THE HYENA PROJECT
SCAVENGING ROBOT

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Spring 97'
Professor Keith L. Doty
Final Report

04/28/97

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ACKNOWLEDGMENTS

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ABSTRACT

The Hyena Project is a modular robot design whose primary purpose is to search for and recover metallic objects that are either on or near the surface. It is designed for high maneuverability to allow for tight search patterns and enhanced object avoidance. Its modular design allows easy maintenance and the possibility of multiple objectives from the same hardware.

INTRODUCTION

Having an entity do useful work that may be considered a waste of time or dangerous for a human being is the goal of this project. Originally, the goal of this project was simply to have a robot that simply detects and recovers small metallic objects. However, the concept has evolved from having a single, narrow set of possible objectives to the idea of having several possible objectives dependent on the hardware that is added to the configuration. For instance, a metal sensing coil module can be added to the front while a sweeper assembly is added to the middle for recovery. Or, instead, a manipulator and camera can be added to the front while extra batteries are added to the middle for prolonged service. Perhaps even some device for exterminating pests without pesticides or doing some type of excavation can be added as a module. In effect, a technician could configure a squad of hyenas for a work site and simply oversee and maintain them.

THE HYENA

MICRO-CONTROLLER

The Hyena obstacle avoidance, metallic object detection, and metallic object acquisition are all accomplished autonomously using the standard Motorola 68HC11 EVBU micro-controller board. Four motors and two servos require control by the EVBU. In addition, five sensors make the obstacle avoidance and metallic object detection possible. The two drive motors are controlled using the standard motor drivers included on the ME11 expansion board. The two servos are controlled using preprogrammed IC libraries called "twoservo.c" and "twoservo.icb". The header pins for the control lines of these two servos are pins 27 and 31 located at port A. In order to control the sweeper motor and the assembly motor, three more digital control lines are necessary. Digital output port J6 is used as both a modulated signal for the IR and the control lines for the additional motors. This was accomplished simply by modulating the ground signal of the IR emitters instead of the 5 V signal simply by switching jumper J11. The first additional control line is simply used as a uni-directional switch to power the relay controlling the sweeper motor. Two more digital outputs are required to control the bi-directional lifting assembly motor.

CHASSIS

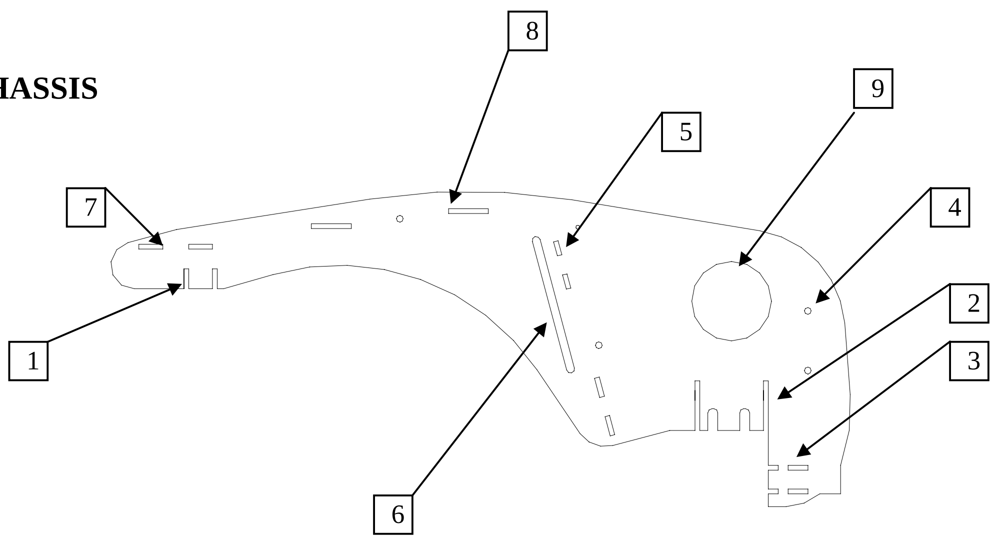
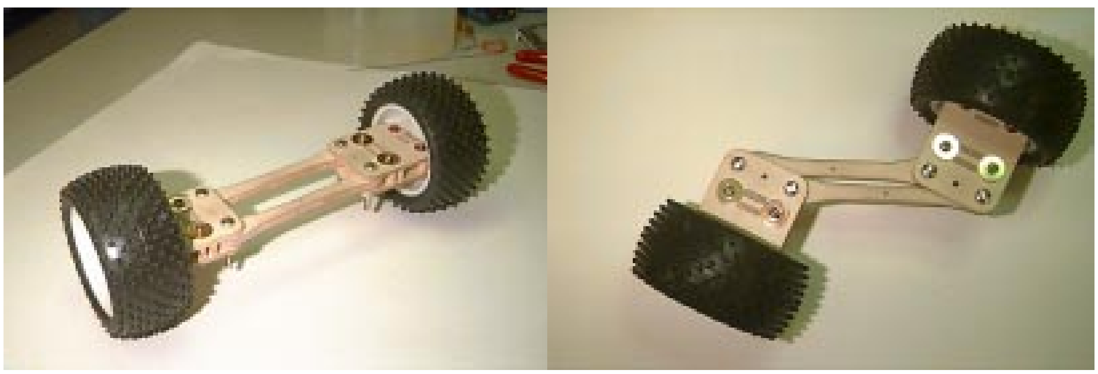


Figure 1. Hyena main chassis

The chassis was specifically designed to accommodate the mount for the metal detecting coil and the lifting assembly. At the rear of the chassis (1) there are two vertical slots for mounting the rear drive module. At the front portion of the chassis (2) are two vertical slots for mounting the forward drive module. The slots located at (3) allow for the mounting of the IR sensor array disc. The pins located at (4) are used by the parallel-bar metal-detecting coil mount. The slanted slots located at (5) are used to mount the lifting assembly motor package. The large slot at (6) is used by the lifting assembly as a slider used by the brush linkage. The slots at point (7) are used by the controller board \ rear drive module mount. The slots at point (8) are used for added structural stability and for wire routing.

DRIVE SYSTEM

The drive system consists of a forward and a rear drive module that attach to the frame at points (1) and (2) of Figure 1. The forward drive module consists of a parallel bar linkage as shown in Picture 1. This parallel-bar linkage is attached to the module at pin holes located near the middle of the wheel mounts as shown in Picture 1 (b). Note the servo mounting pins located in the middle of each of the steering arms. The rear drive module is similar in design to the forward drive module except that it requires at two-tiered mount in order to circumvent the drive motors.



Picture 1.   (a) Straight operation   (b) Turning operation

OBSTACLE AVOIDANCE

Basic obstacle avoidance was implemented based on the premise that the body will follow the head. Since the Hyena is four-wheel steering, properly written code proved this to be true. Figure 2 shows the forward sensor array used for basic obstacle avoidance. The six slots placed radially around the perimeter of the disc allow for the placement of up to six IR detectors. The IR detectors are sandwiched between a similar disc placed below this sensor array. Although four detectors proved to be sufficient for most obstacle avoidance, six would allow for the detection of narrow obstacles.

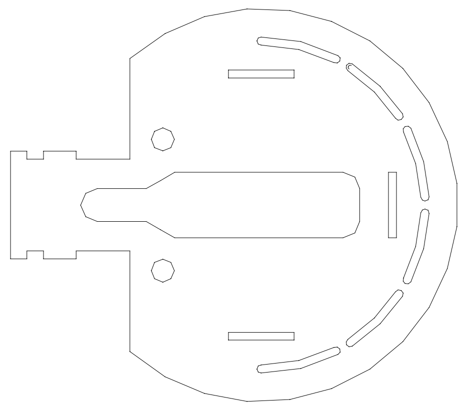


Figure 2. Forward IR sensor array mount

METALLIC OBJECT DETECTION

Metallic object detection was achieved using a Radio Shack Deluxe Metal Detector with Discriminator. The optimum settings for detecting a quarter were found as shown in Table 1.

DISCRIMINATOR	RESPONSE	
CCW - full 260	4.0 in search width	3.5 in search depth
180	3.5 in SW	3.0 in SD
135	3.0 in SW	1.75 in SD
90	3.0 in SW	1.5 in SD
45	3.5 in SW	2.5 in SD
0	2.25 in SW	1.0 in SD

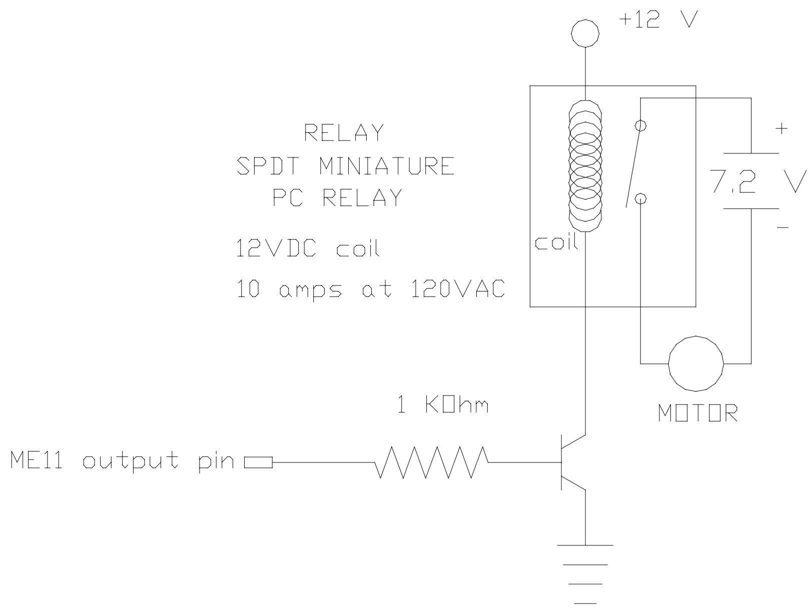
Table 1. Signal response for metal detector

Since the metal detector works optimally with the discriminator at its lowest, usage of the full CCW position would be best in a low ferrous environment. However, since the Hyena is used predominantly indoors, the metal detector is typically run with the discriminator almost full CW in order to avoid interference from ferrous objects such as the re-bar contained within the concrete flooring.

In order to obtain a signal from the metal detector, the board that came with the original package was used and the outputs from the analog display are tapped off of. Since the signal coming from the metal detector board varied between 0 V and approximately 8 V, it was necessary to use a voltage divider in order to keep the input voltage for the 68HC11 EVBU below the 5 V maximum value. Using a 47 kOhm and a 68 kOhm resistor the reduced signal was fed into Port E at pin 50 (Analog(7)).

METALLIC OBJECT ACQUISITION

Metallic object acquisition is achieved using a sweeper assembly mechanism. The assembly consists of a cylindrical sweeper with motor, a scoop, and a lifting mechanism to raise and lower the sweeper and the scoop. Due to the large current requirements, the sweeper required a motor driver as shown in Schematic 1.

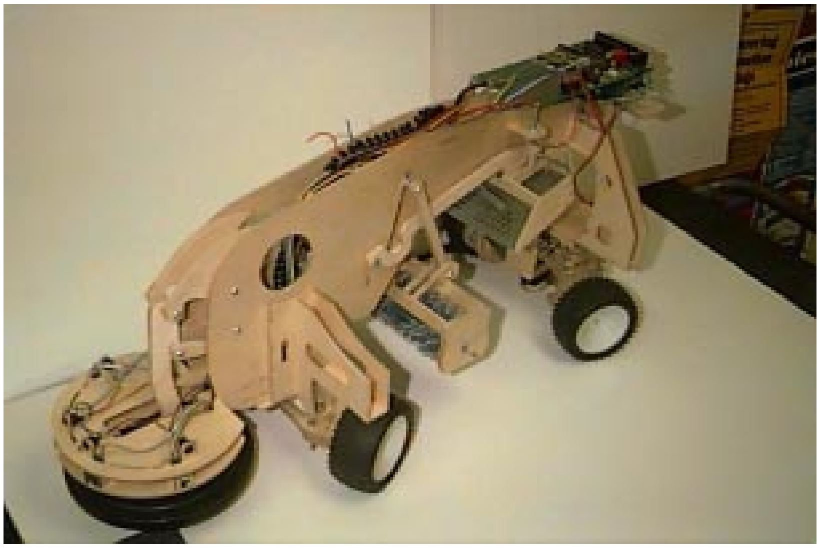


Schematic 1. Motor controller for sweeping assembly sweeper motor.

The lifting assembly requires the use of an H-bridge motor driver similar to the ones used for the drive motors. This motor driver also requires two digital inputs in order to provide bi-directional control for the lifting motors (Enable and Phase). Picture 2 shows the sweeping assembly located at the middle portion of the robot.

CONCLUSION

The mechanical aspects were the focal point of my design strategy. The simple obstacle avoidance code is included in the Appendix. A sound mechanical design allowed for very simple obstacle avoidance code to be written. The Hyena accomplishes the objective of finding and acquiring metallic objects given the current components. However, a higher quality metal detector coupled with more durable motor mounts and motors would be necessary to actually achieve satisfactory or profitable results in a real environment.



Picture 2. The Final Product

APPENDIX