Electronics Platform for Colony Robot

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Abstract

Research of multi-robot cooperation, mesh networking, social interaction, epidemic simulation, traffic congestion management, and much more can take place in a robot colony. This research is often more successful, and always more interesting to watch due to the physical nature of the colony. It is this project's aim to develop and build a prototype controlling electronics that could be mass-produced to create robot colonies.

1 Background

Traditional robot colonies have been limited by available hardware. The robots have to be large to hold large computers and large batteries to carry them. Moving a large robot requires large motors and wheels, further increasing the overall size. If you have a large number of large robots, the environment in which they exist must be enormous. All of this increases the cost of building and maintaining the colony.

Robot colonies have also been limited in terms of mobility. The vast majority of colonies have been built with tracked or differential drive robots. Due to the nature of these kinds of drive systems, these robots can turn in place, but must turn toward the direction they wish to translate before translating. Since there is this 'front' of the robot, any constantly scanning sensor must be mounted on an additional actuator so that it can point away from the direction of motion. These additional actuators also increase size and weight of the robot.

2 Our Approach

Available hardware has limited the size and capabilities of previous colony robots. Recently, however powerful computers have physically shrunk thus consume less power, requiring smaller batteries. Motor systems and gear trains are now able to be manufactured with greater precision, and thus can be made smaller. Sensor systems have also shrunk with the onset of smaller surface mount components and micro-controllers. All of these technological improvements will allow our hardware base to be smaller and cheaper than traditional colony robots.

Our control electronics will use many types of ICs, each performing a task well suited for its capability.

At the highest level we will have our high-level processor, most likely a thumb ARM or Motorola 68k. This processor will be reprogrammed for each colony activity or experiment. It will hold the behavior based code in its flash, as well as some more general code like the mesh networking code and the interfaces to the low level controller on the robot. Since this is going to be a powerful processor it will be running an OS, most likely Linux. This means that the high level control code can really be written in any language, C, C++, Java, Python, or ML. All that needs to be done to support a new language is to create an API in that language which calls the common low level interface and networking code.

At the next tier down we have the low level processor on the robot. This PIC micro-controller will control electronics that control the motors, and it will interface with nearly all of the sensors on the robot. PICs are very well suited for this task, and this team has had lots of experience with them. The discrete logic below the PIC is the lowest level electronics on the robot. These chips will handle decoding the quadrature encoder signals, controlling the 3 DC motors, and interfacing some of the other sensors.

Additionally there will be battery-charging circuitry on the robot. Currently we are hoping to develop a contact-less (with respect to input power) battery charging, but if we are unable to do that we will drop back to a traditional wired approach.

Wireless communication among the robots is also under the scope of the control electronics. We are evaluating several possibilities for the wireless communication including Bluetooth, IR, 802.11b, and RF. Currently we feel that Bluetooth is a good match for the range and power consumption we are looking for.

Fundamentally we want to develop an inexpensive, stable, and reliable colony robot. We want a robot that will operate for extended periods of time, be self-diagnosing when things do go wrong, and be designed for easy maintenance. These are high aims, and we know we have to start low, so we expect many design iterations.

The mechanical base will be developed in parallel with the electronic control systems. It can be developed and tested in parallel before the electronics are complete. This sister-project has a separate SURG grant proposal and is named 'Mechanical Platform for Colony Robot.'

3 Participants

Chris Atwood	Junior	Mechanical Engineering
Lauren Chikofsky	Freshman	Electrical and Computer Engineering
Chris Hoffman	Freshman	Electrical and Computer Engineering

Many of these students have taken classes in the electrical and computer engineering department that have taught basic electronics engineering principals. Additionally many of these students are familiar with the software package, Eagle-Cad, that we will be using to draft and model the pcbs.

Chris Atwood, project leader, has also had a lot of experience in robot design for manufacturing, which will be our primary concern in designing the prototype. He has also worked on past Robotics Club projects, last year helping to lead the Urban Search and Rescue Team.

4 Research Plan: Milestones & Results

I: Specifications November 1, 2003

This milestone will produce a detailed specification document. The document will outline minimum performance specifications and list the constraints and assumptions of the project.

II: Initial Design November 29, 2003

This milestone will produce computer models of our initial subsystem designs. All sub-systems, batteries charging, motor driving, sensor interface, as well as wireless communication will have been investigated and preliminary subsystem designs will be integrated into a complete prototype design.

III: Initial Design Built December 13, 2003

This milestone will produce an initial physical prototype that is ready for reliability and performance testing. All aspects of the design will be subjected to an exhaustive and extended duty test to locate points of failure and performance bottlenecks in the design.

IV: Refined Design March 21, 2004

By this date a second design iteration of the control electronics should be complete and tested, ready for the third and final design iteration if necessary. At this point the mechanical base should be out of the initial development phase, so both will be tested together for the final design iteration.

V: Refined Prototype June 18, 2004

This milestone will produce a complete refined prototype that will be mass-produced to make our colony the following year.

At this point the project will be in its second year. We have not planned this far in advance but fundamentally we will prepare to build a colony of the robots we have designed. Additional funding will be procured and necessary materials will be purchased. When the environment and robots are complete, benchmarks will be taken, documentation produced, and the colony opened for public use.

5 Dissemination of Knowledge

The robot design developed from this project will be presented at the Meeting of the Minds in May of 2004. We also plan on entering the AAAI exhibition at the AAAI conference. Furthermore, we will submit a paper to the newly established undergraduate research journal describing the final robot design developed, as well as the performance characteristics of the robot.

6 Budget

The budget this year is for the sole purpose of building the prototype control electronics.

	PICs:	$100
	Discrete logic:	$200
	Higher level processor:	$200
	Custom pcbs:	$500
Total:	$1000	