# AUTONOMY AND PATH PLANNING IN A PLANETARY ROVER

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**Abstract**

*In this paper we present the autonomous and path planning functionalities of a Planetary Rover system. In order to make the Rover system completely independent of human intervention, a high level of navigational autonomy is desirable. Sun sensing and topographical properties are the two factors that are considered here as the Rover navigational aid. Autonomous hazard avoidance can be achieved using a stereo camera which evaluates terrain safety and to avoid obstacles.*

***Keywords:*** *Planetary Rover, Autonomy, Sun Sensing, Topographical Propeties, Path Planning*

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## I. INTRODUCTION

Images from the Rover system are used to provide global positioning corrections. This may introduce substantial delay as the image must be processed at the ground station. Therefore, by incorporating Autonomy the command sequence for the rover system's operations can be formed without human intervention thereby reducing latency. In Autonomous navigation the rover identifies hazards such as steep and unknown terrains which are difficult to traverse through and therefore steers accordingly to avoid these obstacles. In addition to the terrain identification for the Rover's movement, sun sensing is also another key factor that is looked into for the Autonomous operation of the Rover as it functions as a navigational aid. In order to achieve effective means of obtaining absolute orientation, sun sensors are being made use of. These sensors reduce the drift in navigational accuracy, thereby improving the Autonomous mode of operations of the Rover.

In this paper we first present the various methods used to determine absolute Rover heading and global positions. We then present the challenges faced by the Rover while traversing through rough terrains and the navigational methodologies used to combat such problems. Therefore, our paper focuses on two key aspects 1) on-board autonomy for overall improved efficiency 2) Hardware and Software approaches which overcome terrain difficulties and other challenges faced by the Rover system.

## II. SUN SENSOR BASED ROVER POSITIONING

Sun sensing in a manner to upgrade the heading and the full altitude of the Rover [4].

It has been observed that the cross track error is minimized with the linear growth of the travelling rover via the sun sensing heading mechanism. Several studies have illustrated the phenomenon of the sun sensing mechanism. In a study conducted by Deans et al. ,a sun sensor based on a fisheyelens firewire camera and an inclinometer bundled together was elaborated. . Another study conducted by Pingyuan et al. described the determination of the altitiude at the moon using earth and sun vectors. In addition, Cozman and Krotkov implemented the method to solve for the position of the sun sensor using the"circles of equal altitude".

## III. ROVER TRAVERSAL OF CHALLENGING AND STEEP TERRAIN

The technical challenges involved in mechanical design, sensing, planning and simulation are considerable. Terrains can be classified as challenging in terms of their unpredictable properties such as steepness, rock density and so on. Therefore, the design of vehicles that are to travel on such terrains have to have technical fronts which look into the above stated challenges.

### *A Adaptive Navigation Technique for Rovers*

The adaptive navigation technique aims at facilitating future rovers to traverse through rugged, steep and deformable terrains. A high-level block diagram of this system is shown in Figure 1 [8]. In order to access this terrain in a safe manner, significant deviations from the current state are required in these areas: 1) terrain perception and characterization, 2) traversability analysis and path planning, and 3) path following.

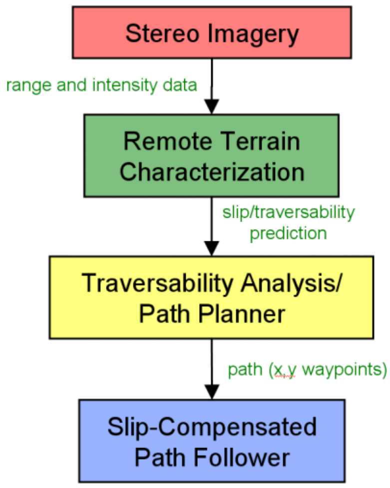


**Fig.1** Block Diagram of Terrain Adaptive Navigation

The distance and other tangible properties of the terrain have been determined by its perception and characterization. Data pertaining to the distance is derived from Stereo Image Analysis. Classification of the terrain is conducted based on its tangible features namely, texture, loose material etc.

By understanding the correlation between previously viewed terrain and the current terrain, the rover is on, its slippage can be predicted which can in turn be used to traverse the rover on a similar surface. In order to assess the terrain difficulty in computational complexity, a path planner is formulated based on terrain triage as well as high-fidelity traversability analysis algorithms. This is followed by the slip-compensated path following algorithm thereby facilitating the accurate rover movement.

## IV. ESSESNTIAL FEATURES IN AN AUTONOMOUS ROVER

For a Rover to operate autonomously it must be capable to sense its environment. The criteria for the same are as follows: 1) Robust Flexible Operation: The Rover must be able to operate based on its execution environment and should be flexible depending on the changes in the execution environment. 2) Resource Utilization: It must be able to fulfill mission objectives efficiently by making full use of the available resources such as power, data, bandwidth etc. even when they change from their expected values. 3) Failure Recovery: The Rover must be able to recover from unforeseen circumstances without reducing its efficiency of operation.

In addition to the above criteria, the other factors that need to be looked into include: uncertainty, need for safety, limited communication, need for understandability and multiple objectives.

**Fig.2** Model Of An Autonomous Rover

## V. CONCLUSION

As we see, this paper shows the behavior of the Rover systems in autonomy which make it more self sufficient and hence increase reliability and thereby reducing chances of failure. We have overviewed a number of challenges in overcoming the terrain difficulties by using adaptive navigation method. We have also looked into the criteria which satisfy the autonomous operation of the rover. In the future, we would like to see rovers that are capable of even higher levels of autonomous operations. These rovers will accept very high-level goals from human operators and will be able to achieve those goals with no further supervision.

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