Intelliquench: Real-time detection of magnet quenches

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Introduction

- Superconducting accelerator magnets operate at **very low temperatures** to maintain superconductivity.
- Due to several reasons (mechanical imperfections, conductor motion, etc.), a **specific spot** in the magnet **heats up.**
- This causes the magnet to become **resistive**, and with **huge amount of current** pumping through, it can be catastrophic.

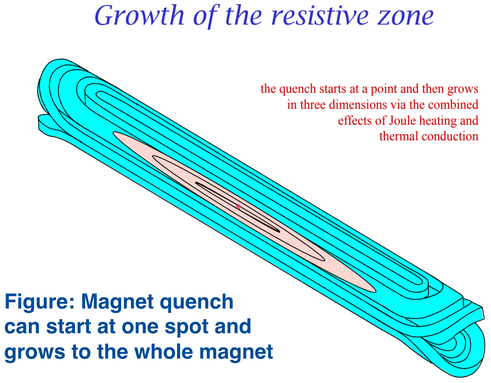
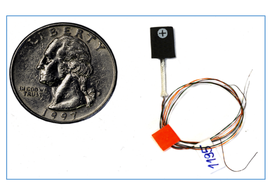


Figure: Magnet quench can start at one spot and grows to the whole magnet

Hardware setup

- Several **acoustic sensors** are placed around the magnet.
- The raw signals are then processed to feed into a Deep Neural Network to detect **abnormal acoustic signatures.**



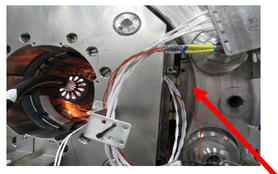


Figure: Acoustic sensor setup for superconducting magnets.

Statistical features

- From the raw signals, we calculate two features, **standard deviation** & **mean of the amplitude** using a **rolling window.**

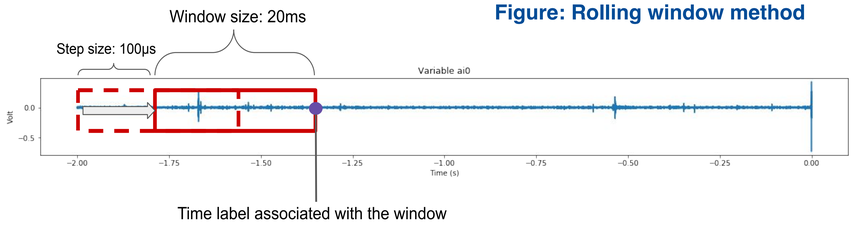
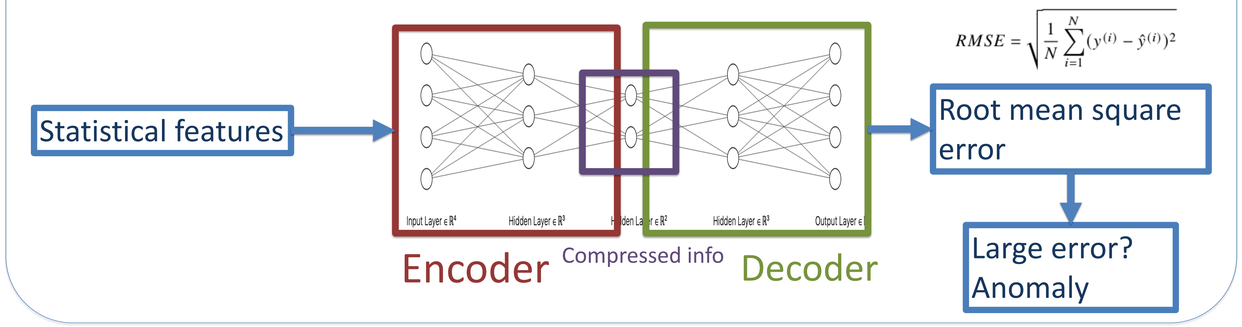


Figure: Rolling window method

Deep Neural Network Auto-encoder



Results

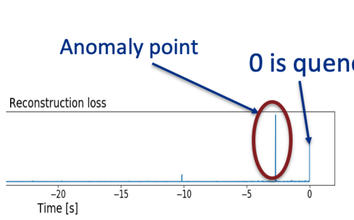


Figure: Anomaly visualization

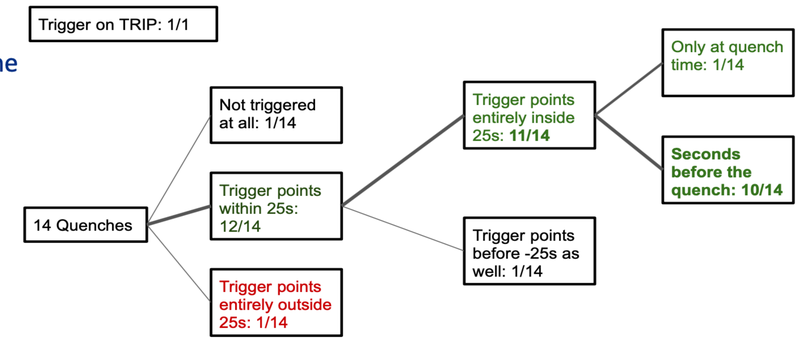


Figure: Result summary

Summary & Outlook

- Magnet quenches **are expensive**.
- We are using Deep Neural Network to **detect anomaly sound signals**, which hopefully enable us **trigger before the quench happens.**
- We've achieved some promising results and will be moving on to **verification step on unseen data.**
- Eventually, we want to have a **real-time system** deployed on **FPGAs** to process streaming acoustic data.

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