

Digital Image Processing Enabled Autonomous Electric Vehicle

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Abstract: This paper presents a factory supply autonomous electric vehicle designed for indoor material transport in a controlled industrial environment. The vehicle uses digital image processing to follow a predefined path inside the factory. An object detection model trained in Edge Impulse is added to detect obstacles and improve safety during movement. A robotic arm with a gripper is included to load and unload materials automatically. The vehicle also supports voice control, so a user can give a command such as “Line 1 supply need,” and the system will move to that location and unload the material. Since the system is made only for factory use, it is not intended for public road driving. This project helps reduce manual work, improve delivery speed, and support automation in factories.

I. INTRODUCTION

Automation is becoming very important in modern industries because it reduces manual work and improves productivity. In factories, materials must be moved from one place to another regularly. This task is usually done by workers or manual carts, which can take time and effort. A small autonomous electric vehicle can make this process easier and faster.

In this project, the vehicle is designed for factory use only. It follows a fixed path inside the factory using image processing. It can also detect objects in its path using an object detection model made in Edge Impulse. In addition, a robotic arm is used to handle loading and unloading automatically.

Voice control makes the system more user-friendly. A worker can simply say a command like “Line 1 supply need,” and the vehicle will go to that line and unload the supply. This makes the system useful for factory automation where quick and accurate supply movement is needed.

II. PROBLEM STATEMENT

In many factories, material transport still depends on manual effort. Workers must move supplies from one section to another, which increases workload and slows down the process. Manual transport can also lead to errors, delay, and fatigue.

A simple line-following vehicle alone is not enough for a smart factory. It should also detect obstacles, respond to spoken commands, and handle loading and unloading automatically. Therefore, a better solution is needed that combines navigation, object detection, voice control, and robotic handling in one system.

III. OBJECTIVE

The main objective of this project is to develop a factory supply autonomous electric vehicle that can move by itself inside a factory and deliver materials to the required line.

The project also aims to:

- follow a predefined path using digital image processing.
- detect obstacles using an Edge Impulse object detection model.
- load and unload materials using a robotic arm.
- accept voice commands for destination-based delivery.
- reduce manual effort in factory transport.

IV. EXISTING SYSTEM

The existing system in many factories uses manual carts or human-operated vehicles to move materials. In some cases, simple line-following robots are used, but they are limited because they cannot detect obstacles properly or respond to voice instructions.

Some advanced systems use expensive sensors or complicated control methods. These systems are not always suitable for small or medium industries because of cost and complexity. Also, many of them still need human help for loading and unloading.

Disadvantages of Existing System:

- Manual transport needs more labour and time.
- Basic line-following systems may fail when an obstacle appears.
- Many systems do not support automatic loading and unloading.
- Sensor-based systems can increase cost and maintenance.
- Existing systems are not always flexible for voice-based factory operation.

V. PROPOSED SYSTEM

The proposed system is a smart factory supply autonomous electric vehicle that combines image processing, object detection, voice control, and robotic arm operation.

The camera captures the path ahead, and image processing is used to identify the route. The Edge Impulse model is used to detect obstacles. A robotic arm is attached to the vehicle so that it can lift and unload materials automatically. Voice input is used to tell the vehicle where to go. For example, when the command “Line 1 supply need” is given, the vehicle moves to Line 1 and unloads the supply there.

This makes the system more useful for industrial automation because it can perform transport tasks with less human intervention.

VI. BLOCK DIAGRAM

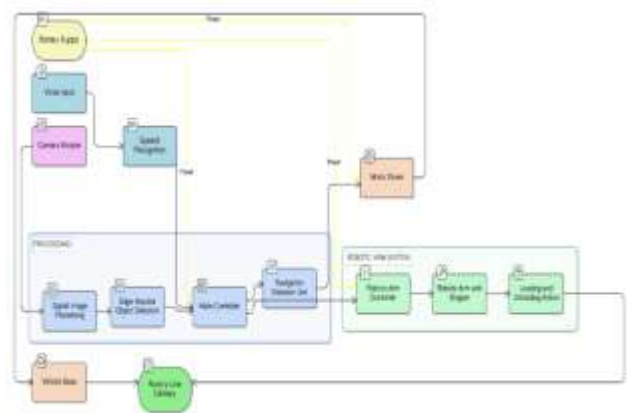


Figure 1: block diagram of the proposed system.

The working process begins when the user gives a voice command such as “Line 1 supply need.” This command is received by the voice input unit and converted into a digital instruction by the speech recognition block. The main controller reads this instruction and decides the destination line for material delivery. At the same time, the camera module continuously captures the forward view of the path. The captured images are processed using digital image processing techniques to detect the guiding line and maintain proper vehicle movement. In parallel, the Edge Impulse object detection module checks for obstacles or unexpected objects in the route. If an obstacle is detected, the controller can slow down or stop the vehicle to ensure safety. Based on the path information and obstacle status, the navigation decision unit sends control signals to the motor driver, which moves the vehicle base toward the required factory line. After reaching the destination, the robotic arm controller activates the robotic arm with gripper to perform automatic loading and unloading of the supply. The robotic arm places or releases the material at the correct location and then returns to its standby position. The battery supply provides power to all major parts of the

system, including the controller, camera, motor driver, object detection unit, and robotic arm. This integration of voice control, vision-based navigation, obstacle detection, and automatic material handling makes the system suitable for smart factory supply automation.

VII. WORKING PRINCIPLE

The vehicle starts when a voice command is given. The command is recognized and converted into a destination instruction. After that, the vehicle follows the path using camera-based image processing.

While moving, the object detection system checks for any obstacle in front of the vehicle. If an object is detected, the vehicle can slow down or stop for safety. Once the vehicle reaches the correct line, the robotic arm is activated, and the material is unloaded automatically.

This working process makes the vehicle suitable for controlled indoor factory movement.

VIII. METHODOLOGY

• Image Acquisition

IX. MECHANISM USED

The recommended mechanical and control arrangement for this project is shown below in the table:

Sub System	Recommended Mechanism	Reason
Vehicle movement	Differential drive with two powered wheels and caster support	Simple indoor turning and control
Path navigation	Camera + image processing	Low-cost structured-route guidance
Safety detection	Edge Impulse object detection	Real-time obstacle awareness
End effector	Servo gripper	Suitable for light factory supplies
Voice input	Microphone + voice recognition module/software	Converts spoken commands into control signals

Table 1 shows the recommended mechanical and control arrangement for the proposed factory supply autonomous electric vehicle. It lists the suitable mechanism for each subsystem and gives the reason for selecting it. The table supports the proposed design by explaining why differential drive, camera-based navigation, Edge Impulse object detection, robotic arm manipulation, voice input,

A camera is fixed on the vehicle to capture the factory path and surroundings.

• Path Detection

The image is converted into grayscale, filtered, and processed to find the guiding path.

• Object Detection

An Edge Impulse model is used to detect obstacles or other objects in the vehicle's route.

• Voice Command Processing

The user gives a command using voice, and the system converts it into a destination instruction.

• Robotic Arm Operation

The arm picks up or releases materials using a gripper mechanism.

• Motor Control

The motors move the vehicle forward, backward, left, or right according to the controller output.

and embedded supervisory control are suitable for this project.

X. TESTING AND RESULTS

The system can be evaluated in four stages:

- Voice recognition accuracy for commands such as "Line 1 supply need."
- Path-following accuracy along the factory route.

- Object detection performance from the Edge Impulse model.
- Robotic arm unloading success at the target station.

Figure 2: validation result of the Edge Impulse object detection model. The result includes the F1 score, confusion matrix, precision, and recall values, which indicate the performance of the trained model.



Figure 2: Validation results of the Edge Impulse object detection model.

Advantages

- Enables hands-free supply requests through voice commands.
- Reduces manual loading and unloading effort through robotic arm integration.
- Improves indoor delivery automation in factories and warehouses.
- Adds obstacle awareness through object detection.
- Combines mobility and manipulation in one intelligent system.

XI. CONCLUSION

The proposed system extends a basic factory autonomous vehicle into a complete smart material-delivery platform by integrating voice control, object detection, and robotic arm-based handling. This combination allows a worker to request supplies verbally, enables the vehicle to navigate safely to the required line, and automates unloading at the destination.

For your project, the most appropriate mechanism is a differential-drive mobile base with a 4-DOF robotic arm and servo gripper, controlled by an embedded processor that connects speech input, vision processing, and actuation. This makes the design practical for a student-level factory automation prototype.

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