Design and Power Management of a Wind-Solar Powered Polar Rover

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ABSTRACT

A robotic rover harvesting energy from wind and sun was designed to roam and supersede humans to complete scientific missions in Antarctica. Specific terrains, temperature, wind & solar availability and wind resistance in Antarctica were taken into consideration. In energy, the rover need consume much more to travel than it harvests. A fuzzy logic approach in power management was developed to make improvements. Using an energy harvest-manage-consume simulator, both the fuzzy approach and the simple approach were tested. Results showed the fuzzy approach made the rover travel 296% longer and 11% farther than the simple approach did.

KEY WORDS: Polar expedition robot; hybrid wind-solar power; Antarctica; power management; fuzzy logic; simulation.

INTRODUCTION

Scientific research on Antarctica plays an important role in geology, meteorology, biology, astronomy and cosmology. However, it’s difficult for researchers to apply to on-the-spot investigation in Antarctica due to the extremely unfavorable climate. The lack of observational data and samples has been the greatest problem which researchers are confronted with at present. As a result, more and more countries are getting involved in developing unmanned mobile robots to supersede human beings to carry on scientific research in the severe environment in Antarctica. Unmanned mobile robots are able to carry on a scientific expedition in a considerably larger area for a much longer time with much fewer supplies than human beings. On the one hand, previous field experiment results of different mobile robots in Antarctica have proved that gasoline powered mobile robots and battery powered mobile robots are difficult to obtain gasoline resupply or be recharged in the harsh field environment in Antarctica (Apostolopoulos, Wanger, Shamah, Pedersen, Shillcutt, Whittaker, 2000; Akers, Harmon, Stansbury, & Agah, 2004; Murarka, Iyer, Miller, Taber, & Hunt, 2005). They are not suitable for the long-distance and long-time scientific expedition in Antarctica. On the other hand, solar-powered Cool Robot (Ray, Lever, Streeter, & Price, 2007; Lever, Streeter, & Ray, 2006) has proved that solar energy is an effective energy source to power mobile robots in Antarctica. However, solar-powered mobile robots cannot work during polar night. For mobile robots to work in Antarctica all the year round, wind is another available energy source of great importance.

We developed a hybrid wind-solar powered robotic rover for scientific research tasks in Antarctica. It was designed to roam and complete scientific missions in Antarctica, such as collecting meteorological data. The specific terrains, surface conditions, temperature, wind & solar availability and consequent wind resistance in Antarctica were taken into consideration to choose the rover's configuration of mechanical structure, drive mode, power system and control system.

Results of experiments which we did on energy harvest and power consumption of the robotic rover indicated that compared with the rover’s energy harvesting from wind and sun, the output energy which the rover consumes to travel was much more. To better test energy harvest, power management and power consumption of the robotic rover to achieve a balance between energy input and energy output and to make improvements before on-site tests in Antarctica, we built a simulator and performed simulations.

After several simulations, we found that the original simple approach of power management did not work well. We developed a fuzzy logic approach to make improvements. Simulation results of both the fuzzy approach and the simple one showed that the fuzzy approach made the robotic rover travel longer and farther with lower risk of failure of mechanical parts due to extreme temperatures in Antarctica than the simple one did. The fuzzy approach made more efficient use of energy harvesting from wind and sun.

This paper focuses on mechanical structure and energy harvesting & consuming.

DESIGN OF THE HYBRID WIND-SOLAR POWERED ROBOTIC ROVER

Considerations

98% of Antarctica’s ground area is covered with ice and snow, leaving only 2% of which in the coastal areas exposed. There is hardly