



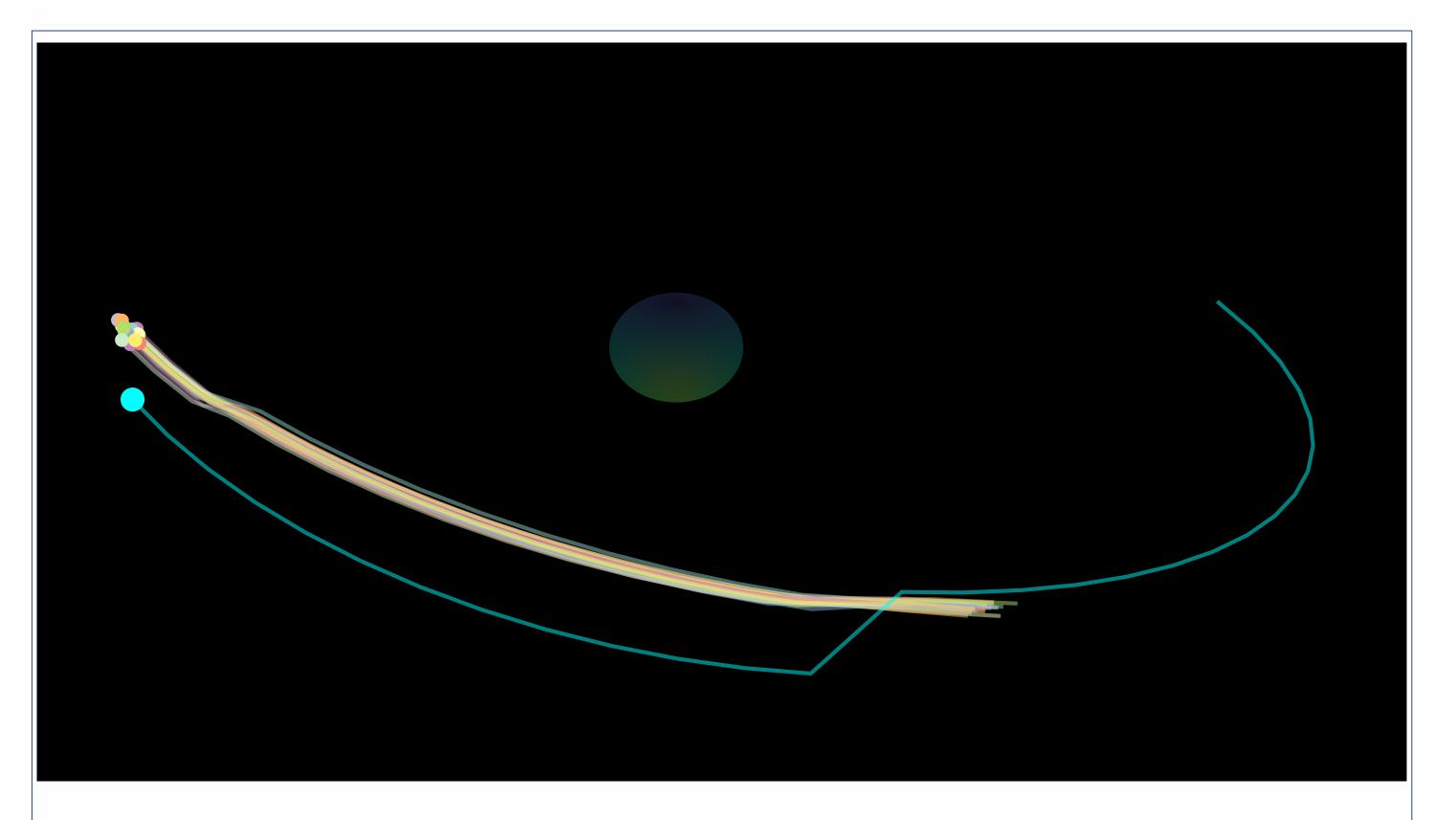
# **A System for Satellite Orbit Anomaly Detection**

David Shorten<sup>1</sup>, Wathsala Karunarathne<sup>1</sup>, Melissa Humphries<sup>1</sup>, John Maclean<sup>1</sup>, Matthew Roughan<sup>1</sup>, Yang Yang<sup>2</sup> and Will Heyne<sup>3</sup>

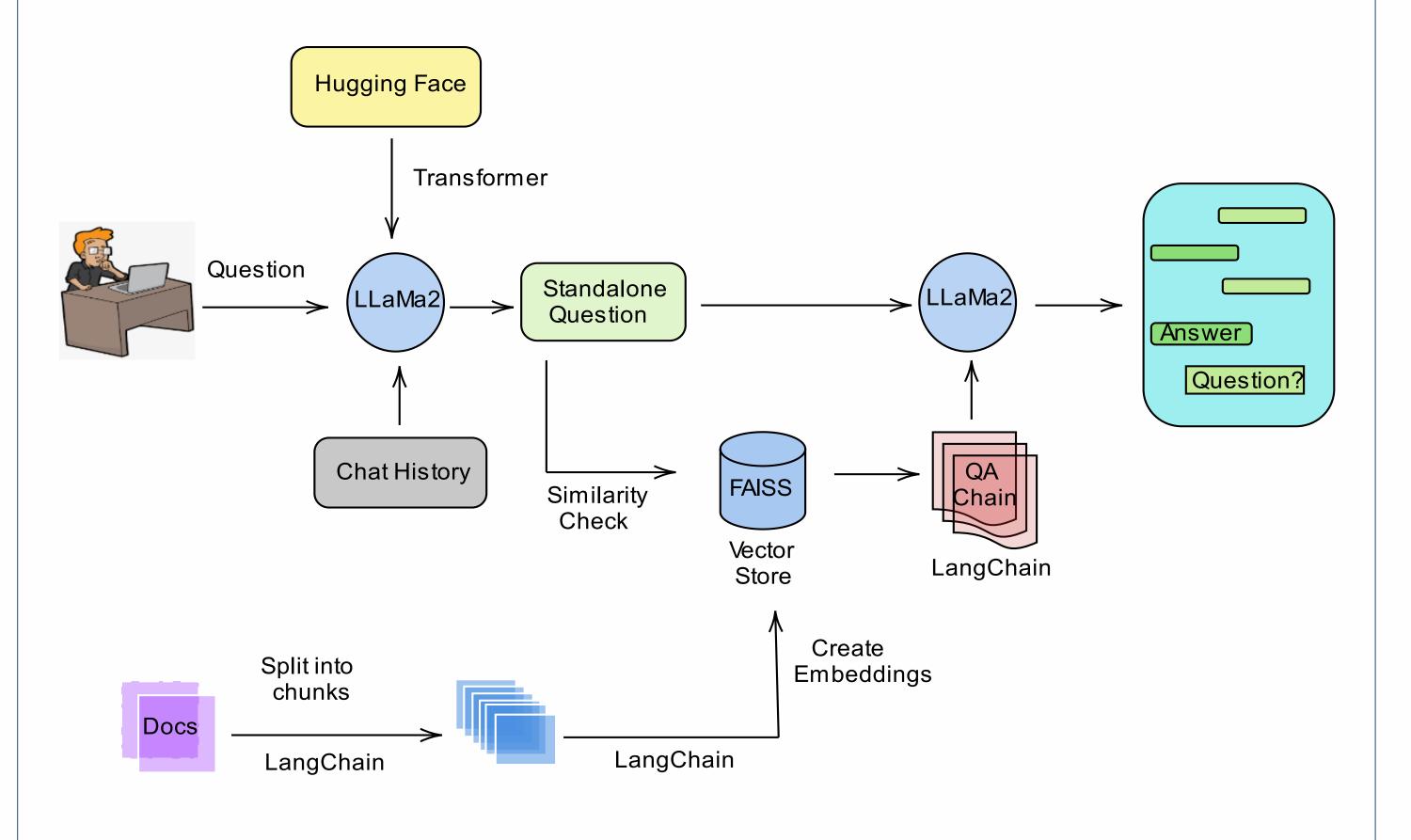
### Introduction

### Natural-Language Interface

- Detects anomalies caused by e.g. malfunction, manoeuvres or collision
- Knowledge of these events aids space situational awareness
- NORAD Two Line Element (TLE) input data
- Intelligent chat interface



- We utilised LLaMa2 model by meta along with LangChain in designing a Question Answering System.
- The interface facilitates the user to query about general satellite features and manoeuvre patterns.



Visualization of particle filter operation.

### **Particle Filter Detection**

- Tracks the mean elements of the satellites' orbits [1] from noisy observations in TLE sets
- Estimates the uncertainty of our belief in these mean elements
- Unlikely future observations, given our current belief are anomalous
- Implementations of both bootstrap and optimal proposal filters - overcome accuracy limitations of the standard SGP4 propagator

Flowchart of the process of Question Answering System

development

#### QAbot created!

What is your question? [What is the inclination of Sentinel\_6A? The inclination of Sentinel\_6A is 66.0385 degrees.

What is your question? [What is the most recent manoeuvre of Sentinel\_6A? The most recent manoeuvre of Sentinel\_6A is manoeuvre 71, which occurred on 202 2-06-27 09:05:02.581107328.

What is your question? [What are the details of Sentinel\_6A manoeuvre 71? Sentinel\_6A manoeuvre 71 is a station keeping manoeuvre with an anomaly confide nce level of medium and an anomaly type confidence level of medium. The date of Sentinel\_6A manoeuvre 71 is 2022-06-27 09:05:02.581107328.

Natural Language Interface

## References

Paper Link:

Diagram shows particles tracking orbit (longer trace) after a manoeuvre

### **Benchmark Dataset**

- TLEs and ground-truth manoeuvres for 15 satellites [1]
- Precise positions for some satellites

 Shorten, D. P., Yang, Y., Maclean, J., & Roughan, M. (2023). Wide-Scale Monitoring of Satellite Lifetimes: Pitfalls and a Benchmark Dataset. Journal of Spacecraft and Rockets, 1-5.



### <sup>1</sup> The University of Adelaide <sup>2</sup> UNSW <sup>3</sup> BAE Systems

