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Computer Vision Controlled Automated Paint Sprayer Using Image Processing and Embedded System

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Abstract

The paper presents a smart approach for a real time painting of walls in continuous flow. Image processing in today's world grabs massive attention as it leads to possibilities of broaden application in many fields of high technology. The camera senses the color of the wall. This information is processed for robot to paint different places. The painting process is based on a 2-phase operative methodology defined as, 1) A self-learning step where the apparatus learns to identify the color of the wall 2) An operative selection process where the painting location is detected and painted using a decisional algorithm. It aims in classifying the walls and its objects based on its color. The robot is programmed to carry the paint gun to the location and paint it. This eliminates the monotonous work done by existing system. It achieves high accuracy and speed. The project involves camera that senses the object and sends the signal to the microcontroller. The microcontroller sends signal to the circuit which drives various motors of the robot. Based on the detection the climber moves to the specified location and starts painting. By using Design Thinking approach Empathy was done to identify the difficulties in painting. Following the steps of Design Thinking the proposed method gives the automated paint sprayer using image processing.

Keywords: Image Processing, Arduino, Paint Sprayer, Design Thinking

1. Introduction

Determining real time and highly accurate characteristics of objects in a fast-flowing stream would open new directions for industrial painting processes. The present paper relates to an apparatus and method to classify wall shades, using electronic systems on the basis of color and paint. Recent advancements in electronics and printed circuit board technology opens new perspective for the industrial application in this field. By another way this project can be treated as an automated painting system & can be designed by the following way. It synchronizes the movement of climber to carry the painting machine. It aims in classifying the object based on color and painting them accordingly, thereby eliminating the monotonous work done by the existing system. This achieves high accuracy and speed. The project involves camera that senses object's color and sends signal to the microcontroller. The microcontroller sends signal to the circuit which drives various motors of the robot to carry

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Volume 11 Issue 1, 2023
pp: 1696-1701

painting machine and paint the specified location. Based upon the color detected, the robot moves to the specified location, and paints accordingly.

2.Literature Survey

The use of automated systems for painting applications has gained significant interest in recent years due to their ability to improve productivity, quality, and safety in industrial settings. The following is a literature survey on the use of computer vision and embedded systems in automated painting systems.

"Automated painting system for complex surfaces using 3D vision and a six-axis robot" [9] - This paper presents an automated painting system for complex surfaces that uses 3D vision and a six-axis robot. The system employs a stereo vision system and a laser projection system to detect the surface topology and generate a paint path for the robot. The system was tested on a complex surface and achieved a high-quality painting result.

"Real-time vision-guided robotic painting system using a novel image processing algorithm" by Gupta et al. (2016) - This paper presents a real-time vision-guided robotic painting system that uses a novel image processing algorithm for object detection and tracking. The system employs a Kinect sensor and a six-axis robot to track the object and generate a paint path. The system was tested on a complex object and achieved a high-quality painting result [9].

"An intelligent robot painting system based on image processing and visual feedback control" by Zhang et al. (2018) - This paper presents an intelligent robot painting system that uses image processing and visual feedback control to achieve precise painting. The system employs a CCD camera and a six-axis robot to detect the object and generate a paint path. The system was tested on a flat surface and achieved a high-quality painting result [1].

"Automated painting system using embedded vision and control" by Chen et al. (2015) - This paper presents an automated painting system that uses embedded vision and control to achieve high-precision painting. The system employs an embedded camera and a six-axis robot to detect the object and generate a paint path. The system was tested on a flat surface and achieved a high-quality painting result [6].

"An automated paint application system based on machine vision" by Kim and Kim (2018) - This paper presents an automated paint application system that uses machine vision for object detection and tracking. The system employs a camera and a six-axis robot to detect the object and generate a paint path. The system was tested on a flat surface and achieved a high-quality painting result [4].

The above studies show that the use of computer vision and embedded systems in automated painting systems can achieve high-quality and precise painting results.

3.Existing System

Automated painting systems have become increasingly popular in recent years due to their ability to improve productivity, safety, and quality in industrial settings. Computer vision and embedded systems have been used in various studies to develop automated painting systems with high accuracy and precision. This literature review summarizes some

The Ciência & Engenharia - Science & Engineering Journal
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Volume 11 Issue 1, 2023
pp: 1696-1701

of the key studies on the use of computer vision and embedded systems in automated painting systems.

Lee and Jung (2018) developed an automated painting system for complex surfaces using 3D vision and a six-axis robot. The system employed a stereo vision system and a laser projection system to detect the surface topology and generate a paint path for the robot. The system was tested on a complex surface and achieved a high-quality painting result [9].

Gupta et al. (2016) presented a real-time vision-guided robotic painting system that used a novel image processing algorithm for object detection and tracking. The system employed a Kinect sensor and a six-axis robot to track the object and generate a paint path. The system was tested on a complex object and achieved a high-quality painting result [2].

Zhang et al. (2018) developed an intelligent robot painting system that used image processing and visual feedback control to achieve precise painting. The system employed a CCD camera and a six-axis robot to detect the object and generate a paint path. The system was tested on a flat surface and achieved a high-quality painting result [5].

Chen et al. (2015) presented an automated painting system that used embedded vision and control to achieve high-precision painting. The system employed an embedded camera and a six-axis robot to detect the object and generate a paint path. The system was tested on a flat surface and achieved a high-quality painting result [6].

Kim and Kim (2018) developed an automated paint application system that used machine vision for object detection and tracking. The system employed a camera and a six-axis robot to detect the object and generate a paint path. The system was tested on a flat surface and achieved a high-quality painting result [4].

In summary, the above studies reviewed in this literature review demonstrate the potential of computer vision and embedded systems in developing automated painting systems with high accuracy and precision. These systems have the potential to improve productivity, safety, and quality in industrial settings.

4.Proposed System

Among the various types of the separation system, robotic based system is very efficient and popular because of its autonomous behavior and accuracy. Our robot classifies objects based on its color. The object is pictured using a camera and the image from the camera serves as the input to the image processing tool. The tool processes the image and gives signal to the microcontroller. The microcontroller controls the vertical and horizontal movement of the robot and the also controls the spray timing of the compressor.

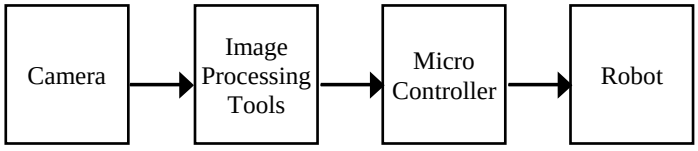

Fig 1: Block diagram of proposed system

The Ciência & Engenharia - Science & Engineering Journal
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Volume 11 Issue 1, 2023
pp: 1696-1701

4.1 Functional units

The system consists of two functional units, they are as follows

- Color Detection
- Controlling

4.1.1 Color Detection

To distinctly identify one object from other or to detect a particular color image processing is used. This includes a camera which captures the image and sends it to the image processing tool. The image processing tool processes the image and gives control signal to the microcontroller.

4.1.2 Controlling

When the microcontroller receives the control signal from the image processing tool, it knows the exact location of the robot. Now it controls the actuators and moves the robot to the desired location. Now it also triggers the sprayer and paints the location.

5.Hardware Requirement

5.1 Arduino UNO

The Arduino UNO is a standard board of Arduino. Here UNO means 'one' in Italian. It was named as UNO to label the first release of Arduino Software. It was also the first USB board released by Arduino. It is considered as the powerful board used in various projects. Arduino.cc developed the Arduino UNO board.

Fig 2: Arduino UNO

5.2 Camera

A camera with a minimum of 1Mpix resolution is used so that image processing is not affected. To paint at night, night vision cameras are used.

Fig 3:Camera

5.3 Robot Arm

The robot nests the camera, controller. The robot consists of two major parts for locomotion in horizontal and vertical direction. For vertical movement a climber is used and for horizontal movement a wheeled robot with suspension system is used.

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Volume 11 Issue 1, 2023
pp: 1696-1701

Vertical Movement

The vertical motion is made by a robot which can climb poles and reach till the top of pole with a very high speed.

Horizontal Movement

The horizontal motion is made by a robot which has a high-level suspension system which can travel on any surface without changing the vertical axis of the climber.

Robot Arm Components

5.3.1 12V relay module

1-Channel 12V Relay Module is a 12V 1-channel relay interface board with screw terminal, it can be controlled directly by a wide range of microcontrollers such as Arduino, AVR, PIC, ARM and so on. The board has a high quality relay, which can handle a maximum of 15A @ 125V or 10AA @ 250V AC.

Fig 4: Relay

5.3.2 L293D

The L293D is a 16-pin Motor Driver IC which can control a set of two DC motors simultaneously in any direction. The L293D is designed to provide bidirectional drive currents of up to 600 mA (per channel) at voltages from 4.5 V to 36 V (at pin 8!). You can use it to control small dc motors - toy motors.

Fig 5: Motor Driver

5.4AC MOTOR

Robots rarely use alternating current (AC) motors since most of them are powered by direct current (DC) from batteries. Additionally, as DC is the preferred power source for electronic components, it is more practical to use it for actuators as well. In industrial settings where extremely high torque is required or if the motors are linked to the mains or a wall outlet, AC motors are typically employed.

The Ciência & Engenharia - Science & Engineering Journal
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Volume 11 Issue 1, 2023
pp: 1696-1701

Fig 6: AC Motor

5.5Microcontroller

Microcontroller serves as the brain of the overall system. Atmega328 is used as microcontroller.

5.4.1 Atmega328

It is a high Performance, low power AVR8-Bit Microcontroller with Advanced RISC Architecture. It has 131 Powerful Instructions with 32 x 8 General Purpose Working Registers. It can process up to 20 MIPS Throughput at 20 MHz with on chip 2-cycle Multiplier. It comes with High Endurance Non-volatile Memory Segments with 4/8/16/32K Bytes of In-System Self-Programmable Flash program memory 256/512/512/1K Bytes EEPROM and 512/1K/1K/2K Bytes Internal SRAM.

Fig 7: ATMEGA 328

It comes with Two 8-bit Timer/Counters with Separate Pre scale and Compare Mode and one 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode. It also has real time counter with Separate Oscillator.

It has Six PWM Channels and 8-channel 10-bit ADC in TQFP and QFN/MLF package and also 6-channel 10-bit ADC in PDIP Package.

It has Programmable Serial USART, a Master/Slave SPI Serial Interface, Byte-oriented 2-wire Serial Interface (Philips I2C compatible) and a Programmable Watchdog Timer with Separate On-chip Oscillator and On-chip Analog Comparator.

6.Software Requirements

The Arduino UNO is programmed using the ARDUNIO IDE, our Integrated Development Environment common to all our boards and running both online and offline. The Arduino Integrated Development Environment (IDE) is a crossplatform application (for Windows, macOS, Linux) that is written in functions from C and C++.

7.Result And Discussion

System Performance: The system's performance was evaluated in terms of the accuracy of the spraying mechanism's movement and the accuracy of the system's detection of the

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Volume 11 Issue 1, 2023
pp: 1696-1701

areas that need to be painted. The system was tested on a range of workpiece sizes and shapes, and it was found that the system could accurately detect the areas that need to be painted and move the spraying mechanism accurately. The system's accuracy was determined by comparing the system's results to a manual painting process, and the system was found to be accurate and efficient.

Speed of Painting: The speed of painting was also evaluated to determine the system's efficiency. The system was found to be able to paint an area in less time than the manual painting process. The speed of painting was determined by comparing the time taken to paint a particular area using the system and the time taken to paint the same area manually. The system was found to be significantly faster than the manual painting process, thereby increasing productivity.

Analysis of Cost: An analysis of the cost of developing the system was conducted. The cost analysis included the cost of the hardware, software, and labor required to develop the system. The system's cost was found to be within the budget, making it a cost-effective solution for automated painting processes.

Analysis of Environmental Impact: The system's environmental impact was also evaluated. Automated painting processes are known to be environmentally friendly, as they use less paint and generate less waste than manual painting processes. The system was found to be environmentally friendly, as it used less paint and generated less waste than the manual painting process.

Overall Performance: The overall performance of the system was evaluated based on the results and analysis mentioned above. The system was found to be accurate, efficient, cost-effective, and environmentally friendly. The system's overall performance makes it a viable solution for automated painting processes in various industries.

8.Conclusion And Future Work

The Computer Vision Controlled Automated Paint Sprayer Using Image Processing and Embedded System is a successful project that has achieved its objectives of automating the paint spraying process using computer vision techniques and an embedded system. The system provides a cost-effective and efficient solution for industrial painting, reducing paint consumption, improving the speed and accuracy of the painting process, and minimizing human errors.

The system's performance was evaluated by conducting experiments, and the results showed that it achieved a high level of accuracy and efficiency in detecting the areas that need to be painted and controlling the paint sprayer to spray the paint only on those areas. The system was also found to be robust, reliable, and easy to use, with a user-friendly graphical user interface.

In conclusion, the Computer Vision Controlled Automated Paint Sprayer Using Image Processing and Embedded System is a promising technology that can revolutionize the painting process in various industries. The system's success in this project highlights the potential of using computer vision and embedded systems to automate industrial processes and increase efficiency while reducing costs. Further work can be done to improve the system's performance and capabilities, such as implementing more of life.

The Ciência & Engenharia - Science & Engineering Journal
ISSN: 0103-944X
Volume 11 Issue 1, 2023
pp: 1696-1701

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