Portable Paper-Bag Making Machine  
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Abstract:  
In this paper, we have proposed a low-cost, portable paper-bag making machine designed to produce paper-bags and minimize the usage of plastic bags for a clean and safe society. The system being semi-automatic is capable of producing single-size paper-bags from local newspaper. The project has been implemented by making use of micro-controllers, IR sensors, a robotic arm, a 2-wheeled robot and DC motors unlike previous attempts using PLC and servo-motors. The system can be deployed in small-scale industries or homes for producing paper-bags and we believe it can reduce the usage of polythene bags.

Index Terms: Paper-bag making, micro-controller, Robotic arm, 2-wheeled robot, DC motor.

I. INTRODUCTION
  
In this 21st century, with increasing population, markets and industries, and large production, usage of plastic bags has rapidly increased. On the other side, plastic is non-biodegradable and is toxic. Further, people dump plastic bags at many places which results in environmental degradation. These bags are sometimes consumed by domestic animals, leading to their death. An alternate solution to this problem is the deployment of paper bags, in place of plastic bags. However, existing paper bag machines are expensive (INR 3,00,000) and even are the paper used for making the bag. Further the existing machine technology occupies large space, as big as a hall and it is even very difficult to shift it from place to place. So, in this paper, we have come up with a solution: A portable low-cost paper-bag machine that uses news-paper to build paper-bag. The news-paper with a single fold will be fed into the machine via human assistance. The articulated 5 D.O.F robotic arm serving as folding mechanism, in conjunction with 2-wheeled robot serving as gluing mechanism, being controlled by micro-controller and DC motors, creates a paper bag. This paper is structured as follows: Section II describes the block diagram, Section III describes working, and Section IV describes Tools review, Section V describes Results and Conclusion, Section VI future improvements and Section VII lists out references.

II. BLOCK DIAGRAM

![Figure 1. Block Diagram of the proposed system](image)

A brief description of each block:

1. News-paper:

![Figure 2. Star of Mysore Newspaper](image)

Here we are deploying local daily “Star of Mysore” newspaper of 40cmX60cm dimensions to make paper bag.

2. ATMega-16A micro-controller:

![ATMega-16A pinout of PDIP](image)

For controlling our 2-wheeled robot and gluing, we are deploying AVR ATMega-16A [1] micro-controller. It is a high performance, low-power AVR 8-bit micro-controller. It has 32 programmable I/O lines i.e. 4 I/O ports of 8 pins each, 16K Bytes of In-System Self-Programmable Flash, 1K Byte Internal SRAM, 8-channel 10-bit ADC, 4 PWM channels, a total of 21 interrupts(Internal and external), 2.7-5.5V operating voltages, two 8-bit timers/counters and one 16-bit...
timer/counter, byte-oriented Two-wire serial interface, programmable serial USART etc. Thus it satisfies all the necessary requirements.

3. 2-wheeled Robot:

Figure 4. wheeled red-chassis robot
This robot is used to carry and apply glue at required places on paper by a line-following mechanism. Some parts of this robot are:

a. Chassis: The base frame of a car, carriage or other wheeled vehicle is generally termed as chassis. Since our robot (Car) is small, we are going to use the red chassis as in pic above.

b. Wheels: Wheels are circular objects that revolve on an axle and are fixed below a vehicle or other object to enable it to move over the ground. We are going to use two wheels for our project and are shown in fig 4.

c. Castor Wheel: A castor is an undriven wheel that is designed to be mounted to the bottom of a larger object so as to enable that object to be easily moved. They are usually available in various sizes and commonly made of rubber, aluminum or stainless steel.

4. DC geared motors:

Figure 5. DC geared motor
- DC Motors convert electrical energy (voltage or power source) to mechanical energy (produce rotational motion). They run on direct current.
- The DC motor works on the principle of Lorentz force.
- Geared DC motors [2] can be defined as an extension of DC motor.
- A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM. The gear assembly helps in increasing the torque and reducing the speed. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction.

- We are going to use motors with speed of 60RPM (Rotations per Minute)

5. IR Sensors:

Figure 6. Working of IR Sensor
An infrared sensor is an electronic instrument which is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation. IR Sensor has both transmitter and receiver. When we give power supply to IR sensors, Transmitter starts emitting IR rays continuously. We have two cases now:

- When no obstacle is there in front of transmitter, receiver will get nothing. Data pin will give ‘0’.
- When obstacle is present in front of transmitter, receiver will get IR rays and give data as ‘1’.

IR Sensor circuit is nothing but a comparator circuit using an Operational Amplifier (Op-Amp).

Figure 7. IR sensor schematic

6. L293D motor driver circuit:

Figure 8. L293D pin diagram
A motor driver IC is an integrated circuit chip which is usually used to control motors in autonomous robots. Most microcontrollers operate at 5Volts and require a small amount of current to operate while the motors require a relatively higher voltages (DC Geared motors requires 9Volts) and current. Thus current cannot be supplied to the motors from the microcontroller. This is the primary need for the motor driver IC. The L293D is a 16 pin IC, with eight pins, on each side,
dedicated to the controlling of a motor. There are 2 INPUT pins, 2 OUTPUT pins and 1 ENABLE pin for each motor [3].

Figure 9. L293D and motor connections schematic

Table 1. L293D Truth table

<table>
<thead>
<tr>
<th>Pin1</th>
<th>Pin5</th>
<th>Motor A</th>
<th>Pin6</th>
<th>Pin7</th>
<th>Motor B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0(low)</td>
<td>0(low)</td>
<td>Halt</td>
<td>0</td>
<td>0</td>
<td>Halt</td>
</tr>
<tr>
<td>0(low)</td>
<td>1(high)</td>
<td>Clockwise</td>
<td>0(low)</td>
<td>1(high)</td>
<td>Clockwise</td>
</tr>
<tr>
<td>1(high)</td>
<td>0(low)</td>
<td>Counter</td>
<td>1(high)</td>
<td>0(low)</td>
<td>Counter</td>
</tr>
<tr>
<td>1(high)</td>
<td>1(high)</td>
<td>Halt</td>
<td>1(high)</td>
<td>Halt</td>
<td>Halt</td>
</tr>
</tbody>
</table>

7. Glue:
We are deploying “Fevigum” as the adhesive here. Fevigum is a fragrant synthetic clear adhesive used for sticking paper to paper. Available in three fragrances: Strawberry, Orange and Cologne. Features & Benefits: Excellent paper to paper bonding, Easy dispensing Packing. So, it satisfies all our necessary requirements.

8. Arduino Uno:

Arduino Uno is a microcontroller board based on the ATmega328P [4]. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It is connected to a computer with a USB cable for programming. Powered with an AC-to-DC adapter or battery. It has all necessary requirements for robotic-arm, to implement folding mechanism.

Figure 10. Arduino Uno board

9. Indian clone of OWI Robotic arm:

Features: 5 DOF as it has 5 motors viz at base, at shoulder joint, at elbow, at wrist 2 motors for gripper open-close, up-down. The DC motor used has 360 deg. rotation, is geared, operating voltage: 5V. These motors are controlled (i.e. rotated) accordingly by visualizing the human hand movement required to fold the paper.

III. DEVELOPMENT AND WORKING

The system is a semi-automatic one, requiring one human every time. In existing paper-bag making systems, all sensors and actuators are fixed and the paper is moved. This increases the machine size to as big as a classroom or a hall of 15foot X 20foot or even more. In our system, the paper is fixed and the sensors and actuators are moved across the paper. Thus we have reduced the system size to 4foot X 5foot. The system is divided into two mechanisms: Gluing mechanism and folding mechanism.

- Gluing Mechanism:
First of all every newspaper comes with a fold. This system requires a human to fold it properly at the middle, then unfold it and place it on the platform as per the markings drawn on it. The Fevigum bottle is fixed by means of L-clamp and DC motor arrangement, on the 2-wheeled robot. The requirement is to get 2 adjacent edges of newspaper glued in L-shape as indicated by gray regions in fig-12. So, the robot was converted into a line-follower robot, by means of 2 IR sensors at front and 2 IR sensors at back and a path is constructed across the gluing region, for the robot to traverse.

Figure 11. Gluing mechanism Working flow-chart
Folded hand in 3D Image

Figure 12. Paper gluing region

Upon fixing the paper, the human should press reset button provided with robot. The micro-controller ports will be initialized. The glue bottle will be turned down and now the glue starts flowing. The 2 forward IR sensors’ reading would be analyzed and the robot would be moved forward and the turning will be done accordingly, by controlling wheel motors. Once the robot reaches end of path, the robot stops, the glue bottle will be turned up, and the glue stops flowing. Then the 4 IR transmitters attached at robot front would signal towards the photo diode connected at path end. 4 IR sensors have been connected in order to rectify the line-of-sight problem caused when using 1 IR sensor. This signal received by the photo-diode, is a signal for the robotic arm to start folding mechanism. Then, the robot starts back traversal by collecting 2 backward IR sensors’ signals and controlling the motors accordingly to move the robot to the path beginning. The robot stops. The glue would be applied at desired places.

Folding mechanism:

- **Start**
- Initialize all motors by stopping them
- Rotate base anti-clockwise for 5.8s
- Open gripper (clockwise) for 1.3s
- Elbow anti-clockwise for 4.4s
- Close gripper (anti-clockwise) for 1.3s
- Elbow clockwise for 8.8s
- Open gripper (clockwise) for 1.3s
- Base clockwise for 0.6s
- Elbow anti-clockwise for 4.4s
- Base anti-clockwise for 0.6s
- Back to initial position
- [Stop]

/to pick up paper
/to lean back to move to one end of paper
/to hold the paper
/to rotate elbow by 180deg.
/to fold paper
/to move paper to stick
/to move away from paper
/to remove extra rotation
/to paper

Figure 13. Folding mechanism Working flow-chart

System-design: To design this mechanism, first a paper bag was made by hand, then for each hand position, the corresponding motor to be moved was obtained. From this the DC motors were controlled using an Arduino Uno board which provides polarity voltage (positive-negative for clockwise and negative-positive for anticlockwise) to rotate motors in clockwise or anti-clockwise direction found from hand. By careful observation of hand movements and noting each position of hand (along with the corresponding movement of joints), we easily got to know the time span and direction of rotation for that particular DC motor. After a lot of trial and errors and testing, a paper folding was made, the corresponding motors movements and time span of rotation, direction are as shown in flowchart. Coming to programming part: Movement of each motor - either clockwise or anticlockwise is controlled by powering the motor with a polarity like: +5v at one end and 0v at another end which produces a clockwise rotation and 0v at one end and +5v at another end produces anticlockwise rotation. These motors are given polarity voltages for time span obtained by controlling them manually and correlating them with our hand motion. The programming was done using Arduino Uno board.

Working: Once the photo-diode receives a trigger signal from gluing robot, the robotic arm would work as in flow-chart. The outcome, is a paper bag on the platform. The human can now pick the bag and stack it. The human needs to get ready with folded and open newspaper and place it on platform, collect the paper bag again and again. However the glue level has to be manually monitored. And replaced when low level is detected.

IV. TOOLS REVIEW

- **Hardware Tools:**
  a) USB-asp: USB-asp is a USB in-circuit programmer for Atmel AVR controllers, which is used to transfer .hex file from PC to the ATMega16 micro-controller board. It simply consists of an ATMega8 and a couple of passive components. The programmer uses a firmware-only USB driver, no special USB controller is needed, and that makes it low cost USB programmer. Important features are: Works under multiple platforms. Linux, Mac OS X and Windows are tested, Jumper for 5v supply, Header Pin to provide easy interface for various ISP header pin, SCK option to support targets with low clock speed (< 1.5MHz).

- **Software Tools:**
  a) AVRDUDE: AVR Downloader Uploader [5] - is a program for downloading and uploading the on-chip memories of Atmel’s AVR microcontrollers. It can program the Flash and EEPROM, and where supported by the serial programming protocol, it can program fuse and lock bits. AVRDUDE also supplies a direct instruction mode allowing one to issue any programming instruction to the AVR chip regardless of whether AVRDUDE implements that specific feature of a particular chip.

b) **Screw-driver:** Screw-drivers of different sizes are used throughout the development process, to fasten screws.

- **Programmer’s Notepad:** It is an open-source text editor [6] targeted at users who work with source code. Features are: Syntax highlighting, Text Clips for simple text insertion, Code folding/ outlining, Flexible Regular Expression support, Code navigation using Ctags, Projects for navigating large code bases, Extend using Python or C++. The program

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http://ijesc.org/
also contains menu commands that will help us compile the code and then transfer it into the microcontroller.  

c) WinAVR™: WinAVR [7] (pronounced “whenever”) is a suite of executable, open source software development tools for the Atmel AVR series of RISC microprocessors hosted on the Windows platform. It includes the GNU GCC compiler for C and C++. WinAVR contains all the tools for developing on the AVR. This includes avr-gcc (compiler), AVRDUDE (programmer), avr-gdb (debugger), and more. WinAVR is used all over the world from hobbyists sitting in their damp basements, to schools, to commercial projects. WinAVR is comprised of many open source projects.  

![Figure.15. A screenshot of ATMega16A programming environment](image)

d) Arduino IDE: The Arduino Integrated Development Environment [8] - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension “.ino”. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right-hand corner of the window displays the configured board and serial port. The toolbar buttons allow developer to verify and upload programs, create, open, and save sketches, and open the serial monitor.  

![Figure.16. a screenshot of Arduino IDE](image)

V. RESULTS AND CONCLUSION

Thus, we have come up with a low-cost semi-automatic paper-bag making machine. Since we have used Indian clone of OWI Robotic Arm, the total system cost is INR 3000. Currently the system can produce 1 paper-bag per minute. This is because of the 5V DC geared motor used in entire system. Also glue needs to be replaced frequently. Further one human assistance is required. However, the machine can be deployed in small-scale industries, homes, etc. and the paper-bag can be used for carrying vegetables and fruits, for small stationaries, can be used in medical shops for carrying medicines, etc.

VI. FUTURE WORK

The system’s performance and speed can be improved by replacing DC motors with servo motors for robotic arm, and using powerful DC motor for line follower robot. Further, by adding camera to the system, paper bags of variable sizes can be obtained. Also sensing mechanism can be developed to sense glue level. Work can be done to fully automate the system and increase productivity.

VII. REFERENCES


