ANID IDEA I+D 2026

Operational log analysis using NLP

Techniques and Applications in Telescope Operations

Juan Pablo Gil – Software Group at Paranal

Santiago- August 11, 2025

What we do

ESO mission:

To design, build and **operate advanced ground-based observatories**, and to foster international collaboration for astronomy.

- We use world class, complex machines
- Our telescopes and instruments are prototypes (low TRL)
- Our operational data is unique

Knowledge must be managed in-house

Why Software Log Analysis?

*Wikipedia: Log analysis is an art and science seeking to **make sense** of computer-generated records*

- SW Logs are a type of **telemetry data** produced during the operation.
- Written in **natural language** for human consumption.
- Used in:
  - Observation execution
  - Technical troubleshooting
  - Performance analysis
  - Commissioning activities

Logs at LS/Paranal

Sources	VLTSW systems sending logs to Datalab	50
	Facilities	La Silla, Paranal
Log Generation	Average single log line size	~200 bytes
	Average insertion rate	150 logs/second
	Peak insertion rate	70,000 logs/second
Storage	Logs by Month (averaged in 2023)	$517*10^6$ events/month 195.6 GB / month
	Retention in Elasticsearch	5 years 11.5 TB
	Retention of Raw files	15 years

Key Analysis Techniques

Pre-processing

- Cleansing: remove bad traces
- Tokenization (equivalent to stemming, etc, in NLP)
- Vocabulary generation

Event Representation

- Time series
- Tokens
- Bag of Words (BoW)
- One Hot BoW
- Embeddings
- Graphs

Technique

- Time series analysis
- Naive Bayes
- Cluster detection:
  - K-Means
  - DBScan
  - SVM
  - T-SNE
  - UMAP
- Topic Modelling
  - LDA
- Deep Learning
  - Autoencoders
  - Transformers
- Sequence Detection

- Statistical methods
- Machine learning algorithms
- Natural Language Processing (NLP)

Log Libraries

- ELIANA
  - https://github.com/paranal-sw/eliana
  - Open Source (BSD-3 License)
  - Event Log and Incident Analysis
  - Dataset generator class based on Pandas, log tokenizer, statistical anomaly detection modules.

- ELIANA-VLT
  - https://scgitlab.sc.eso.org/jgil/eliana-vlt
  - Privative version of ELIANA
  - Fine tunned for VLTSW
  - Base for several MSE analysis and tools

- Public Dataset
  - https://huggingface.co/datasets/Paranal/parlogs-observations
  - Curated dataset of VLTI observations
  - Six months of 2019, VLTI subsystems and AT logs
  - Successfully used with students and researchers

Tokenizer: Log Colorizer

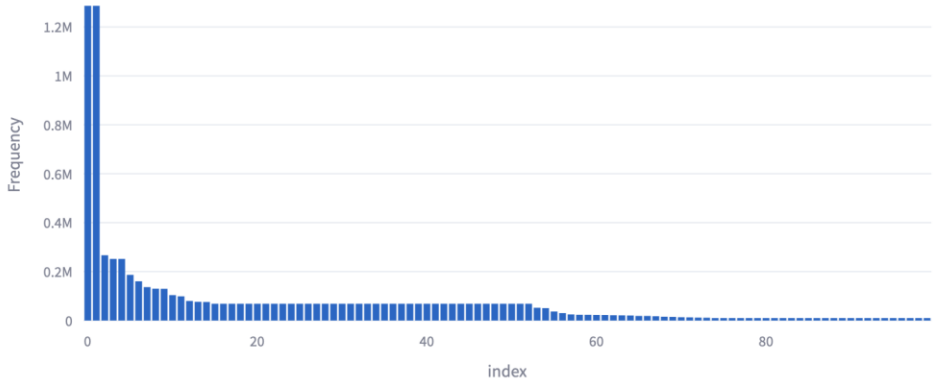
Loaded Model

```
Base class       : VltLogColorizer
Training dataset : VltTemplatesFor-GRAVITY-2025_05_15T08_00_02_617-2025_07_31T08_00_02_6
Training time    : 0:21:10.296468
```

Information

```
Num of regexps   : 10
Num of templates: 111
Vocabulary size  : 3612
```

Color distribution



Model: Strange Log

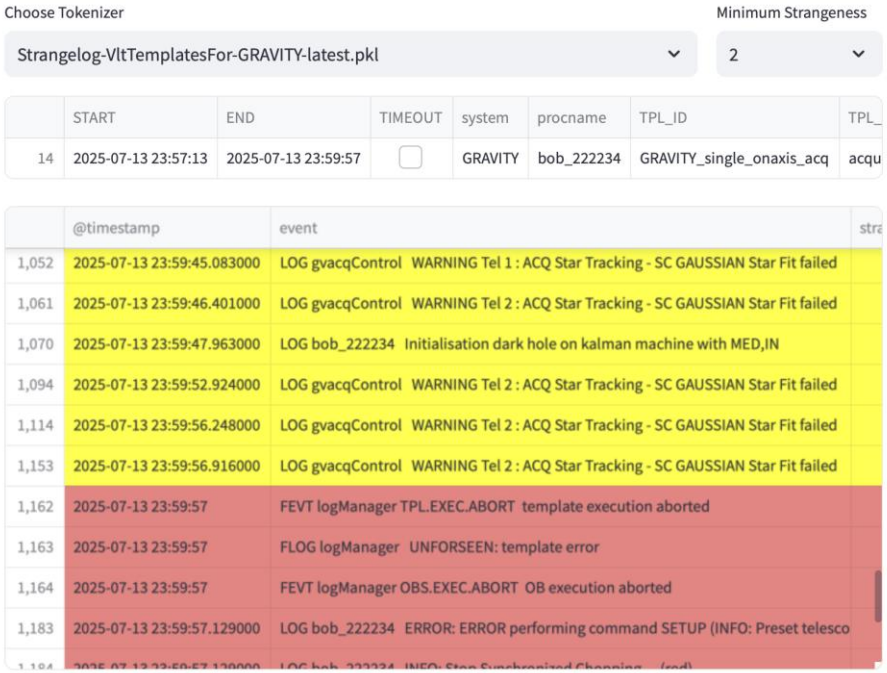
Strange Logs

Description

Statistical approach to label anomalies in event logs based on percentile analysis of tokenized events.

It returns a labelled dataframe from a test df_trace with new column 'strangeness' for each event:

Strangeness	Meaning	Comment
0	Boring	Observed in 80% or more of the traces
1	Common	Observed in 20% - 80% of the traces
2	Rare	Observed in 20% or less of the traces
3	Unexpected	Never seen in the subset



Model: Flood detector

Sentinels of the Systems

These experts oversee the entire infrastructure, ensuring operational stability, tracking changes, detecting anomalies, and uncovering hidden patterns across logs, tickets, and version control. The Sentinels of Systems safeguard the broader operational framework, maintaining vigilance over failures, recurring issues, and evolving system behaviors.

Choose a sentinel:

Tsunami | Haystack | SeVeN | DejaVu

Tsunami

Tsunami, a flooding detector for logs, is the vigilant sentinel. He has an uncanny ability to detect the moment when a single log entry begins to swell into an unrelenting torrent. With his warnings, you can brace for the deluge before it wreaks havoc.

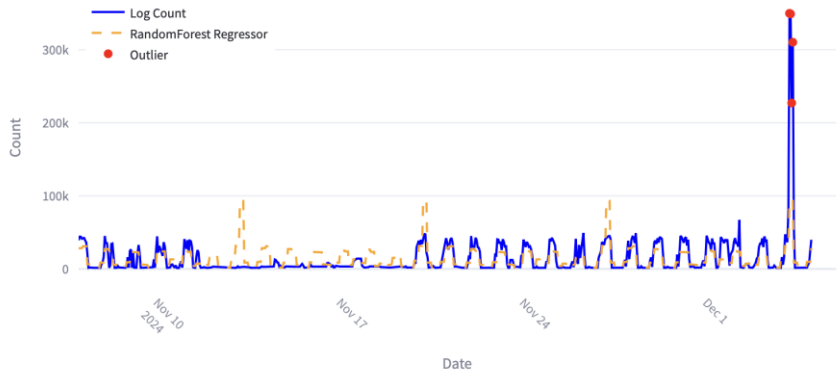
System	Timestamp	Method to detect outliers	Weeks to train
AT*	2024-12-05T00:00:00.000	RandomForest Regressor	4

Run Tsunami

The RandomForest Regressor is an ensemble learning method that constructs multiple decision trees during training and outputs the mean prediction of the individual trees. For this analysis, we used features ['4-hour'

Log Counts Outliers by RandomForest Regressor

4 outliers detected between 2024-11-07 00:00:00 and 2024-12-05 00:00:00




```
Inspecting logs between 2024-12-04 04:00:00, 2024-12-04 05:00:00
```

```
Most logs appears between 2024-12-04 04:10:00, 2024-12-04 04:11:00
```

Outlier logs (sample)

@timestamp	system	logtype	envname	procname	logtext
2024-12-04 04:10:00	AT2	LOG	wat2nao	PixelDisplaySrv	Application got PIPE signal while writing on socket
2024-12-04 04:10:00	AT2	LOG	wat2nao	LogGateway	[ERROR] 0 0 1 W rtdSendImageInfo failed
2024-12-04 04:10:00	AT2	ERR	wat2nao	PixelDisplaySrv	rtdcoreERR_SOCKET_WRITE : Error writing on socket (E

— Not a single error—an avalanche of them.

Daily Support Analysis Tool

nightmare

observation-experts

system-sentinels

dashboard-library

OSSana, the ultimate OSS Analysis Tool

Night of interest

2025-08-12

Hour of event

00:00:00

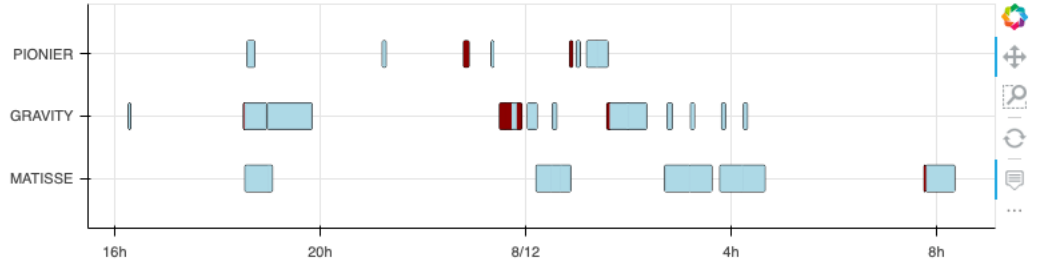
What happened at night?

Select the telescope

UT1 | UT2 | UT3 | UT4 | VLTI | VISTA | VST

Below are the events between 2025-08-11 16:00:00 and 2025-08-12 16:00:00 for:
VLTI

VLTI



Write the day and hour, and select an instrument to let the experts speak.

2025-08-12 | 00:00:00 | PIONIER | GRAVITY | MATISSE

— A night of anomalies, recorded in silence, awaiting the next watcher. 🌑

Tool: Explain an Observation

Sherezade

Sherezade, a log compiler and event interpreter, brings clarity to chaos. The storyteller of the system, she has an uncanny ability to gather execution details from countless logs and spin an intricate tale of what unfolded at a precise timestamp. Her narratives reveal the hidden threads of cause and effect, illuminating the path through the labyrinth of system events.

2025-05-24T23:46:29.000 ☑ Tell me the story

Once Upon a Timestamp

```
... For the OB 'SCI_ASAS-J132336-4718.7' being executed in GRAVITY between 23:45:00
and 23:48:11
```

```
... The template that was running ended in ERROR
```

	value		value
START	2025-05-24 23:45:00.173000	USER_ABORT	False
END	2025-05-24 23:46:29.887000	ERROR	True
TIMEOUT	False	PRESET	True
system	GRAVITY	estimated (h:m:s)	00:10:00

```
... All the templates for the current observation were
```

	START	END	TPL_ID	SECONDS	ERROR
0	2025-05-24 23:45:00	2025-05-24 23:46:29	GRAVITY_single_onaxis_acq	89	true

```
... The observations in the previous 4 hours were
```

	START	procname	OBS.NAME	OBS.ID	ABORTED	duration
0	2025-05-24 23:23:54	bob_Stephanie	CAL_BCen_GRA4MAT_L	3854633	false	574
1	2025-05-24 23:45:00	bob_1794225	SCI_ASAS-J132336-4718.7	4169326	true	89

```
... The software installed in the last week was
```

@timestamp	module	svn	revision
2025-05-24 18:37:00	gvngcir	^/trunk/VLTI/Instruments/GRAVITY/DCS/gvngcir	405620
2025-05-24 18:35:00	gvttp	^/trunk/VLTI/Instruments/GRAVITY/OS/gvttp	389088
2025-05-24 17:01:00	gvttp	^/branches/GRAVITY/TTR-115.0061.06/OS/gvttp	uncommited
2025-05-24 16:58:00	gvttp	^/branches/GRAVITY/TTR-115.0061.06/OS/gvttp	uncommited

Tool: Suspicious Logs

SherLog

Sherlog, a log comparison expert, is the tireless investigator. By analyzing the last five minutes of activity against the preceding twelve hours, he sniffs out the rare and the unusual. His keen senses reveal the whispers of potential errors before they can grow into calamities.

Hint: you can ask in more than one system by using parenthesis, e.g. `(GRAVITY ISS DL ARAL UT*)`

2025-05-24T23:46:29.000 | GRAVITY | ☑ Investigate! | ☐ Advanced

Let's the investigation begins

```
... An issue was flagged around: 2025-05-24T23:46:29.000
... I will extract problems (300, 30) seconds around the timestamp
... and compare with those (43200, 30) seconds, which corresponds to events
... from 2025-05-24T11:46:29.000000 to 2025-05-24T23:46:59.000000
... About to learn something new, wish me luck!
```

Running `model_run(...)` .

RUNNING... Stop

```
... Based on my investigation I concluded that the events below are possible cause of the
errors. They have not been seen in GRAVITY more than 2 times in the last 12 hours
```

	@timestamp	system	logtype	envname	procname	logtext
0	2025-05-24 23:44:58	GRAVITY	LOG	wgv	gvoControl	##STATUS command failed
1	2025-05-24 23:44:58	GRAVITY	ERR	wgv	gvoControl	bossERR_GENERAL : ERROR processing buffer (replies f
2	2025-05-24 23:44:58	GRAVITY	ERR	wgv	gvoControl	bossERR_GENERAL : STATUS command failed
3	2025-05-24 23:44:58	GRAVITY	ERR	wgv	gvoControl	ixacERR_STORE_EXTR_BUF : Invalid buffer 'N...'. The list
4	2025-05-24 23:45:27	GRAVITY	LOG	wgv	gvacqControl	gvacqControl: sending command lgvics2/ic0lcuServer -
5	2025-05-24 23:45:32	GRAVITY	LOG	wgv	gvacqControl	gvacqControl: sending command lgvics2/ic0lcuServer -
6	2025-05-24 23:46:29	GRAVITY	FLOG	wgv	logManager	UNFORSEEN: template error
7	2025-05-24 23:46:29	GRAVITY	LOG	wgv	bob_1794225	ERROR: ERROR performing command SETUP (INFO: Pre
8	2025-05-24 23:46:29	GRAVITY	ERR	wgv	bob_1794225	PRESET). (red)
9	2025-05-24 23:46:29	GRAVITY	LOG	wgv	bob_1794225	ERROR performing command SETUP (INFO: Preset tele

```
... Preset was mentioned, let's check the ISS problems
```

Running `model_run(...)` .

Experiments: Generative Log Predictor Transformer (gLPT)

- Two transformer-encoder layers
- Input and hidden dimensionality: 200
- Deep-learning framework: PyTorch
- Azure - Machine learning studio
- Masking tokens learning objective with cross-entropy loss

INPUT

[' Exposure status: FINISHED (SpringGreen4)',
'ended exposure 5 of 5 (2021-01-01T05:51:33) (underlined)',
'New image: PIONIER$_O$*BS*$_F$*RINGE*001$_0$015.*fits* – –*from.Exposeof* :: *pnoseqOBS* :: *BobTPL* :: *obs*(*Blue*)',
'WAIT -expoId -all -cond ObsEnd (blue)',
'INACTIVE (SpringGreen4)']

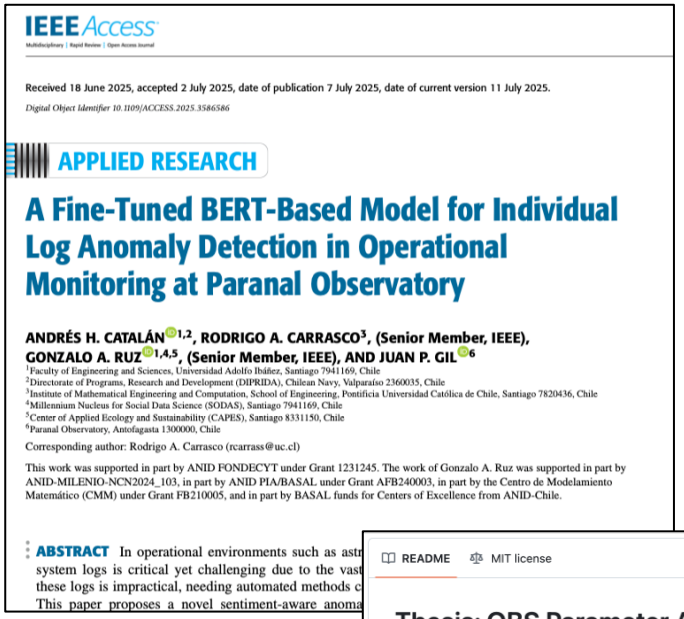
PREDICTION

'Template PIONIER$_o$*bs*$_c$*alibratorfinished*.',
'Finished in seconds at (underlined)',
'TplExecTimeStats: TPL.ID PIONIER$_o$*bs*$_c$*alibrator* estimated :: real :: diff seconds (::)',

instrument	batch size	vocab. length	max. length	training time	cost
Gravity	8	2726	4000	35 hours 33 minutes	150 €
Matisse	16	2790	1000	3 hours 36 minutes	15 €
Pionier	16	901	500	2 hours 10 minutes	9 €

Specifications, times and estimated cost for training 200 epochs

Collaborations



IEEE Access

Received 18 June 2025, accepted 2 July 2025, date of publication 7 July 2025, date of current version 11 July 2025.

Digital Object Identifier 10.1109/ACCESS.2025.3586586

APPLIED RESEARCH

A Fine-Tuned BERT-Based Model for Individual Log Anomaly Detection in Operational Monitoring at Paranal Observatory

ANDRÉS H. CATALÁN[1,2], RODRIGO A. CARRASCO[3], (Senior Member, IEEE), GONZALO A. RUZ[1,4,5], (Senior Member, IEEE), AND JUAN P. GIL[6]

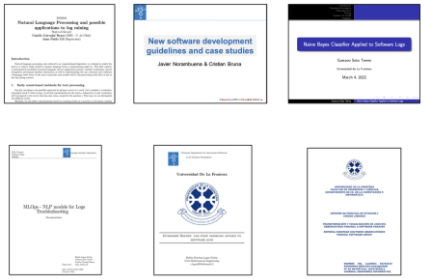
[1]Faculty of Engineering and Sciences, Universidad Adolfo Ibáñez, Santiago 7941169, Chile
[2]Directorate of Programs, Research and Development (DIPRIDA), Chilean Navy, Valparaíso 2360035, Chile
[3]Institute of Mathematical Engineering and Computation, School of Engineering, Pontificia Universidad Católica de Chile, Santiago 7820436, Chile
[4]Millennium Nucleus for Social Data Science (SODAS), Santiago 7941169, Chile
[5]Center of Applied Ecology and Sustainability (CAPES), Santiago 8331150, Chile
[6]Paranal Observatory, Antofagasta 1300000, Chile

Corresponding author: Rodrigo A. Carrasco (rcarrass@uc.cl)

This work was supported in part by ANID FONDECYT under Grant 1231245. The work of Gonzalo A. Ruz was supported in part by ANID-MILENIO-NCN2024_103, in part by ANID PIA/BASAL under Grant AFB240003, in part by the Centro de Modelamiento Matemático (CMM) under Grant FB210005, and in part by BASAL funds for Centers of Excellence from ANID-Chile.

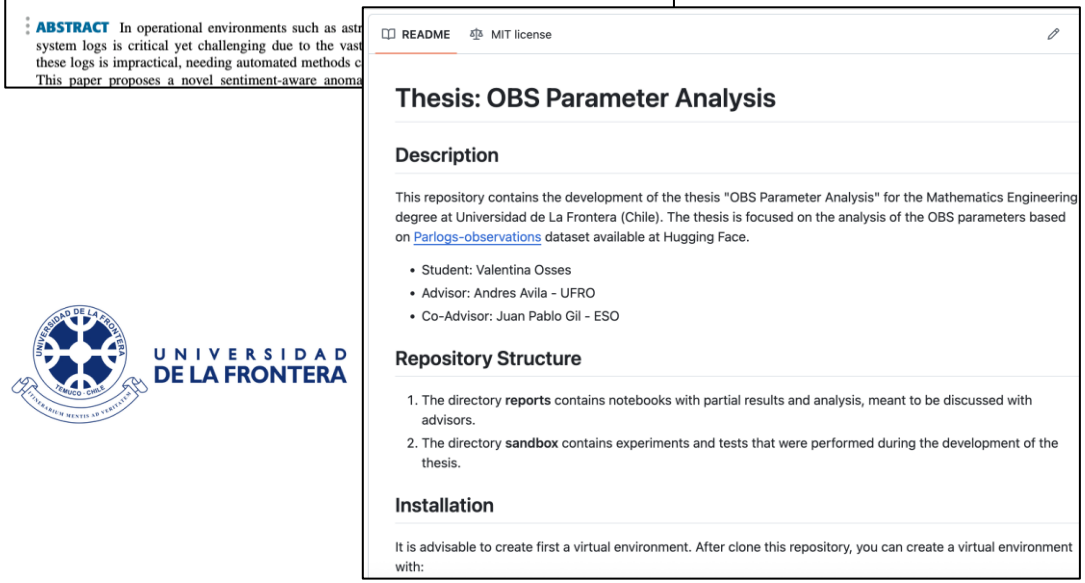
ABSTRACT In operational environments such as astr
system logs is critical yet challenging due to the vast
these logs is impractical, needing automated methods c
This paper proposes a novel sentiment-aware anoma

UNIVERSIDAD ADOLFO IBÁÑEZ



UNIVERSIDAD TECNICA FEDERICO SANTA MARIA

UNIVERSIDAD DE CHILE



README MIT license

Thesis: OBS Parameter Analysis

Description

This repository contains the development of the thesis "OBS Parameter Analysis" for the Mathematics Engineering degree at Universidad de La Frontera (Chile). The thesis is focused on the analysis of the OBS parameters based on Parlogs-observations dataset available at Hugging Face.

- Student: Valentina Osses
- Advisor: Andres Avila - UFRO
- Co-Advisor: Juan Pablo Gil - ESO

Repository Structure

1. The directory **reports** contains notebooks with partial results and analysis, meant to be discussed with advisors.
2. The directory **sandbox** contains experiments and tests that were performed during the development of the thesis.

Installation

It is advisable to create first a virtual environment. After clone this repository, you can create a virtual environment with:

UNIVERSIDAD DE LA FRONTERA

Open Opportunities

1. Support open source framework for Event Log and Incident Analysis (ELIANA)

   Benefits: Baseline for tool development and external collaborations

   Effort: Low, based on roadmaps

2. REST microservice architecture for diagnostic information.

   Benefits: First step to **agentic** operation.

   Effort: Medium, data engineering skills

3. Integrated diagnose framework that suggest specific actions based on multiple sources and sympthoms.

   Benefits: Mix context to reach prescriptive analysis. Leverages LLMs.

   Effort: Medium, depending on size of MVP.


THANK YOU!
Juan Pablo Gil – jgil@eso.org