Submission for the African Robotics Network (AFRON) "10 Dollar Robot" Design Challenge

MAVBOT Summary

This summary describes an inexpensive robot design which allows for autonomous motion and sensing using inexpensive sensors and servo drives. This robot design is intended for the consideration in the Traditional category. It utilizes an on-board processor which can be In-Circuit Programming (ISP) programmed via 3-wire interface to an external computer serial port (virtual via USB or 9-pin). In other words, the programming is done using a separate off-board computer. The robot is intended to be constructed using a small collection of components easily acquired from a few online stores. There is no intent to generate a "kit". However because of the low parts count, a bag of parts could easily be put together and sold or distributed as one package. There is one "manufactured" part in the prototype which uses a small piece of scrap aluminum cut and formed in a machine shop. One could easily substitute another material obtained from a typical household or school. There is also an interface cable which is needed for programming. If the off-board computer does not have a 9-pin serial port, a USB-to-serial adapter is needed. This could be used for programming multiple robots.

High Level Description

The robot is designed as a simple line-follower based on a reflective IR sensor. The robot uses two servo drives with large wheels for a differential drive system. The design also includes a simple caster assembly. The robot could be modified to accommodate any number of sensors. The goal of the robot design is to create a low cost autonomous robot which can be easily assembled using readily available parts, by people having little robotics experience, and provide a flexible platform for use in robotic competitions and for robotics education/experimentation. The robot design does not utilize a separate chassis assembly. The breadboard, servos and battery holder are simply taped together. This provides for a relatively lightweight robot with simple assembly. The robot uses a PICAXE microcontroller which is inexpensive and readily programmable using a 3-wire serial interface. The programming

environment is an open source software application using BASIC syntax. The software is available as a free download for Windows, Mac and Linux OS environments.

Educational Applications

This robot design is intended as an experimentation platform. The use of a breadboard to connect all electronic components allows for easy modifications and sensor additions. Students would have ample opportunity to "learn by doing" as part of the assembly process, to learn the BASIC programming language and to learn about sensor interfacing. The robot uses a servo driven differential drive and this provides the students an opportunity to learn about pulse-width modulation (PWM), voltage regulation and logic design as well as fundamental Newtonian Physics concepts regarding distance, force, velocity, light, etc.

Parts List

Part Description	Quantity	Source	Price Each	Optional
HK15138 Servo	2	HobbyKing.com	$3.12	No
Light Foam Wheel (Diam: 75, Width: 20mm)	2	HobbyKing.com	$2.00	No
270-point breadboard	1	Pololu.com	$3.30	No
Battery Holder 4-AA	1	Futurlec.com	$0.40	No
9V Battery Clip	1	Futurlec.com	$0.10	No
PICAXE 14M2	1	Sparkfun.com	$3.95	No
QRD1114	1	Sparkfun.com	$1.13	No
Table Tennis Ball	1	Various	<$0.50	No
Paperclip (Large)	1	Various	<$0.10	No
Screws (6-32,5/8"), washer and nut	2	Various	<$0.25	No
Hook-up Wire (22 gage)	1 (spool)	Sparkfun.com	$2.50	No
T1 (3mm) Red LED	1	Pololu.com	$0.20	Yes
Heat Shrink Tubing	1 (foot)	Various	$1.00	Yes
Zip Ties	3	Various	<$0.50	Yes
LM317	1	Futurlec.com	$0.65	No
1/4W resistors	8	Futurlec.com	$0.08	No
100uF Radial Electrolytic Capacitor	1	Futurlec.com	$0.10	No

6-pin 0.100” header	1	Futurlec.com	$0.07	No
Epoxy	1 (small tube)	Various	$2.00	No
AA Batteries (Alkaline or NiMH)	4	Various	<$0.50	No
3M Scotch Heavy Duty Mounting Tape	1 (2” piece)	Various	$0.20	No

Total without optional items: $28.38

The resistor values needed are provided in the MAVBOT_Schematic.pdf document. The only replaceable parts are the batteries. If rechargeable batteries are used, the replacement frequency may be reduced but assuming Alkaline batteries are used, the replacement interval is expected to be between 10-20 hours of continuous use. If NiMH or other rechargeable batteries are used, the recharge rate will depend on the battery capacity.

Other Tools and Equipment

The QRD1114 sensor has four pins and to connect the sensor to the breadboard requires a four-wire extension. This extension can be connected to the sensor using wire jumpers or via soldering. A soldering iron and a small amount of solder would be necessary if soldering is used. Soldering irons cost around $10-$15 and solder can be purchased in small quantities for around $1. These can also be used on multiple robots. All other components do not require soldering nor special wire jumpers. One tool that is recommended but not necessary is a wire stripper. The cost is around $7. If the robot will be programmed from a computer having only USB ports, programming will require a USB-to-serial cable which can be used on multiple robots and purchased for around $10.

Drawings

The Assembly_Instructions.pdf document provides a lot of detail regarding the physical shape of the robot. The

MAVBOT_Schematic.pdf document provides the schematic drawing for the electronic components.

Assembly Instructions

The Assembly_Instructions.pdf document provides detailed instructions to complete the build.

Reduction of Costs

The prototype is estimated to cost around $28 without accounting for optional items, tools and the labor it took. It also does not include shipping costs which vary quite a bit between different suppliers. If multiple items are purchased for the purpose of assembling multiple robots, a cost benefit can be realized such as lower shipping and/or lower per item cost. As an example, Sparkfun.com and Pololu.com provide bulk order discounts on some items.

Software

The software used to program the robot is the PICAXE Programming Editor which is available via free download from the following link: (www.picaxe.com/Software) No other software is needed.

Experiments, Pictures, Videos

The robot was constructed and then programmed using the PICAXE Programming Editor. A sample program was generated to cause the robot to track a line around an oval track. This program is available in the MAVBOT_line_follower_code.bas file. A video of this code running on the robot is available in the MAVBOT_Video.avi file. Pictures of the robot are shown in the Assembly_Instructiuons.pdf file.