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Warehouse Automation System

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Abstract: ***This paper focuses on automating a warehouse in which various forklifts are controlled manually for moving package in various shelves. We analyzed the various tasks and suggest a new system for automation of warehouse. The proposed system provides a good interface for the controller to handle all tasks from a single workstation. It also focuses on the efficient and smooth handling of packages in the warehouse. The risk of accidents and fatigue of the worker is also reduced in this scenario. The proposed system is faster than the conventional warehouse. The warehouse is completely operated automatically and presence of external object is prevented which minimizes the chances of accidents and the whole system works smoothly. It also benefits the business as human resource is reduced and machine can work regularly with proper maintenance.***
Keywords: Forklift, LiDAR, Controller, Main-controller, Automation

I. INTRODUCTION

All the forklifts are manually controlled by workers in the warehouse. The driver in the forklift are assigned task from main workstation. It is up to the driver to decide its route and perform the given task. The Task includes various commands like bringing, storing, rearranging a package in the racks of the warehouse. In order to automate the process, we need to automate the controls of the forklift, by replacing the role of driver with a controller on the forklift. Controls like, moving forward, backward, taking a turn, etc., needs to be operated using the controller on the forklift. Further, path finding algorithms are applied to decide the path taken. Various other sensors are also used to ensure that forklift doesn't collide if any obstacle or another forklift accidently blocks its path.

II. SENSORS AND DEVICES

A. LiDAR

LiDAR (Light Detection And Ranging) is a device that uses light to measure the distance of objects. It illuminates target with pulsed laser light and measures the reflected pulse with sensor. The Laser return time and wavelength are used to calculate the distance. The LiDAR is mounted on forklift and distance of all obstacles around the forklift is passed to controller.
In case, any object is close to forklift and tends to collide with it, the controller stops the vehicle, preventing any accident. It consists of rotating head with an emitter and receiver. As the head rotates it sends distance and angle with respect to its position to the controller.

B. Potentiometer

Potentiometer is a three-terminal register with a rotating head, which provides voltage based upon the number of turns of the head. Potentiometer is mounted on the frame which is connected to the pulleys. According to the size of the crates, the arms of the forklift get adjusted, and the number of rotations done by potentiometer provides us with the distance between arms.

C. RFID

RFIDs (Radio Frequency Identification) is a technology whereby digital data encoded in RFID tags or smart labels are captured by a reader via radio waves. RFID cards are used to get access to the system.

D. QR Code

QR (Quick Response) Code is used to quickly communicate data with system by just scanning it. The QR codes are pasted all over the floor in the warehouse for guide the forklift to the destination. The QR code provides coordinate details to the forklift at that position.

E. Raspberry Pi

The raspberry pi acts as a controller on the forklift. It is further controlled by master controller in the main workstation. The master controller assigns task to the controller. All the actions by the forklift are controlled by the controller. The controller collects various data from the sensors and commands the forklift to the destination.

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III. COMPONENTS

A. RFID Card

RFIDs (Radio Frequency Identification) is a technology whereby digital data encoded in RFID tags or smart labels are captured by a reader via radio waves. RFID cards are used to get access to the system.

B. Warehouse Environment

The warehouse consists of stationary racks and moving forklifts. It is necessary for the forklifts to identify various elements in the surrounding in order to complete its task successfully. The floor is marked with QR codes in a grid with its coordinate details in the warehouse. The racks are at definite positions which are already known to the master controller.

C. Forklift

The forklift is the only controlled moving entity in the warehouse. It can move forward, backward and turn at various angles. Apart from this locomotion, it has two parallel arms which can move up and down, close and farther.

Sensors are used to provide the precise data of each element to the controller. All the actions by the forklift are operated by the controller.

D. Controller

It operates the forklift in the warehouse. It commands all the movement, and monitors the performance. Its prime focus is to prevent any accident. This is ensured by accurately monitoring the data received from the sensors and performing each step precisely. The various subtasks of picking up a package and dropping it at a location is done by the controller itself.

E. Charging Station

The charging station is connected with power supply which provides power to the whole system and used for charging the forklift batteries. The station is fully automatic, having multiple sockets to charge the forklift in parallel.

F. Master Controller

The master controller is operated by a worker in the main workstation. It assigns tasks to each forklift in the warehouse and keeps track of each movement of the forklift. Firstly, it ensures that each forklift is fully charged for upcoming tasks. As soon as a card is waved, the task from the database is fetched.

Now, a forklift is chosen based upon its distance from the starting point of the task and battery level. The path taken in decided here, considering other forklifts that may cross its path and their positions to prevent any accident. In case of any unexpected behavior in the warehouse, the master controller is capable of stopping all currently executing task and hold each vehicle at their place.

IV. PROPOSED SYSTEM

The warehouse is automated and limits the human intervention till waving an RFID card for each task to initiate. The moment card is read by the master controller a series of automated steps takes place.

Firstly the main controller fetches task from the database and a forklift is assigned to for the task. The forklift is chosen based upon their battery level and distance from the starting point of task. Then, path-finding algorithm is applied to get suitable path for the task.

The path details, pickup and drop points, are sent to the chosen forklift. The controller reports its status to the main controller at regular interval.

The main controller based on the inputs from the controllers, monitors each movement in warehouse.

The GUI attached to main controller provides whole information regarding the current locations of forklifts and stats about their performance. The main controller is monitored by a user using this interface.

This provides a central access to the entire warehouse.

During idle time the forklifts are sent to charging stations and wait until new task is assigned to them. The measure for preventing collision is already taken during path finding step.

In case, there is possibility of accident in current scenario then the master controller can modify the path details to prevent the accidents.

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A. Our Proposed Architecture Is

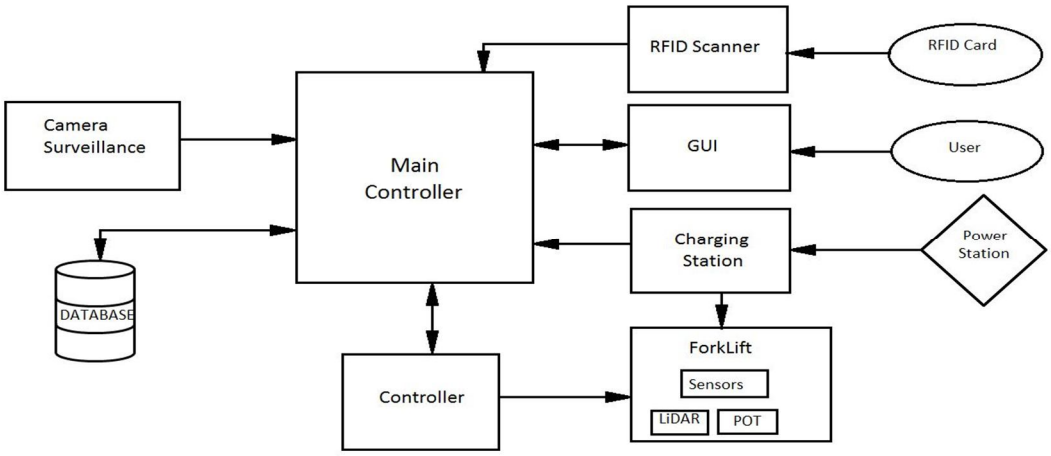


Fig. 1 Proposed Architecture

V. PATH FINDING

The path needs to be chosen considering the distance to travel and time taken to travel. The task of allotting path to controller is with the main controller. Blind search and A* algorithm are used for path finding. The best of both is chosen for the task. Both algorithms have their own advantages and limitations. Thus, comparing their results and choosing the best one smart way out.

A. Blind Search

This technique is based upon evaluating every step based upon distance from the target. It keeps on moving until an obstacle is detected. If an obstacle is detected it has to move around it to get to the target.

The evaluation process is as follows

$abs[(e_x - t_x) + (e_y - t_y)]$,

here, (e_x , e_y) is coordinates of entity and

(t_x , t_y) is coordinates of the target.

There are few limitations of this search that it may get trapped in a closed loop. It may also provide a complex path for which other algorithm can provide a much simpler path.

B. Optimized A Algorithm*

The A* algorithm works based on heuristic. The classification is done by a binary heap. All squares near it are evaluated in eight directions. The evaluating function is defined as $f(x) = g(x) + h(x)$, here, $g(x)$ is the cost required to reach the next step and $h(x)$ is the cost from next step to the target.

The algorithm maintains two list, OPEN and CLOSED list. The OPEN list contains all the unvisited steps and closed list includes the visited steps on the map.

The algorithm is efficient enough for path-finding and provides good results. But in some cases the result can be optimized to get better output. A comparison is shown below:

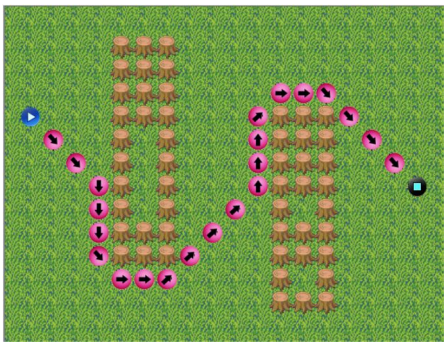


Figure 2. Non-Optimized

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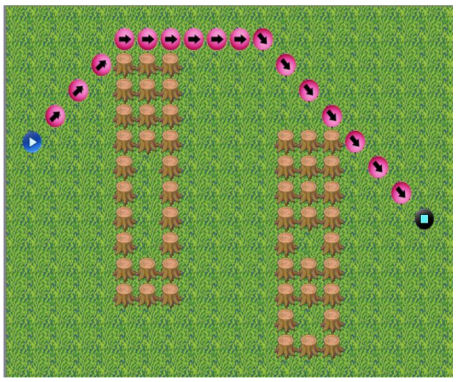


Figure 3. Optimized

VI. CONCLUSION

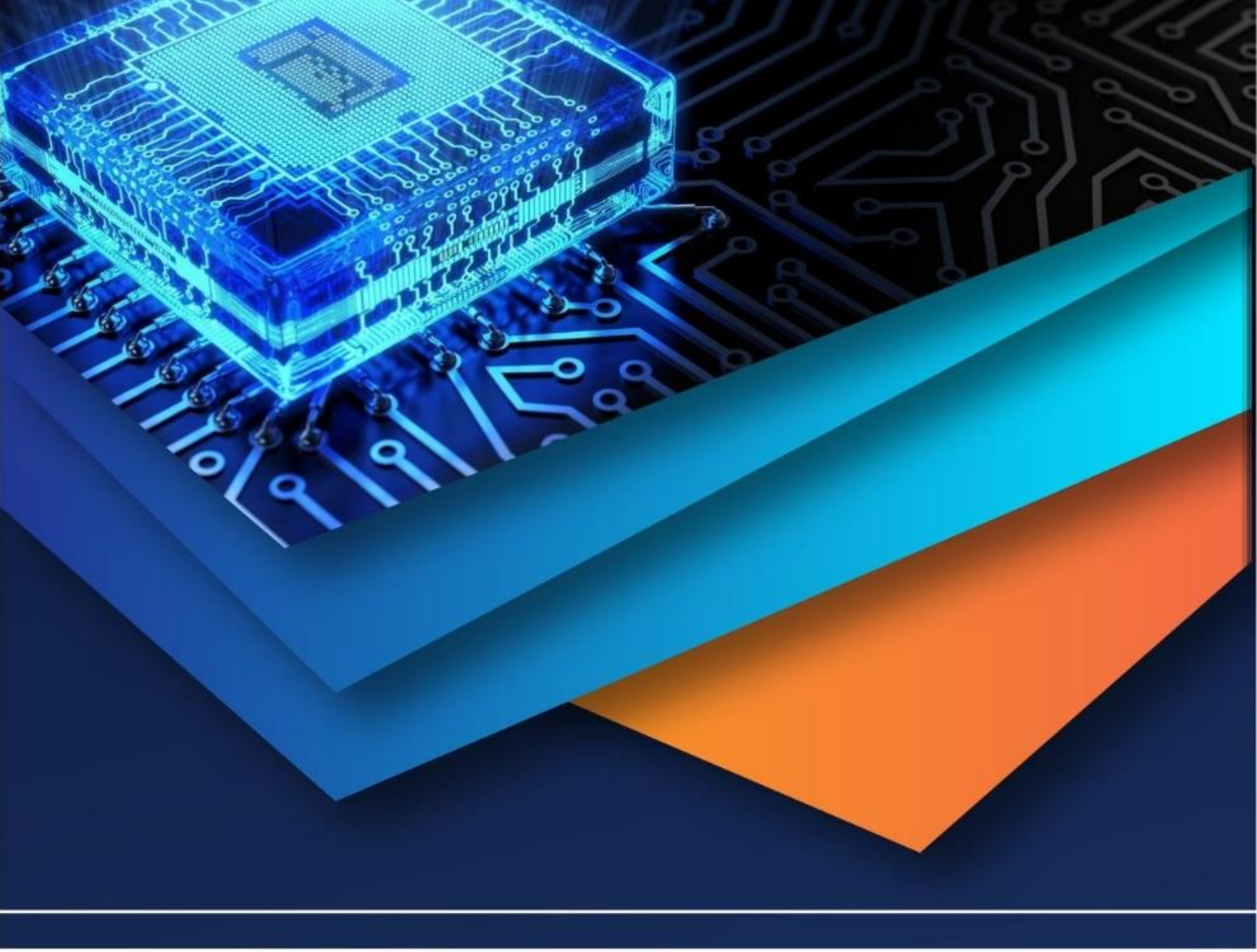
The proposed system is developed to provide automation in the warehouse. The system will reduce the workload of the workers in warehouse and manpower required to perform the task. Also, the automated system can work efficiently for long hours. The chances of accident are reduced with planned path for the forklifts. Moreover, it fastens the process of handling the task at each step with precise movement.

The speedup of the existing system and cost reduction motivates the businessmen to implement this system in their warehouse. The system also provides them central access of whole warehouse. Very few workers are required for operating it and only maintenance is required periodically.

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