Robots for Mars: Expanding exploration capabilities through innovative improvements

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I Introduction

According to [1] and [2], scientific interest in Mars habitability is high. Thus, planetary explorers conduct robotic missions to study Mars for signs of life. The most common types of robots for Mars exploration are wheeled robots, aerial robots, walking robots, hoppers, and robotic arms. However, even these robots are not fully adapted to the extreme Martian environment. The problem of robot adaptation exists due to engineers' inability to predict all possible obstacles for robots on Mars in the development stage. Therefore, improving robot types will enhance the efficiency of Mars exploration missions. Specifically, this study seeks to answer the following question: How can different Mars exploration robot types be improved?

II Literature Review

A. Wheeled robots

Planetary researchers use wheeled robots to explore Mars. However, six-wheeled robots perform less efficiently than two-wheeled robots due to the lower mobility [3]. Moreover, [3] and [4] mention that robotic systems allow for more complex tasks than autonomous wheeled robots do. What is more, wheeled robots are affected by deep sand, rocks, craters, cliffs, and slopes [5], [6]. Therefore, wheeled robots need to know how to plan their paths to avoid obstacles.

B. Aerial robots

Scientists explore Mars using aerial robots. However, such robots encounter the obstacle of limited flight time caused by the thin Martian atmosphere [7]. Moreover, [8] claims that aerial robots' rotor blades fail to give thrust in the Mars atmosphere. Therefore, the rotor blades need to be improved for the Martian atmosphere. Additionally, the flight time of aerial robots needs to be increased.

C. *Walking robots*

The exploration of Mars also extends to walking robots. However, [9] and [10] claim that walking robots sometimes sink into the granular soils. Therefore, walking robots need legs that do not sink into the soft terrain.

D. *Robotic arms*

Robotic arms can be used on Mars orbital station and for Mars exploration. Despite the arm's ability to collect geological samples [11], [12] and maintain Mars orbital station [13], [14], a robotic arm can cause docking failures due to the arm's inaccurate orientation [11]. Therefore, robotic arms need improved control systems.

E. *Hoppers*

Hoppers are robots that could be used for travel on Mars. Despite [5] and [15] claiming that hoppers are designed to be reusable by accumulating carbon dioxide, the operation time of the hopper is limited by the daily consumption of carbon dioxide [5]. It leads to compliance with usage intervals and reduces the flexibility of the system [5]. Moreover, hoppers have limitations with flight distance [5]. Therefore, hoppers' flight distance and flight time need to be improved.

III Methodology

In the research, we will describe ways to overcome the limitations mentioned in the Literature Review section. Using an inductive research design, we will analyze possible improvements to a specific robot model and then generalize it to the robot type. Initially, the data collection phase will take six months as we conduct interviews with experts in Mars exploration robots. Data collection will be followed by a six-month period dedicated to analyzing the data and writing up the study. We will be able to access the required data with the help of interviews with experts in Mars exploration robots. Criteria for defining an expert will be based on a person's education, working experience, research experience, previous missions involvement, and leadership. The survey will help collect data from in-person interviews. The survey will contain the following questions: 1) What is the purpose of the robot model? 2) Did you have difficulties related to the limitations from the Literature Review with the robot model? 3) How did you overcome these difficulties? Secondary data will not be used because we will have enough time to get the required data by ourselves. The population for the research will be Mars exploration robot experts selected by the above criteria. We will use stratified sampling because it will help us interview experts in different robot types. The sampling size will be 278 people. Qualitative analysis will be used for analyzing data because the information we will get from the interviews will be non-numerical. However, we will have a limitation on experts' time availability for interviews. We plan to overcome the limitation by spending six months on interviews.

IV Anticipated Results

Based on the articles utilized in the methodology, we expect to receive the following feedback from the respondents. Firstly, path planners could improve wheeled robots, as shown in [6]. Secondly, improved propulsion systems could enhance the efficiency of aerial robots, as shown in [16]. Thirdly, robotic arms could be improved through remote control, as shown in [11]. Fourthly, the optimization of leg construction and materials to reduce weight could improve hoppers, as shown in [5] and [15]. Finally, walking robots could benefit from increased footpads, as shown in [9].

V Discussion

The research findings can have a significant impact on the development of Mars exploration robots, resulting in improved design, functionality, and overall characteristics. This proposal will benefit scientists, researchers, and engineers in the field of Mars exploration, as well as space agencies and organizations involved in Mars missions. The research results can be implemented in robotics to improve Mars exploration robots. Our research insights and recommendations can inform future Mars exploration missions and lead to successful missions, increased scientific discoveries, and a better understanding of the Martian environment. However, the research might have limitations related to the inability to improve all existing Mars exploration robot types. Thus, we plan to expand the scope of robot types for future research.

If the proposal is not accepted, the potential benefits mentioned above will not be realized. Consequently, the field of robots for Mars exploration will continue to face these identified limitations. This could result in missed scientific opportunities and slowed progress in Mars exploration.

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