



# Vision Based Hand Gesture Control of Dobot Magician

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**ABSTRACT:** Human–robot interaction is an important area in modern robotics, where intuitive and efficient control methods are required for operating robotic systems. Traditional robot control approaches usually depend on keyboards, controllers, or manual programming, which can make interaction less flexible and more complex for users. To overcome these limitations, this project presents a vision-based hand gesture control system for the Dobot Magician robotic arm. The system allows users to control the robot using natural hand gestures captured through a camera, enabling a more interactive and contactless control mechanism. By using computer vision techniques, the system detects and interprets hand gestures in real time, allowing users to perform robot movements without the need for physical control devices.

The proposed system integrates computer vision and robotic control to enable real-time gesture-based interaction with the Dobot Magician robotic arm. Hand gestures are detected using OpenCV and MediaPipe, which track hand landmarks from the live video stream. The recognized gestures are converted into robot commands through a command mapping module for controlling arm movements. The system uses the ROS 2 communication framework to transmit commands between modules efficiently.

This approach enhances the intuitiveness and accessibility of robotic systems and can be applied in areas such as robotics education, industrial automation, human–robot interaction, and assistive technologies. The developed system demonstrates the potential of vision-based gesture interfaces as an efficient and user-friendly method for robotic control.

**KEYWORDS:** Hand Gesture Recognition, Computer Vision, Human–Computer Interaction, Gesture-Based Control, Vision-Based Robotics, Image Processing, Real-Time Object Detection, Feature Extraction, Machine Learning, Deep Learning

## I. INTRODUCTION

### The Growing Need for Natural Human–Robot Interaction

The rapid advancement of robotics and automation has significantly improved the efficiency of industrial and educational applications. However, many robotic systems are still controlled through traditional interfaces such as keyboards, controllers, or pre-programmed commands. These methods often require technical knowledge and limit the natural interaction between humans and machines. With the development of **computer vision and artificial**



**intelligence**, gesture-based control has emerged as a promising solution that allows users to interact with robots in a more intuitive and contactless manner.

### The Challenge: Real-Time Gesture Recognition and Robot Control

Although hand gesture recognition systems provide a natural way to control robotic devices, implementing them in real-time environments presents several challenges. Accurate detection of hand gestures from live video streams requires efficient computer vision algorithms and reliable tracking of hand landmarks. In addition, seamless communication between the gesture recognition system and robotic hardware is necessary to ensure smooth and responsive robot movements. Without an optimized architecture, gesture detection delays or misinterpretations can affect the overall performance of the robotic control system.

### Our Proposed Solution

To address these challenges, we developed a **Vision-Based Hand Gesture Control System for the Dobot Magician robotic arm**. The proposed framework integrates multiple components to enable real-time human-robot interaction:

- **Camera Module:** Captures live video frames of hand movements.
- **Gesture Recognition:** Uses **OpenCV and MediaPipe** to detect hand landmarks and recognize gestures.
- **Command Mapping:** Converts detected gestures into predefined robotic commands.
- **Robot Control:** Utilizes the **ROS 2 communication framework** to transmit commands and control the Dobot Magician robot.

### Impact and Practical Applications

By combining computer vision with robotic control, the proposed system provides a natural and efficient method for controlling robotic arms using simple hand gestures. The modular architecture ensures flexibility, real-time performance, and easy scalability. This system can be applied in **robotics education, industrial automation, assistive technologies, and advanced human-robot interaction systems**, demonstrating the potential of vision-based gesture control for modern robotic applications..

## II. RELATED WORK

### A. Evolution of Vision-Based Gesture Recognition

Hand gesture recognition has become an important research area in computer vision and human-computer interaction. Early gesture recognition systems relied on **sensor-based devices such as gloves and motion controllers** to capture hand movements. Although these systems provided accurate tracking, they required additional hardware and were not convenient for natural interaction. With the advancement of computer vision techniques, camera-based gesture recognition systems were introduced. These systems use image processing and machine learning algorithms to detect hand gestures directly from video streams, enabling contactless and more intuitive interaction between humans and machines

### B. Gesture Recognition Using Computer Vision Techniques

Recent research has focused on using **computer vision frameworks such as OpenCV and MediaPipe** to improve the accuracy and speed of gesture recognition. MediaPipe provides a powerful hand tracking solution that detects multiple hand landmarks in real time, enabling precise gesture identification. Several studies have applied these techniques for applications such as sign language recognition, virtual interfaces, and robotic control. However, many systems focus only on gesture detection without integrating a complete framework for controlling robotic hardware in real-time environments.

### C. Vision-Based Robot Control Systems

Vision-based robot control systems aim to combine gesture recognition with robotic motion control. In these systems, recognized gestures are mapped to predefined commands that control the robot's movement or actions. Communication frameworks such as **Robot Operating System (ROS)** are commonly used to enable interaction between computer vision modules and robotic hardware. While previous research has demonstrated gesture-controlled robotic systems, many implementations are complex or require high computational resources. Therefore, there is a need for lightweight and modular frameworks that allow efficient gesture-based control of robotic arms in real-time applications.



### III. PROPOSED WORK

The proposed system, **Vision-Based Hand Gesture Control of the Dobot Magician**, is designed to enable intuitive human-robot interaction using real-time hand gestures. The main objective of the system is to allow users to control the robotic arm without using physical controllers or complex programming interfaces. To achieve this, the system integrates computer vision techniques with robotic control mechanisms to detect hand gestures and convert them into robot commands.

#### 1. Gesture Detection Module

The first stage of the system involves capturing live video input using a camera module. The captured frames are processed using **OpenCV and MediaPipe**, which are used to detect hand landmarks and track hand movements in real time. MediaPipe provides a robust hand tracking model that identifies multiple key points on the hand, enabling accurate recognition of different gestures. The detected landmarks are analyzed to determine the gesture pattern performed by the user.

#### 2. Command Mapping Module

Once a gesture is recognized, it is translated into a predefined robot command. Each gesture corresponds to a specific robotic movement such as moving the robotic arm upward, downward, left, or right. This module acts as a bridge between gesture recognition and robot control by converting visual information into executable instructions.

#### 3. ROS 2 Communication Layer

To ensure efficient communication between the gesture recognition system and the robotic hardware, the system uses the **ROS 2 (Robot Operating System)** framework. ROS 2 acts as a middleware communication layer that transmits the generated commands from the vision system to the Dobot Magician robot. This communication layer enables smooth data exchange and real-time execution of commands.

#### 4. Robot Control Module

In the final stage, the robot control module receives commands from the ROS 2 framework and performs the corresponding robotic movements. The Dobot Magician robotic arm executes the instructions by adjusting its joints and performing the required motion. This enables users to control the robot through simple hand gestures without any physical interaction with the robot.

#### 5. Architectural Advantages

The proposed system follows a **modular architecture**, where each component operates independently while maintaining efficient communication with other modules. This design ensures flexibility, scalability, and real-time performance. By combining computer vision with robotic control technologies, the system provides a user-friendly and efficient approach for gesture-based robotic manipulation.

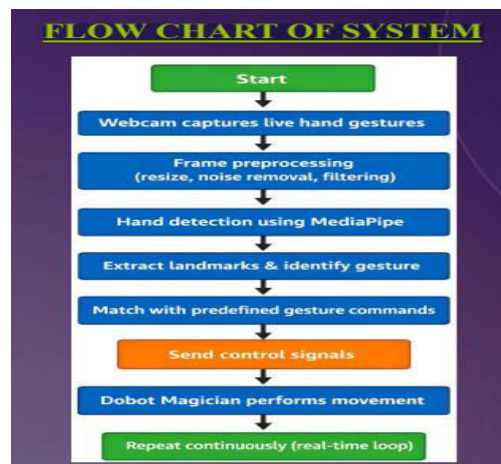


Figure- 1:Proposed Workflow

#### IV. SYSTEM ARCHITECTURE

The proposed **Vision-Based Hand Gesture Control System for the Dobot Magician** follows a modular architecture designed to ensure efficient communication between the vision system and the robotic hardware. The system consists of several interconnected components including the **Camera Module**, **Gesture Recognition Module**, **Command Mapping Module**, **ROS 2 Communication Layer**, and **Robot Control Module**. Each module performs a specific task in the process of converting human hand gestures into robotic movements.

##### A. Camera Module

The camera module is responsible for capturing real-time video frames of the user's hand gestures. A standard webcam is used to continuously stream video input to the system. The captured frames serve as the primary input for the gesture recognition process.

##### B. Gesture Recognition Module.

The gesture recognition module processes the captured video frames using **OpenCV and MediaPipe**. MediaPipe detects multiple hand landmarks and tracks the position of fingers and palm movements in real time. Based on the detected landmarks, the system identifies predefined hand gestures that correspond to specific robot actions.

##### C. Command Mapping Module

After the gesture is recognized, the system converts the detected gesture into a predefined robot command. Each gesture is mapped to a specific robotic movement such as moving the robotic arm **up, down, left, or right**. This module acts as a bridge between the vision-based recognition system and the robotic control system.

##### D. ROS 2 Communication Layer

The system uses **ROS 2 (Robot Operating System)** as the communication framework between the computer vision module and the Dobot Magician robot. ROS 2 enables reliable message passing between different modules, ensuring that the recognized commands are transmitted efficiently to the robot controller.

##### E. Robot Control Module

The robot control module receives the commands from the ROS 2 communication layer and executes the corresponding movements on the **Dobot Magician robotic arm**. Based on the received commands, the robot performs the required motion by adjusting its joints and performing the specified actions.

This modular architecture enables real-time gesture recognition and robotic control while maintaining system flexibility and scalability. By integrating computer vision techniques with robotic communication frameworks, the system provides an intuitive and contactless method for controlling robotic arms.

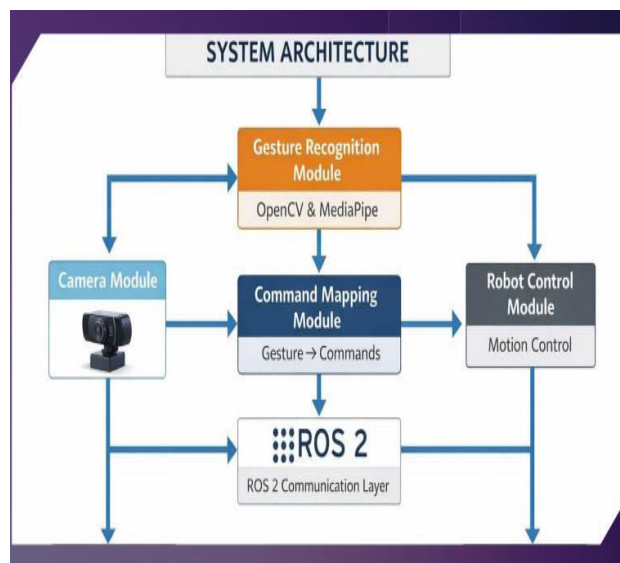


Figure- 2: System Architecture



## V. DATASET/ INPUT PROCESSING

The proposed system uses real-time visual input to detect and interpret hand gestures for controlling the Dobot Magician robotic arm. Instead of using a pre-recorded dataset, the system processes live video frames captured through a camera. The input processing stage focuses on extracting hand features and identifying gesture patterns that correspond to robot commands.

### A. Video Input

The system captures real-time video using a webcam connected to the computer. The camera continuously records frames containing the user's hand movements. These frames are processed sequentially using computer vision techniques. The live video stream acts as the primary input source for detecting hand gestures and initiating the gesture recognition process.

### B. Hand Landmark Detection

Hand landmark detection is performed using the **MediaPipe framework**, which is integrated with **OpenCV** for image processing. MediaPipe identifies multiple key points on the hand, including the fingertips, joints, and palm center. These landmarks provide precise spatial information about finger positions and hand orientation. By tracking these points across frames, the system can accurately analyze hand posture and movements.

### C. Gesture Detection Process

Once the hand landmarks are detected, the system analyzes the relative positions of the fingers to identify predefined gesture patterns. Specific gestures such as raising one or more fingers correspond to different robot control commands. The detected gesture is then mapped to a predefined action that controls the movement of the Dobot Magician robotic arm. This process enables real-time gesture recognition and allows users to interact with the robot in a simple and intuitive manner.

## VI. ALGORITHM FRAMEWORK

This section describes the core logic and operational workflow of the **Vision-Based Hand Gesture Control System for the Dobot Magician**. The proposed system follows a lightweight and efficient approach by combining computer vision techniques with robotic communication frameworks. Instead of using computationally heavy deep learning models, the system relies on real-time hand landmark detection and rule-based gesture interpretation to achieve reliable and responsive robot control. By integrating OpenCV, MediaPipe, and ROS 2, the system ensures accurate gesture recognition while maintaining minimal processing delay.

### A. Hand Landmark Detection

The first step of the system involves detecting the user's hand from the video stream. The camera continuously captures frames, which are processed using **OpenCV** for image handling. The **MediaPipe hand tracking model** is applied to detect multiple landmarks on the hand, including fingertips, finger joints, and palm positions. These landmarks provide precise spatial information about the structure and movement of the hand, which is essential for recognizing gesture patterns.

### B. Gesture Recognition Strategy

Once the hand landmarks are detected, the system analyzes the relative positions of the fingers to determine the gesture performed by the user. The gesture recognition process follows a rule-based approach where specific finger combinations correspond to predefined commands. For example, raising one finger may represent an upward movement, while multiple fingers may represent other directional commands. This approach ensures fast and consistent gesture detection without requiring complex training datasets.

### C. Command Mapping Mechanism

After identifying the gesture, the system converts it into a corresponding robot command. The command mapping module acts as an interface between the gesture recognition module and the robot controller. Each detected gesture is mapped to a predefined robotic movement such as moving the robotic arm **up, down, left, or right**. This mapping allows the system to translate visual gestures into executable instructions for the robotic arm.

#### D. Robot Communication and Execution

In the final stage, the generated commands are transmitted to the **Dobot Magician robotic arm** through the **ROS 2 communication framework**. ROS 2 enables efficient data exchange between the gesture recognition module and the robot control system. Once the command is received, the robot executes the corresponding movement by adjusting its joints and performing the required action. This process enables real-time gesture-based control and ensures smooth interaction between the user and the robotic system.

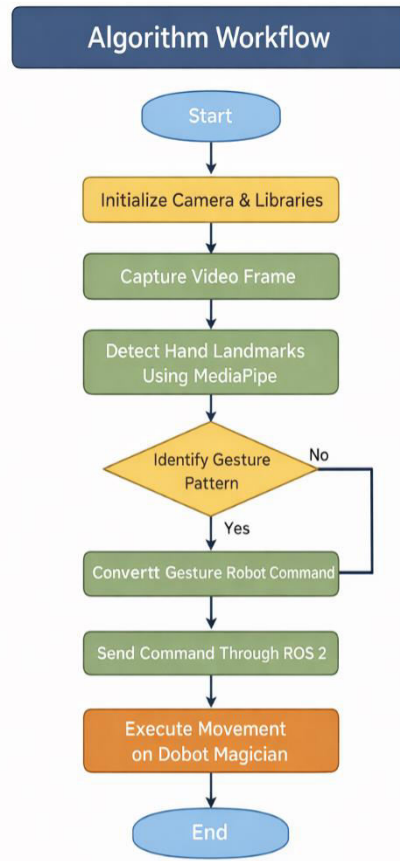


Figure -3: Algorithm Flowchart

## VII. EXPERIMENTAL RESULTS

The performance of the **Vision-Based Hand Gesture Control System for the Dobot Magician** was evaluated through multiple experimental tests. The system was tested under different conditions to measure the accuracy of gesture recognition, response time, and overall system performance. The experiments were conducted using a webcam for capturing hand gestures and a computer system running the gesture recognition module integrated with the ROS 2 communication framework

#### A. Gesture Recognition Accuracy

The gesture recognition module was tested using several predefined hand gestures corresponding to different robot movements. The system successfully detected and classified most gestures by analyzing the hand landmarks generated by the MediaPipe framework. The results showed that the system achieved high accuracy in recognizing gestures under normal lighting conditions. Minor variations occurred when the hand was partially visible or when lighting conditions were poor.



## B. System Response Time

Response time refers to the time taken by the system to process a gesture and execute the corresponding robotic movement. The response time was measured from the moment a gesture was captured by the camera until the robot performed the command. Experimental observations showed that the system responds within a short time interval, enabling real-time interaction between the user and the robotic arm.

## C. System Testing Results

The complete system was tested by performing a sequence of hand gestures to control the movement of the Dobot Magician robotic arm. The system successfully detected gestures, mapped them to commands, and transmitted them through the ROS 2 communication framework. The robot executed the corresponding movements smoothly, demonstrating the reliability and effectiveness of the proposed gesture-based control system. These results confirm that the system provides a practical solution for intuitive human–robot interaction.

## VIII. ADVANTAGES AND LIMITATION

The proposed Vision-Based Hand Gesture Control System for the Dobot Magician provides an intuitive and efficient method for controlling robotic movements through visual hand gestures. While the system offers several benefits in terms of usability and interaction, it also has certain limitations that can affect its performance under specific conditions.

### A. Advantages

- **Contactless Robot Control:** The system allows users to control the robotic arm without using physical controllers or devices, enabling a touch-free interaction method.
- **Real-Time Gesture Recognition:** By using OpenCV and MediaPipe, the system can detect and interpret hand gestures in real time, allowing quick response and smooth robotic movements.
- **Easy Human–Robot Interaction:** The gesture-based interface simplifies the process of controlling robots, making it easier for users without programming knowledge to interact with the robotic system.

### B.

### C. Limitations

- **Sensitivity to Lighting Conditions:** The accuracy of gesture detection may decrease in poor lighting environments or when the hand is not clearly visible to the camera.
- **Limited Gesture Set:** The system currently supports a predefined set of gestures for controlling the robot, which limits the number of possible commands that can be performed.

## IX. FUTURE WORK

The proposed **Vision-Based Hand Gesture Control System for the Dobot Magician** provides an effective approach for controlling robotic movements using hand gestures. However, several improvements can be made to enhance the functionality and performance of the system in future developments.

- **More Gesture Commands:** Future versions of the system can include additional hand gestures to perform more complex robotic operations. Expanding the gesture set will allow the robot to execute a wider range of movements and tasks.
- **Deep Learning-Based Gesture Recognition:** The system can be improved by integrating deep learning models such as Convolutional Neural Networks (CNN) for more accurate and robust gesture recognition. This can help the system recognize complex gestures and improve performance under different lighting conditions.
- **Integration with Voice Control:** In future implementations, voice commands can be combined with gesture control to create a multimodal human–robot interaction system. This would allow users to control the robot using both speech and hand gestures, improving usability and accessibility.

## X. CONCLUSION

This paper presented a **Vision-Based Hand Gesture Control System for the Dobot Magician robotic arm**, designed to enable natural and intuitive human–robot interaction. The system uses computer vision techniques with **OpenCV and MediaPipe** to detect hand landmarks and recognize predefined gestures from a live video stream. These gestures



are converted into robot commands through a command mapping module and transmitted using the **ROS 2 communication framework** to control the movement of the robotic arm.

The experimental results demonstrate that the system can recognize hand gestures accurately and control the robotic arm in real time with minimal response delay. The modular architecture consisting of the camera module, gesture recognition module, command mapping module, and robot control module ensures reliable system performance and easy scalability. By enabling contactless and user-friendly control of robotic systems, the proposed approach can be applied in areas such as **robotics education, industrial automation, assistive technologies, and advanced human-robot interaction systems.**

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