Design and construction of small autonomous robots

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Abstract
The purpose of this project is to design and build a small autonomous robot. The ideal application of the project would be to have a big group of such robots that could perform tasks together. They have to be small because if a big number of robots have to work together, their size could be a problem in terms of mobility and adaptability. And they have to be autonomous because controlling a big number of robots from a single computer and communicating with all of them individually and continuously is too expensive in terms of computational resources. The easiest task that can be achieved is probably the formation of patterns and environment exploration, and that was the main goal of this project. However, since the project has been started from scratch, from the beginning it was clear that this meant aiming really high, taking into account that not much time was available.

Two prototypes of robots have been built and effective communication between them has been achieved, as well as accurate movement. Near obstacles can be detected too.

Basic Components
Each robot is driven by a microcontroller, has two motors (and two drivers to control them), 4 infrared sensors (infrared led and phototransistor) and an RGB led so that its state can be known, as well as a means of communication with us. Other components are needed to complement these. The body of the robot is a circular, double sided printed circuit board (PCB) where all the components have been soldered. It also needs a battery.

Results
Obstacles can be detected up to a distance of 25cm if they are in front of the sensor and 10cm if they are at an angle of 45°, and the output was saturated if the distance was smaller than 1cm. The robot speed is approximately 1cm/s. In terms of communication, a bit rate of 10Hz on a carrier of 1KHz was used to establish functional communication.

Communication and obstacles detection
Reception and emission circuits.

The value of 1V of the reception circuit was chosen to keep the transistor out of saturation and the operational amplifier at a good operating range. Some operational amplifiers were tested too. The selection criteria in this case was the size and the gain-bandwidth product. The output of the reception circuit is \( V_O \approx 1V + I_{phototransistor} \times R_1 \). Thus, the higher the value of \( R_1 \), the higher the sensitivity of the reading, but if the value is too high, then the output could saturate with a small signal or ambient illumination.

The value of the resistor in the emission circuit was \( R_2 = 100\Omega \). That provides a maximum current of 25mA, which is below the maximum 50mA that the emitter can handle. The voltage has been set to 3.7V because of the battery chosen for the robot.

Robot design
PCB design of the second prototype:

References