A Stereo-Vision Based Hazard-Detection Algorithm for Future Planetary Landers. S.Woicke[1] and E. Mooij[2], [1]MSc Student, Delft University of Technology, Kluyverweg 1, 2629 HS, Delft The Netherlands, svenja.woicke@gmail.com [2]Assistant Professor, Delft University of Technology, Kluyverweg 1, 2629 HS, Delft The Netherlands, E.mooij@tudelft.nl

To increase the autonomy of spacecraft during landings, to reduce the risk of a failure, and to increase the area accessible, it is necessary that the lander can judge the safety of possible landing sites by itself, in real-time. This capability can be given to the spacecraft by equipping it with a so-called "hazard detection and avoidance algorithm". This algorithm can be split into two main tasks: detecting hazards, and adapting the landing trajectory based on the outcome of the hazard detection. It gives the lander the ability to land in areas, which are not entirely hazard-free, as well as, mitigates the risk posed by hazards, which are to small for detection from orbit.

An algorithm was developed and verified that can detect these hazards. This is done using maps, which are constructed using a stereo vision algorithm. Stereo vision was selected, as cameras are low-cost, lightweight and low in power consumption. The developed algorithm uses block matching with a sum-of-squared differences cost function for matching the stereo images. The resulting digital elevation model is used for generating slope and roughness maps, and in addition a texture map is generated based on the input image. Slope and roughness maps are computed using a linear regression plane, while texture detection is done based using a histogram-based variance algorithm. All these maps are merged to create a final hazard map, as shown in Figure 1.

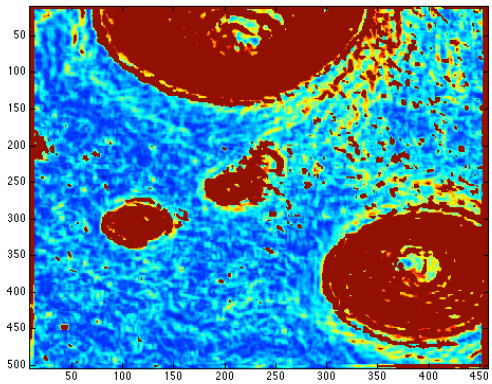

Figure 1: Computed hazard map

To determine the limitations of this method, with respect to the maximum altitude, terrain complexity, and minimum baseline, a sensitivity analysis is conducted.

Using PANGU, a planetary surface generator, it is possible to simulate a pair of cameras taking images of a scene, of which the digital elevation model is known. Therefore it is possible to compare the digital elevation model, as well as, the slope and roughness maps, to their ground-truth and computes the quantitative errors. The results of a sensitivity analysis show that stereo-based hazard-detection is feasible at altitudes below 150 m if a baseline of 2 m is used. Higher altitudes are possible at larger baselines. However, it was concluded that baselines larger than 2 m are hardly feasible for current lander designs.

It is thus shown that stereo vision can be used to give a lander the capability of evaluating the safety of a landing site, or region, in a hazardous terrain, which will increase the vehicle autonomy while reducing the risk of a failure.