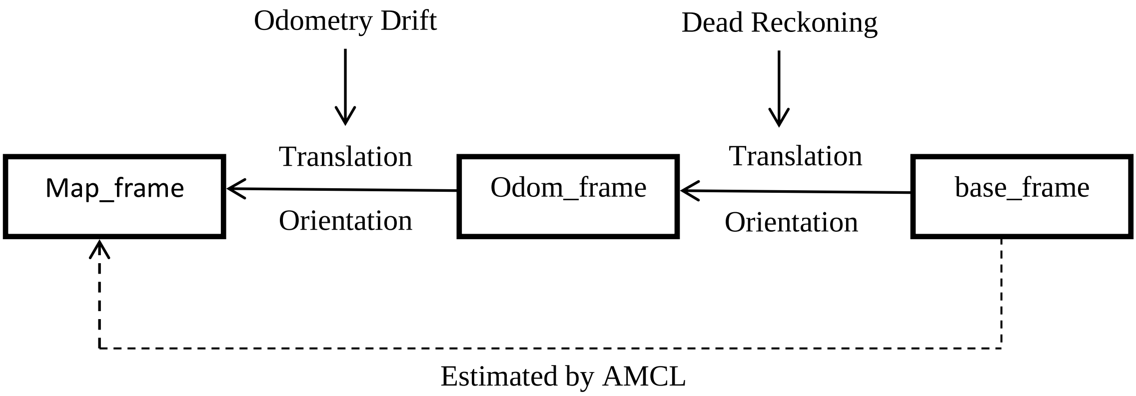

Fig.3.2. Schematic diagram of AMCLmap localization

When steering, the robot receives complete information from the Kinect and laser sensor to correlate with the settings on the static map. This delivers the robot's pose, which is comprised of both direction and location. The positioning methods depend on particle filtering. To acquire an accurate spinal alignment, the particles are first set up spanning a wide range of values. As the runtime increases, estimated errors lessen and the vast majority of the particles slip within a less wide range. Periodically, the particles suffer resizing in the form of several steps that are contingent on weights that are estimated based on the extent to which the authentic sensor data matched a predicted reading from each particle's assumed pose in the still map. The robot spot is obtained from the particle with the largest weight. Following that, the robot will go forward to its target while averting roadblocks. When integrated alongside AMCL, gamma mapping permits the robot to understand its atmosphere and concentratethemself. The robot can travel across the scheduled area to any destination besides effectively averting obstacles.

3.3 Path Planning and Optimization

One of the basic challenges regarding path planning for mobile robots is identifying a path free of encounters. This duty can be summed up as mapping a trajectory $y \in \mathbb{S}^{U \times o}$produced of robot configurations that are free of crashes. The target configuration and the existing configuration are interlinked by$y_u \in \mathbb{S}^{o}$. Meanwhile, this trajectory needs to be short sweet flawless, and sensitive to any conceivable robot differential constraints. Pathfinding and trajectory optimization have been the two main classifications into which trajectory planning algorithms drop. Discovering a path can be completed by employing fundamental search algorithms likeB^{*}Dijkstra on a netchart, which always represents a discretization of the circumstances. In cases where it relates to pathfinding in discrete domains, search algorithms are extremely efficient because they can rapidly identify the shortest path amid a start cell and a goal cell. Trajectory optimization is a substitute option for path estimation. Trajectory optimization requires determining a cost function g ensuring the optimal path y may be expressed as

$$y = \min_{y} g(y) \qquad (2)$$

It also indicates that trajectory optimization necessitates a well-defined cost function for the purpose to attain the envisioned optimum. In the majority of situations, more than just the cost function illustrates the path optimization problem due to the fact several needs have come together. These challenges may be the specific restraints applied to nonholonomic systems, or they could be implemented with the aim to limit challenges. The major drawback is commonly investigated as either equal or unequal treatment. If every individual of these obligations are considered into account, the issue with optimization for the path y can be phrased as

$$\min_{y} g(y)\ t.u.h(y) \leq 0, i(y) = 0 (3)$$

The scalar cost function$g: \mathbb{S}^{U\times o} \rightarrow \mathbb{S}$, the function $g: \mathbb{S}^{U\times o} \rightarrow \mathbb{S}^{e_h}$defined e_h inequality constraint functions, and the function $i: \mathbb{S}^{U\times o} \rightarrow \mathbb{S}^{e_i}$ defining e_i equality constraint functions are the three functions which the aforementioned language condenses all demands on a trajectory into.This implies that to generate the envisioned optimum, pathenhancement necessitates a accurate cost role. As several requirements have usually come together, the path optimization problem is often defined by more than just the cost function. These constraints can be implemented to avoid challenges or they can be the unique constraints of nonholonomic systems. Either equal or unequal treatment is the universal interpretation of a constraint. Assuming all these constraints are factored into consideration the optimization problem for the path y may be described as $c_y = \tau(u_y) + d_y, \tau(u_y) + d_y, c_x = q_x exp(u_x), c_i = q_i exp(u_i)$. The three outputs such as class loss, confidence loss and cbox loss are present in the YOLO v3.

$$cbox\ loss = \sum_0^o 1^{obj} * \left[\left(c_y - J_y\right)^2 + (c_z - J_z)^2 + (c_x - J_x)^2 + (c_i - J_i)^2\right] (4)$$

$$confidence\ loss = \sum_0^o LM(q_0, r_0) (5)$$

$$class\ loss = \sum_0^o 1^{obj} * \sum_{d=0}^{D} LM\big(q(d), r(d)\big) \quad (6)$$

where $J_y J_z$ is the truthful value and $c_y c_z$ is the projected result of the center coordinates. The envisioned bounding box's width and height have been assigned by $c_x c_i$ and the real value by $J_x J_i$. The existentassessment is r_0, while the assurance adhering entityrecognition can be expressed by q_0. The maximum number of categories is D. The realistic probability for each category is expressed by $q(d)$ and $r(d)$.

We incorporate the modest YOLO v3 model, which is centered on the Darknet example network, bearing into thought elements like the high requirements on GPU performance for recognizing things, motherboard portability, and power consumption. Employing merely nine convolutional layer combinations and six pools of layers, the "tiny" YOLO model is faster than the traditional YOLO model but less accurate. Keeping into thought each one of these elements, speed should be gained at cost of accurate recognition accuracy [14].

4. Implementation and Results

Numerous challenges substantially hinder conventional surveillance, notably unequal points of view and objects that might possess similar looks. Additionally, the preciseness of face recognition will be greatly influenced by major shifts in posture and illumination. Despite the fact the majority of investigations have taken place in static circumstances, image recognition is more unpredictable if an encrypted robot is in operation. The persistence of this industry is to theory a graphicalproof of identityequipment on a observation robot that can acknowledge certain people while on patrol in various lighting situations and various stances and could differentiate between a target who demands to be tracked and a human being who is questionable.

The LiDAR sensor module is paired with the patrol sections of the safekeepingmachine to conveyself-governingcourse plotting and obstacle avoidance. Many researchers have proposed different techniques to progress image recognition to tackle the factors mentioned above. These variables comprise the Lambert reflectance strategy, TBE-CNN, which removes structures from spotsprocured around makeovermodules, deep DSN, a face recognition approach designed around a directional histogram of oriented gradient, and sphericalproportioned Gabor filter 2D PCA neural networks. Two CCD cameras and Faster R-CNN were utilized in the research, and the average recognition rate for all six unique illumination and occlusion circumstances was 97.33%, by the results. The DSN face recognition method was presented; the experimental results displayed that, if compared to 8 distinct techniques, the mean rate of facial identification of the DSN algorithm is 92.0% under numerous exposures and postures, which is better than other algorithms, under 20 sunlight changes and 6 different angle changes.

In the disciplines of obstacle avoidance and robot navigation, other scholars have further proposed SLAM solutions. The idea put forward envisioned stereo visual-inertial LiDAR (VIL) SLAM; research results demonstrated that the absolute trajectory error, or ATE, is less than 0.3 meters. A picture intriguing point-and-line characterized by features 2D LiDAR SLAM was proposed; the evaluation observations demonstrated an average absolute mapping error around about 5 percent. A declared visual-inertial SLAM was identified. The experiments conducted shown that the estimated SLAM's absolute trajectory of the root-mean-square error is less than 0.1 m, which is better than conventional techniques when compared to ORB-SLAM (oriented fast and rotated short) and OKVIS (open keyframe-based visualinertial SLAM). Soon after acquiring face photos under different environments using the Viola-Jones appearanceexposure algorithm, three CNN models—AlexNet, VggNet, and GoogLeNet—were trained.

The average face recognition accuracy underneath these four brightnessbackgrounds is 0.95,0.95, and 0.6. Under a 15-degree perspective, the accuracy is 0.39, 0.7, and 0.63, in that sequence. The Hector SLAM algorithm and ROS navigation stack were employed to boost a mobile robot's navigation and obstacle avoidance, permitting it to simultaneously discover elements and generate a map. In the first indoor environment, the illustrating error's root mean square error (RMSE) was 0.134 m (0.957%), whereas, in the subsequent indoor circumstances, it was 0.222 m (0.653%). The sequence of events for the experimental setup is illustrated in Figure 4.1.

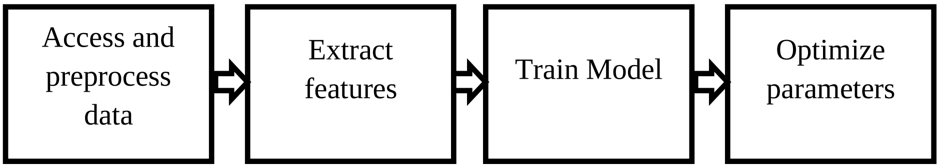

Fig. 4.1. Experimental workflow diagram

4.1 Face Recognition and CNN Model Development

The Haar-like feature algorithm's face detection was tested in an indoor room setup in the first experiment. The compilation of human face images under multiple times illumination parameters could be accomplished by modifying the illumination. Six fluorescent lamps, each with 20 watts, had been placed in the scene: three of the lamps were situated directly above the target, and a further three were situated above it. Six lights in total, resulting in 120 watts, are depicted in the top left figure; three lights in total, encompassing 60 watts, are presented in the top right figure; three lights in total, with a value of 60 watts, are illustrated in the bottom left figure; along with the bottom right figure reveals that all of the lights are off. Images of four separate types of illumination transforms were obtained. Preprocessing must be performed whenever the face photographs have been collected.

Each of the images of the individuals was first removed from any inconsistencies, then cropped applying the Viola-Jones methodology, and then compressed to a predetermined dimension. The GoogLeNet photographs were diminished to 299 × 299, and the pics for the AlexNet and VggNet models needed to be compressed to 224 × 224. Each goal was pre-prepared for 200 images in total, containing four categories of illumination adjustments and five authorized and five unregistered users in each image. The three separate CNN design concepts of AlexNet, VggNet, and GoogLeNet were constructed making use of the Keras model class, and machine learning was later applied using the sk-learn toolkit. In both cases, the SGD optimizer and the cross-validation method's machine learning model were implemented right after the savings of the face screenshots into 2 separate records, the two folders' tags were set.

The training circumstances were created pursuing the finished product of the labeling. The default settings for the training data comprised 70%, the test data was 50%, the evidence for validation was 30%, the batch size was 20, the acquisition rate was 0.001, and the dropout parameter was 0.5. The models are put together after the parameters are set, training starts with and ultimately the trained CNN model is produced. The epoch to perfection and epoch period to loss of three CNN algorithms are highlighted in Figure 4.2 and Figure 4.3. Table 1 illustrates a comparison of the three CNN models' parameters. The outcomes of the experiment revealed that AlexNet had the lowest execution time and the fewest parameters. GoogLeNet is in the center of the floor, with VggNet obligating the most time and possessing the most parameters. Whereas, the Table 2 given below shows the Metric comparison via various illuminations**.**

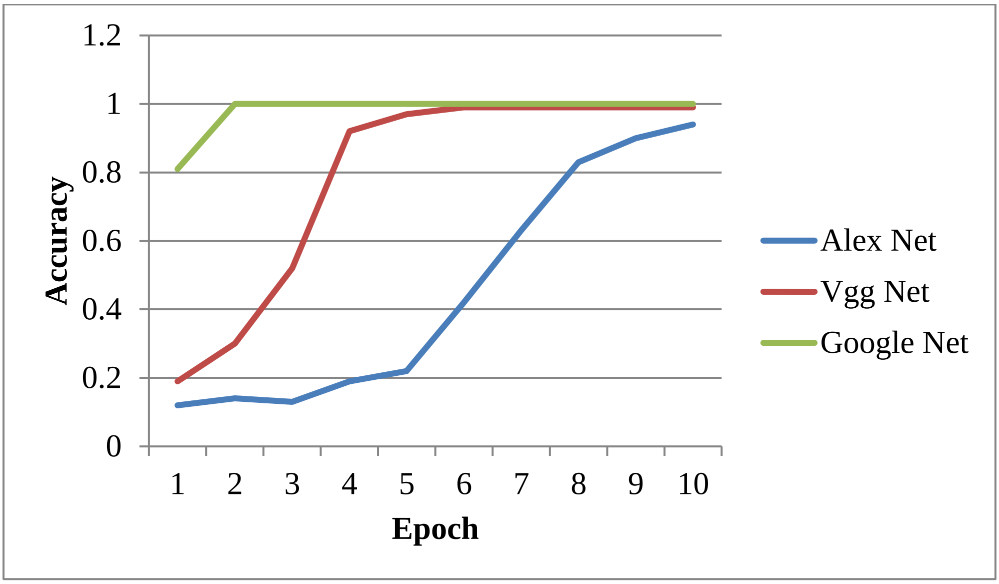

Fig. 4.2.Three CNN Models' Accuracy-Epoch Charts Are Presented

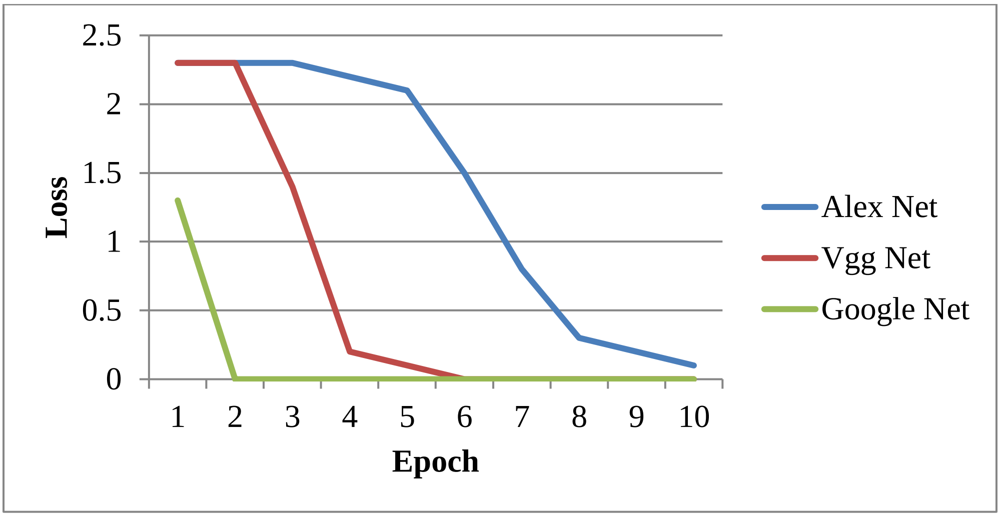

Fig. 4.3: CNN models' loss-epoch Curves

Table 1. Training Parameters across three CNN Models

Description	**AlexNet**	**Vgg Net**	**GoogLeNet**
Total stratum	9	17	23
Convolution sheet	6	14	22
Pooling film	4	6	6
Fully connected film	4	4	2
Constraints	63499465	120507897	24962895

Training Precision	0.888	0.889	0.988
Cross Entropy Loss	0.13	0.007	0.005
RMS Error	0.1	0.09	0.08
Preparationstretch	23 min	211 min	121 min

4.2 Testing Systems inside an Unstable Environment

A wide range of perceptual algorithm inspection indicators, which included the CNN model's rapidity, reliability, complication ROC curve, recall and preciseness rate, P-R curve, and F1-score, have been utilized for the model verification segment. The confusion matrix, involving the true affirmative rate, counterfeit negative pace, false positive rate, and true negative rate, is first obtained.

Table 2.Metric Appraisal Via Various Lightings

Measurement	**AlexNet**	**Vgg Net**	**GoogLe Net**
Accuracy	0.96	0.96	0.61
Correctness	1.01	0.98	0.70
Reminiscence	0.91	0.94	0.36
F1 score	0.95	0.96	0.46
Sensitivity	0.91	0.94	0.36
Specificity	1.01	0.98	0.87

To analyze the recognition rate under multiple reasons thresholds, the ROC curves and P-R contours of three CNN approaches pursuant to four brightness discrepancies have been generated. After that, further investigation was performed on the ROC curves to calculate the AUC. Table 3 evaluates a variety of alternate models. The experiment's determinations confirmed that VggNet and AlexNet maintain their significant rate of recognition in a wide range of lighting scenarios. The AUC will differ considerably under four illumination distinctions given that GoogLeNet has inadequate registration rates depending on lighting situations. The ROC curves of three unique CNN models are put on display under varied view points in Figure 4.4 below [15].

Table 3. AUC Comparison for Different Lighting Situations

Radiance	**AlexNet**	**VggNet**	**GoogleNet**
Illumination 1	1.01	1.01	0.85
Illumination 2	1.01	1.01	0.85
Illumination 3	0.97	0.98	0.83
Illumination 4	0.88	0.91	0.77

Average	0.97	0.98	0.88

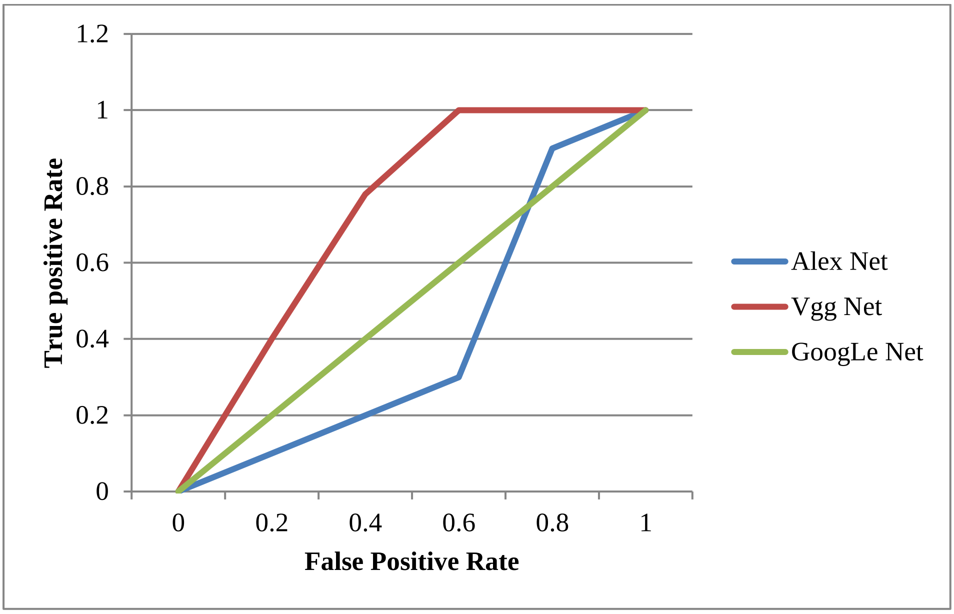

Fig. 4.4. The three CNN models' ROC Curves From Multiple Perspectives.

5. Conclusion

This paper talked about a robotic surveillance system. If there happens to be an immediate shift in the scene, it uses information from several sensors to trigger an alarm. More specifically, the system's every field architecture was laid out. To execute robotic site monitoring assignments we presented the integration and incarceration of several self-driving maneuvering and observation capabilities on a multisensor mobile robot. The main aim of the research project was to showcase the suitability of the recommended methods in actual-life situations by presenting an extensive system overview and empirical results in real-world situations. We showcased our autonomous mobile robot completion, which bases itself on the ROS system. We recommended an upgraded hybrid approach that blended the robot's inherent object recognition with a mapping strategy. Easily operated using voice, the robot comes with an embedded voice recognition system. Despite employing two-stage methods, we suggest using a state-of-the-art little YOLOv3 model for object detection. We recommended installing a four-port USB 3.0 hub to bridge four VPUs in parallel to enhance object recognition capabilities while spending less electricity. The current inquiry employed the use of three CNN models: AlexNet, VggNet, and GoogLeNet. Accuracy, accuracy, remembrance, sensitivity, specificity, F1-score, ROC curve, AUC significance, and P-R curve are only a few of the evaluation statistics. The experiment's initial stage involved gathering snapshots of people's faces in different levels of lighting conditions and then applying those to train three CNN models. In the intervening time, the real-world robot platform was currently implemented using all of the algorithms. The instances expressed the positive outcomes and characteristics of our initiatives. An immense indoor mall with significant traffic, government opportunities with a fixed service window, an academic building or hospital with a fixed door number, alongside other circumstances requiring robot services can all be managed by the described integrated system. Pairing the object detection observations with the move base package's cost map is a single approach to managing this dispute and diminishing the influence of the dynamic challenges. Additionally, the overall experimental result's accuracy was not adequate as a result of the device sensor's shortcomings. In the future, to further boost environment sensing and navigation, we are required to produce a 3D map employing a 3D laser sensor. These challenges will also direct forthcoming research initiatives.

References

1. Papoutsidakis, M., Kalovrektis, K., Drosos, C., & Stamoulis, G. (2017). Design of an autonomous robotic vehicle for area mapping and remote monitoring. *Int. J. Comput. Appl*, *167*(12), 36-41.
2. Luo, R. C., Hsu, T. Y., Lin, T. Y., & Su, K. L. (2005, July). The development of intelligent home security robot. In *IEEE International Conference on Mechatronics, 2005. ICM'05.* (pp. 422-427). IEEE.
3. Panigrahi, P. K., & Bisoy, S. K. (2022). Localization strategies for autonomous mobile robots: A review. *Journal of King Saud University-Computer and Information Sciences*, *34*(8), 6019-6039.
4. Noh, S., Park, J., & Park, J. (2020, October). Autonomous mobile robot navigation in indoor environments: Mapping, localization, and planning. In *2020 International conference on information and communication technology convergence (ICTC)* (pp. 908-913). IEEE.
5. López, J., Pérez, D., Paz, E., & Santana, A. (2013). WatchBot: A building maintenance and surveillance system based on autonomous robots. *Robotics and Autonomous Systems*, *61*(12), 1559-1571.
6. Micheloni, C., Foresti, G. L., Piciarelli, C., & Cinque, L. (2007). An autonomous vehicle for video surveillance of indoor environments. *IEEE Transactions on Vehicular Technology*, *56*(2), 487-498.
7. Palacin, J., Salse, J. A., Valgañón, I., & Clua, X. (2004). Building a mobile robot for a floor-cleaning operation in domestic environments. *IEEE Transactions on instrumentation and measurement*, *53*(5), 1418-1424.
8. Singh, K. J., Kapoor, D. S., Thakur, K., Sharma, A., & Gao, X. Z. (2022). Computer-vision based object detection and recognition for service robot in indoor environment. *Computers, Materials & Continua*, *72*(1).
9. Galaktionov, O., Zavyalov, S., Shchegoleva, L., & Korzun, D. (2021). Features of building a forestry intelligent robotic system. In *Proc. 29th Conf. Open Innovations Association (FRUCT)* (pp. 433-436).
10. IshratZahanMukti, EbadurRahman Khan, and Koushik Kumar Biswas, “1.8-V Low Power, High-Resolution, High-Speed Comparator With Low Offset Voltage Implemented in 45nm CMOS Technology”, JVCS, vol. 6, no. 1, pp. 19–24, Dec. 2023.
11. Li, H., Li, B., & Xu, W. (2015, August). Development of a remote-controlled mobile robot with binocular vision for environment monitoring. In *2015 IEEE International Conference on Information and Automation* (pp. 737-742). IEEE.
12. Chen, Q., Chen, Y., Zhu, J., De Luca, G., Zhang, M., & Guo, Y. (2020). Traffic light and moving object detection for a guide-dog robot. *The Journal of Engineering*, *2020*(13), 675-678.

13. Shaikh, M. H., Kosuri, K., Ansari, N. A., & Khan, M. J. (2013, March). The state-of-the-art intelligent navigational system for monitoring in mobile autonomous robot. In *2013 International Conference of Information and Communication Technology (ICoICT)* (pp. 405-409). IEEE.
14. Guan, W., Chen, S., Wen, S., Tan, Z., Song, H., & Hou, W. (2020). High-accuracy robot indoor localization scheme based on robot operating system using visible light positioning. *IEEE Photonics Journal*, *12*(2), 1-16.
15. Cao, L., & Zhu, X. (2020, April). An autonomous service mobile robot for indoor environments. In *2020 Asia-Pacific Conference on Image Processing, Electronics and Computers (IPEC)* (pp. 8-15). IEEE.
16. Lee, M. F. R., & Shih, Z. S. (2022). Autonomous surveillance for an indoor security robot. *Processes*, *10*(11), 2175.