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Author: Mr. Maximilian von Arnim
Zentrum für Telematik, Germany, maximilian.vonarnim@telematik-zentrum.de

Mr. Ilham Mammadov
Zentrum für Telematik, Germany, ilham.mammadov@telematik-zentrum.de
Mr. Lukas Draschka
Zentrum für Telematik, Germany, Lukas.Draschka@telematik-zentrum.de
Mr. Julian Scharnagl
Zentrum für Telematik, Germany, julian.scharnagl@telematik-zentrum.de
Prof. Klaus Schilling
Zentrum für Telematik, Germany, klaus.schilling@telematik-zentrum.de

THE CLOUDCT FORMATION OF 10 NANO-SATELLITES FOR COMPUTED TOMOGRAPHY TO IMPROVE CLIMATE PREDICTIONS

Abstract

In the CloudCT mission 10 nano-satellites self-organize in orbit to collect backscattered Sun light from different perspectives. From these measurements the interior of clouds will be characterized. The images are processed slice by slice through computed tomography methods to determine the 3D composition of the clouds. As clouds contribute mayor uncertainties to climate models, improved climate predictions result.

This contribution addresses details of the formation mission, the satellite system design as well as the related control approaches. This novel earth observation method is based on coordination of all satellites in formation to orient by distributed control methods with high precision towards the same target area for measurements with a polarization camera. Challenges relate to calibration and filtering methods to improve the sensor precision and attitude estimation accuracy. For attitude determination high-precision digital sun sensors are included. Miniature reaction wheels enable pointing and tracking of the satellites. Targets can be tracked to enable multiple observations of the same target in quick succession, which is especially useful to understand rapidly developing convective clouds. Simulations generate the pointing accuracy requirement by calculating the overlap area and number of overlapping images of each image set.

Position determination is based on 4 GNSS receivers placed on different side panels and on retroreflectors for laser tracking from ground. Orbit control is enabled by an electric propulsion system. The distributed control design ensures in an energy-efficient way maintenance of the formation, as well as transitions between appropriate configurations in 3D, in order to provide most suitable observation geometry. Here Distributed Consensus Control and Model Predictive Control approaches are prepared.

In the context of joint observations absolute and relative pointing schemes are employed. Standard preplanned target area observations can be specified by their coordinates (latitude, longitude and height) and all satellites are oriented at given time from their well-known position towards the target. But there are also event dependent observations, such as by example halo effects. When the first satellite detects a halo, via inter-satellite link the other partners in the formation are informed to point to the same spot using relative distances and orientations. Autonomous reactions to environmental effects that impact the image quality, such as the position of the sun relative to the target, are to be considered.

CloudCT is in system implementation process for a planned launch in 2023. In parallel already high precision/high dynamics turntables for hardware-in-the-loop multi-satellite testing are prepared.