Detecting Spoofing Attacks in Industrial Control Systems Using Machine Learning

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Motivation and Challenges

Motivation

- Industrial Control Systems (ICS) are vulnerable to attacks due to cyber components
- Spoofing attacks can cause damage to ICS
- Very few simulated testbeds available for launching attacks and performing detection

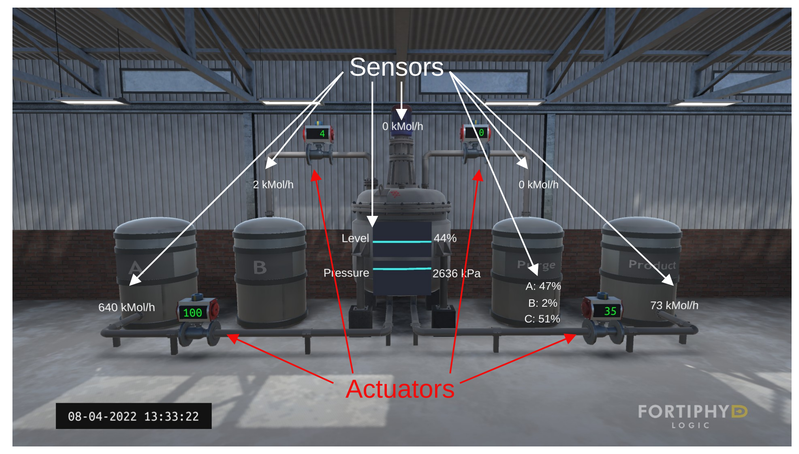
Challenges

- Conventional classification is not appropriate
  - Only benign, unlabled data is available
- Feature selection for training from multiple processes, sensors, and actuators
- Tradeoff between robustness and accuracy

Platform

GRFICS

- Chemical plant simulation created at Georgia Institute of Technology
  - Maximizing product of 3 reactants while minimizing purged excess
- Simulation consists of 5 sub-processes controlled by a single PLC
  - Modbus TCP/IP
- 9 sensors and 4 actuators
- Enables launching man-in-the-middle (MITM) attacks on communication between the PLC and sub-processes
- Rendered using a game engine



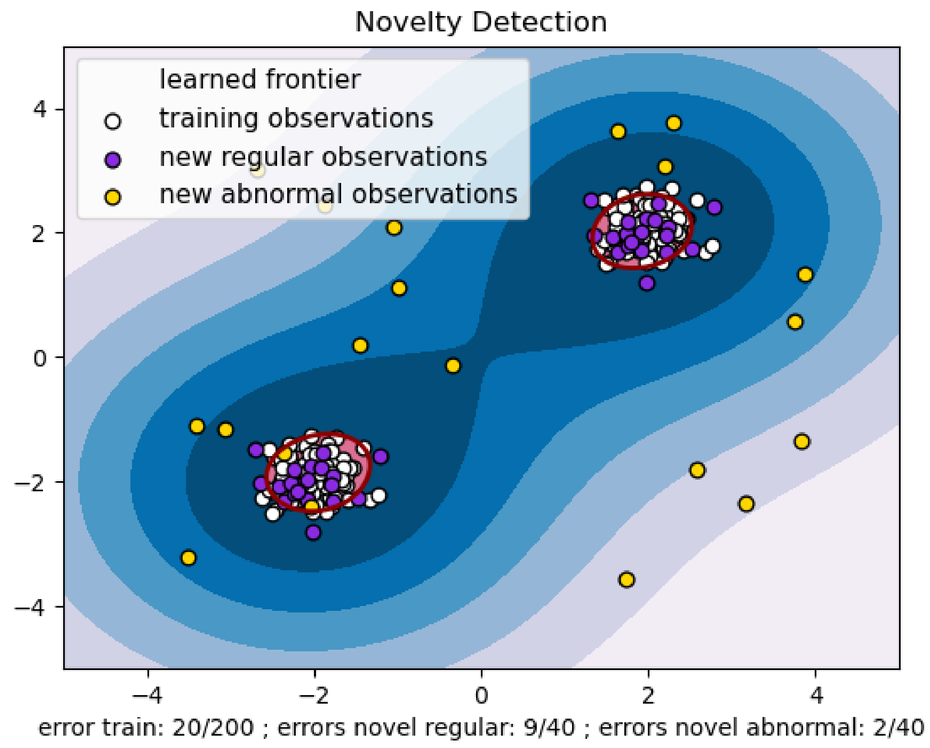
Approach

Attacks

- We create 54 attacks of 5 different categories
  - Single-sensor, multi-sensor, single-actuator, multi-actuator, and complex
- Attacks are strictly limited to manipulating sensor readings from each sub-processes in transit to the PLC and manipulating actuator write commands in transit from the PLC to each sub-process
- A number of the attacks are stealthy attacks – i.e., difficult to detect

Machine Learning Model

- We test several ML algorithms and find One Class Support Vector Machine (SVM) to be the most accurate
- Trained on benign, unlabled data
  - Impossible to know every attack, so we train the model on normal behavior
- Feature set
  - Collected from PLC
  - Sensor and actuator readings
  - Calculated difference between the current sensor reading and the previous
  - The new actuator value calculated by the PLC
- We use a sliding window with a 20 second interval for classification
- Binary classification with a threshold of 60%
  - When the classifier identifies 60% or greater of datapoints in the window as abnormal, the system is determined to be under attack



Results and Future Work

Results

- Our model correctly identifies 47 of 54 attacks (87%)
- Furthermore, 6 of the unidentified attacks are stealthy attacks
- Average detection time of 54.6 seconds
- Median detection time of 18.5 seconds
- We experience no misclassifications of benign data, with over 5 hours worth of testing

Future Work

- In the future, we plan to test our model against different ICS scenarios using the FactoryIO platform
- We plan to run an experiment with a real PLC, allowing us to conduct a hardware-in-the-loop experiment