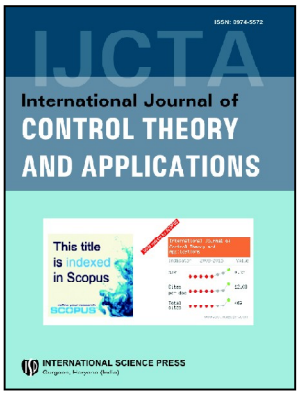

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Automatic Paint Spray System Based on ARM7 TDMI

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Abstract: Proportion advances in robotics and its application shared a little in terms of research on wall painting applications. In this paper, we propose a prototype design of system that use motorized winches to move a robot with a paint spray gun parallel to a given plane surface like wall, based on ARM7 TDMI processor. Mural is monotonous, fatigue and perilous which stimulates towards automation. Integration of robots with human efforts in constructions can lead to reduce man power, cost and time involved in the work with increasing safety, performance and precision. ARM processor is embedded with an apt program to control the motorized winches positioned at base of the respective surface. By winding and unwinding cables, the system allows robot to reach any required position in the given two dimensional plane.

Keywords: ARM7 TDMI, Automation, Paint spray gun, Safety, Robotics

1. INTRODUCTION

Infrastructure plays a major role in development of any sector, area or even a country. Building and construction takes a vital role in infrastructure. In current world wide scenario construction industry is highly influenced by ambiance provided within the construction itself such as provisions for natural light, wind and painting both interior and exterior. Increased awareness on education at various levels without dignity of labor is also major cause for increased labor problem. Mural is monotonous, fatigue and perilous which stimulates towards automation [1]. In early 90's applications of bionic person were introduced in building erecting industry to optimize the equipment. Integration of robots with human efforts in construction can lead to reduce man power, cost and time involved in the work with increasing safety, performance and precision. ARM processor "Fig. 1" is fed with a program as an input to control motorized winches position at the base of the respective surface. With effect of synchronized controlling of all the motorized winches the mount with spray gun can be placed at various positions as per our requirement, which mainly eliminate the time taken by a worker to relocate himself to reach the distributed area within the work space. This automatic paint spraying system [2] is portable and depicted with simple peripherals which ensure the reduction of skilled labor requirement.

System set up

System set up mainly consists of two parts (1) Electronics equipment and (2) Mechanical Equipment

(A) LPC 2148 Processor

NXP LPC2148 processor is a 16-bit/32-bit ARM7 TDMI CPU with real time emulation and embedded trace support, with embedded high speed flash memory 32kb to 512kb and on-chip static ram 8kb to 40kb. In spite of its small physical magnitude and low power ingestion LPC2148 is ideal for applications where diminutive is a key requirement. It consists of USB, two 10 bit analog to digital convertors, two digital to analog convertors in addition this device provides two 32-bit timers/counters, pulse width modulator and watchdog timer. ARM architecture is based on Reduced Instruction Set Computer much simpler than those micro programmed complex instruction set computers. These results in high instruction debit and effective interrupt response from a small and low cost core. Pipeline techniques are on board so that all peripherals of processing and memory devices can be operated continuously. While one instruction is being executed, its next is being decoded and third being fetched. ARM also employs unique thumb mode, main reason behind thumb is that of a super reduced instruction set.LPC2148 has mainly two instruction sets one is 32 bit ARM set and second Thumb mode set. Thumb instruction length allows it to avenue twice the density of standard ARM code while retaining most of the ARM's performance advantage over a traditional 16 bit CPU using 16 bit registers. It is recommended to program short and performance critical code sections in ARM mode. The impact on the overall code size will be minimal but the speed can be increased by 30%. LPC 2148 minimum needed power supply, crystal oscillator, reset circuit, RTC crystal oscillator to ensure that it is ready to be used in the work space. LPC 2148 works on 3.3V power supply.

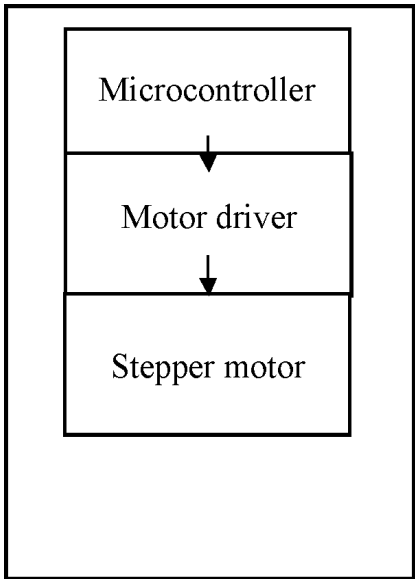

Figure 1: Block Diagram

(B) Stepper motor

Stepper motor "Fig 2" is a device which converts digital pulses into discrete mechanical movements. When digital command pulses fed to the stepper motor in proper sequential order the axel of stepper motor rotates in discrete step increments. The motor rotation has direct relations to these input digital pulses, so the speed of the motor is comparable to the input pulse frequency and rotor angle is relatively influenced by the number of input digital pulses.

Following advantages makes stepper motor to be a better option for controlled movements and applications where control angled rotation, speed, position and synchronism is needed.

Figure 2: Stepper Motor

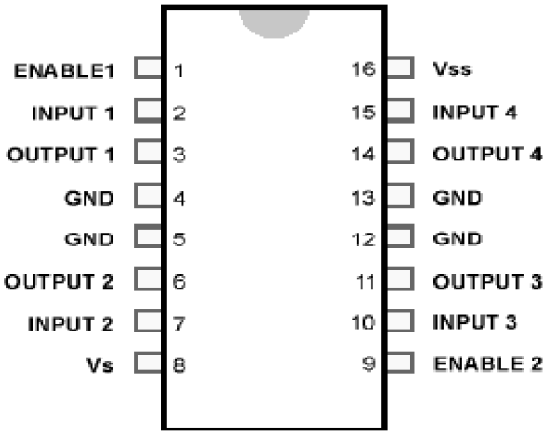

Figure 3: L293d IC

a) Precise positioning and repeatability of movement since good stepper motor have an accuracy of 3.5% of a step and this error is non cumulative

b) Response for starting, stopping and reversing is excellent.

c) The motor responds to digital excitation, purvey open loop control making the motor simpler and less cost effective to control.

d) Realization for wide range of rotational speeds can be obtained as the speed is comparable to the input pulse frequency.

Stepping sequence of stepper motors

As we discussed above stepper motors are excited sequentially. This type of sequence is called a stepping sequence. Normally there are four type of stepping sequences. Wave drive sequence, Full drive, half drive and Micro stepping.

a) Wave drive sequence
In this sequence only one of the two adjacent phases is excited and all others are off for finite duration, before exciting the next phase the first is off hence it is wave drive sequence.

b) Full step Sequence
It is two phase on sequence. Both the adjacent phases are on so that the rotor is positioned at a point resultant to both the fields.

c) Half Step Sequence
This is the combination of both wave drive and full step. The stepping angle can be reduced to the half.

d) Micro stepping Sequence
Here the excitation between two adjacent phases may increase or decrease gradually. When the phase 1 is excited and phase 2 is not, the rotor positioned towards the phase 1 and now if the current to the phase 1 is decreased and current to the phase 2 is increased the mortar will move by a small angle due to the resultant

magnetic field intensity of both the phases. When current in first phase further decreased and second phase current is increased the rotor keeps moving towards clock wise direction in very small step angels. If magnitudes of both phase currents are equal then the magnetic field intensity is equal, so the rotor is positioned between the two phases. Using this kind of excitation we are able to produce smooth movement of rotor. This method is more complex than other methods.

As we describing a prototype we are using 5V unipolar stepper motor and Micro stepping sequence is opted.

(C) Motor Driver IC

L293D "Fig. 3" driver with two H –bridge circuits allows us to operate stepper motor as per our requirements with respective direction of rotation. H-bridge is the concept behind controlling the voltage flow to manipulate direction of rotation of motor shaft. Size of this IC is the main advantage in automation and robotic applications [3] for controlling motors. It can be applied for DC motors as well as stepper motors.

Features

i) Supply voltage 4.5v to 36v

ii) Separate input logic supply

iii) High noise immunity inputs

(D) Keil MDK software

Keil is a cross compiler to convert source code into logic code. Cross compiler is a platform to write a program for the target processor on the host processors. Kiel compiler provides you Integrated Development Environment. The Keil MDK compiler supports all classic and extended versions of NXP variants. Compiler extension provides fall access to all processor resources and supports to extent of 16 Mb memories. The Keil MDK generates code efficiency and speed of hand optimization assembly. This compiler and linker optimizations deflate programs into the smallest single chips and provides control of the compiler, assembler, RTOS, project manager and debugger in a single development environment. Keil MDK is ultimately the best choice of our LPC2148.

(E) Flash magic software

NXP microcontroller provides both on-chip flash memory and reprogramming ability using IN SYSTEM PROGRAMING technology. Flash magic is one programmer which allows easy access to all the IN SYSTEM PROGRAMING features such as programming, reading and erasing the flash memory. Flash magic is used to embed the command control program into the microcontroller.

(F) Power supply

A 12 V battery is used as power source, IC 7805 "Fig 4" is used to restrict the output voltage up to 5V, since the stepper motors we are using in the set up operate at 5V. IC LM117 is used to provide 3.3V is the voltage required to LPC 2148 to operate.

(G) IC LM7805

IC7805"Fig 3" belongs to IC 78XX series, it is a 5V voltage regulator that deprives and draws 5V regulated power supply. 35V is the maximum input voltage that can give as input to IC 7805. When the input voltage exceeds 7.5V a heat sink is required for regulation to eradicate heat being developed in the process.

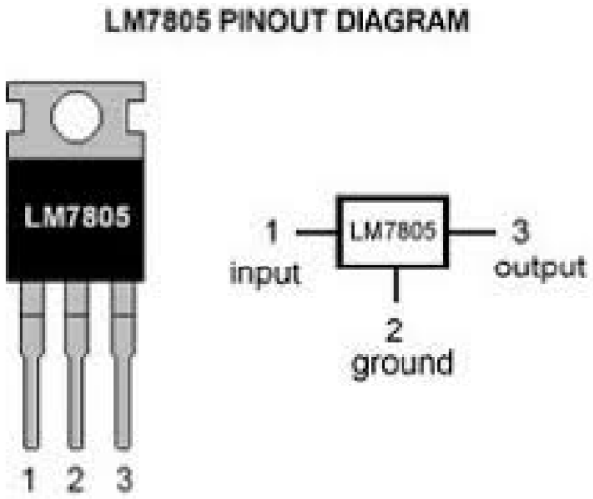

Figure 4: IC7805

Pin1 take the input voltage and pin3 provides the output voltage. Pin 2 is ground for both the input and output.

(H) IC LM117

LM117 "Fig. 5" is a 3 pin positive voltage regulator and is able to supply excess of 1.5A over 1.25V to37V and wide temperature range. This IC is compatible and is easy to set 3.3v as output voltage when provided with only two external resistors.

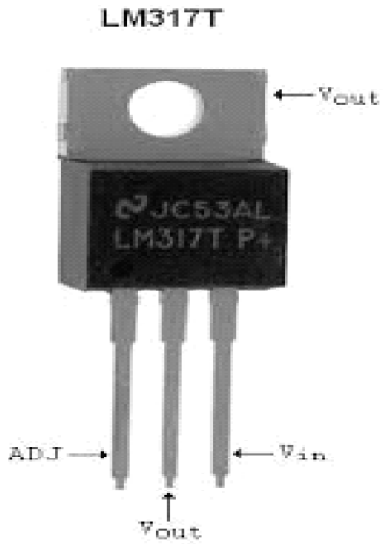

Figure 5: LM117

(I) RS 232 Cable

RS 232 "Fig. 6" is communication protocol for serial data exchange and synchronization of computer and its peripherals. It acts as a bridge between Data terminal equipment and Data communication equipment. A typical RS 232 is shown below.

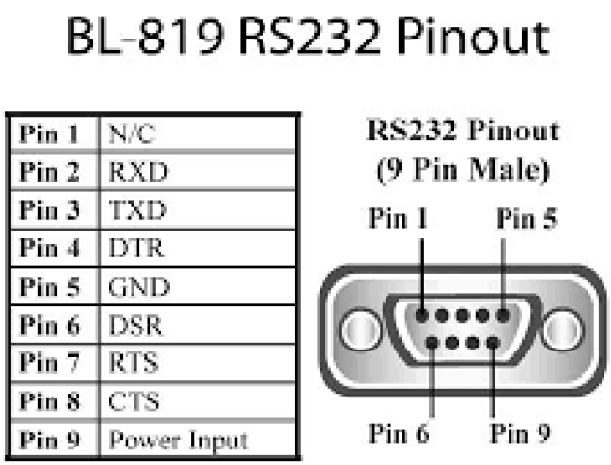

Figure 6: RS232

Data Terminal Equipment and Data Communication Equipment communication through RS 232 requires at least 3 pins each one dedicated to transmission, reception and ground to hand shake and to acknowledge each other

(J) Max 232 IC

MAX 232 "Fig. 7" is an IC which converts signals from RS 232 ports to signals suitable to CMOS compatible digital logic circuits. The influence of MAX 232 IC is to exchange the CMOS logic levels to RS 232 logic levels for serial communication between microcontroller and personal computers. The LPC2148 processor operates at CMOS logic levels of 0-3.3V and personal computer operates at RS 232 logic levels of -25V to +25V this difference in voltage levels makes communication establishment difficult. MAX232 IC as level shifter establishes communication between microcontroller and personal computer.

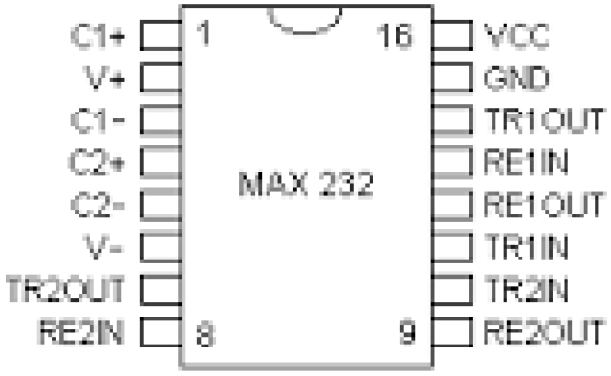

Figure 7: MAX 232 IC

(A) Motorized winches

Winch is a mechanical device used to adjust tension of a cable or wire. By assembling these winches with a stepper motor, we can control the winding and unwinding with help of digital signals through microcontroller.

(B) Pulleys

Pulley "Fig 8" is a wheel on a shaft to control the movement and direction of a wire or cable along its circumference. Pulleys are used for cables deflection from winch to paint gun robot.

Figure 8: Free moving pulley

(C) Paint spray gun

It is a pneumatic operated device where compressed air is used to distribute paint flow on to a plane surface. This consists of paint spray gun with a pump, paint tanks and a compressor to drive the pump. The paint spray gun is light weight type greatly reduces the desperation of paint mist. Atomization is an optimized procedure in terms of efficiency and precision which can be included in regular spray systems to transform its current phase.

(D) Frame

Frame consists of two individual metal bars. Each bar is inculcated with height adjustability and interlocking mechanism, to improve ergonomics and portability. A pulley is attached at each end of the bar for free motion of the cables

3. OPERATION OF SYSTEM

Assembly of the above briefed equipment is installed at the working area and break free power source is to be availed, as soon as the system is powered up the processor will be initialized at start up state. At these state four cables hold the mount through the pulleys at the base of the respective surface. The winding and un winding of the cables will be done by rotating the stepper motors coupled with the winches. Winding and unwinding combinations of all the four motors can move the position of the mount with spray gun to cover the surface according to our requirement. Desktop or a laptop can be connected to microcontroller through serial interface to give the appropriate direction control to the system.

4. RESULTS AND DISCUSSION

Considering 10X10 feet of a wall as an unit to be painted manually, the worker will be equally engaged by two main operations such as painting and relocating himself to various positions within the unit with the help of structures like ladders, tables and even cables in the case of exterior wall painting [4]. First operation painting which is our main criteria is been prolonged with the interpretation of the second operation within the work to be done in our unit. In our proposed system we can completely eliminate the second operation and hence total time

involved in painting the unit can be reduced. Further reduction of time can be attained by supplying continuous power to the system and sufficient amount of paint to be sprayed per unit.

5. CONCLUSION

Precise controlling of the mount connected to winches through cables can be obtained with the help of an apt program as an input to ARM processor. Synchronized output of above assembled mechtronics system can lead to reduction of existing gap between painting and infrastructure up to an extent. The total setup may initially cost a moderate amount but reduction of intervention, working time and expenses can be ensured, appropriate percentage can be assessed using prototype which is under construction.

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