The D.R. - Diego's Robot

A tag-playing companion

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I. Abstract

The D.R. is based on the idea that a remote control car should be able to chase you, tag you and then run away from you. With this in mind, a remote control truck was selected, gutted, and the PVR board was used to act as the "autonomous" portion of the truck. The PVR board is responsible for coordinating 3 sonar modules for object avoidance and a CMUcam1 for color tracking along with a servo for steering and a DC motor for actuation. Bump switches along the front rail will allow the PVR to decide when a "tag" has been made, and switch it into running away mode.

The idea is that the person interacting with the D.R. would wear an LED bracelet around their leg with full super bright RED LEDs. After a synchronization period, the CMU camera would start chasing the red bracelet, and therefore the user, simulating a tag experience. Figure 1 shows the current build of the D.R. The sonar, CMUcam1, LCD and PVR board are visible from this view.

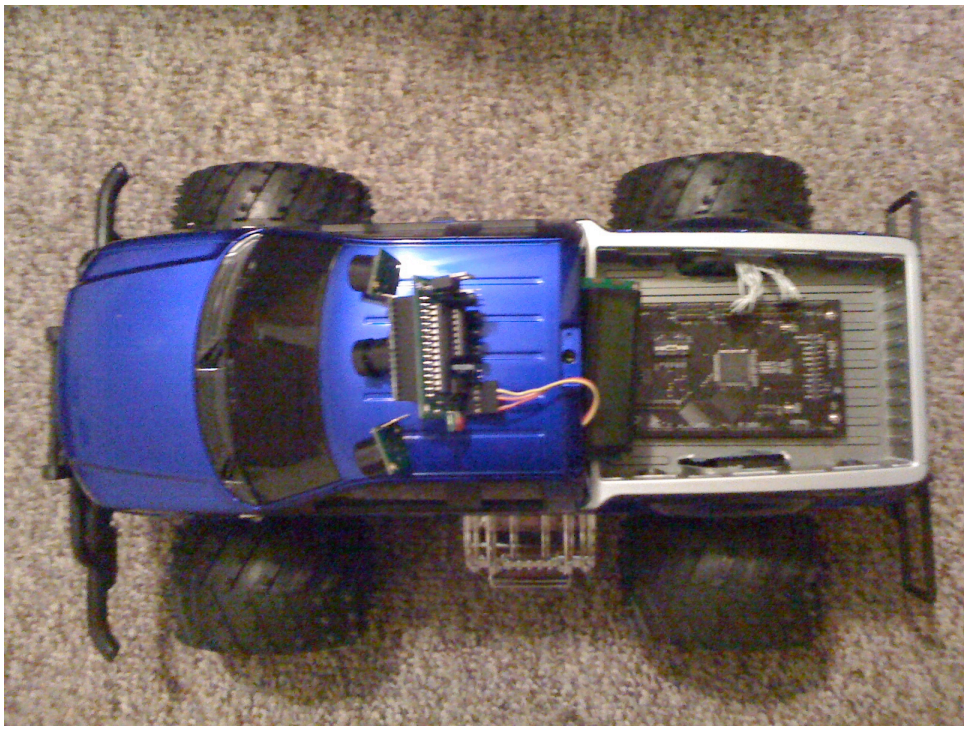

Figure 1 – Current D.R. build

II. Executive Summary

As mentioned earlier the D.R. is an autonomous tag-playing companion for a slow moving, small person, i.e. a child. The D.R. will run around avoiding obstacles until it spots the red LEDs (in the future these will be placed on a band and fastened around knee level). It will then begin intelligently tracking the LEDs. If it looses it in one direction it will continue traveling in that direction until it is acquired once again. This prevents loosing a fast, side moving object. If a front bump is made while tracking is engaged, the D.R. counts that as a tag and will then allow for the player to move out of the way.

After the tag has been made it will then put some distance between itself and the other player. If it detects someone is approaching it from the rear, it will then scurry along trying to avoid obstacles. Once the other player tags the D.R. the game starts all over!

The D.R.'s hardware is based on two front sonars for obstacle avoidance, a rear sonar for detecting when someone is getting closer, and a CMU camera for color tracking. Built upon the body of an RC car, it's a perfect toy for a small child. s

III. Introduction

The D.R. is being built for the Intelligent Machines Design Laboratory in the spring semester of 2010 at the University of Florida. It is designed to accomplish the broad goals of color tracking, object avoidance, and autonomous control. Making use of the sonar, bump-switches and CMUcam1 sensors, the robot will autonomously navigate itself around a field and towards the person interacting with it. That person, as mentioned above, will be wearing an LED badge around his/her leg.

Using the PVR board and the provided AtxMega128a1, the D.R. will try to handle the task of driving itself along towards a goal that is also moving, while avoiding obstacles in its path.

This report will address many of the sub systems that the D.R. relies on to accomplish these goals, giving an overview of the design decisions and the rational behind them.

IV. Integrated System

The major components of the D.R.'s integrated system are shown below. Figure 2 shows an outline of the I.S. and how each piece communicates with the PVR. Each of these sub systems will be discussed in detail in the following sections but a brief outline of the major pieces are provided here as well:

- PVR Board
  - Makes use of the ATxMega128a1 and handles coordination of components.
- Sonar
  - 2 facing front and 1 rear facing sonar modules are responsible for object avoidance and detection.
- Motor
  - The motor that initially came with the RC truck is responsible for the actuation.
- Motor Driver (not shown)
  - Interfacing with motor and PVR board.
- Servo
  - 1 custom servo is used to steer the RC truck and another is used to position the camera.
- CMUcam1
  - Responsible for color tracking.

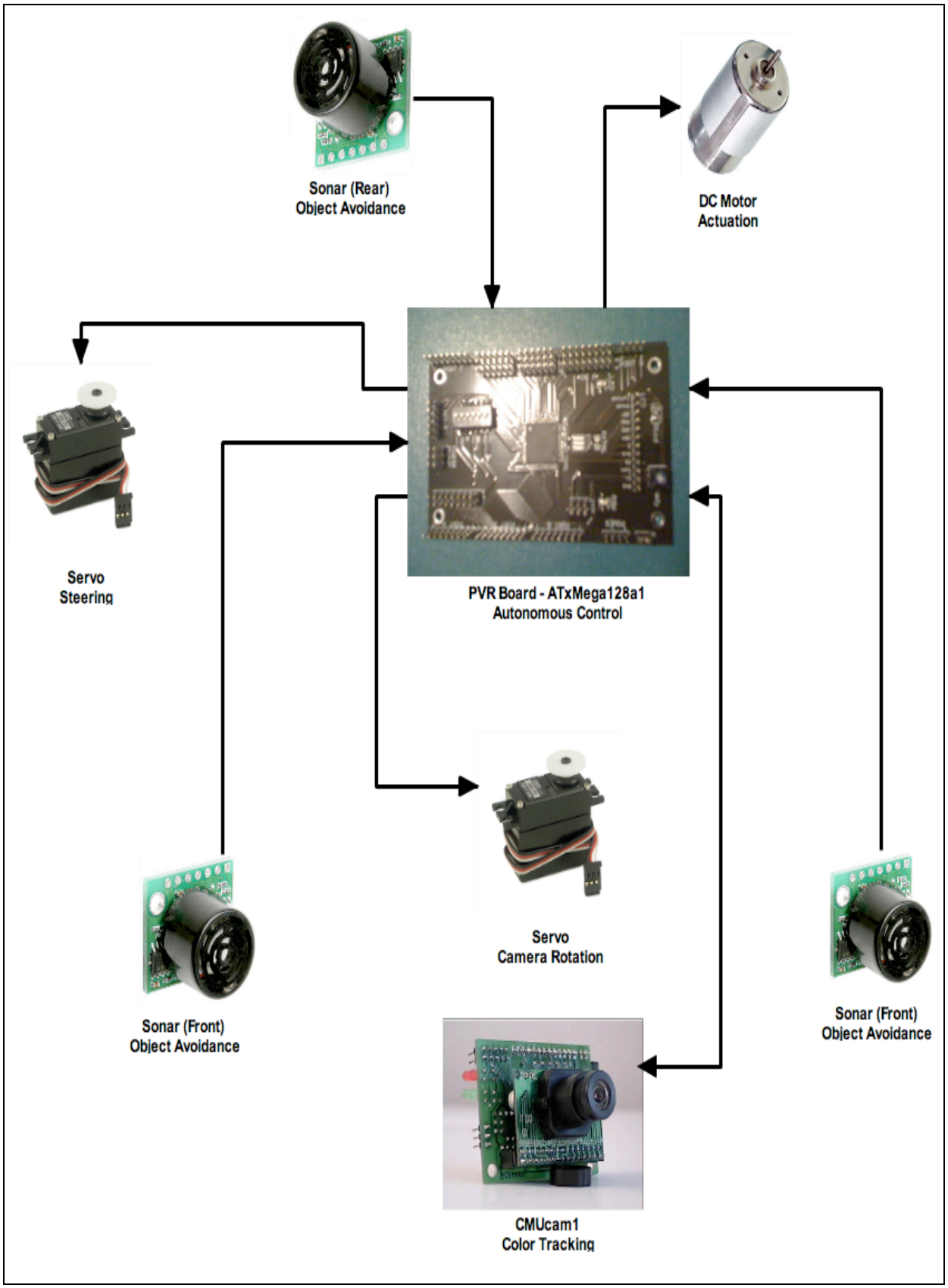

Figure 2 – Integrated System

V. Mobile Platform

The mobile platform used for The D.R. is that of a replica Ford F-150 RC truck. The original truck was disassembled and most of the original electronic components were removed. The front wheel steering, rear wheel driving truck had a number of modifications performed on it to make a suitable environment for the D.R. The original steering mechanism was replaced with a servo that has a custom piece (taken from the original steering mechanism) attached to the head to allow it to steer the front wheels. The original motor and wheels were kept.

Interfacing with the motor however, required some stress testing to be performed. Once this was done it was determined that the current that is drawn under full load (the wheels stop moving) would be too much for the motor driver in lab so a new motor driver was purchased that is rated at a peak voltage of 9A.

Significant work was done to the plastic frame of the body to create a “home” for the PVR. The rear window was removed, as well as sections of the truck bed. Sections of the roof were also cut, allowing for wires to be run to the respective components. Figure 3.a shows some of the bodywork done to the original RC truck frame (notice the removal of the rear window and the truck bed) while Figure 3.b shows what was left of the original RC truck after removing the electronic components that were not necessary.

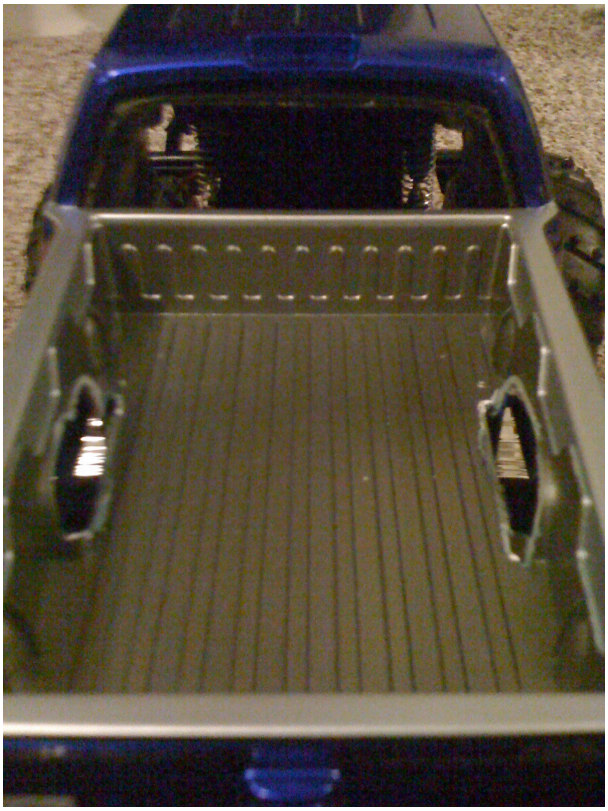

Figure 3.a – Body Work

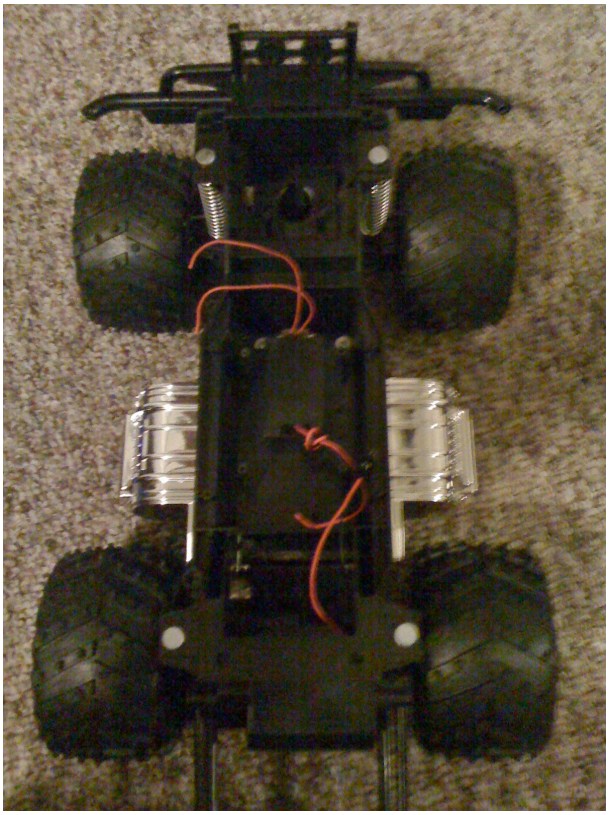

Figure 3.b – Original Pieces

VI. Actuation

The actuation of the D.R. consists of a custom fitted servo (figure 4.a) which is responsible for front wheel steering as well as a dc motor interfaced with a motor driver (figure 4.b) that is responsible for moving the rear wheels. Both of these components receive PWM signals and power directly from the PVR board. The PWM signal sent to these components determines the speed and direction with which they perform their specific tasks.

The servo used was a T-Pro 55g High Torque Servo and was chosen for its power, reliability, cost, and recommendation from a friend. A custom piece was fitted on top to allow it to fit directly in to the "slot" left by the old steering mechanism.

The motor driver used was a 1channel, 9A Motor Driver purchased from Sparkfun. This motor driver was purchased because after stress testing the wheels, it was determined that a high rated motor driver would be required to handle the current drawn incase the car should hit a wall and the wheels would be forced to stop.

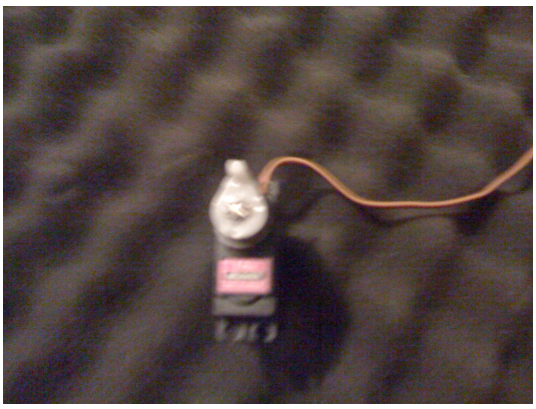

Figure 4.a – Custom Servo

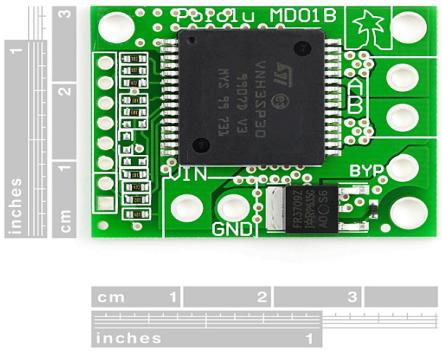

Figure 4.b – Motor Driver

VII. Sensors

The D.R. makes use of different sensors to accomplish its goals: Bump-switch (contact sensor), Sonar, and a CMUcam1 (special sensor).

- Bump-Switch (figure 5.a)
  - These sensors were placed on the front railing of the D.R. allowing it to sense when it has come into contact with something. Since it is being used with the camera, we will be able to tell whether or not that something is an obstacle or the objective, based on the average size of the "color blob" which we are tracking.

Figure 5.a – Generic bump switch

- Sonar (figure 5.b)
  - The 2 front facing sonar have their beams about to cross to minimize the dead-zone. They will be used to detect obstacles, and when used in conjunction with the camera, can be overridden when the objective is close enough. The rear facing sonar is responsible for detecting when something is getting closer to it, when its in its "retreating" phase. The sonar being used are the Maxbotix LV-EZ1 that offer a compromise between a wide beam and a narrow beam. They are being powered off 5v and we are using the analog output to feed into the A/D on the PVR board to read its value.

Figure 5.b – Maxbotix LV-EZ1

- CMUcam1 (figure 5.c)
  - The CMUcam1 is responsible for tracking a "color blob" which will originate from an LED bracelet placed on the leg of the person playing "tag". Its detection of average size can be used as the distance of the color blob and when the size is large enough (the target is close enough) we can essentially turn off the sonar modules (override object avoidance) to successfully make a bump (tag the other person).

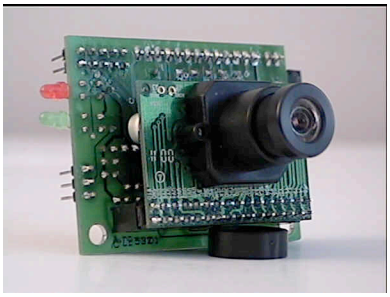

Figure 5.c – CMUcam1

VIII. Behaviors

As mentioned earlier in the report, the desired behaviors for the D.R. are obstacle avoidance, and color tracking. These two behaviors will be combined in two different phases:

- Tag!
  - The robot will avoid obstacles while tracking the bracelet and moving towards it until it determines its close enough to get a bump. If a bump is successful it will then move on to the next phase. If not, it will remain here.

- You're it!
  - Once the robot is in this phase, it will turn around and run away from the person. Once it has put some distance between itself and the target, it will stop and read the rear sonar. It will then do this again, and if the rear sonar is less than it was a fraction of a second ago, then someone is moving towards the robot and it will then attempt to continue running away until it is bumped. At this point, it will then transition back to the Tag phase.

IX. Conclusion

As outlined above, the D.R. will be a tag-playing companion consisting of the subsystems already described. During the design process I learned a good deal about many different types of hardware and how they behave together.

The D.R. was a success and successfully plays a game of tag with the person it is interacting with. In the future, I want to do some more bodywork to make the car visually look much better. Also, I would like to try having it move a little faster and turn around as opposed to having the player have to move in front of it.

I would like to give some recognition and appreciation to fellow class mates who have helped me along: Crawford, Sean and Jason have helped me with misc hardware/software issues, and Seong Kim's library for camera communication gave me an excellent starting point for mine.