Technical Review Paper Evaluation Form

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____/ 30 **Technical Content** • Current state-of-the-art and commercial products • Underlying technology • Implementation of the technology Overall quality of the technical summary ٠ / 30 Use of Technical Reference Sources • Appropriate number of sources (at least six) Sufficient number of source types (at least four) • Quality of the sources ٠ • Appropriate citations in body of text ٠ Reference list in proper format / 40 Effectiveness of Writing, Organization, and Development of Content • Introductory paragraph Clear flow of information • Organization • Grammar, spelling, punctuation ٠ Style, readability, audience appropriateness, conformance to standards ٠

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Efficient Power Systems for Robotic Applications

Introduction

Wireless robotic systems are used in many fields to accomplish important tasks accurately and efficiently. One of the crucial questions to consider when developing efficient mobile robotic systems is the energy consumption of the system. Powering a wireless system requires foresight of the system and what tasks it will need to accomplish. This paper is a review of the current state of the art technology used to efficiently power wireless robotic systems.

Commercial Applications of Powering Robotic Technology Wirelessly

The International Federation of Robotics predicted in its 2016 "World Robotics Report" that over 1.4 million new industrial robots would be implemented in factories worldwide by 2019. This would bring the total number of industrial robots to around 2.6 million units across the globe [1]. Fields where robotic technology is particularly prevalent include health care, agriculture, food preparation, manufacturing, and the military. Applications in these fields can vary widely showcasing both the versatility of robotic technology and the demand on the robotics industry to perform at a high level. For example, in the health care industry, robots can assist surgeons in performing minimally invasive surgeries with tiny, precise instruments while in agriculture, farmers have been using large robotic tractors and harvesters which are self-guided by GPS [2]. While these pieces of equipment are more expensive because of their specialized abilities, more generally owned mobile systems such as drones with recording capabilities can be sold for \$300-\$3000 depending on quality desired [3]. This wide range of commercial applications for wireless robotic technology adds to the complexity of the challenge of choosing the most efficient power system for a robot.

Research on New Materials to Power Mobile Systems

Robotic Materials

Laboratories around the world have begun to research new materials including artificial muscles, compliant materials for soft robots, and advanced manufacturing and assembly strategies that could potentially work alongside or replace the traditional gears, motors, and electromechanical actuators that are considered fundamental to many current robotic platforms. These new technologies could promise future robots that are more power-efficient, multifunctional, and autonomous in ways similar to biological organisms. Like all technology, however, these experimental systems have their own trade offs including the need for improved portable energy storage and harvesting as well as new materials with tunable properties [4].

Power Sources

Improving power and energy sources is therefore one of the greatest and most important challenges facing the areas of robotic research and implementation, particularly mobile robots. There are distinct energy sources currently accepted in the robotics field: power generators, energy storage technology, and power harvesting technology and nanogenerators. Examples of power generators include fuel cells, solar cells, and classical electromagnetic generators while examples of energy storage technology are batteries and capacitors or supercapacitors. Power harvesting technology and newly developed nanogenerators comprise micro-/nano-energy sources, self-powered sensors, and flexible transducers. Metal-oxygen, lithium-sulfur, aluminum-ion, and sodium-ion batteries are some of the main technologies being widely researched for mobile, autonomous robotic systems [4]. The operational longevity of a mobile system relies on battery power as well as the system's size and weight; therefore, these are all key elements to consider at the beginning of a design process to ensure the robot is power-efficient for a substantial amount of time.

Technology for Wirelessly Charging Mobile Systems

In addition to methods such as changing the batteries in a robot periodically or recharging the battery in the robot via a standard electrical outlet, there have been some technologies created to wirelessly charge mobile systems. These wireless technologies generally use a wireless power charger or transmitter and a wireless power receiver to allow a transfer of power across a distance. With the rapid increase in number of electrical and electronic devices, providing simple and universal methods of charging these devices is an important concern to address in design. One such technology that provides this wireless power is using induction or "magnetic charging" through charger and receiver coils and other magnetic materials. This process allows for freedom of device placement as well as ease of use and compatibility with multiple different systems such as robots, electrical vehicles, and other mobile devices [5].

Power Necessary to Implement a Mobile System

A key part of many robotic systems is the Raspberry Pi. A raspberry pi is a series of computers that make up a small portable computer which is slower than a normal Linux, but also consumes a lot less power. A Raspberry Pi 3 is powered by a +5.1V micro USB supply, but exactly how much current it requires is dependent on the peripherals connected to it. The maximum power a Raspberry Pi can use is 1 Amp due to an internal fuse that cannot be bypassed; if the design includes a device that will take the power requirements above 1 Amp, then an externally-powered USB hub must be used [6].

Most small, mobile robots rely on a battery for power. While this battery will provide only one voltage level, the peripherals of the system may each require a different voltage level to operate. If this

main DC battery system also powers the drive motors on the robot, it is necessary to achieve voltage isolation and filters for the robot's computer subsystems. This voltage isolation and regulation can be implemented with a flyback converter which is a transformer-isolated version of the buck-boost converter. This flyback converter uses Primary-Side Regulation to accomplish Constant-Current Regulation while also processing information from opto-coupled feedback and an auxiliary flyback winding. The way it processes the information makes it a useful tool for achieving high-performance control of output voltage and current [7]. With this information, the team must decide the most efficient power system and source for their design based on the peripherals that are needed for the project.

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