Emergent Behavior Robot

Senior Project Proposal

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Introduction

The objective of this project is to design and build a robot that uses a software architecture based on subsumption to demonstrate emergent behavior. Subsumption architecture is an approach for designing intelligent systems based on several behavior modules [1]. When the robot's environment matches the conditions required for a specific behavior, that behavior is executed. The robot's most basic behavior module is searching for and traveling to an ultrasonic beacon. Another behavior module is the tendency to evade loud noises by seeking low light areas for safety. When the environment is deemed safe the robot will resume pursuit of the beacon. Programming the robot to exhibit these simple behaviors produces an emergent behavior. The idea of emergent behavior is that multiple simple behavior modules combine to create a sophisticated, intelligent response that is greater than the sum of the parts [2].

Goals

The goal of this project is to build and develop a robot that will use a combination of simple behaviors that result in complex actions in response to its environment. Other goals include:

- Learning the development software for the ATmega128 microcontroller,
- Developing and constructing a robot platform, including mounted sensors, batteries, a microcontroller, motors, other and accompanying hardware,
- Using IR and bump sensors to avoid obstacles,
- Using microphones to detect loud noises (above 80dB) [3],
- Using photosensors to determine the ambient light at the robot's location and in close proximity of the robot,
- Developing the software that will give the robot its behavior
    - The robot shall detect and avoid obstacles
    - The robot shall be drawn to darkness
    - The robot shall evade loud noises
    - The robot shall seek out a beacon

High-Level System Overview

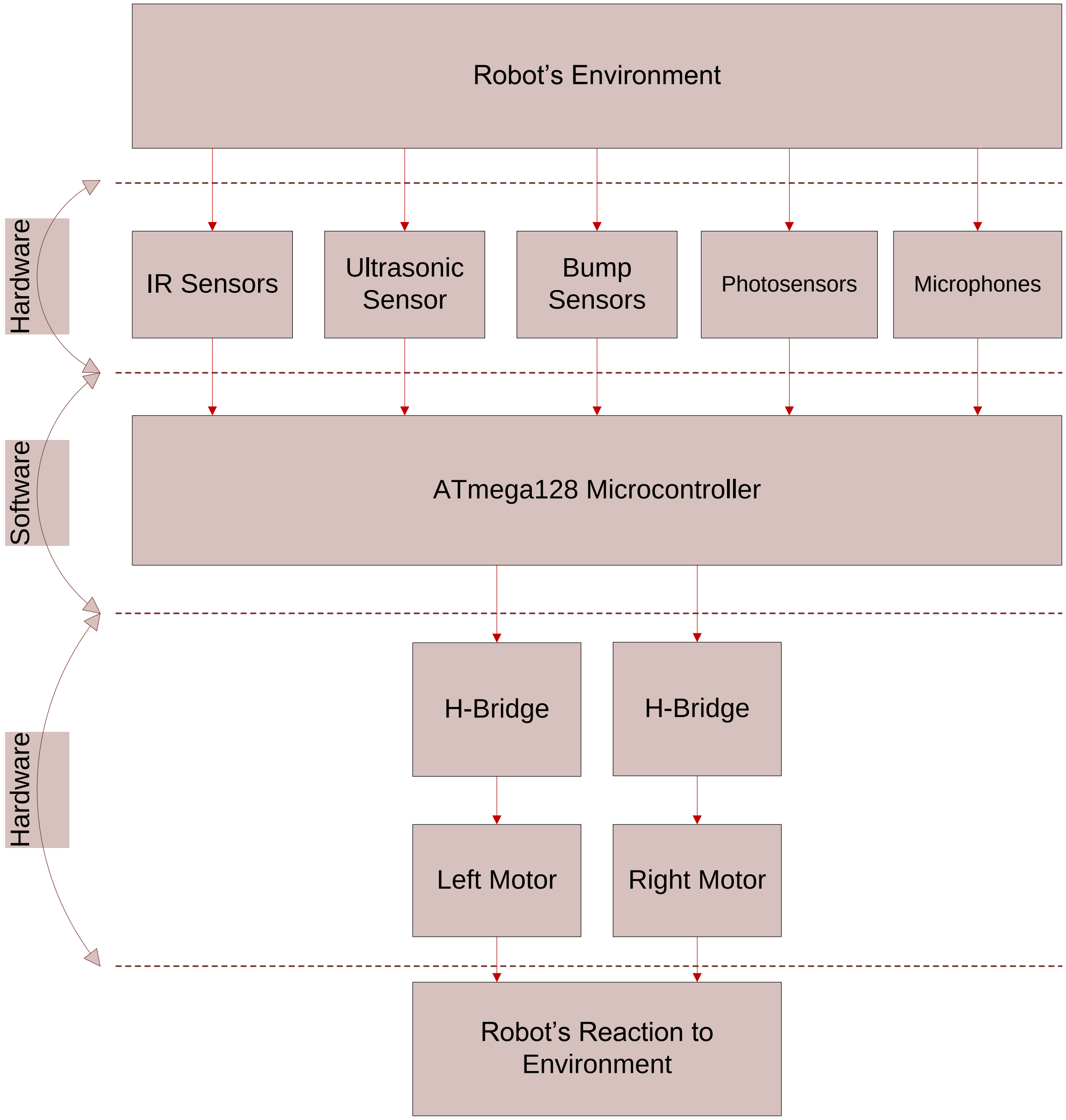

Figure 1: High Level System Block Diagram

Figure 1 shows the how the robot will gather data about its environment using sensors and then react through movement. The robot platform will be built from the ground up to ensure that the design has the features necessary to perform its tasks successfully. The platform will be controlled by an ATmega128 microcontroller, which will be programmed in C. The microcontroller will utilize the input from several sensors to extract the environmental features necessary to react intelligently.

The robot will have three basic modes. In Roam mode, the robot will search in a random pattern for the beacon while avoiding obstacles. Evade mode will be active once the robot detects a loud noise. In Pursuit mode, the robot will have received a signal from the beacon and will travel toward it.

A set of three microphones will be connected to the ATmega128 to detect loud noises and determine the direction of the source of the noise. The robot's response to a loud noise will be to enter Evade mode and travel away from the source at a speed twice the normal roam speed (60cm per second). When the robot is in Evade mode, it will become more sensitive to the level of sound (50dB threshold instead of 80dB).

Photosensors will determine the amount of light at the robot's current location and light levels in the robot's path so it can determine the darker path during travel. The robot will use this information to find shelter when in Evade mode.

IR and bump sensors will be mounted on the robot to avoid obstacles while traveling. The IR sensors cannot detect an object closer than 10cm, so the bump sensors ensure obstacle detection when the IR sensors fail.

Ultrasonic receivers will also be included on the robot to detect the beacon that the robot is seeking. Matching ultrasonic transmitter will be mounted on the beacon so that the robot can locate it.

The only outputs from the microcontroller are two signals driving the H-bridges. The H-bridges allow the microcontroller to control motor speed using a PWM and the drive direction of the motors independently.

High-Level Software Block Diagram

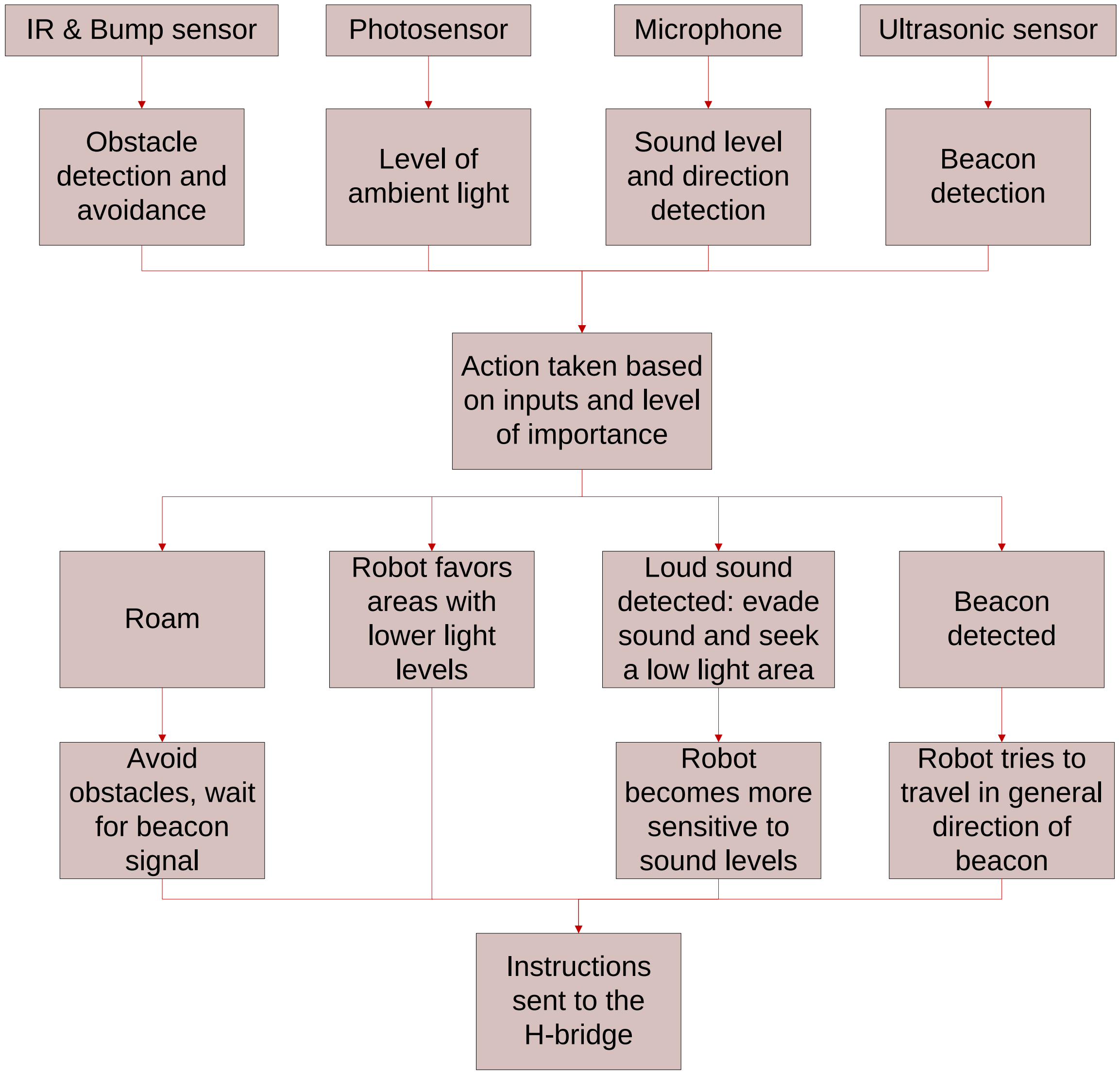

Figure 2: High-Level Software Block Diagram

The projected operation of the software is shown in Figure 2. The response of the robot depends on its environment and actions are weighted based on priorities, shown in Table 1.

Table 1: Task Priorities

Task	Roam	Travel in low light	Beacon found	Detection of a loud sound
Priority	5	4 (2 if in Evade mode)	3	1

Detection of a loud sound takes priority over all other tasks. Roam receives the lowest priority. Traveling toward the beacon is more important than traveling in low light, unless a loud sound had been detected and the robot is in Evade mode. Key modules are described in the following paragraphs.

Obstacle Detection and Avoidance: This will use IR and bump sensors to determine the robot's distance from an object or if the robot has run into an object. If a nearby obstacle is detected or the bump sensor is triggered, the robot will take action to move around the object and continue travel.

Level of light sensed: This will use photosensors to decide if the robot is in a low light area. The robot will favor low light areas while traveling, especially if it is in Evade mode. If the robot is in Evade mode, it will seek darkness and hide there. Once in the dark, the robot will determine when it is safe to leave and continue traveling. A safe environment may be determined by a combination of time delay and a consistently low noise level.

Sound level and direction detection: The robot will detect if there is a loud noise and will then react by traveling away from the source of the sound. If the robot senses the noise, it will attempt to evade and seek a low light area as described earlier. After the robot has heard a loud noise it becomes more sensitive to noises and will be easier to scare.

Beacon detection: The robot will roam trying to detect a signal beacon. Once the beacon is detected, traveling to the beacon source will be the robots goal.

Instructions sent to H-bridges: The instructions sent to the H-bridges will control the motors to get the robot to complete its tasks.

Functional Requirements and Specifications

The success of this project depends on the hardware-software interface to correctly display an emergent behavior in response to the robot's surroundings. The interactions with the environment shall serve as the inputs into the system and shall dictate how the robot reacts. The robot will not be programmed to perform exact complicated tasks, but rather to perform many small tasks, which should display an emergent behavior.

The robot must be able to detect obstacles and avoid them while it is roaming and searching for the beacon. The robot shall use infrared sensors to avoid obstacles and will try to stay 15cm away from them, since the IR sensors minimum detection range is 10cm. The robot needs to be able to detect a loud noise, in which case the robot will travel away from the source of the noise, favoring dark areas. We define a loud noise as a noise above 80dB, which is above normal conversation volume level [3]. The robot must also be able to sense the ambient light above itself and the light levels in close proximity to enable the robot to travel in the darkest path. Using these objectives, the robot shall effectively seek out an ultrasonic beacon and get within approximately a 60cm of the beacon.

Performance Specification Summary

The robot shall:

- Avoid all obstacles within 15cm
- Detect a loud noise (above 80dB) and determine the direction of origin
- Reach an ultrasonic beacon within a 60cm radius
- Determine which areas in its path are darker
- Travel at a speed of 60cm per second nominally
- Travel at a speed of 120cm per second when evading

Preliminary Schedule

A preliminary schedule, Table 2, has been developed with the goal of completing this project around Spring Break. The idea behind this is to allow for delays and setback that naturally occur in a large project.

Table 2: Preliminary Schedule

Week	Andrew Elliott	Nick Hanauer
1-3	Research & Website Development	Parts Research
4	Learn ATmega128	Parts Testing & Research
5	Interface with the Digital I/O	Parts Testing & Finalizing Parts List
6	ADC Setup	Parts Testing & Order Remaining Parts
Winter Break	Construct Chassis	
7	Interface IR Sensors & Photosensors	Motor & H-Bridge Circuitry/Testing
8	Interface Microphones	Microphone & Photosensors Circuitry/Testing
9	Interface Motors & H-Bridge	Ultrasonic Circuitry/Testing
10-11	Integrating All Sensors	Circuitry Clean-Up & Wire Wrapping
12	Final Software/Hardware Testing	
13-14	Final Documentation and Presentation Preparation	

Equipment

Table 3: Parts List

Component	Vendor	Part Number	Crucial Spec	Unit Cost	#	Ordering Cost
MAVRIC-IIB	BDMICRO	MAV2BPH16		$99	1	$99.00
Motor	Robot Marketplace	0-BHG31	Torque & RPM	$23.99	2	$47.98
IR Sensor	Acroname	Sharp GP2Y0A21YK	Distance(Min & Max)	$12.50	4	$50.00
H-Bridge	Bradley University	LMD18200	Max Current	$0.00	2	$0.00
Wheels	Robot Marketplace	0-DAV5540	Diameter	$8.99/pair	2	$17.98
Microphone	Digi Key	CMB-6544PF		$0.72	5	$3.60
Photosensor						

Table 3 contains all the parts necessary to complete the project. The table does not include the cost of items available in the lab, such as wire, resistors, capacitors, and other circuitry items. It also does not include the price of materials that will be used to build the chassis.

References

[1] N. Nilsson, “Artificial Intelligence: A New Synthesis”, San Francisco, CA: Morgan Kaufmann, 1998.

[2] R. Cioarga, B. Ciubotaru, D. Chiciudean, M. Micea, V. Cretu, and V. Groza, “Emergent Behavioral Modeling Language in Obstacle Avoidance”, Warsaw, Poland, May 2007.

[3] Galen Carol Audio, "Decibel (Loudness) Comparison Chart," [Online document], 2007, [cited 2009 Nov 11], Available HTTP: http://www.gcaudio.com/resources/howtos/loudness.html