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S.C.M.I.P - Software Controlled Monochromatic Image Painter

Ankul K. Jain[*1], Preethi Ramaswamy[2], Supriya S. Sehgal[3], Urvaksh K. Tavadia[4]

[*1,2] Department of Electrical and Electronics Engineering, Veermata Jijabai Technological Institute, Mumbai, India.

ankuljain19@gmail.com

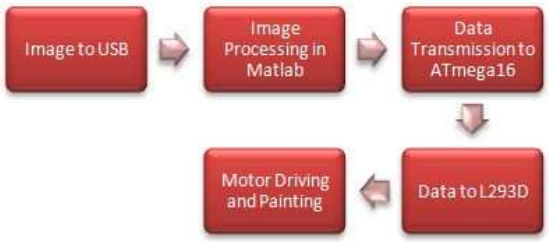
Abstract

This report illustrates the concept of a user friendly robot which can print an image fed into it, on any plain surface. The robot is MATLAB controlled, functioning with the help of ATmega16 and has a simple printing mechanism. The robot is initially be used for monochromatic black and white images and later on it can be modified to paint colored images as per requirements. The image to be painted is first fed into the controlling laptop through a USB and is processed by MATLAB, suitably run on a laptop. The MATLAB code then divides the image into a finite number of pixels of black and white depending on the threshold. Value of intensity entered by the user and creates a matrix. Each element of this matrix is then sent serially to ATmega16 which controls the motors forming the printing mechanism.

Keywords: Image Processing, Accuracy and Symmetry, Motor Positioning, Printing Mechanism, Motor Control, Large Scale Painting.

Introduction

With the growth of industrialization, sports events and cultural activities, the need for large scale floor painting, layout designing, field designing etc. is on the rise. The time consuming job apart from being tedious also demands a high level of precision and geometric symmetry. The automation of this process would not only save time but also improve the quality of work and reduce the reliability on manpower. All that is required is to feed the image with appropriate dimensions to the robot which will get the job done in no time with desired accuracy and acceptability. Being an aid for design and art, there can be various custom made requirements. Each can be satisfied with different printing mechanisms and more importantly chemical composition of paints. The resolution would be decided based on the size and complexity of the image. Apart from the various fields of floor painting like factories' floor layouts, basketball courts, parking lots.



Block Diagram

Image Processing

In computer memory, images are stored as bit patterns. An image can be considered as a matrix of pixels, where each pixel represents a dot. Depending on the image, a particular bit pattern is allocated for a pixel. More the number of pixels, higher is the resolution and better the quality of the image. The value of the bit pattern is decided by the intensity of colour at the particular pixel position. Any colour is made up of a combination of three primary colours Red, Green and Blue. Intensity of each colour is measured and accordingly a bit pattern is stored of the particular pixel. The software used for Image processing here is MATLAB[1]. MATLAB is a high-level language and offers an interactive environment for numerical computation, visualization, and programming. The required image will be fed into the laptop through a USB.

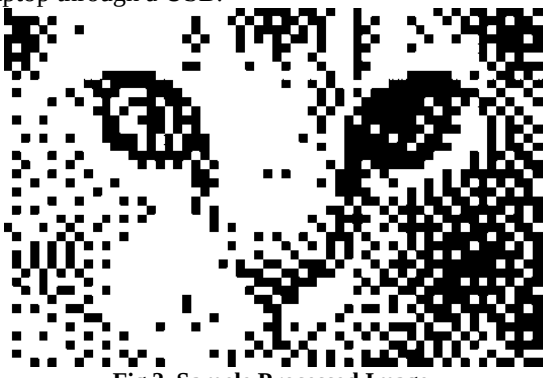


Fig.2. Sample Processed Image

The image processing will be done using the following algorithm:

A) Algorithm :

- A threshold is set by user according to requirements as any value between 0 and 255. 0 representing black and 255 representing white according to the RGB format followed my MATLAB. If the image is dark then the threshold will be set to a lower value else a higher value is used for a bright image.
- The image is then be scaled to reduce the dimensions so that we can obtain a matrix with dimensions feasible for painting.
- The intensity of each pixel of this scaled down image is checked. If above the threshold it is assigned 255 and below it is assigned 0.
- This data is then sent via USART[2] to ATmega16 which controls the motors in the printing mechanism accordingly.

Microcontroller

The microcontroller used here is ATmega16[3]. It is an 8-bit high performance microcontroller of Atmel's Mega AVR family with low power consumption. It has RISC architecture. The maximum clock frequency at which it can be used is 16MHZ. It has 16KB of programmable flash memory and 32 I/O lines which are divided into four 8-bit ports called as PORTA, PORTB, PORTC and PORTD. It also has various built-in peripherals like USART and ADC.

The need for the microcontroller is to guide the robot to the specified location within its workspace and print each pixel as per the data provided by the controlling laptop using MATLAB. The entire workspace is divided into smaller blocks, where each block corresponds to a single pixel of the image.

The data is received by the controller using its USART peripheral. Based on the data received, it drives motors connected to the I/O ports to achieve desirable motion and printing.

Data Transmission

The MATLAB software is programmed to generate data which represents the locations at which the printing has to be done. This data is transmitted to the Atmega16 microcontroller which controls the motors to position the robot to the required co-ordinates on the surface. This data transmission to microcontroller is done serially via the serial communication ports of the controlling laptop.

The serial communications ports of the controlling laptop follow the RS-232 standards. Hence it is necessary to convert the data given to the Atmega16 to TTL level. This is achieved by using a Max232 integrated circuit which converts signals from an RS-232 serial port to TTL compatible signals.

In the ATmega16, USART (Universal Synchronous and Asynchronous Serial Receiver and Transmitter) is used for the required communication. USART provides full-duplex communication. Atmega16 is equipped with independent hardware for serial USART communication. Pin-14[4] (RXD) and Pin-15 (TXD) provide receiver and transmitter interfaces to the microcontroller. We use Asynchronous mode of communication where the synchronization is achieved by using proper BAUD rate along with start and stop bits. By setting the same BAUD rate in the transmitting laptop and the receiving ATmega16 we can send and receive data between the two devices. Each frame of data consists of start and stop bits and in between the two, the actual 8-bit data is sent. Even parity can be included in the data.

Printing Mechanism

A. MOTORS

Motors are required to convert electical energy to mechanical energy and move the various parts of the robot printing mechanism. DC motors operate on direct current. DC motors[5] consist of one set of coils, called armature winding, inside another set of coils or a set of permanent magnets. Applying a voltage to the coils produces a torque in the armature, resulting in motion. . The speed of a DC motor can be controlled by changing the voltage applied to the armature or by changing the field current.

Four DC motors are used as follows :

1. ***Motors 1 and 2***: Two motors are used for driving the main chassis which moves in forward and backward direction corresponding to row-wise movement.

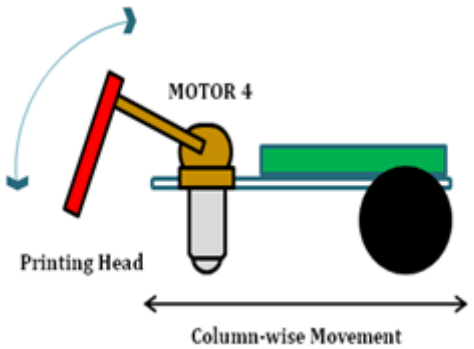


Fig.3(a).Robot Side View

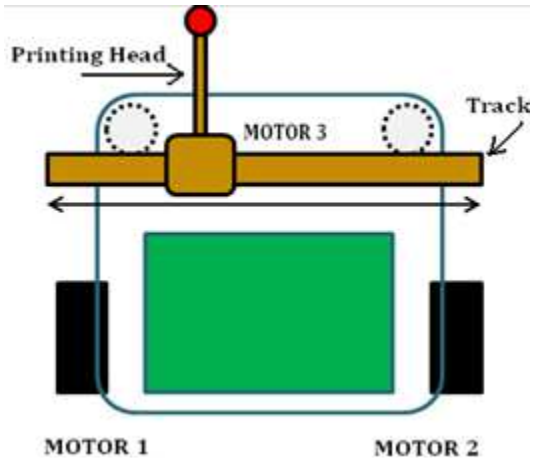


Fig.3(b). Robot Top View

2. ***Motor 3*:** A track is attached to this chassis and houses the third motor (75 rpm) controlling the sideways motion corresponding to column-wise movement.
3. ***Motor 4*:** This is used for the up-down motion of the printing head which in this case is a set of permanent markers. This can be modified according to the sophistication of the application as and when required.

B. MOTOR DRIVERS

The microcontroller is not powerful enough to drive motors and thus DC motor drivers are required. The 16pin L293D[6] is used here for this purpose. Each L293D has the capacity to drive two DC motors, thus two L293Ds are used. Its working is as follows.

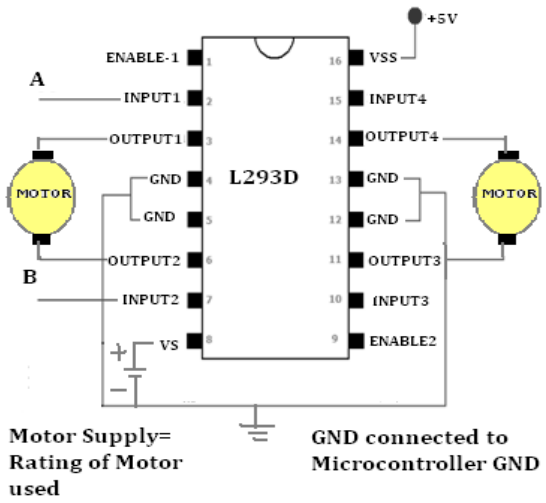


Fig.4. Pin Configuration of L293D

On giving the appropriate voltages to the two input pins corresponding to each motor, its functioning can be controlled as shown below.

Table I. Motor Inputs

Motion	A	B
Stop	Low	Low
Clockwise	Low	High
Anti- clockwise	High	Low
Stop	High	High

C. SPEED CONTROL AND CALIBRATION OF MOTORS:

Calibration is done initially to decide the size of each block to be printed in accordance with the size of the printing head. The size of each block is 1x1cm. The distance travelled by the head is a function of the wheel radius and angle turned by wheel. This distance is given by:

D = Radius of wheel(R) x Angle of Rotation(α)

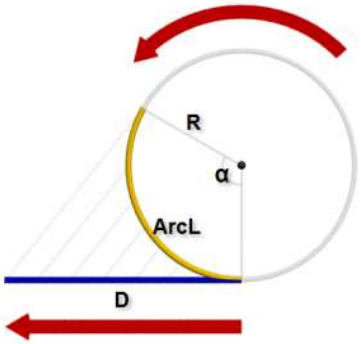


Fig.5. Distance Travelled by Wheel

From the angle and rotations per minute (rpm) rating of motor, the on time of motor can be calculated.

On-time(mins) = { α /(2π)} ÷ rpm rating

This on-time can be generated accurately by using timers in the microcontroller. If the rpm of motor does not provide smooth and precise movements, Pulse Width Modulation (PWM) can be used. The PWM is so designed to obtain this resolution for corresponding motor movement.

D. WORKING

- For every pixel, MATLAB sends a particular data containing information regarding its intensity and position i.e. row and column.

- The ATmega processes this data received via USART and sends commands to the L293D which then drives the corresponding motors.
- The ATmega decides which motor is to be driven. For example, if a full row is completed then the ATmega sends control voltages to the L293D so as to position the Motor 3 to its starting point and move Motors 1 and 2 ahead by one row.

Applications

- Floor layouts: To mark positions of machinery to their exact size in factories.
- Sports field: To paint on basketball courts and cricket grounds.
- Parking Lots: To paint markings and numbers on the floor of parking lots

Future Developments

- Using a spray painting mechanism, it will be possible to paint even on rough surfaces.
- With the use of a sophisticated printing head, it can be used for coloured painting as against the black and white scheme used in our project.
- With some mechanical modifications it can also be used for painting on the outer faces of building, wall paintings, murals etc which will save efforts and time and reduce the risk of accidents for men working on scaffoldings.

Conclusion

Thus the Monochromatic Image Painter robot performs the function of printing an image fed into it according to the precision requirements specified by the user.

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