SMART Science and Mechatronics Aided Research for Teachers *2004*

The S.M.A.R.T. Intersection

Michael G. Koumoullos
Aviation High School
Long Island City, NY 11101

Robert H. Winston
Canarsie High School
Brooklyn, NY 11236

[1] A Mechatronics Demonstration Project This work was supported by the National Science Foundation under an RET Site Grant 0227479.

The National Science Foundation
Division of Engineering Education & Centers

Raison d'etre—Why this project is important!

- Cars dominate urban, suburban and rural travel among every segment of the population.

- Public's increasing need to travel and the difficulty of providing additional roads

- Travel has increased congestion and reduced mobility in many cities.

Automated vehicle guidance (AVG is a technology that allows individual vehicles to move without physical control by a driver.

AVG has two components:

in-vehicle components / sensors:

- a controller/processor
- other vehicles
- roadway location
- vehicle roadway position
- sensors to detect the presence of:

roadway infrastructure components:

1. markings used to delineate the roadway
2. signals that can regulate flow
3. traffic management system that directs the flow and protects
4. roadside transceivers to communicate with the automated vehicles

This project reflects part of an **Automated Highway System (AHS**).

An **AHS** is intended to ameliorate:

1. traffic flow
2. patterns of vehicular traffic volume
3. excessive vehicle speed
4. chaotic vehicular situations
5. heavily trafficked intersections
6. gridlock in vehicle-intense urban centers

Ultimately, the goals are:

1. increased vehicle and pedestrian safety
2. maintenance of reasonable rates of traffic flow at intersections
3. decreased the likelihood of long wait-times at traffic lights
4. decreased probability of gridlock at major inner-city intersections

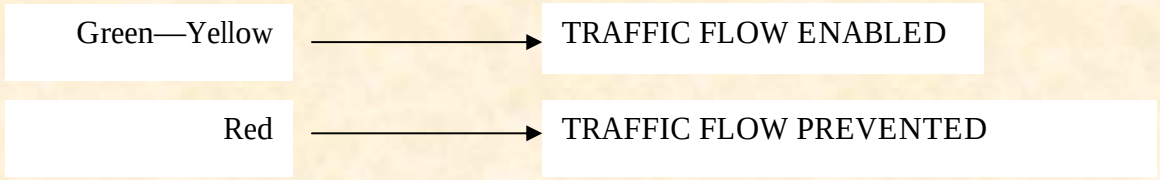
- Only in-situ sensing in the form of **infrared detection** is used—***Why?***

- **Infrared light** or IR has lower frequency than red light. It is not part of the visible spectrum. It can be used in a number of applications, including:

    1. night-vision goggles
    2. temperature sensors
    3. object detection
    4. object counts
    5. distance determination

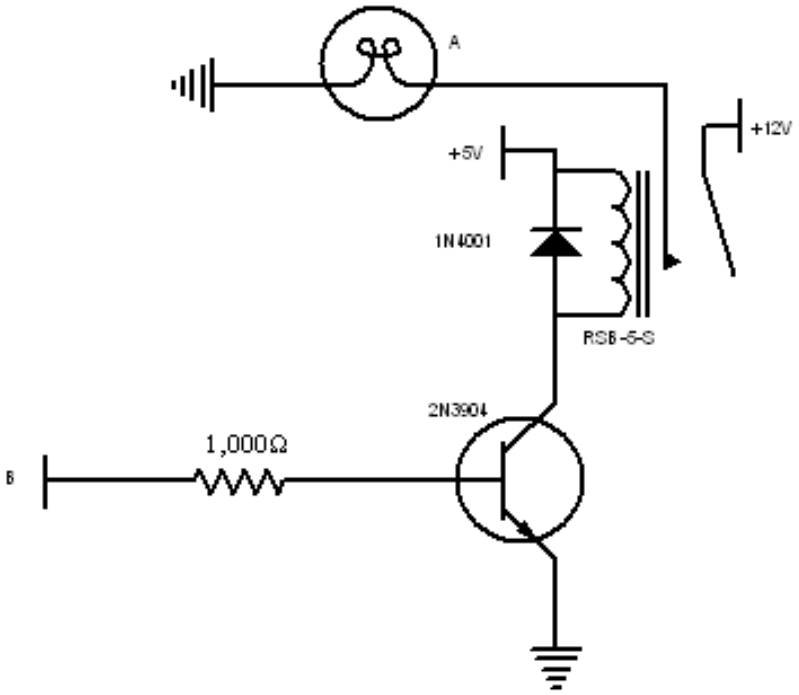
- At intersections that have experience heavy traffic patterns, traffic lights are put in place to regulate the flow of vehicles to. Why?

- The light operate through a standardized cycle that involves:



Answers:

1. insure safety
2. reduce traffic
3. prevent accidents involving pedestrians and/or vehicles
4. prevent grid-lock.



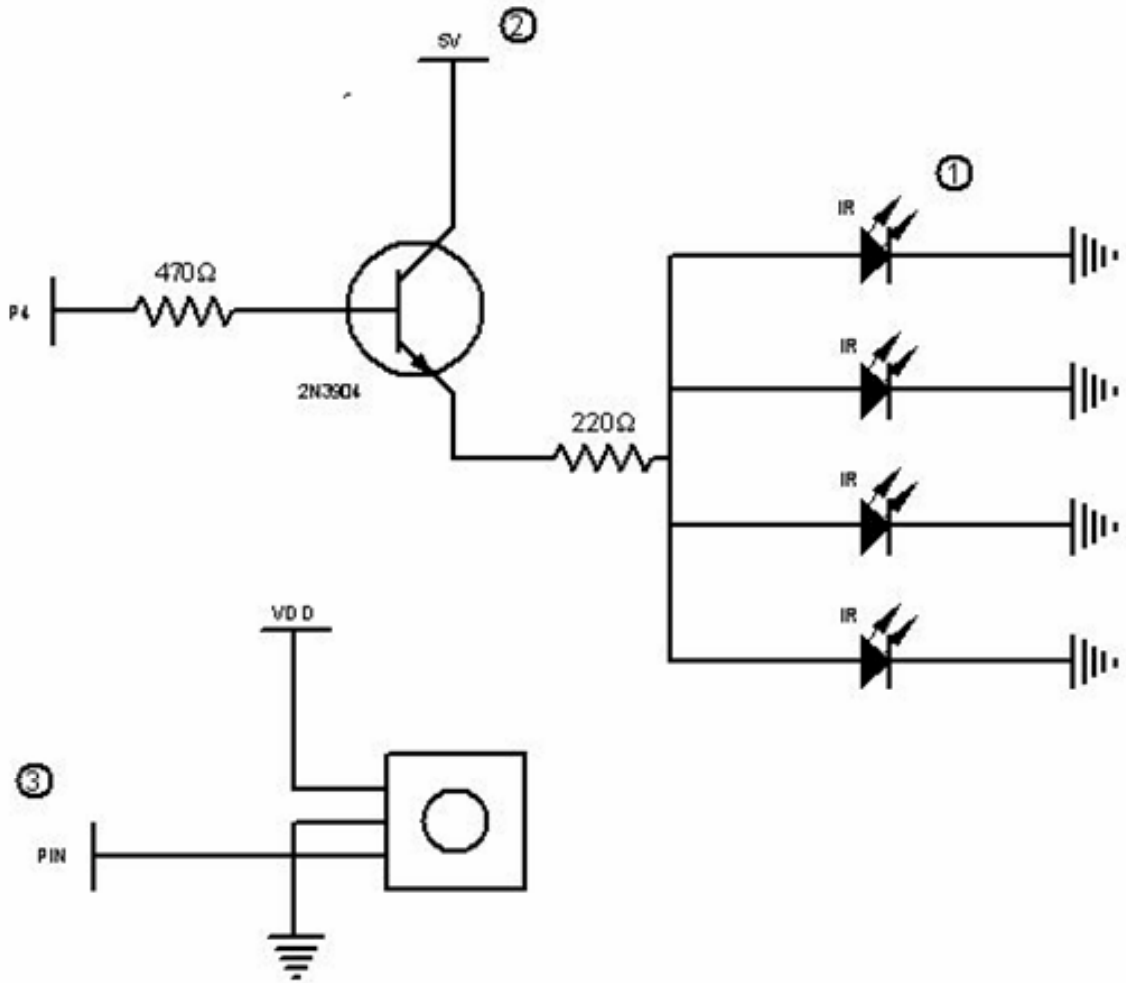
BILL OF MATERIALS

QTY.	Ref No.	NAME
6	9	Resistor 1K Ohm
6	6	Relay
6	8	Transistor
6	7	Diode
2	10	Lamp, Red
2	11	Lamp, Yellow
2	12	Lamp, Green

Pin No.	Lamp Color	Street
7	Red	NS
8	Yellow	NS
9	Green	NS
10	Red	EW
11	Yellow	EW
12	Green	EW

NOTES:
1. The portion of the circuit represented above occurs six (6) times in the complete circuit.
2. All instances are identical, with the exception of items A and B.
3. "A" represents the bulb color and location. "B" represents the Basic Stamp pin.
3. See the chart to the right for lamp (A) and pin (B) identification.

Infrared Traffic Signal		
DRAWN Koumoullos, M	SIGNALING SYSTEM	
DRAWN Winston, R		
DATE 07-22-2004	SIZE A	DWG NUMBER 0000-0002
SCALE NONE	REV -	SHEET 1 OF 1



BILL OF MATERIALS

QTY.	Ref No.	NAME
1	17	Resistor 470 Ohm
1	20	Resistor 220 Ohm
4	4	IR Emitter Diode
4	5	IR Photo-sensor
1	8	Transistor

IR Sensor Pins

Pin No.	Road	Position
0	NS	Near
1	NS	Far
2	EW	Near
3	EW	Far

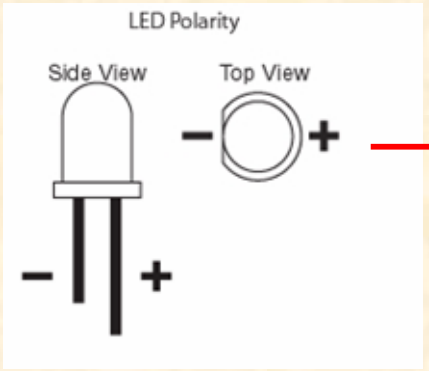
4

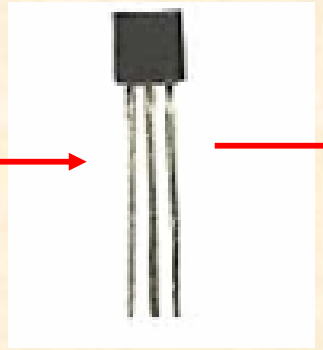
NOTES:
1. The IR LEDs flash at 38.5 kHz with a 50% duty cycle.
2. The 5V source connected to the collector of the transistor is isolated from VDD.
3. See the chart to the right for IR sensor pin identification.
4. Near/Far refers to the distance from the intersection.

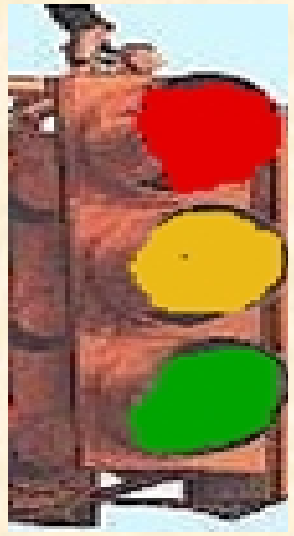
Infrared Traffic Signals		
DRAWN Koumoullos, M	DETECTION SYSTEM	
DRAWN Winston, R	Infrared LEDS and Infrared Sensors	
Date 8-02-2004	SIZE A	DWG NUMBER 0000-0001

Information Processing:

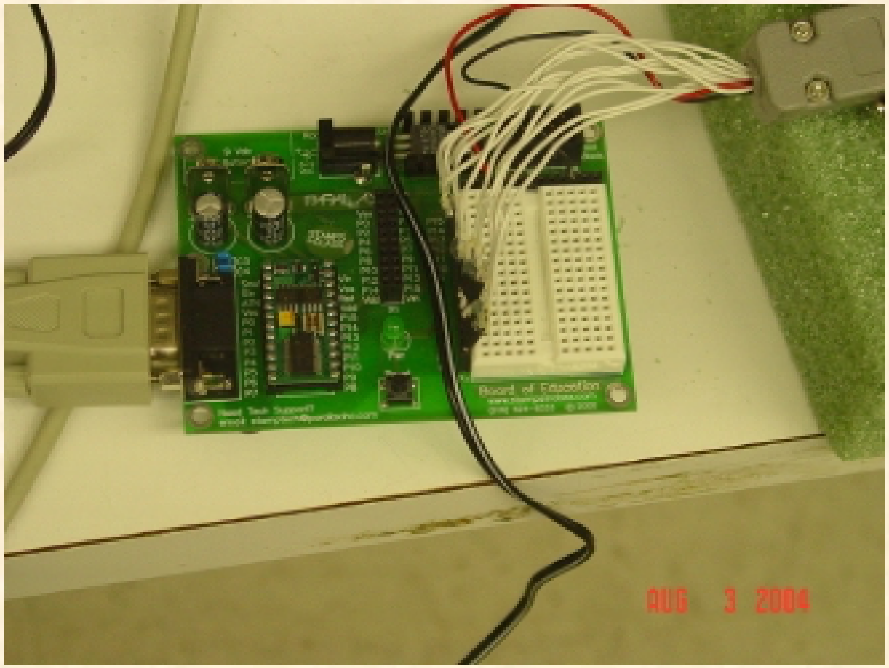
The change in the flow of information when objects are sensed—application of feedback loops. **Why the plural, *loops*?**







Experimental Parts when Assembled



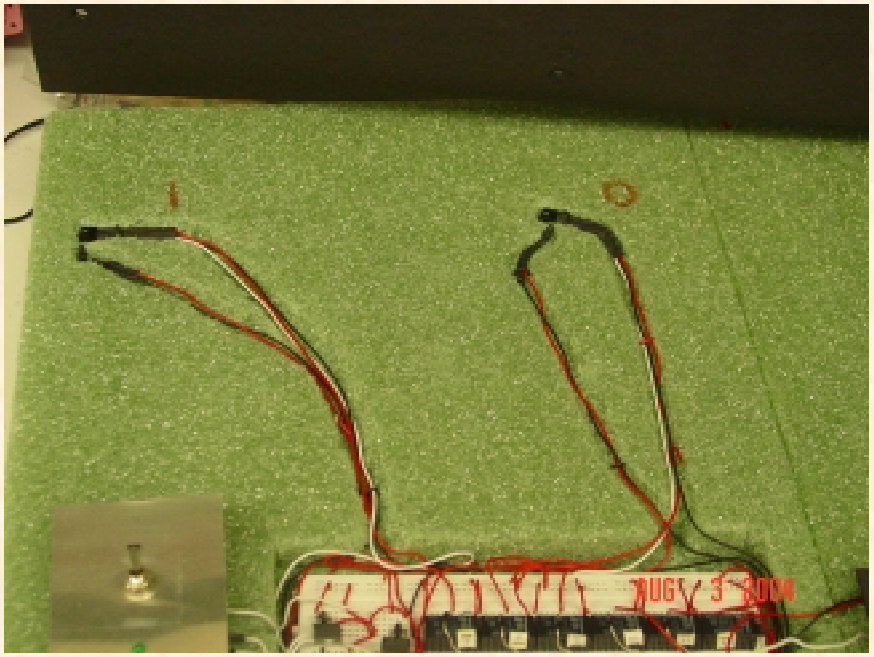


Figure-BOE acting as an interface. Figure—Individualizing and hiding wires.

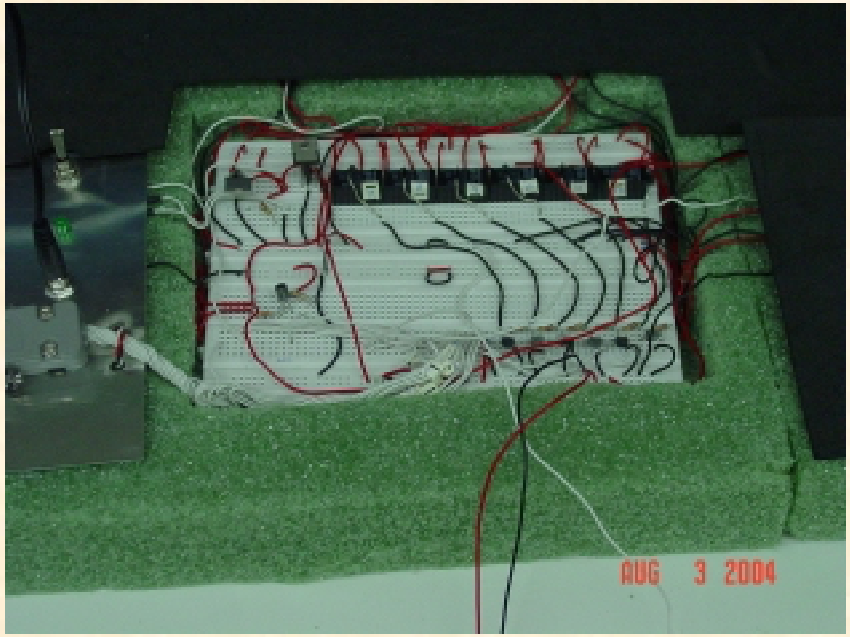
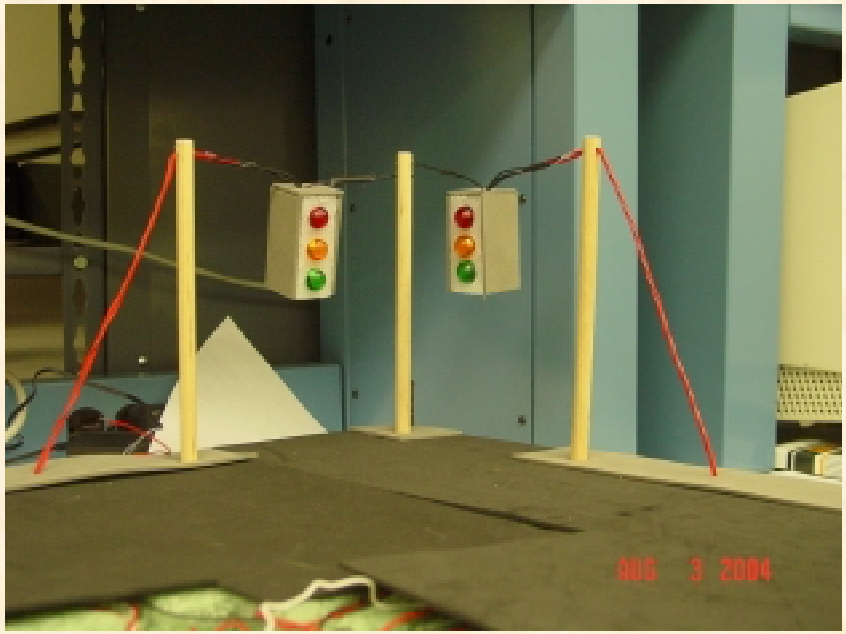


Figure --The complex series of wires for the project.



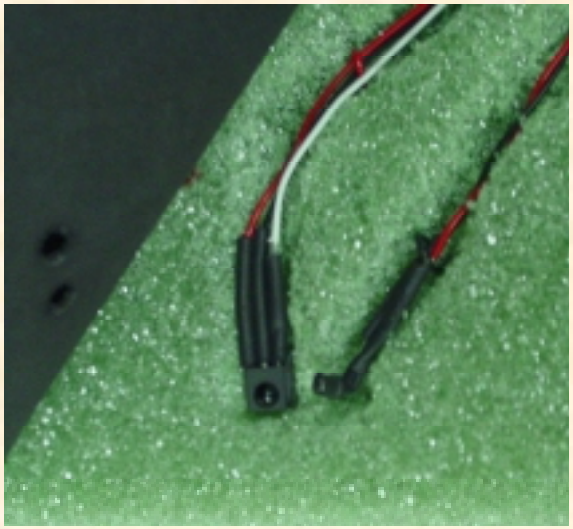
Figure—The North-South Intersection and its East-West counterpart.

Table 1—The Traffic Signal Cycle with and without sensor triggering

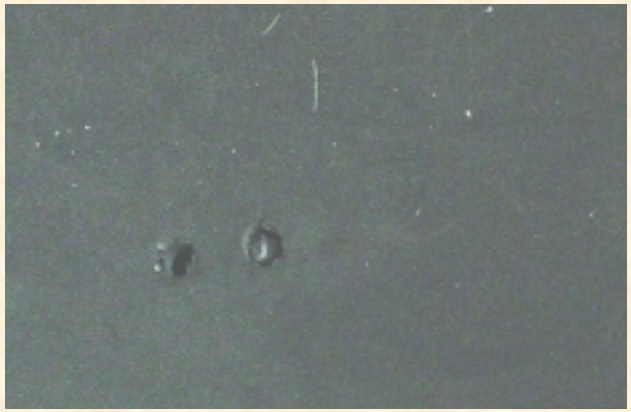
Color of Traffic Light Signal	Duration of the Signal Light (in s) as a function of the number of IR sensors triggered					
	0 (<4 vehicles)		1 (4-6 vehicles)		2 (7-12 vehicles)	
	Compass (Directionality)					
	N-S	E-W	N-S	E-W	N-S	E-W
Green	5	5	10	10	15	15
Yellow	2	2	2	2	2	2
Red	9	9	14	14	19	19

Notes:
N-S = North-South
E-W = East-West

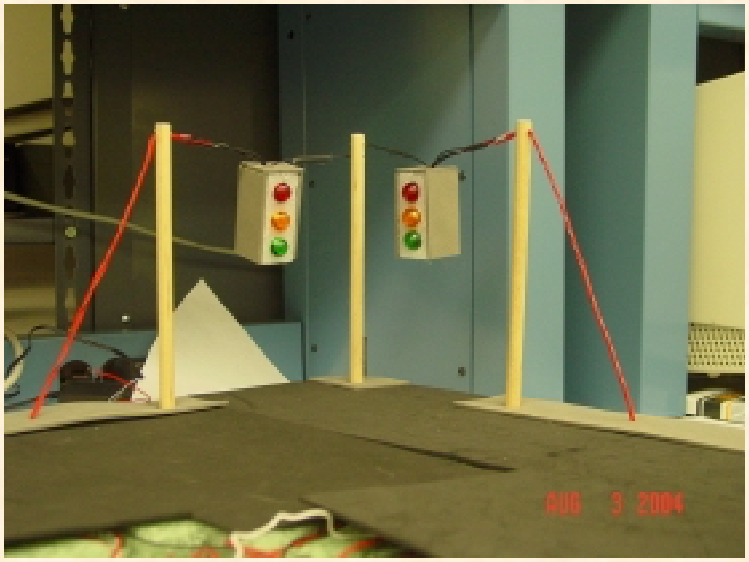
The table (above) summarizes the changes in light signaling that are result of feedback between the IR LED's—sensors and the vehicles in the model.



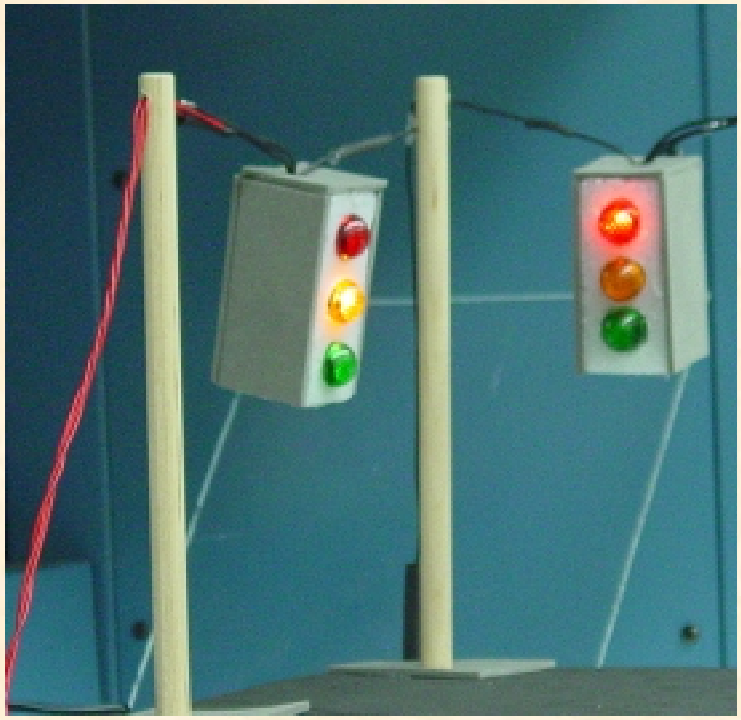
LED’s and photodetectors
as the lay embedded side-by side
under the artificial roadway.



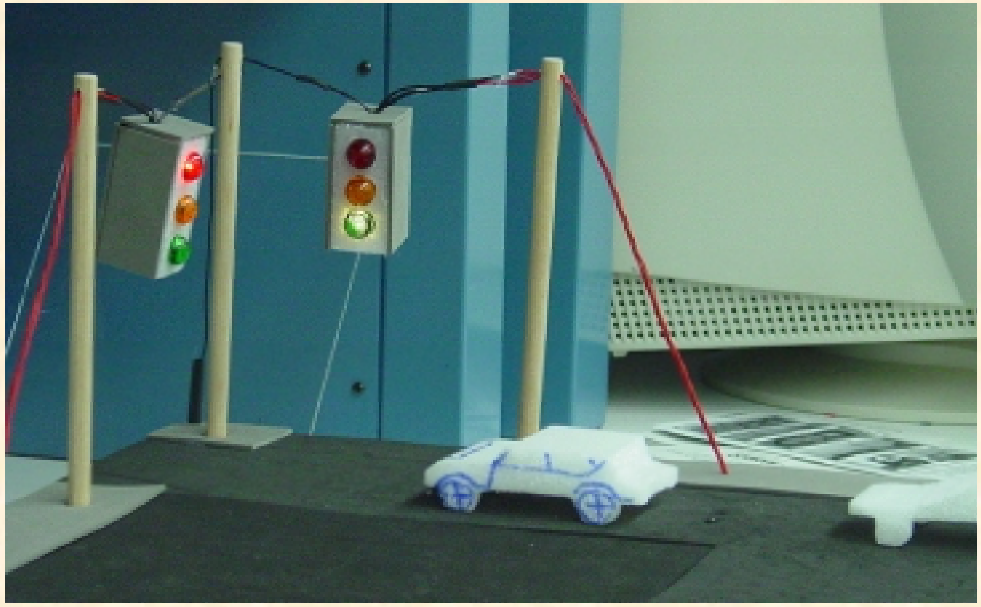
The sensors as they
appear in a top view
In the asphalt



The North-South
Intersection and its
East-West
counterpart.



The *paradigm* in action without any vehicles present. The traffic lights cycle without any changes whatsoever



The paradigm in action with vehicles present. The traffic lights now cycle with changes dictated by the “cars, etc. etc.”

Conclusions

- **Once IR sensor detection takes place, feedback mechanisms are generated!**
- **This translates into a longer green signal.**
- **The length of the green light is a function of the number of IR emitter-sensor pairs triggered!**
- **The model that has been created in our virtual intersection can be extended to real world traffic intersections either in:**
  - **variably-sized cities**
  - **urban streets**
  - **suburban streets**
  - **street-highway junctions**
  - **highway-highway junctions**

Follow-up Studies

Set up a sensor array in order to:

- increase the diversity and position of sensors at intersections to count and describe in other ways the type of vehicles present
- employ sensors on roadways a highways to: adjust distances between vehicles change vehicle speed communicate with vehicles regarding itinerary depending on other vehicles traffic, weather, etc.

Acknowledgments

We would like to thank SMART Project Director Professor Vikram Kapila, Project Instructor Sang-Hoon Lee, Project Assistant Anshuman Panda, Graduate Student—Jon Blyer, and the rest of Polytechnic University's Mechanical Engineering Department for their assistance and patience. We would also like to thank Professor Noel N. Kriftcher and Alessandro Betti for their consultative assistance and/or support.

Parenthetically, we would like to thank Parallax, Inc. for donating a "Homework Board", and a "What's a Microcontroller" text and parts kit to each teacher involved in the project and Polytechnic University and the National Science Foundation for making this program possible.

Rob Winston & Mike Koumoullos SMART, August 6, 2004