IAF SPACE EXPLORATION SYMPOSIUM (A3)
Solar System Exploration including Ocean Worlds (5)

Author: Ms. Camilla Bandinelli
Politecnico di Torino, Italy

Prof. Elisa Capello
Politecnico di Torino, Italy
Dr. Ashish Goel
Jet Propulsion Laboratory - California Institute of Technology, United States
Dr. Federico Rossi
Jet Propulsion Laboratory - California Institute of Technology, United States
Dr. Marco Quadrelli
Jet Propulsion Laboratory - California Institute of Technology, United States

REAL TIME DATA-BASED WIND MODEL FOR A VENUS AEROBOT: DEVELOPMENT AND TESTING

Abstract

The surface of Venus is characterized by extreme temperature and a crushing pressure. However, at altitudes between 51 to 62 km, conditions resemble Earth's surface, making it an ideal location for a proposed mission concept involves deploying a balloon with a suspended science gondola, collectively known as an aerobot. Due to the planet's extreme wind conditions, with gusts reaching up to 100 m/s, and the complexities of balloon dynamics in the atmosphere, detailed models of wind gusts are crucial. Unfortunately, previous missions have only collected surface wind data and vertical gusts, leaving horizontal gusts data missing. The goal of this paper is to develop a robust gust model capable of capturing the highly non-stationary and random characteristics of wind gusts from real-time data, so it can be used in predictive simulations of the Venus aerobot behavior. The proposed model relies on a set of stochastic differential equations (SDE), specifically a bidimensional Ornstein-Uhlenbeck process, to accurately represent the autocorrelation function (ACF) and probability density function (PDF) of a measured wind signal. The first one introduces a memory effect into the signal while the second function serves as a tool for reproducing the observed data and quantifying their probabilistic characteristic. An extended Kalman filter is used too process the real-time wind signal captured by measurement instruments before incorporating it into the model. This filter adeptly captures the dynamics of an atmospheric balloon and processes data from inertial measurement units (IMUs) and wind measurement instruments. The proposed method wass tested using real-world wind speed measurement data collected by JPL during flight tests in the Mojave Desert. Results indicate that the proposed method is simple to implement and can accurately capture simultaneously the autocorrelation and probability distribution of wind speed measurement data.