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Tracing Component Wear Signatures in ASTRI-Horn Historical Monitoring Time-Series*

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INTRODUCTION

ASTRI-Horn [1] is an Italian telescope designed to detect gamma rays as a **prototype** of the Small-Sized Telescopes of the CTA (Cherenkov Telescope Array) project [2]. It was developed in the context of ASTRI [3] and was installed in 2014 at the observing station of the INAF Astrophysical Observatory of Catania, in *Serra La Nave*, on Mt. Etna. Since the beginning of operations, **three significant issues** have necessitated the suspension of its activities.

In **May 2019**, water infiltration resulted in gear oxidation and seizure of the Azimuth motor.
In early **November 2021**, gradual wear on the tape of the Azimuth relative encoder began to cause an increment in the number of errors displayed to the operator. Upon replacement, which occurred during April 2022, damages were identified at multiple points of the tape.
Lastly, in **February 2022**, oxidation resulting from condensation caused damage to the brake of the elevation motor.

The limited number of occurrences complicates the utilization of typical supervised learning algorithms for *Predictive Maintenance* (PdM) (See: [4], [5], [6]).

An **analysis** was conducted on **time series** data from the Telescope Control Unit (TCU), Telescope Health Control Unit (THCU), and a Weather Station (WS) near the telescope. Over 200 time series were monitored at approximately 15-second intervals. The focus was on a subset of 19, 27, and 4 features for TCU, THCU, and WS, respectively, covering variables such as currents, voltages, positions, temperatures, and environmental factors such us temperature, humidity, wind speed, and solar radiation [7]. The analyzed data spans from June 2017 to March 2024.

FEATURE ANALYSIS

We identified **two anomalous time series** occurring between December 2018 and May 2019, during which peaks in the currents of both the master and slave Azimuth motors were observed, as reported in Fig. 1 and Fig. 2, respectively. These peaks correspond to the period when the Azimuth motor encountered water infiltration. The increased current absorption reflects the Azimuth motor's struggle to operate due to increased friction. Following the motor's replacement in June, the current absorption returned to normal levels.

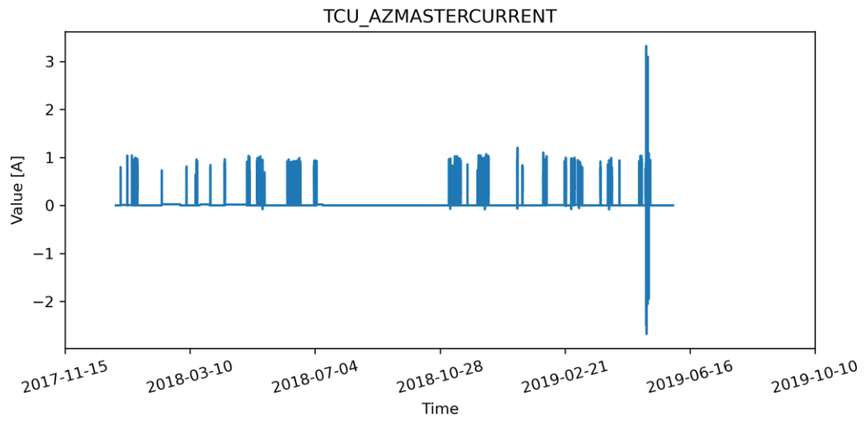

Fig. 1 The profile of the master Azimuth motor's electrical current spanning from January 2018 to May 2019. Under normal conditions, the current typically settles around 1 Ampere; however, it surged to 3 Amperes during the documented period of water infiltration.

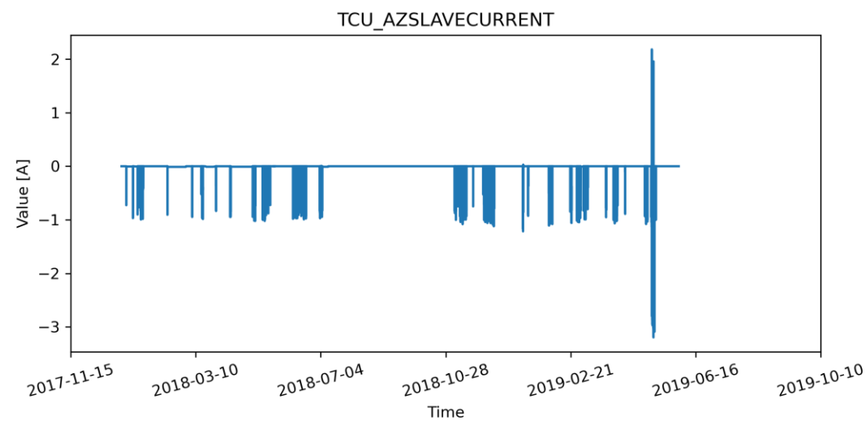

Fig. 3 The trend of the slave Azimuth motor's electrical current from January 2018 to May 2019. Both the Master and Slave motors work in opposition to maintain traction for the telescope.

We also observed a notable **increase in errors** during two out of three of the periods associated with telescope faults.

The variable "TCU_ERROR_NUMBER" indicates the number of errors reported to the operator over time. As depicted in Fig. 3, an increase in errors coincided with the occurrences of faults, which happened in November 2021 and February 2022.

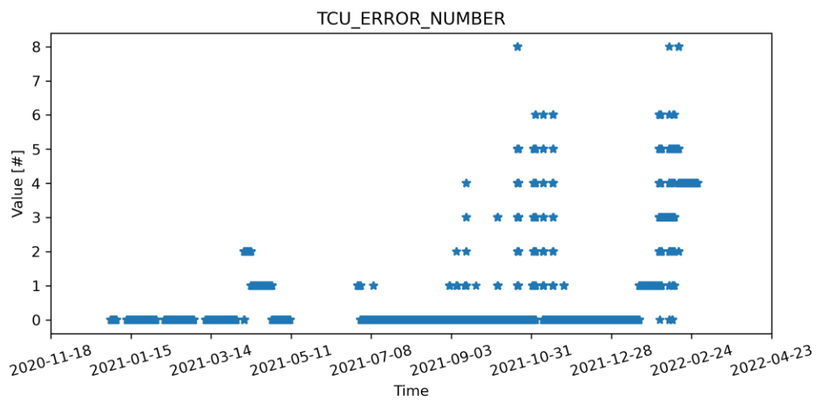

Fig. 3 The number of errors reported to the operator from December 2020 to February 2022. The two bumps correspond with the occurrences of faults.

CONCLUSIONS

The analysis focused on 50 features from the ASTRI-Horn monitoring system, **identifying a pattern of gear oxidation correlated with equipment malfunction**. The 15-second sampling rate limited detection of episodic events like peaks on shorter time scales. Data showed no other signs of progressive degradation on timescales exceeding 15 seconds. **Elevated error counts during two out of three fault periods suggest potential for log analysis integration**. The next step involves developing a model to compare actual and predicted values continuously, triggering alarms for deviations in expected patterns as part of Predictive Maintenance (PdM).

ACKNOWLEDGMENTS

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