Architectural Robotics
Arch 879 / ECE 893
Spring 2009
Dr. Keith Green & Dr. Ian Walker
Intelligent Materials and Systems for Architecture (IMSA)
www.imsa-research.org

Project 2 – Disaster Relief/Mitigation in an Urban Context
J. Manganelli & Ivan Siles

Title: pCAP – Particulate Control and Air Purification

Youtube URL: http://www.youtube.com/watch?v=YTphm_MGDqc

Abstract: Use misting devices and/or fire suppression system sprinkler heads, mounted on building parapets, actuated by gas and/or particulate sensors to rapidly generate atmospheric mist in response to an accidental explosion and/or a terrorist attack. The mist localizes the health risks associated with hazardous particulate matter, gas and/or a dirty bomb by reducing the extent to which the hazardous particulates/gases migrate through the city. The proof of concept simulates the misting device but in actual usage it could be fed by a building's existing fire suppression system and use standard components.

Scenario: Bus shelters become safe havens for people caught within the hazardous cloud. A curtain deploys separating the inside of the bus shelter from the outside and an air filtration system cleanses the air and pumps the cleaned air down into the shelter. The shelter also deploys masks to provide the cleansed air to those who cannot fit within the shelter.

The air filtration is symbolized by large “breather” bellows on top of the structure. These breathers are lit from the inside. As people make their way through the cloud toward the shelter, they are guided by the light, the movement and the sound of the breathers. People wait at the shelters for rescue. The map below showing locations of bus shelters throughout Manhattan suggests the potential of utilizing the existing infrastructure as part of this strategy.

Hardware:

- Arduino Microcontroller – (2)
- 180° Range of Motion Servo Motor – (2)
- Ultraviolet LED – (2)
- Green LED – (4)
- 150 GPH Garden Pump – (1)
- Plastic Tubing – (10 ft.)
- Spray Mister Heads – (8)
- Tubing Connectors & T's – (8)
- Wire Coat Hangers – (2)
- Screw Eyes – (5)
- OSB – (4 ft x 4 ft)
- Chipboard – (10 sheets)
- Sandwich Bag – (1)
- Light Weight Bristol Board – (1 sheet)

- Duct Tape – (1 role, color to match bristol board)
- Plexiglass – (2ft x 2ft)

Code:

```
///////////////////////////////////////////////////////////////////////////////////////////////////////
// //
// Particulate/Gas Localization - Board 1 (Ivanduino) //
// //
// Joe Manganelli and Ivan Siles //
// //
// Project #2 - Architectural Robotics (Arch879/ECE893) //
// //
// Spring 2009 //
// Clemson University, Clemson, SC //
// //
//////////////////////////////////////////////////////////////////////////////////////////////////////
#include
// Declare all the IN/OUT pin variables
// Inputs
int Sensor = 6; //variable for ir sensor
//Outputs
int Joeduino = 5; //variable for communication with second arduino
int UV_LED = 13; //variable for UV LED
int Pump = 4; //Variable for water pump
//Servos
ServoTimer1 Bellows;
ServoTimer1 Breathers;
int Angle_Bellows = 0;
int Angle_Breathers = 0;
int Smoke = 0;
int IR = 0;
void setup()
{
Bellows.attach(9); // attaches the servo on pin 9 to the servo object
Breathers.attach(10); //attaches the servo on pin 10 to the servo object
```

```
pinMode(Sensor, INPUT);
pinMode(UV_LED, OUTPUT);
pinMode(Pump, OUTPUT);
pinMode(Joeduino, OUTPUT);
} //Close void setup
void loop()
{
digitalWrite (UV_LED, LOW); //Make sure all LEDs are OFF
digitalWrite (Pump, LOW); //Make sure Pump is OFF
digitalWrite (Joeduino, LOW); //Make sure Arduino 2 is OFF
// goes from 0 degrees to 35 degrees
for(Angle_Breathers = 0;Angle_Breathers <=35;Angle_Breathers+=1) {
Breathers.write(Angle_Breathers); // tell servo to go to position in variable
delay(20); // waits 20ms for the servo to reach the position
}
// goes from 180 degrees to 100 degrees
for(Angle_Bellows = 180;Angle_Bellows >=100;Angle_Bellows-=1) {
Bellows.write(Angle_Bellows);
delay(10); // waits 10ms for the servo to reach the position
}
while (Smoke == 0) { //If no smoke, keep updating sensor
IR=digitalRead(Sensor); //Read from Sensor
if (IR==HIGH){
Smoke=1;
}
else{
Smoke=0;
}
} //Close while
digitalWrite (Pump, HIGH); //Activate relay for the Pump
// goes from 100 degrees to 180 degrees
for(Angle_Bellows = 100;Angle_Bellows >=0;Angle_Bellows-=1) {
Bellows.write(Angle_Bellows); // tell servo to go to position in variable
delay(30); // waits 30ms for the servo to reach the position
}
digitalWrite (UV_LED, HIGH); //Activate UV_LEDs
digitalWrite (Joeduino, HIGH);
while(1) {
for(Angle_Breathers = 10;Angle_Breathers <=60;Angle_Breathers+=1){
Breathers.write(Angle_Breathers); // tell servo to go to position in variable
delay(20); // waits 30ms for the servo to reach the position
}
for(Angle_Breathers = 60;Angle_Breathers >=10;Angle_Breathers-=1) {
Breathers.write(Angle_Breathers); // tell servo to go to position in variable 'pos'
delay(20); // waits 20ms for the servo to reach the position
}
} //Close while loop
} // Close void loop
///////////////////////////////////////////////////////////////////////////////////////
// //
// Particulate/Gas Localization - Board 2 (Joeduino) //
// //
// Joe Manganelli and Ivan Siles //
// //
// Project #2 - Architectural Robotics (Arch879/ECE893) //
// //
// Spring 2009 //
// Clemson University, Clemson, SC //
// //
//////////////////////////////////////////////////////////////////////////////////////
// Declare all the IN/OUT pin variables
//Inputs
int Ivanduino = 5; //variable for input from Ivanduino
//Outputs
int LED_right_breather = 9; //variable for Green LED
int LED_left_breather = 10; //variable for White LED
int Signal = 0; //variable for Ivanduino
int Pin5 = 0; //variable for Pin5
int LED_rb = 0; //variable for activiating LED_right_breather
int LED_lb = 0; //variable for activating LED_left_breather
void setup()
{
pinMode(Ivanduino, INPUT);
pinMode(LED_right_breather, OUTPUT);
pinMode(LED_left_breather, OUTPUT);
} //Close void setup
void loop()
{
analogWrite (LED_right_breather, 55); //Make sure right breather lights are low
analogWrite (LED_left_breather, 55); //Make sure left breather lights are low
while (Signal == 0) { //If no smoke, keep updating sensor
Pin5=digitalRead(Ivanduino); //Read from Ivanduino
if (Pin5==HIGH){
Signal=1;
}
else{
Signal=0;
}
} //Close while
while(1) {
for(LED_rb = 55, LED_lb = 255;LED_rb <=255,LED_lb>=55;LED_rb+=4,LED_lb-=4) {
analogWrite (LED_right_breather, LED_rb);
analogWrite (LED_left_breather, LED_lb);
delay(20);
} //Close for loop
for(LED_lb = 55, LED_rb = 255;LED_lb <=255,LED_rb>=55;LED_lb+=4,LED_rb-=4) {
analogWrite (LED_right_breather, LED_rb);
analogWrite (LED_left_breather, LED_lb);
delay(20);
} //Close for loop
} //Close while loop
} // Close void loop
```

Lessons Learned:

- The water pump we bought did not have enough pressure to make the water become mist through the misters so we resorted to using a spray bottle to simulate the intended misting effect
- Overall, this was a solid and successful project and is compelling as future research.
- An important next step would be to determine the efficacy of creating such a system in reality in a particular location and determining whether or not existing technology is adaptable to this purpose.