Modeling & Testing of Automatic Pneumatic Sliding Door Using Sensors & Controllers

Ashis Mohapatra, Aman Anand

[1](Department of Mechanical & Manufacturing Engneering, Manipal University , India)
[2](Department of Mechanical & Manufacturing Engneering, Manipal University , India)

Abstract- Automatic Pneumatic Door Using IR Sensors, serves to automate the mechanism of door operation using Pneumatic, Arduino microcontroller and infrared sensor technology.

The methodology applied in the project is divided into three parts, firstly designing and fabrication of the door with the calculated dimensions, secondly, developing a program on the Arduino for door operation and thirdly, interfacing the different components to work together in a cohesive manner.

When an object comes in or goes out of the range of the sensor, a signal is sent to the Arduino which controls the electro-pneumatic circuit to open or close the door. The significance of this system is automation of the door which can be customized according to the industrial, commercial or domestic requirements.

Based on the results obtained a small prototype was designed and a suitable code was developed taking into account the ambient light conditions

Index Terms- Automatic Sliding Door , Arduino Controlled Door, Electro-Pneumatics , IR Proximity sensor applications , Mechatronics Application in Home & Industry

I. INTRODUCTION

Automation, as defined by the Automation Federation, is "the creation and application of technology to monitor and control the production and delivery of products and services." With respect to doors, Automation is generally reserved for two purposes, accommodating high flows of pedestrian traffic and providing accessibility for people with disabilities. In this chapter, we will briefly discuss the various fields incorporated in our project, objectives, motivation, the work schedule and the organization of the report. The automatic pneumatic door consists of a sliding mechanism which is pneumatically operated, uses IR proximity sensors to serve as input and a microcontroller to provide the required logic The project incorporates the various fields, viz., Pneumatics, Microcontrollers, Sensor Technology and Carpentry, to ensure smooth and hassle free door operation. Pneumatics is a branch of technology that deals with the study and application of pressurized gas to effect mechanical motion. In this system a centrally located and electrically powered compressor is used that powers cylinders and other pneumatic devices through solenoid valves. A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. An infrared proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. This sensor uses infrared light wave to detect the object in front .

1.1 MOTIVATION

The main reason which motivated us to take up this project is the growing demand of automation in the industrial and commercial space. But these needs can't be fulfilled at the cost of degrading the environment. In keeping up with the idea of a green industry, pneumatic systems provide a far better alternative. Pneumatic systems are cleaner, more efficient and require lesser maintenance as compared to their traditional counterparts. Also, as stated earlier, automatic doors help reduce congestion and aid people with disabilities. These doors can also be installed with different security measures for enhanced safety.

1.2 OBJECTIVE

The objective of this project is to design and fabricate an automatic pneumatic door using IR proximity sensors. The door is to open automatically upon detecting a person standing in front of it, and after the person has passed through, should close automatically. The door opens only after the person is present for a stipulated amount of time. If, after detecting a person in front of it, the person does not cross the door and goes in some other direction, then the door should close after a preset "timeout" limit. We are using microcontroller/Arduino to provide the logic for the operation of the door. One major advantage of using the microcontroller/Arduino is that we can use the same door for different applications just by altering the programming logic without any change in the hardware. In this project we are designing a basic prototype of the automatic pneumatic sliding door which can be modified for various industrial and commercial purposes.

II. METHODOLOGY

The door is designed to slide on appropriate slider and works on pneumatic air pressure. It consists of two IR proximity sensors which sense the presence of obstacle in their way. Each sensor consists of an emitter and receptor unit. When the signal from the emitter is obstructed it signifies the presence of an obstacle. The signal from IR sensors is the input of the Arduino .This signal goes to the Arduino which has a specific program written for it. The pneumatic actuator works according to the set of codes in Arduino .The cylinders retract when the obstruction is detected by the IR sensors thus opening the door and expands when the obstacle has been detected by the second IR sensor located on the other side. This pneumatic operation is controlled

by suitable electro-pneumatic circuit. The 2nd IR sensor is installed at the other end of the door. It senses whether the object which came in through the door has passed out of it successfully .This signal is sent to the Arduino and it has set of codes to control this operation.

2.1. MAKING OF THE SLIDING DOOR

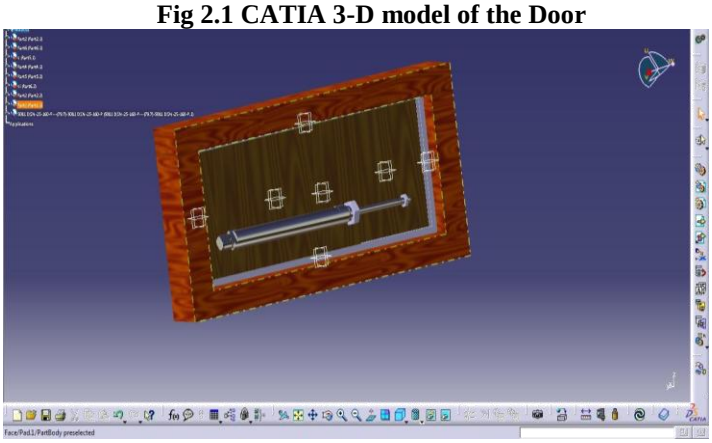
2.1.1. WOODEN FRAME

The wooden frames are made up six different wood pieces which are initially cut into approximate length and planned to get a smooth and parallel surface. The four pieces are joined in such a way that it forms a rectangular shape in order to accommodate two doors. Two more pieces of wood are used as stand so that the door frame can be clamped inside it and the door doesn‟t topple. The four frames are joined together using four dovetail joints. Then glue and nails are used to clamp the joints together and increase the strength of the dovetail joints.

2.1.2 SLIDING DOOR AND GLASS SLIDING CHANNEL

The doors are made in such a dimension that it suits the wooden frame slot. The door is made of plywood according to the required dimension. Glass sliding channels (E- channels) are fixed in the inner side of the rectangular frame using nails so that the plywood sheets can easily slide on them.

Fig 2.1 CATIA 3-D model of the Door



2.1.3. MOUNTING OF THE CYLINDER

The door consists of a fixed part and a movable part. The pneumatic cylinder is mounted on the fixed part using bolts and nuts. The piston is clamped to the movable part using a 2 inch L clamp and using suitable dimension of nuts and bolts. By clamping this movable part of the door moves according to the movement of the piston i.e. the door closes when the piston expands and the door closes when the piston retracts.

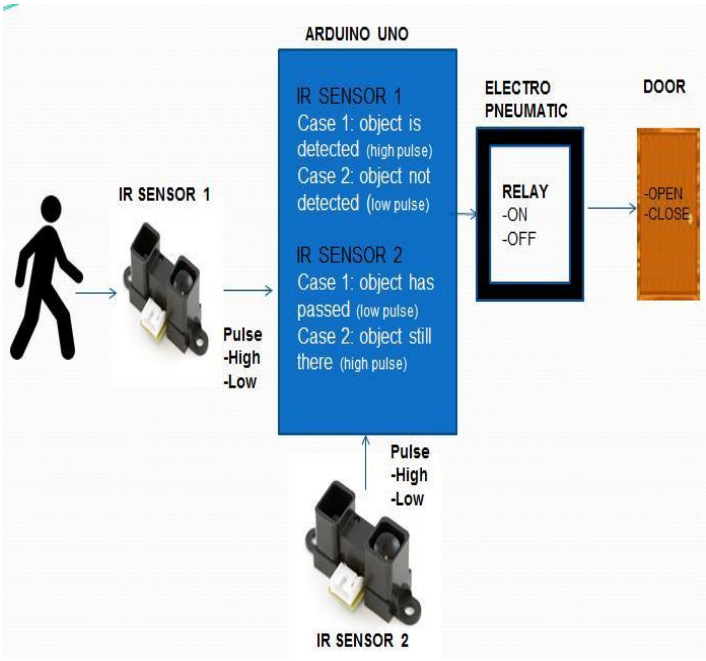
2.1.4 MOUNTING OF IR PROXIMITY SENSORS

There are two infrared sensors mounted on the both sides of the door. The sensor consists of an emitter and receptor unit. When the signal from the emitter is received by the receptor it signifies the presence of an obstacle. The signal from IR sensors is the input of the Arduino. This signal goes to the Arduino which has a specific program written for it.

2.1.5. DEVELOPING ALGORITHM AND CODES FOR ARDUINO

The basic setup for the programming consists of two IR proximity sensors mounted on either side of the door.

fig 2.2 Schematic diagram depicting the logic of program



- The sensor gives different output signals to the Arduino depending upon the presence or absence of an object, the value of which differs in different ambient light conditions.
  - If no object is present in front of the IR sensor then it gives a value ranging from 0-100 (subject to ambient light conditions) .When the object is detected by the IR sensors then this value increases to 250-400 (subject to ambient light conditions).
  - The Arduino has a condition written for values which are greater than 300 and values which are less than the 300 mark. (subject to ambient light conditions)
  - When there is no object present in front of the IR sensor 1 (which is mounted on the entry side of the door), a signal whose value ranges from 0 to 100 is sent to the Arduino.
  - When the IR sensor 1 detects an object in front of it and the object stays there for minimum of 20 milliseconds, a signal is sent to the Arduino whose value is greater than 300 (subject to ambient light conditions).
  - When a signal of value less than 300 is received by the Arduino, it generates 0V output to the relay.

- When a signal of value greater than 300 is received by the Arduino, it generates a 5V output which is sent to the relay.
- A 5 V output by the Arduino actuates the solenoid which in turn causes the piston of the cylinder, thereby opening the door.
- On the other hand a 0V output causes no change in the position of the piston cylinder.

The same logic is applied to IR sensor 2 mounted on the exit side of the door

2.1.6. ARDUINO PROGRAM FOR THE ABOVE LOGIC

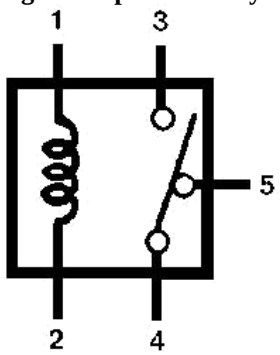
```
int opened=0;

int outerSensor=0; int innerSensor=0; int countIn=0;

int countOut=0; int inSense=0; int outSense=0; int entering=0; int exiting=0; int cycleLock=0; int timeout=0;

int delayLoop=0;


void setup(void) { Serial.begin(9600); pinMode(2, OUTPUT); pinMode(3, OUTPUT); pinMode(4,OUTPUT); digitalWrite(4,HIGH);

}


void loop() { outerSensor=analogRead(A1); //delay(500); innerSensor=analogRead(A0); Serial.println("a0"); Serial.println(innerSensor); //delay(1000); //Serial.println("a1");

//  Serial.println(outerSensor);


//  If outer sensor detects something, wait for 20 positives before setting flag



if (outerSensor > 300) { countOut++;

if (countOut > 20) { outSense=1;

}

} else { countOut=0;

}

// Same again for the inside sensor, but with different sensitivity if (innerSensor >300) {

countIn++;

if (countIn > 20) { inSense=1;

}

} else { countIn=0;

}


if (timeout > 0) { timeout--;

}


//  If the sensor is triggered for the first time, open the door if ((outSense == 1) && (timeout == 0))

{

entering=1;

openDoor();

} else if ((inSense == 1) && (timeout == 0)) { exiting=1;

openDoor();

}



//  This one is for entering from outside to inside - wait until the inner sensor is triggered before closing...

if (entering > 0) {


entering++;

if (inSense == 1) { closeDoor(); timeout=200; entering=0; exiting=0;

}

}


// Or until the timeout is reached if (entering > 1000) {

entering=0;

exiting=0;
```

```
closeDoor();

timeout=200;

}


// Same again but the other way around...

if (exiting > 0) { exiting++;

if (outSense == 1) { closeDoor(); timeout=200; exiting=0; entering=0;

}

}


if (exiting > 1000) { exiting=0; entering=0; closeDoor(); timeout=200;

}


inSense=0;

outSense=0;


}


// The open and close door routines - these trigger a relay which in turn supplies 24V to the pneumatic solenoids...timings are slightly different and tuned to the door characteristics

void openDoor() {

digitalWrite(3, HIGH); delay(1100); digitalWrite(3, LOW);

}
void closeDoor()
{

digitalWrite(2, HIGH); delay(750); digitalWrite(2, LOW);

 }
```

2.1.7.INTERFACING ARDUINO WITH ELECTRO-PNEUMATIC SYSTEM

Arduino is a microcontroller which generates an output of 5V dc, but the solenoid requires 24V dc to get actuated. The main challenge faced was to operate the solenoid with 5V dc supply. This was solved by using 5 pin 5V relay.

fig 2.3 5 pin 5V Relay

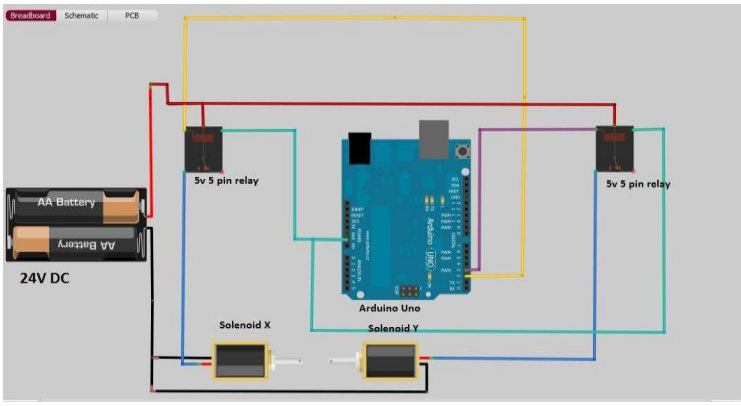


A 5 pin 5V relay is a switching device consisting of 5 pins. Pin no. 1 is connected to the 5V power supply from Arduino; pin no. 2 is connected to the ground of Arduino. Pin no. 5 is left open as it is normally closed, pin no. 5 is connected to 24V dc power supply and pin no. 3 is connected to the solenoid.

When a 5V signal is sent from Arduino to the pin 1, an electromagnetic field is generated which attracts the contact to the pin no. 3. Thus the normally closed circuit becomes open and 24V power supply passes through the solenoid. Due to this the solenoid gets activated and further the pneumatic cylinder gets actuated.

When a 0V signal is sent from the Arduino to the pin 1 the electromagnetic field is depleted and the contact switches from pin 3 to 5, and power supply to the solenoid is switched off.

fig 2.4 Electrical Schematic Showing the Logic and the Components used



2.1.8. JUSTIFICATION FOR THE MATERIALS USED

Pneumatic systems provide power in a cheaper, safer, more flexible, environment friendly and more reliable way than the orthodox electric motors and actuators.

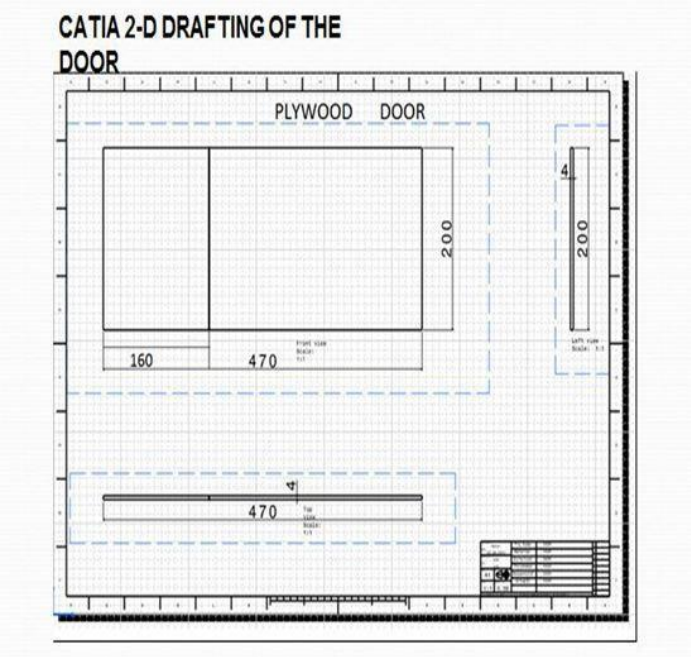
We are designing a pneumatically operated automatic door using infrared proximity sensors as these are cheaper, responsive and have a greater range of application compared to other variety of sensors. Moreover it is cheaper and effective compared to other sensors.

We are using Arduino to provide the logic for the operation of the door. One major advantage of using the Arduino is that we can use the same door for different applications just by altering the programming logic without any change in the hardware. Using an Arduino simplifies the amount of hardware and

software development one needs to do in order to get a system running. Using an Arduino simplifies the amount of hardware and software development you need to do in order to get a system running. On the software side, Arduino provides a number of libraries to make programming the microcontroller easier. The simplest of these are functions to control and read the I/O pins rather than having to fiddle with the bus/bit masks normally used to interface with the Atmega I/O. More useful are things such as being able to set I/O pins to PWM at a certain duty cycle using a single command or doing Serial communication.

There is an overlapping of 10mm between the moving and the fixed panels.

fig 3.1 CATIA 2-D drafting of the door with dimensions



Interfacing was done between the Arduino and electro pneumatic components. When an object was kept in front of the IR sensor 1, the solenoid responsible for opening of door, got activated which led to actuation of the pneumatic cylinder and the door was open. Then the object was kept in front of the IR sensor 2, the solenoid responsible for closing of the door got activated and the door was closed.

In this project we are designing a basic prototype of the automatic pneumatic sliding door which can be modified for various industrial and commercial purposes.

We have used double acting cylinder instead of single acting cylinder. A double acting cylinder can be controlled in both extended and retracted conditions, while a single acting cylinder can be controlled in only one direction. Also, a double acting cylinder needs air supply only once to maintain its position whereas a single acting cylinder needs continuous supply of air to remain in extended mode.

The Arduino can give only 5 V power supply, but we need 24 V power supply to activate the solenoid. For this we have used 5V 5 pin relays. By using relays we can provide 24V power supply to the solenoids indirectly.

2.1.9. TOOLS REQUIRED

2.1.9.1 MECHANICAL & PNEUMATIC TOOLS AND COMPONENTS

1. Pressure source
2. Pneumatic cylinder
3. Pneumatic compressor
4. 5/2 solenoid valve
5. Connecting pipe
6. Wooden reaper-planed ben teak wood
7. Glass sliding channels
8. Plywood sheets
9. Carpentry equipment
10. Drill bit

2.1.9.2. ELECTRICAL COMPONENTS

1. Arduino/ microcontroller
2. Two IR proximity sensors
3. Two 5V 5pin relay switches
4. Soldering equipment
5. Jumper wires
6. Single core connecting wires
7. 24 V dc supply
8. Banana pin
9. Bread board

III. RESULT ANALYSIS

3.1 RESULT

The door was fabricated in the carpentry workshop and was tested in the automation laboratory. The piston length of the cylinder is 160 mm. Keeping this in consideration; the following dimensions were decided for the door:

- Length of the frame: 500mm
- Height of the frame: 210mm
- Width of the frame: 60mm
- Length of fixed panel: 320mm
- Height of the fixed panel: 200mm
- Width of the moving panel: 4mm
- Length of moving panel: 160mm
- Height of the moving panel: 200mm
- Width of the moving panel: 4mm

3.2. READINGS

Following readings are obtained on the serial monitor

1. *Case 1*: when no object is present in front of sensor 1 and sensor

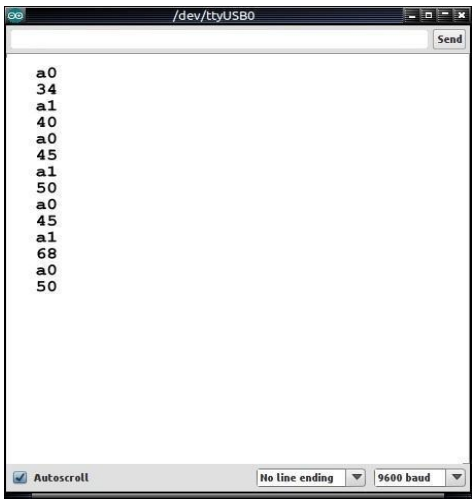


fig3.1 Arduino Reading of Case-1
a0- Reading of IR sensor-1
a1- Reading of IR sensor-2

2. Case 2: when the object is in front of the sensor on the entry side and there is no object in front of sensor on the exit side

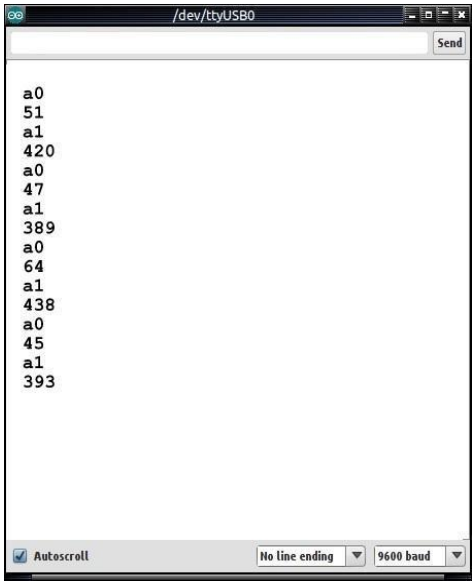


fig3.2 Arduino Reading of Case-2
a0- Reading of IR sensor-1
a1- Reading of IR sensor-2

Case 3: when the object is in front of the sensor on the exit side and there is no object in front of sensor on the entry side

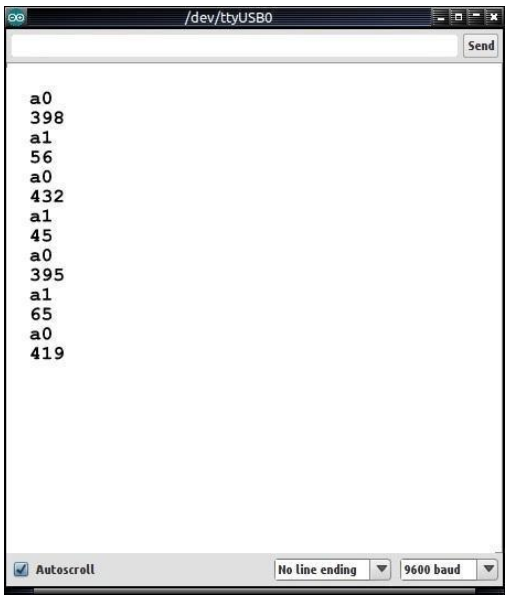


fig3.3 Arduino Reading of Case-3
a0- Reading of IR sensor-1
a1- Reading of IR sensor-2

IV. CONCLUSION

The objective of this project was to design and fabricate an automatic pneumatic door using IR sensors. Pneumatic systems provide motive power in a cheaper, safer, more flexible, and more reliable way than the orthodox electric motors and actuators. We have designed a pneumatically operated automatic door using IR sensors and Arduino.

The door will open whenever the IR proximity sensor 1 (mounted on the entry side of the door) senses the object and it will close only if that object has passed through the door and the IR sensor 2 (mounted on the exit side of the door) senses it. The whole phenomenon is controlled by a set of codes which we have written in the Arduino. The Arduino basically provides the logic for the entire operation which can be modified according to the user‟s requirement.

The door was tested in the automation laboratory and the program was modified according to the ambient light conditions in the laboratory. The opening and closing of the door was smooth and the IR sensor sensed each and every object without any flaw. The prototype and the program can be modified according to the requirement and this project can be applied in industrial, commercial and domestic sectors.

As the whole world is switching towards automation , the automatic pneumatic sliding door has a huge role to play in future industries, malls and shopping centers , buses, airports, educational institutions, hospitals and also in domestic usage. It can be enhanced by adding techniques like face detection, retina detection etc. and can be used to increase the security of important places. The pneumatic part will ensure that the door is cheaper and has smooth operation compared to other automatic doors.

ACKNOWLEDGEMENT

Prior to presenting the textual details of this journal , we feel it our duty to express our gratitude to all the members who have contributed towards the successful attainment of the project.

First and foremost our heartfelt gratitude and thanks to our guide Prof. Nagaraja, Associate professor (senior scale), Department of Mechanical Engineering for his unflinching support, encouragement and help provided. Throughout the project he has been a source of inspiration and role model by far.

We extend our thanks to Dr. Divakara Shetty S, H.O.D., Department of Mechanical and Manufacturing Engineering for letting us be a part of this project.

We would also like to thank the workshop technicians, especially Mr. Ganesh Acharya and lab staff for their help during the fabrication process.

Last but not the least we would like to thank our parents and friends for directly or indirectly helping us in the completion of this project. It has been a pleasant learning experience.

REFERENCES

Journal / Conference Papers

[1] Edward Steinfeld and G. Scott Danford, "Automated Doors: Towards Universal", The Center for Inclusive Design and Environmental Access, School of Architecture and Planning SUNY/Buffalo, USA, October 25,1993

Reference / Hand Books

[1] Joji P., "Pneumatic Controls", Wiley India Pvt Ltd, 1stEdition, ISBN: 8126515422

[2] Peter Croser & Frank Ebel ,"Pneumatics- Basic Level", FESTO Handbook,2002 Edition,
MIT Library-078190

Web

[1] Automation Importance, www.robots.com

[2] Arduino Uno, www.arduino.cc

[3] Arduino, en.wikipedia.org

[4] History of Automatic Doors, www.edoors.com

[5] Automatic Doors, www.uclue.com

[6] AAADM Timeline, www.aaadm.com

AUTHORS

First Author – Ashis Mohapatra, Department of Mechanical & Manufacturing Engneering, Manipal University , India
Second Author – Aman Anand, Department of Mechanical & Manufacturing Engneering, Manipal University , India