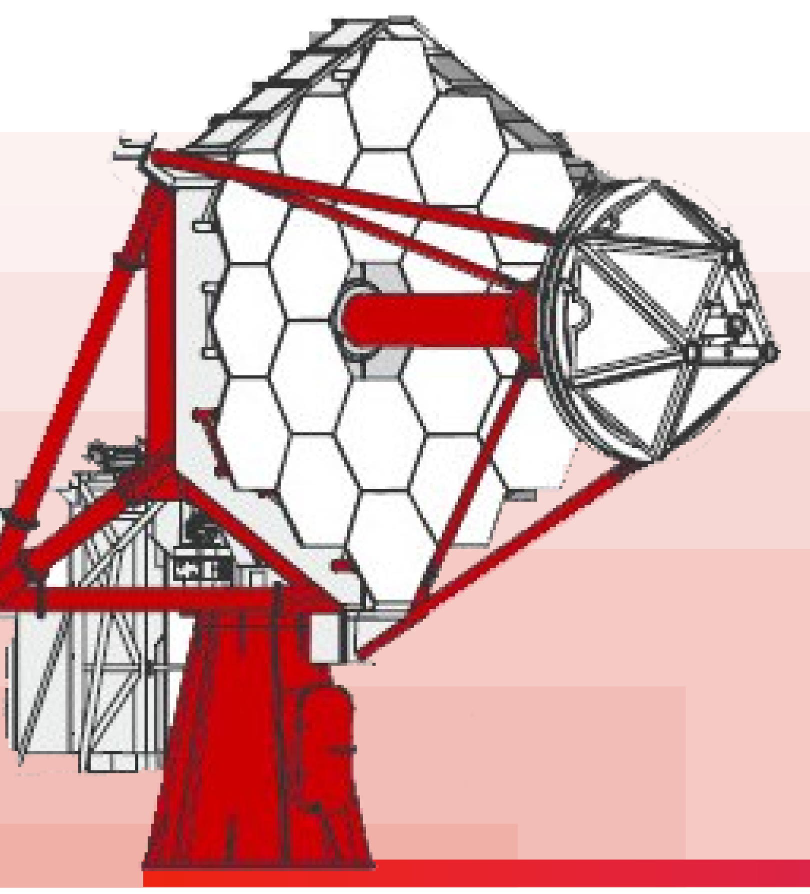

Predictive Maintenance for Array of Cherenkov Telescopes

Salvatore Gambadoro *(UNICT- INAF)*,
Salvatore Cavalieri, Alessandro Costa, Diego D'Urso, Federico Incardona, Kevin Munari and Pietro Bruno

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Salvatore.gambadoro@phd.unict.it

Abstract

An Array of Cherenkov Telescopes is equipped with a multitude of sensors spread all over the instrumentation and collects a large volume of housekeeping and auxiliary data coming from telescopes, weather stations and other devices in the array site. In this poster we will present how we intend to exploit the sensor's information to perform predictive maintenance (PdM) using with the most advanced artificial intelligence algorithms. This technique will be useful to detect in advance the remaining useful life of the array components, and to estimate the correct timing for performing their maintenance. The application of PdM will allow to minimize the array downtime, to increase the telescopes sub-components longevity, and to reduce the costs due to unforeseen maintenance. Our model used a time series data coming from several different sensors (temperature, current, torque, etc.) dedicated to monitoring several mechanical components of the telescopes (engines, cameras, encoders, etc.). The adopted unsupervised machine learning approach will allow us to perform the correct trade-off between preventive and corrective maintenance.

Array of Cherenkov Telescopes

Arrays of Cherenkov telescopes will be the largest and most advanced ground-based facility for detection of very-high-energy electromagnetic radiation, from 20 GeV to 300 TeV. When entering the atmosphere, this radiation generates secondary charged particle cascades that can be detected directly or, as in the case of Arrays of Cherenkov telescopes, through the Cherenkov radiation they emit. Since the area hit by this light is wide, in the order of 105 m2, multiple telescopes are required to intercept it all, and to reconstruct the properties (energy, direction) of the primary gamma-ray who generated the cascades.

Why this research?

This research comes from the need to have a maintenance system able to minimize the array downtime, to increase the telescopes sub-components longevity and to reduce the costs due to unforeseen maintenance.

Fault Tree Analysis

The first point of our research is to perform a reliability analysis of our system. For this purpose, the fault tree analysis (FTA) is used, this is considered as one of the main techniques of traditional risk analysis theory. The "FTA" enable us to identify the telescope components most likely to fail.

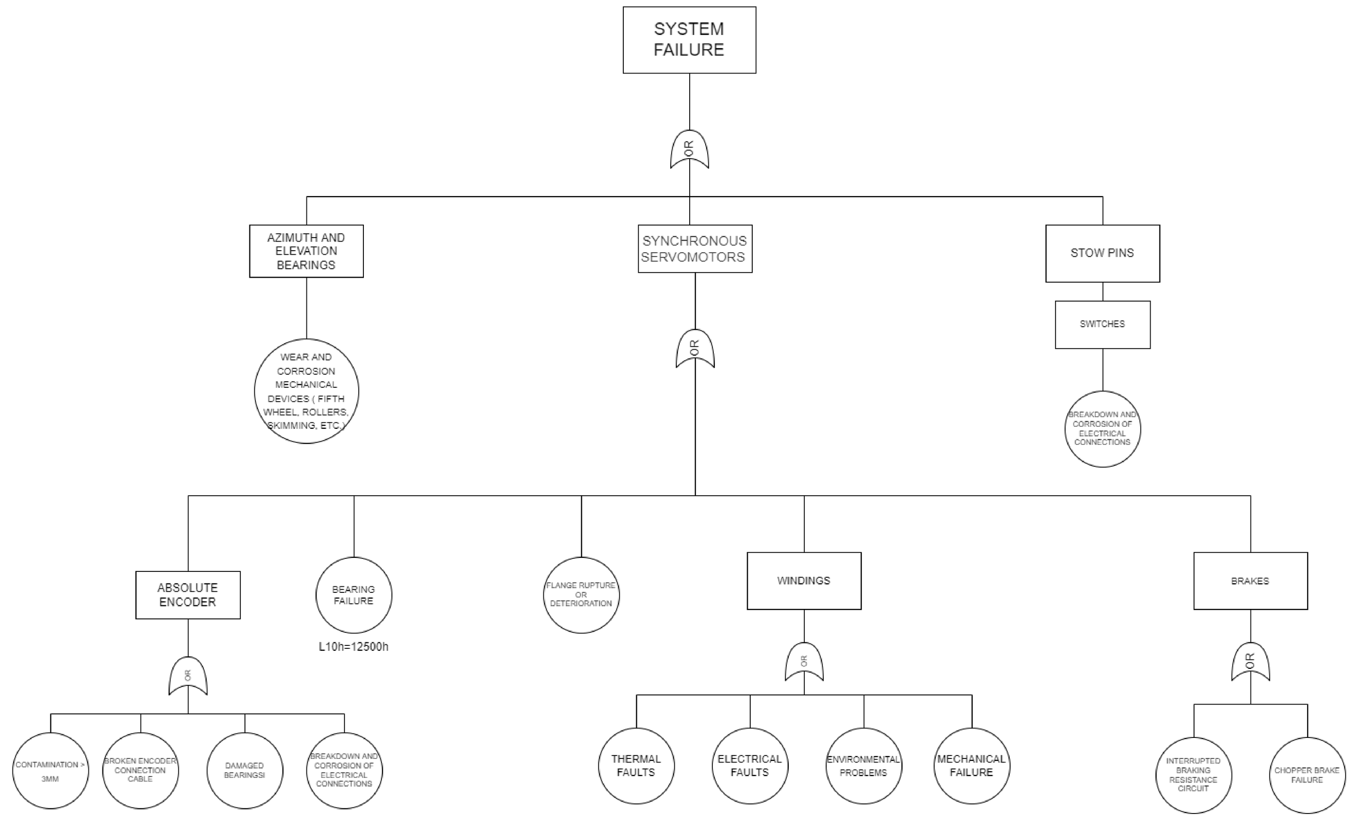

Fig. 1: Fault Tree Analysis of a prototype of a small size telescope located in Catania at the Serra La Nave astronomical observatory.

Unsupervised learning model for maintenance

The telescope sends a time series of data from a number of different sensors designed to monitor several mechanical and electrical components.
Once the large amount of Array of Cherenkov Telescopes data is obtained, various techniques for extracting data are applied as the data are presented in raw form. The approach used for data storage is based on the cross-industry standard process for data mining (CRISP-DM) model. This model offers a standard process for implementing a data mining project. It consists of 6 phases: business understanding, data understanding, data preparation, modeling, evaluation and deployment. For Step 5, modeling, of the CRISP-DM, unsupervised models are chosen because the data in our possession do not present information related to the failures of our telescope. The unsupervised model that gives the best result is the clustering model. In fact, it, can find the fault of the telescope well ahead of time. This work enhances the analysis of the maintenance of telescopes little present in the literature, focusing on critical components, that is to say components with a greater probability of failure.

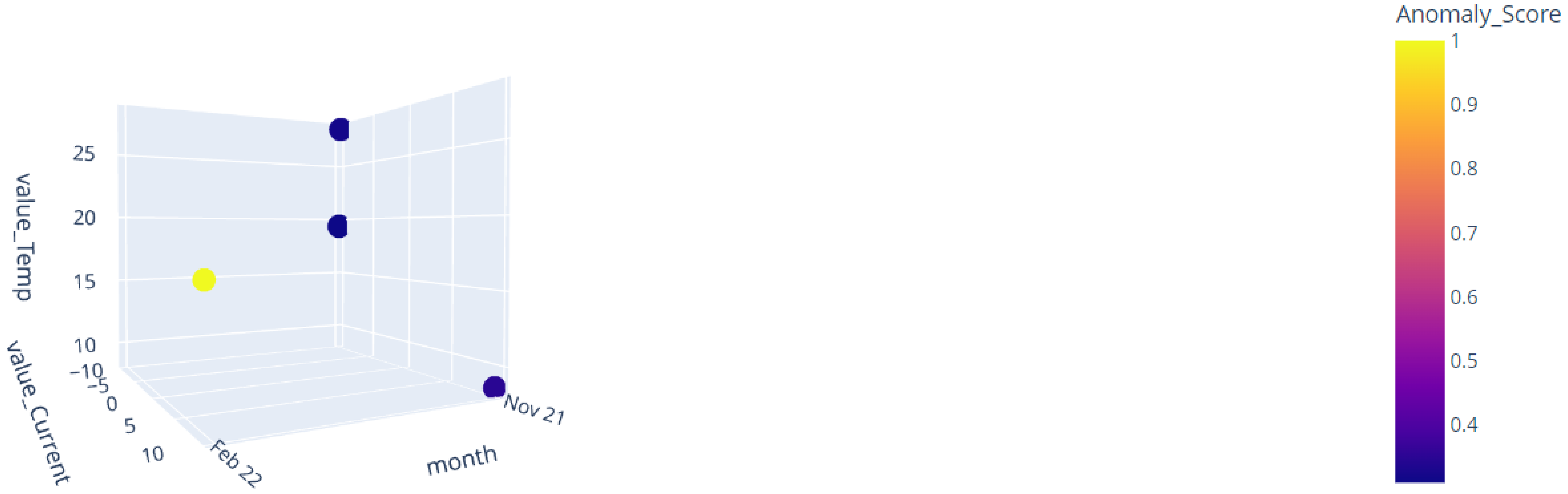

Fig. 2: As an example of the failure event that occurred on February 2022. The telescope brake failed and the telescope remained unusable for a long time. But our model would have signaled this at November 2021, based on the engine temperature, torque, current and status information. This would have prevented the telescope engine from breaking and would have reduced the telescope's down time.