Predicting Machine Failure in Large Machine Diagnostics

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Abstract

- The Nevada National Security Site (NNSS) is a United States Department of Energy complex located about 65 miles north of Las Vegas, Nevada and is home to the Cygnus X-Ray diagnostic machine.
- They perform hydrodynamic and shockwave physics experiments and use Cygnus to capture radiographic images.
- Being able to detect failures of machinery is vital when performing large-scale experiments on the timescale of a few months to even a year.
- Our team will be using machine diagnostic data from Cygnus to detect failed shots from the Cygnus machines.

Figure 1: Cygnus X-ray Diagnostic Machines [4].

Data Description

- 2861 diagnostic files for 94 total shots.
- Each file has a signal where it has originated from.
  - 28 signals total.
- The diagnostic measured voltage or current depending on the signal.
- Example diagnostic file: s@1660 SCRP2@VCELL_688.txt
- 38 shots from Cygnus 1 (C1).
- 10 shots from Cygnus 2 (C2).
- 46 dual shots ran on both machines.

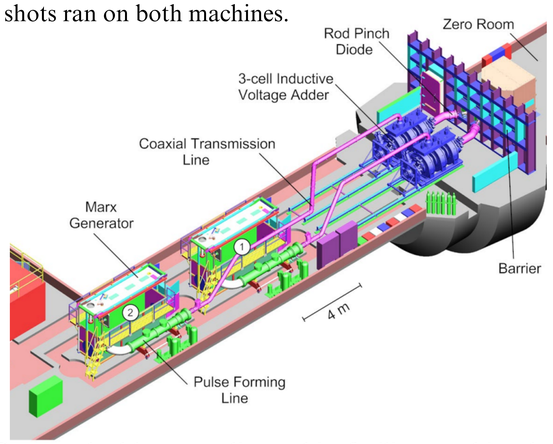

Figure 2: Cygnus dual-beam radiographic facility machine layout at the Nevada Test Site, U1a Complex [3].

Methods

- We are focusing on the VMRX and IMRX signals pertaining to the voltage and current generated from the Marx Generator, being one of the major Cygnus elements as seen in figure 2 [2].
- We have analyzed prominent features such as minimum and maximum values of these signals to compare possible failed shots and successful shots.

Results

- Plots were effective in distinguishing between failed shots and successful shots based on their respective positions on the plot.
- Failed shots were characterized by a wider and more scattered distribution of points on the plot, indicating erratic behavior and instability during the shot.
- Successful shots were characterized by a relatively narrow and elongated distribution of points on the min-max plot.
- Failures detected:
  - 3/38 shots for C1
  - 2/10 shots for C2
  - 1/48 shots for dual shot

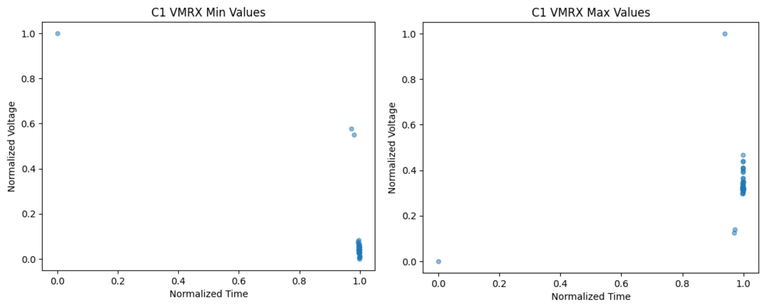

Figure 3a (Left) and Figure 3b (right): Normalized plots of the minimum and maximum values for the VMRX signal from Cygnus 1

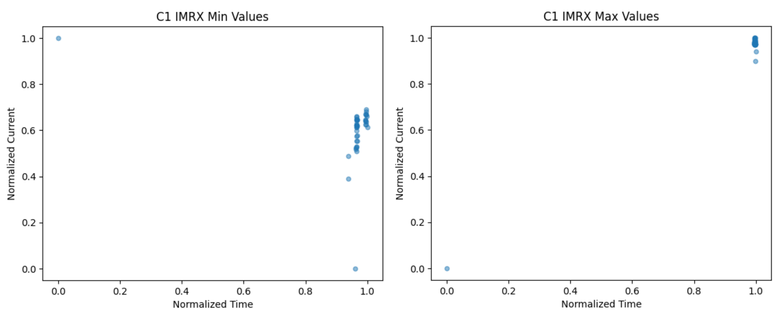

Figure 4a (Left) and Figure 4b (right): Normalized plots of the minimum and maximum values for the IMRX signal from Cygnus 1

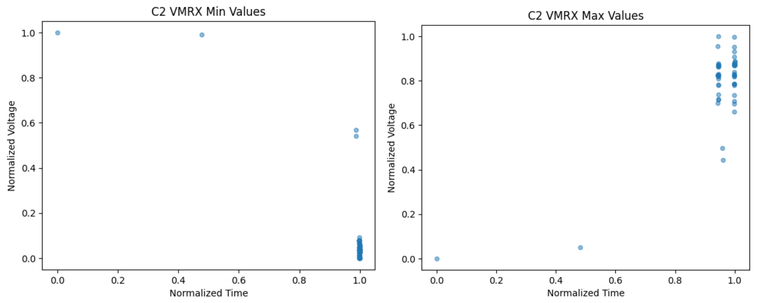

Figure 5a (Left) and Figure 5b (right): Normalized plots of the minimum and maximum values for the VMRX signal from Cygnus 2

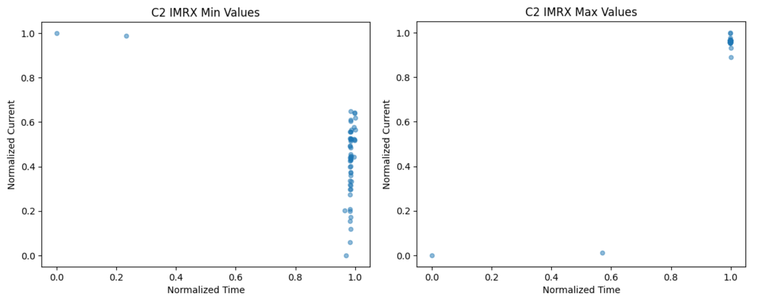

Figure 6a (Left) and Figure 6b (right): Normalized plots of the minimum and maximum values for the IMRX signal from Cygnus 2

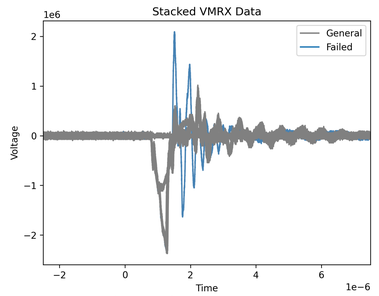

Figure 7: Plot of all Cygnus 1 VMRX signals together. The orange lines are confirmed failed shots while the gray lines

References

1. *Adams, J. (n.d.). ERAU Industrial Math Project Proposal: Failure Prediction in Large Machine Diagnostic.*
2. *J. R. Smith et al., "Cygnus Performance in Subcritical Experiments," 2007 IEEE 34th International Conference on Plasma Science (ICOPS), Albuquerque, NM, USA, 2007, pp. 685-685, doi: 10.1109/PPPS.2007.4345991.*
3. *H. Truong et al., "Analysis of Cygnus Electrical Signals," 2019 IEEE Pulsed Power & Plasma Science (PPPS), Orlando, FL, USA, 2019, pp. 1-6, doi: 10.1109/PPPS34859.2019.9009968.*
4. *U1a Complex. Nevada National Security Site. (n.d.). from https://www.nnss.gov/pages/facilities/U1aComplex.html*