PROBABILISTIC STRATEGY OF OBSTACLE AVOIDANCE FOR SAFE MOON LANDING

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Abstracts: For the safe landing to the unexplored or obstacle-rich area of the moon or planets, the real-time and reliable autonomous obstacles avoidance algorithms are essential requirements.

In this presentation, the probabilistic strategy, to guide the lander to more safe/landable area from high altitude, is proposed under the assumption, that there will be some non-uniformity of the obstacles distribution. The effetiveness is demonstrated using CG simulation images.

This strategy is developed for the Japanese SELENE-B, that will be the Japan's first moon lander. For SELENE-B. The safe and precise moon landing are strongly requested to meet the severe scientist requests for the unexplored moon site, such as a vicinity area of a central hill of a large crater.

Obstacles and Sensors

For the SELENE-B lander design target, the obstacles are assumed such as rocks of larger than 50cm x 1m, craters of wider than 2m diameter, shadow areas, and steep slopes. In this presentation, the strategy against rock obstacles will be discussed. The rock distribution is assumed as rich as the Surveyer-7 landing site, as the most severe and rock-rich situation, ever observed.

Landing Scenario and Obstacle Avoidance

The lander will begin the vertical descent sequence from about 3-4km above the landing target site, after the powered descent flight. Only a few safe landing points, for example 10x10 m area, could be found for the site with assumed rock distribution, Surveyer-7. Therefore the final landing point selection shall cover wide area, such as 1000x1000m. For this wide area, around 2 to 4 landable points could be found, even if the area is covered by the most severe uniform rock distribution probability, acccording to our Montecarlo simulation.

Finding such rare landable points in the wide candidate area from high altitude is too difficult. Even for the most precise optical sensor, the required resolution will become more than 6000x6000 pixels for the 0.5m rocks recognition from 1000x1000m area, since the image processing empirical rule requires 3x3 pixels for the reliable identification of small target,

Probabilistic Obstacle Avoidance Strategy:

From the Apollo result, for the rock distribution we could roughly assume that in the region where a large-scale rock is rough, the small-scale rock is also rough. Therefore, in the area where large-scale rocks exist sparser than the surrounding, 50cm class small rocks also exist sparse only, and the suitable points for safe landing exist more rich than the surrounding.

Based on the above assumption, a new and simple probabilistic strategy of obstacle avoidance will be proposed. In this new strategy, at higher altitude (ex. >2000m), the local rock distribution will be estimated using only the large rocks (ex. >3m) distribution, that could be well identified and detected from such higher altitude, by 1000x1000 resolution camera. The landing guidance control will guide the lander with relatively wide landing zone (ex. 250m), where the local rock distribution is minimum through adjacent wide area. When the lander altitude will become lower and lower, the obstacle detection sensor could well identify from midium size to small size rocks. The guidance control will guide the lander from a zone to a point according to the identified rock size. Using this strategy, the lander would already be guided to the rock sparse area at the low altitude, safe landing could be expected with high probability by short distance rock avoidance, available even for low altitude.

Such a process is a strategy similar to the human operator's techniques tacitly assumed, when the operator decides the search target point from the Apollo photograph etc. beforehand. Obvious large-scale rocks region will be avoided, and a landing point will be specified to the zone where no obstacle such as rocks is recognized from the photograph, if the lander safety is the primary priority. This proposed strategy is the one that implements such a human selection process stochastically and autonomously.

Conclusion: The advanced computer technology, especially the optical image processing, will enable the more safe obstacle avoidance landing technology to the more risky area, such as the central hill of the crater.

References:

[1] http://yyy.tksc.nasda.go.jp/Home/Projects/SELENE/index_e.html

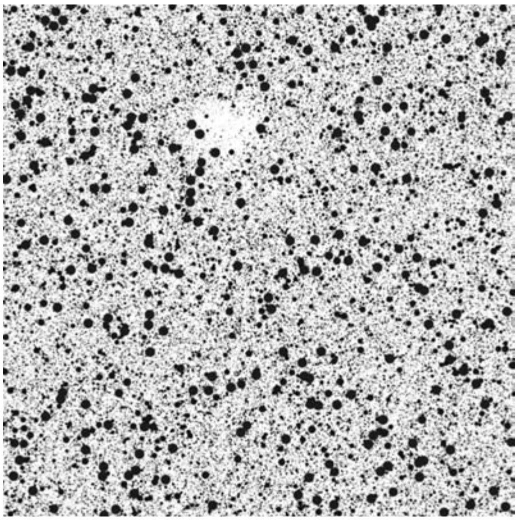

Fig. 1 Rock Distribution larger than 0.5m
1000 x 1000m
(Same distribution to Surveyer-7 Site)
with 1/6 lower rock distribution zone of 100m

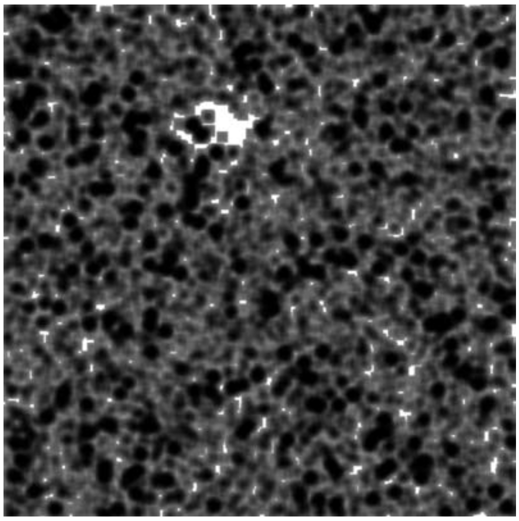

Fig. 2 Identified rock sparse/landable zone.
From Rocks larger than 3m with
rock image expanding processing.

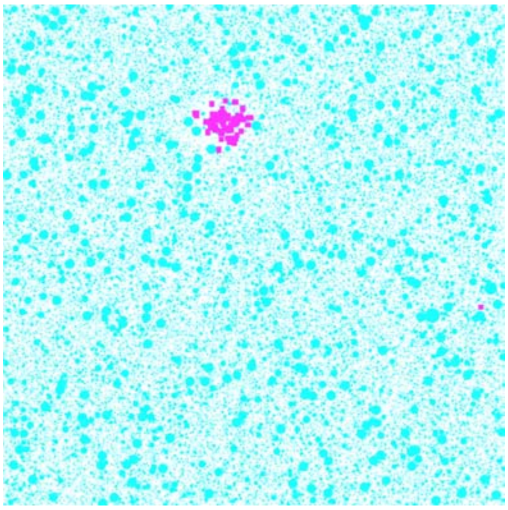

Fig. 3 Safe Landable points of 10x10m extent.
Identified using all rock data of larger
than 0.5m