Robotic Movement and Efficiency: Examining Methods for Sensing, Learning, and Physical Travel

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INTRODUCTION: Why is Robotic Movement so Important?

Movement can "make or break" the usefulness of a robot. *Curiosity* and the recently deceased *Opportunity* (fig. 1) could not work without their large, track-like wheels allowing them to move on Mars' sandy surface. *Opportunity* is no longer functional precisely because after being buried in a sandstorm, she was unable to move, which is what warmed her battery and allowed her to "stay alive."

Abstract

The method of movement for a mobile robot is one of its most vital aspects, as it determines its efficacy in difficult terrains and environments like uneven, slippery, or sticky ground. This study will explore the differences and commonalities between the possible approaches for travel: articulating bipedal legs, articulating legs (quadrupedal or higher), continuous track, flippers (in the case of aquatic traversal), and traditional wheels, then how to actually navigate: infrared, ultrasonic wave, cameras, or Wifi/Bluetooth. Ways to "teach" movement also differ, as it can be coded rigidly or allowed to grow through trial and error. By comparing and contrasting methods and results, the most efficient approach—both in general and for specific land and floor textures—can be found.

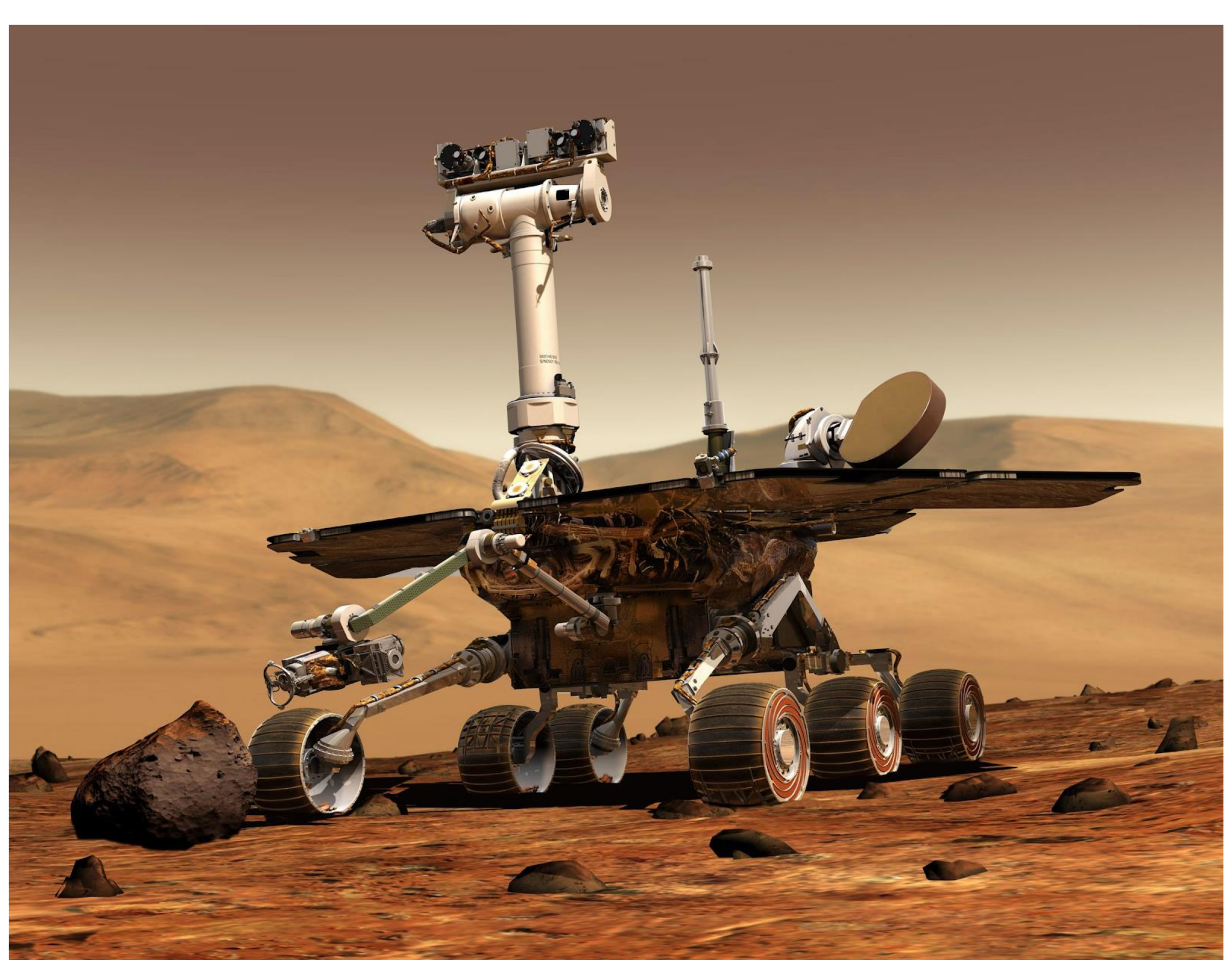

Figure 1. NASA's Opportunity, which lasted 15 years, "50 times longer than originally planned" (Greshko, 2019).

FINANCIAL / MANAGEMENTAL COST

LOW	MEDIUM	HIGH
TRADITIONAL WHEELS	**CONTINUOUS TRACK**	**BIPEDIAL / QUADRIPEDAL+ LEGS**
• Inexpensive • Lightweight • Common (easy to obtain) • Have difficulties traversing rough terrain or scaling obstacles	• Traction and surface area increased • Stability highly increased • Difficult to maneuver • Low speeds	• Good in rough terrain and in navigating environments • Balance increased with each leg added • Expensive

LOW	MEDIUM	HIGH
INFRARED AND ULTRASONIC WAVE NAVIGATION	**CAMERA**	**VIRTUAL REALITY AND WIFI / BLUETOOTH**
• Inexpensive • Low-light no issue • Reliable (IR more than USW, which is temp-sensitive) • Occasionally imprecise • Limited detection ranges	• Very detailed • Possibilities for use endless • Somewhat high relative cost • Reliability concerns	• Speed increased • Easily implemented by users • High relative cost • Not intensively tested

LOW	HIGH
ALGORITHM-BASED CODING	**TRIAL AND ERROR**
• Inexpensive • Consistent • Adjustments are complex and time-consuming • No "learning"	• Independent • Potential much, much greater • Expensive • Long learning process

CONCLUSIONS

Staying in the middle range of cost versus benefits--and focusing purely on data--it seems the most efficient robot would be one using a continuous track, a camera, and algorithm-based coding. This is certainly possible, but different environments will drastically change the requirements for a "useful robot." The ANYmal (fig. 2) is a robot using a mix of technology: quadrupedal legs, RGB and thermal cameras, and a trial-and-error learning system which can use what it perceives in its environment to map its surroundings. While expensive, this robot is capable of impressive mobility and action, including opening doors and pressing buttons to navigate as autonomously and independently as possible.

Figure 2. The ANYmal, a robot made for all terrains.

FUTURE WORK

In the future, it may be hypothesized that all current manners of locomotion, detection, and learning will become cheaper and more reliable. Humanity may also heighten the feasibility of more mobile flying or hovering robots, like autonomous drones, and machine learning and AI could also expand to allow for quicker learning of navigation. Regardless, robotic movement and learning will improve over time due to the steady advancement of technology and the lowering cost of new designs and implementations like virtual reality and leg-based movement.

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