

# Echo State Networks: An Approach to Non-Intrusive Anomaly Detection in Manufacturing

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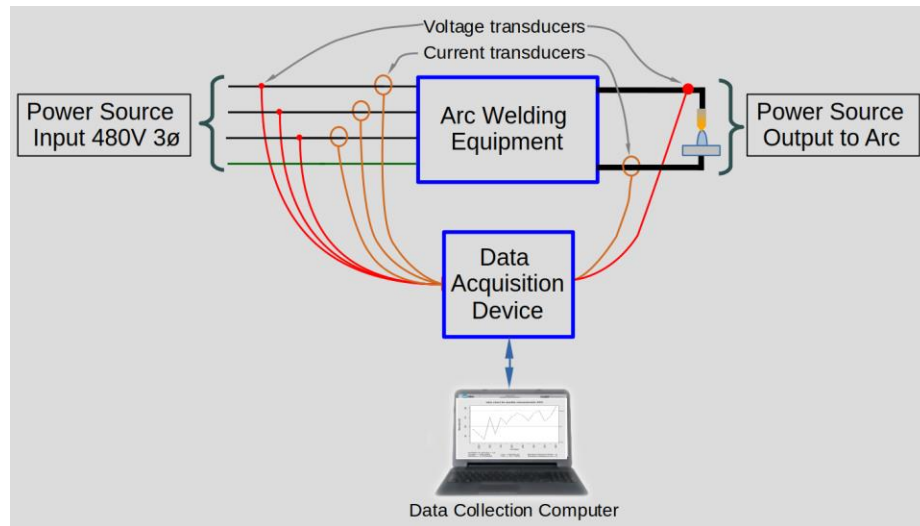
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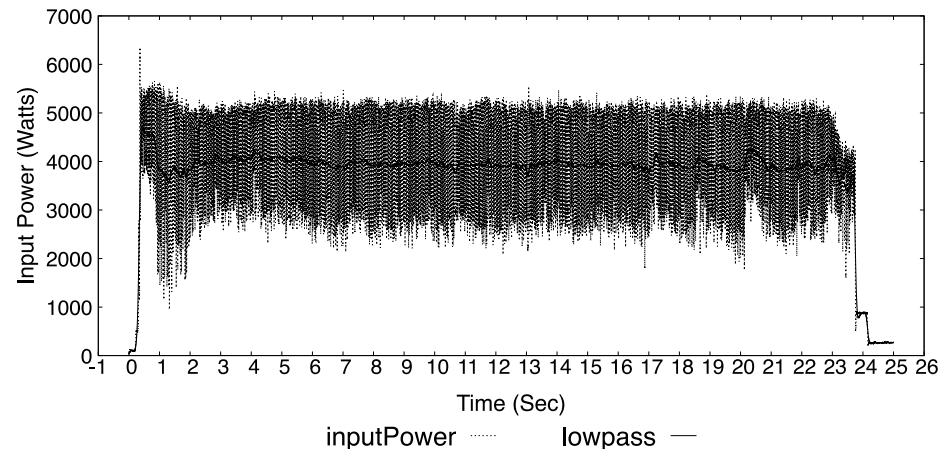
# Industry 4.0

## SMART MANUFACTURING

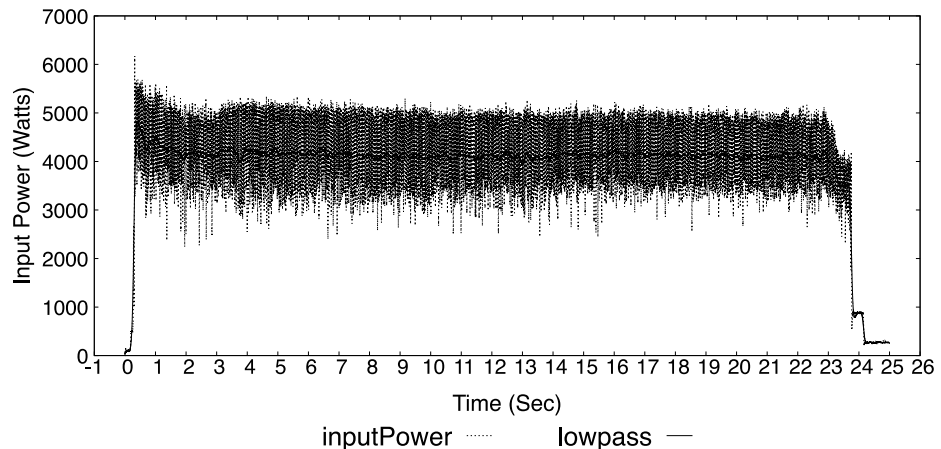
- Gas metal arc welding (GMAW)
  - vital process in manufacturing
- Non-destructive tests (NDT)
  - do not destroy welds while evaluating its quality
- Non-Intrusive Load Monitoring (NILM)
  - monitors power consumption without modifications, collecting *input power*
- Artificial intelligence (AI)
  - maps input power to weld anomalies



# WELD WITHOUT DEFECT



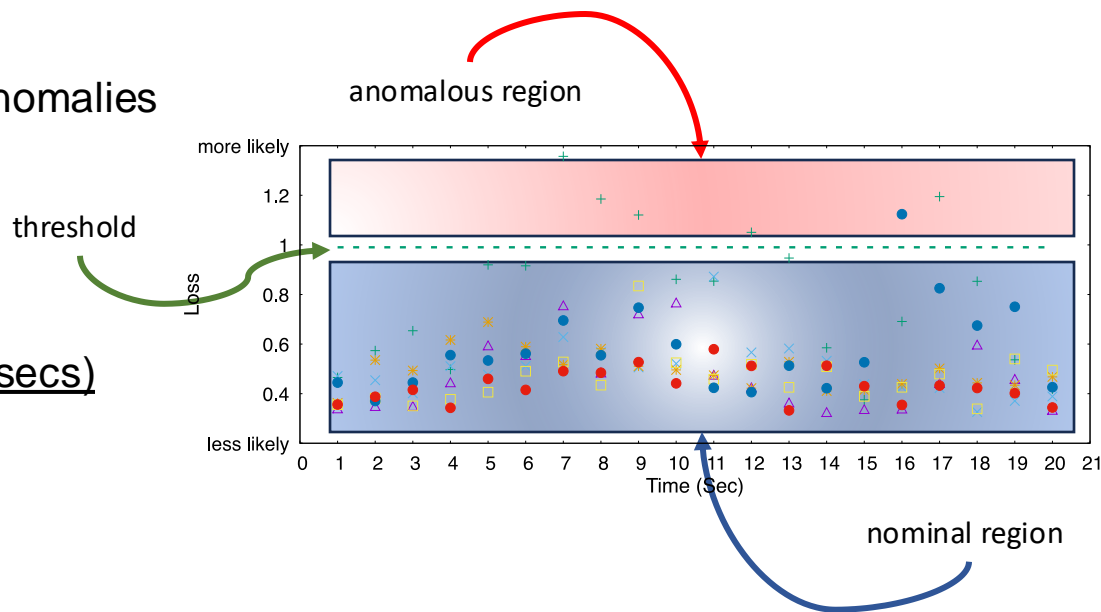
# WELD WITH DEFECT



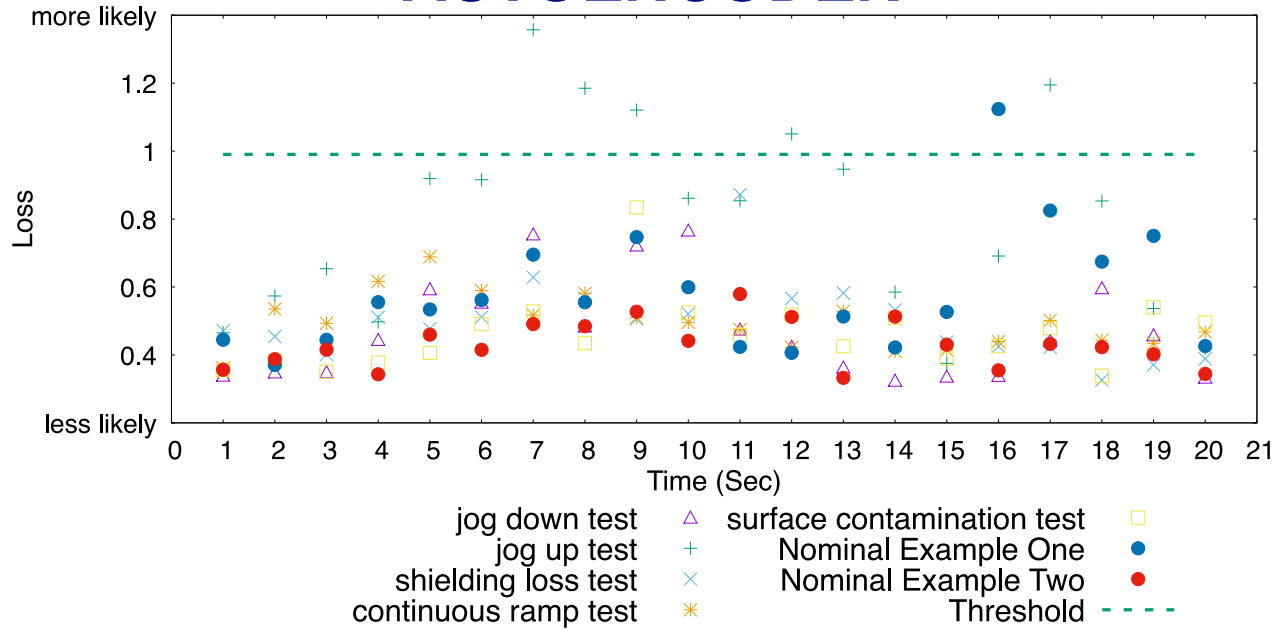
# Which model is the best?

HAS THE BEST SEPARATION OF ROUND DOTS FROM OTHER SYMBOLS

- We compare different AI models
  - determine the best fit for detecting anomalies in welds based on input power
  - each model has a threshold
  - points above are anomalies
  - points below are nominal
  - All anomalies are in the center (7-14secs)
- Common models used
  - autoencoder
  - CNN (ResNet)
- Less common models
  - echo state network

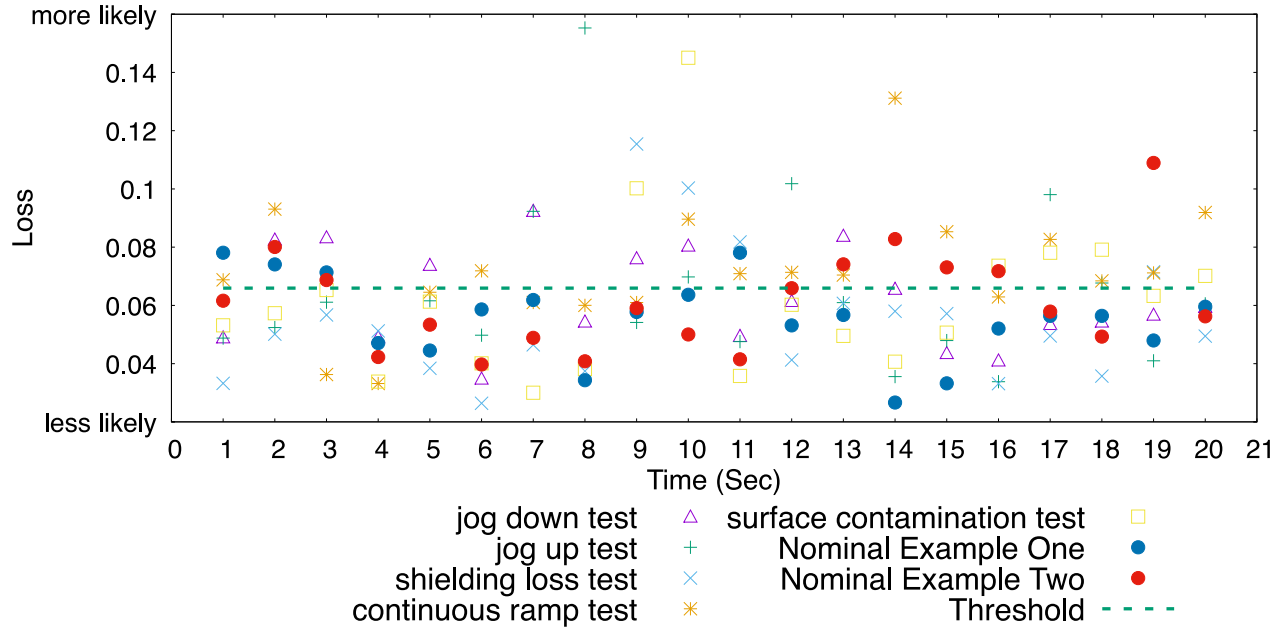


# AUTOENCODER



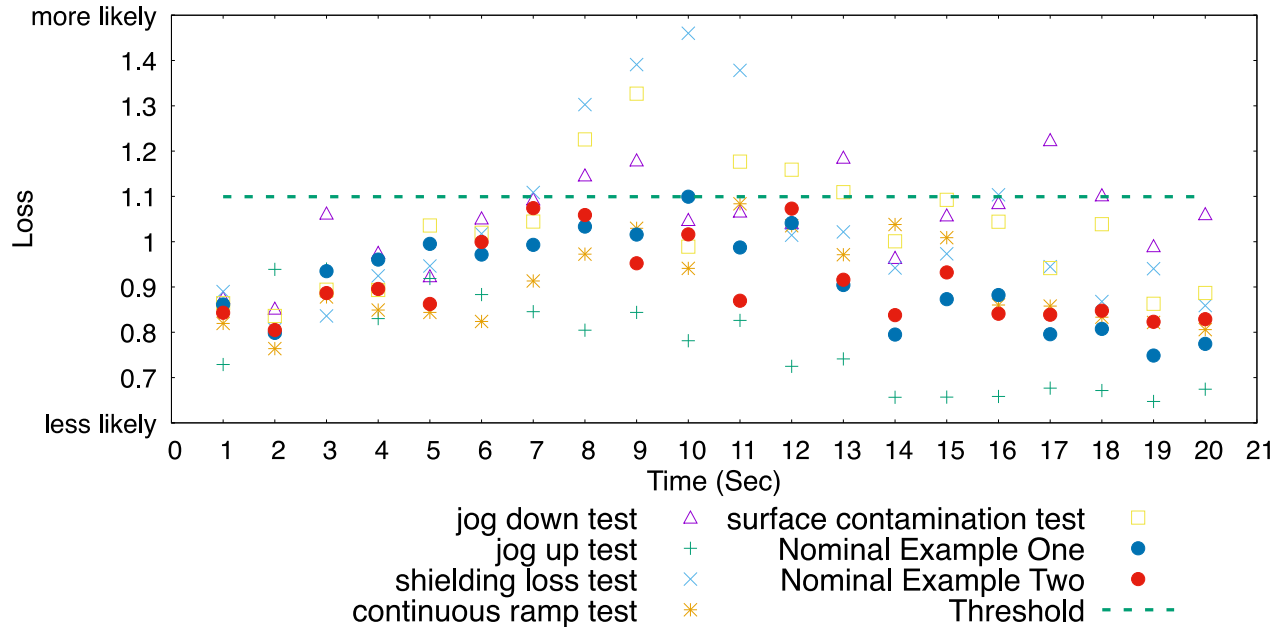
- plenty of nominal points that are above the threshold
- autoencoder only correctly flagged few points of off-nominal welds

# RESNET



- requires some preprocessing
- better then the autoencoder
- many correctly flagged points
- many false positives

# ECHO STATE NETWORK



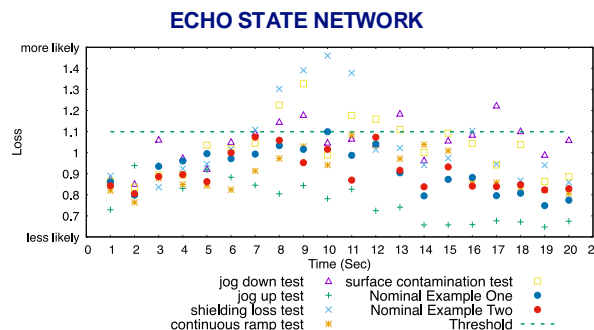
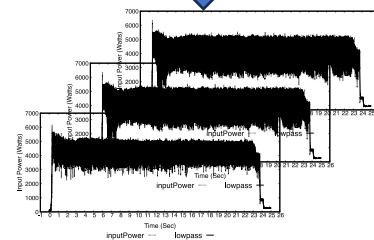
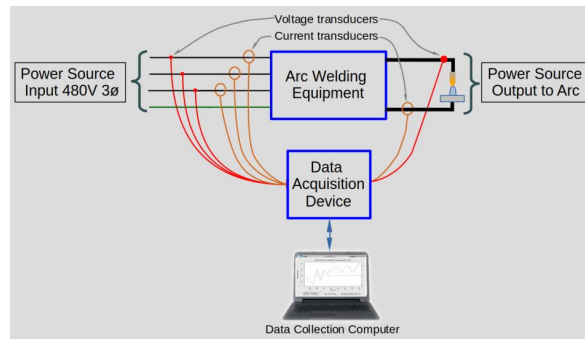
- very well at detecting off-nominal welds
- almost all points are correctly flagged
- very few false positives

**performs the best compared to other models**

# Conclusion

## WHAT TO TAKE AWAY

- Gas metal arc welding (GMAW)
  - is a vital process in manufacturing
- For better GMAW we need
  - Non-destructive tests (NDT)
  - Non-Intrusive Load Monitoring (NILM)
- Artificial intelligence (AI)
  - maps input power (NILM) to weld anomalies
  - NILM + AI = NDT
  - echo state networks has the highest performance compared to other models





Thank you to



**GRAY BEARDS**  
**ENGINEERING**

