Velocit y estimation of a wind driven Ma I tian balloon

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1. Introduction

Balloon borne instruments have long been used to measure **the** properties of the Earth's atmosphere., More recentl y, the French-Russian VEGA mission placed 2 balloon probes into the atmosphere of Venus (Preston, et al., 1986). Approximately 46 hours of Earth-based radio tracking of these balloons enabled estimation of the. three dimensional wind velocity along the. track of each balloon. The Mars '96 mission is a multinational effort to land a probe on the Martian surface. and to release two balloon borne instrument payloads into the Martian atmosphere.. While the primary task of the. balloon probes is to acquire high resolution images of the Martian surface from 4 down looking cameras, other instruments will include an altimeter, sun sensor, and a meteorologica 1 package. A n umber of surface probes wil I be contained in a guide rope that will lie on the surface during the Martian night. As in the case of the VEGA mission, tracking of the balloons' motion will provide a direct measurement of the Martian wind velocity.

II. Measurement of Martian winds

During the VEGA mission, the proximity of Venus to the Earth and the available signal power from the balloon probe transmitters allowed their positions to be measured by Earth - based radio metric tracking. However, in the case of the Mars '96 mission, the limited power of the. transmitter and the increased Earth-Mars range make direct l;arth-based radio metric tracking unfeasible,. It may be possible to use the radio links between the balloons and both the Mars '96 orbiter and the U.S. Mars Observer spacecraft to obtain some information on the balloon velocity, but the. limited periods of mutual visibility may severely restrict the frequency and duration of these measurements.

Because of these inherent problems, we have focused on the use of onboard instruments alone to estimate the motion of the wind driven balloons. In particular, the availability of the 4 down looking cameras suggests the use of image based methods to estimate the motion of the balloon. These techniques are currently used in many applications such as autonomous vehicle guidance, machine vision, and target tracking. The fundamental idea is to USC. common information contained in a sequence of 2 or more images to infer the motion of the earner-a, which irr our case, is being driven by Martian winds.

The application of image based methods for tracking a Martian balloon is in certain ways simpler than other applications of the.sc. techniques. Because them arc no moving objects on the Mar tian surface, all motion can be attributed to the camera-balloon system alone. On the other hand, the small bandwidth and low power of the onboard transmitter limit the number and frequency of images that can be transmitted to the. orbiters and then to Earth. Hence, it may be necessary to perform initial processing of the image sequences with the computer onboard the. balloon probe.. Since this computer is expected to have. limited power and memory and must be shared by all other instruments on the probe, only relatively simple. algorithms can be used to process the image sequences. These simple algorithms, however, are more susceptible to image distortions introduced by the dynamics of the balloon. For example, changes irr the altitude of the balloon will cause scale differences in the images, and the axial rotation of the. camera will induce. a Notational distortion. Since most simple. image matching algorithms are very sensitive to these types of distortions it may be necessary to use other onboard sensors to correct the. images pri or to processing.

in addition to the balloon motions which cause image distortions, the camera is expected to undergo a continuous pemtulum-like swinging motion that will be difficult to separate, from the purely translational motion of the balloon and the.rcforc introduce. a systematic error into the wind velocity estimation. While. it might be possible to estimate the parameters of this swinging motion, it is unlikely that enough image.s would be available to do this accurately.

111. Mars balloon simulation

llc.cause of the problems discussed above, our work has focused on the simplest possible. algorithms using the smallest number of images necessary to estimate the balloon velocity. The images used in these studies were generated synthetically since there. are. no real images of the Martian surface with the resolution expected from the balloon cameras. The software that generates these images uses a fractal based technique and attempts to simulate the actual geophysical processes responsible for the surface features (Gaskell, 1992). A model for Martian winds was used to generate typical flight paths for the balloon, and a simple dynamical model for the. balkmn-camera system was used to represent the expected swinging motion of the camera. The parameters of this model arc based upon actual test balloon flights at high altitudes intended to simulate Martian atmospheric conditions. It was furthermore assume.d that data from the sun sensor cou Id be used to correct the, rota t ions 1 c1 istort ions to an accuracy of approximate.ly 0.5 deg.

The purpose of these. simulations is to:

1. determine the expected accuracy of the estimated balloon velocity for a number of d i fferent image sequences and balloon flight paths

2. assess the effects of the came.ra swinging, motion on the. accuracy of the estimated velocity

3. test the efficacy of various algorithms to extract the. camera motion from the image sequence

4. assess the computational and memory requirements of each method

IV. Summary

Tracking the. motion of wind driven Martian balloons will provide important information on the d ynam ics of the Martian at mosphere. An image base.d technique using onboard processing of the images has been tested using simulated images of the. Martian surface. The results of this simulation have provided valuable information on the requirements for achieving wind velocity estimation that will be of scientific interest,

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VI. References

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