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A NOVEL METHOD OF EXTRACTING REAL-TIME REACTOR CONSOLE DATA

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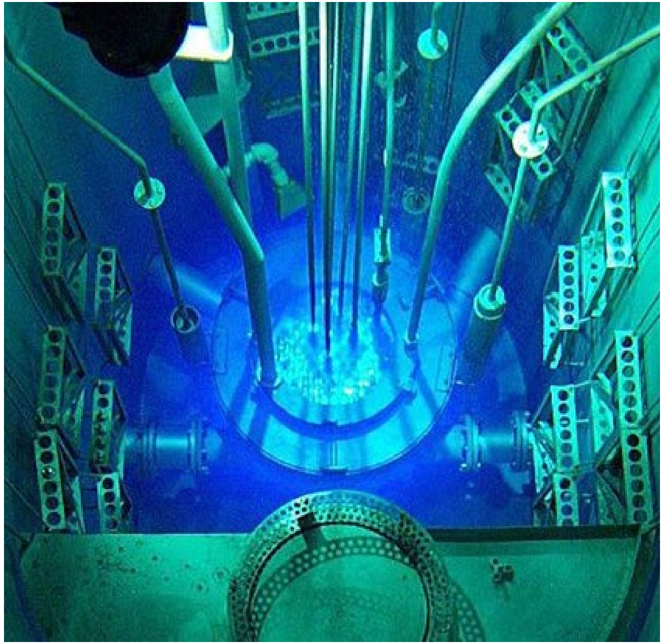
Introduction

- Many reactor facilities cannot retrieve, save, or stream continuous reactor console data
  - For example, indicated power, control rod positions, coolant temperatures, and fuel temperatures
  - In many cases, data storage limitations precluded this
- At UT-Austin, we are developing a digital twin for the NETL reactor which requires continuous data retrieval and storage
- In this work, we developed a simple method for extracting and storing real-time data from legacy reactor systems



UT-NETL TRIGA MkII Research Reactor

Short Aside on Digital Twin

- UT-Austin has funding from the State of Texas to study the application of digital twins to nuclear energy
  - One component of that project is to build and test a digital twin for the UT-NETL core
- This twin will be used to study:
  - Power smoothing
  - Core reactivity and sample activity predictions during long irradiations
  - Predictive knowledge for reactor maintenance, transients, shutdown margin, and rod worth predictions
- We have a faster than real-time model now
  - the next step is linking it to the physical system

Goals

- Record console data real-time with as high of timing precision as possible
- Store data indefinitely and make accessible to digital twin model
- No impact on console or safety channels
- Accessible and user-friendly

Design Considerations

- The UT-NETL console data in steady-state mode has a significant lag
  - (at least 100 ms between data points)
- We considered using an opto-isolator and tying directly into reactor console signals
  - This is possible but requires significant study to ensure that the system can't disrupt console data to operators
- We wanted a simple system that could be implemented quickly and not retard the digital twin development

Solution

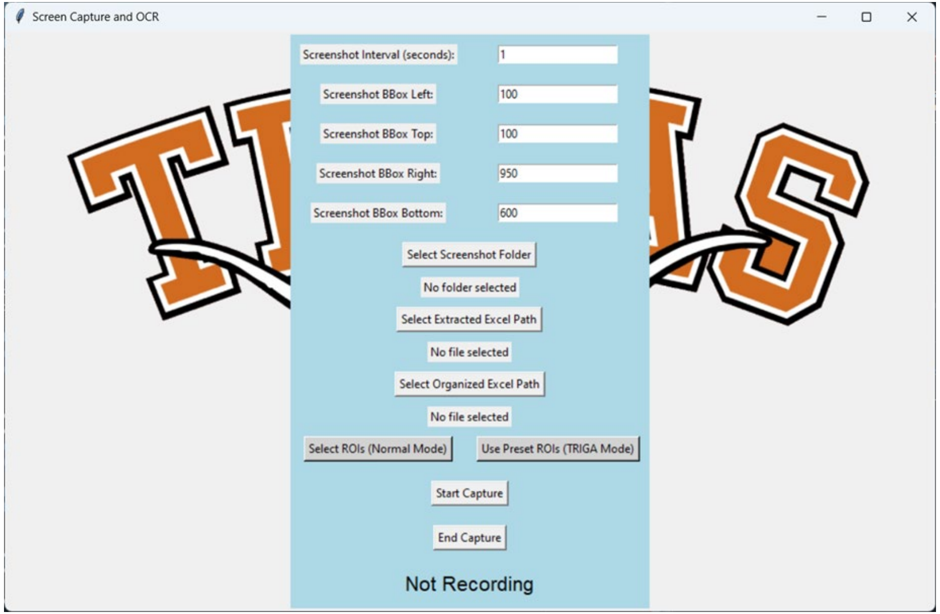
- The UT-NETL reactor displays console data on a small screen for the operator in the “hot seat” and on a large monitor for the rest of the control room
- That data is outputted by the console computer via an HDMI cable running at 80 fps
- A simple solution was to mirrored the console display onto another device using OBS Studio and a video capture card

Python Code using Tesseract

- A python code was written that:
  - allows the user to interactively select the regions of interest (ROI) on a screen to record
  - extract the numerical data from video images using the ML algorithm: “Tesseract”
  - store data in an Excel file
    - data can be sorted by columns such as water temperature, rod heights, demand power, and linear power
  - data is assigned an ROI number for ID purposes
  - To ensure the extraction was accurate, screenshots were obtained every second to compare with the Excel data.
- Versatile code with a standard mode that can be used for any systems where video capture is possible

GUI

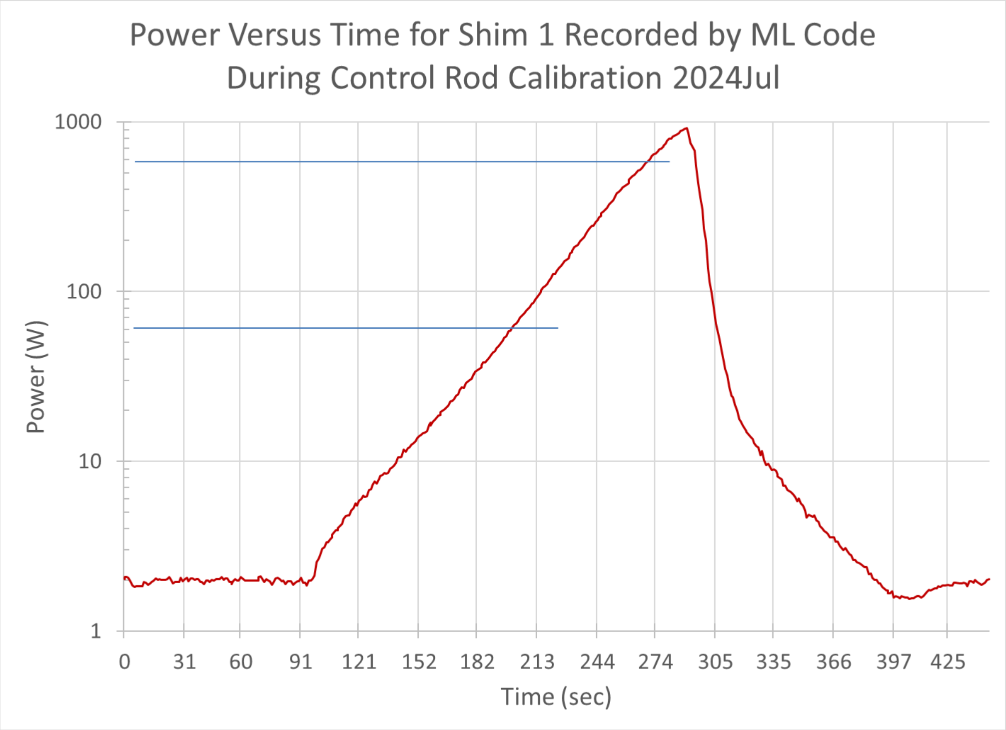
- GUI was developed for user-friendly interaction:
  - Specify save locations
  - Time intervals for screenshots taken
  - Interactively select the ROIs and automatically map them when they wanted to start the recording
  - "Start" and "stop" recording with indicator lights
- Set a "UT TRIGA" mode which maps the known ROIs for our TRIGA video capture through OBS



Graphical User Interface

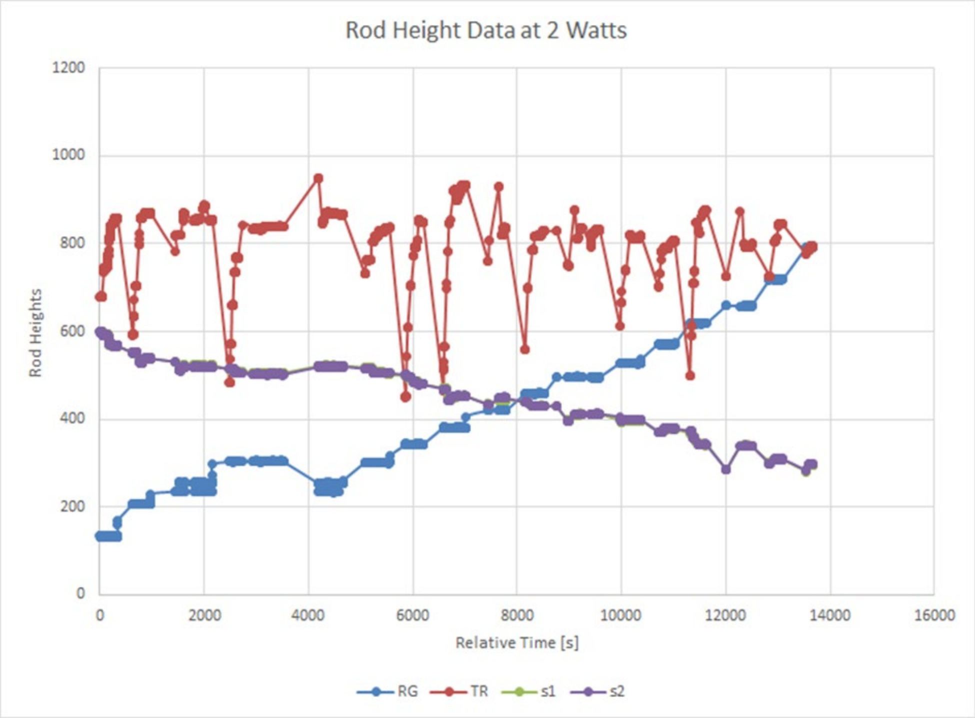
Example: Rod Cal P(t) Data

- NETL measures rod worths using the positive period method and recording time between 60-600W using a stopwatch
  - This method is subject to significant uncertainties
- In 2024Jul, we tested using the ML code to collect data continuously during rod pulls
  - Results were exceptional



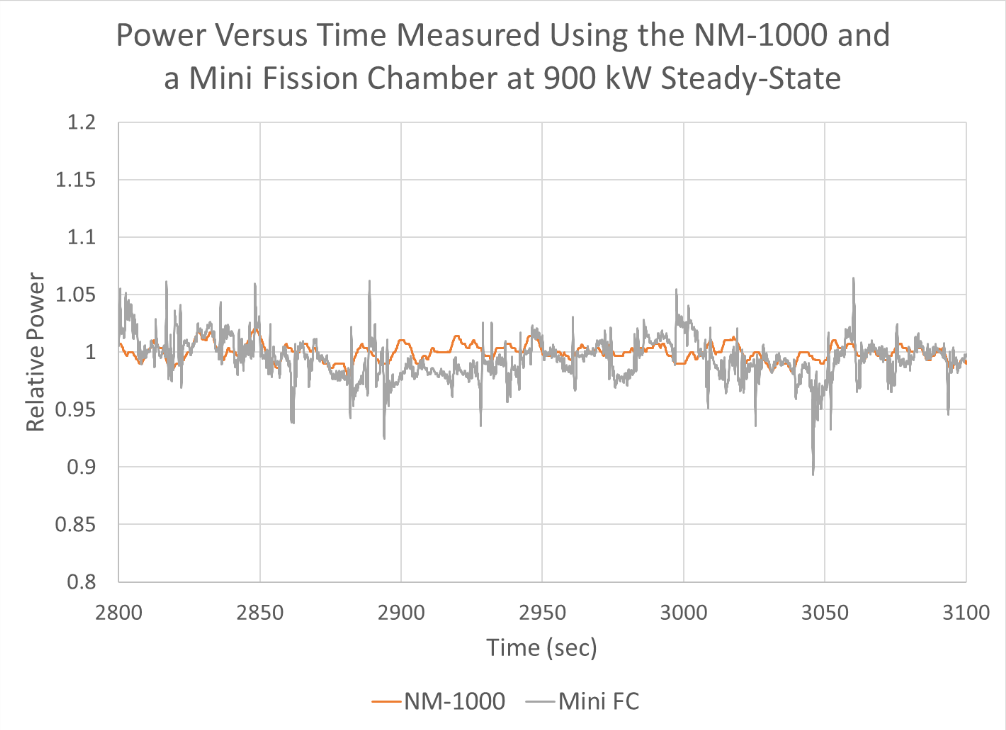
Example: Recording Rod Positions

- During rod cals, we used the ML code to record rod positions versus time over a long time period



Example: P(t) Time Resolution

- We tested the ability of the code to P(t) during steady-state operation at 900 kW
  - Compared result to that recorded using a mini fission chamber located inside the core and with ns time resolution
- The code is limited by the refresh rate on the video signal, but more importantly it is limited by the time lag in the labmaster for the console
  - Limited to no better than 100 ms resolution



Conclusions

- The ML code is easy to implement and has no impact on the console
  - So a good short-term solution
- Excellent for use in positive period method rod cals, for teaching labs, and to support the digital twin development
- Long-term we intend to implement a new board that will allow for extraction of console data at higher timing resolution
  - but this will require a 50.59 evaluation

Acknowledgements

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