Anomaly Detection and Task Planning via Neural Networks and Hierarchical Task Networks

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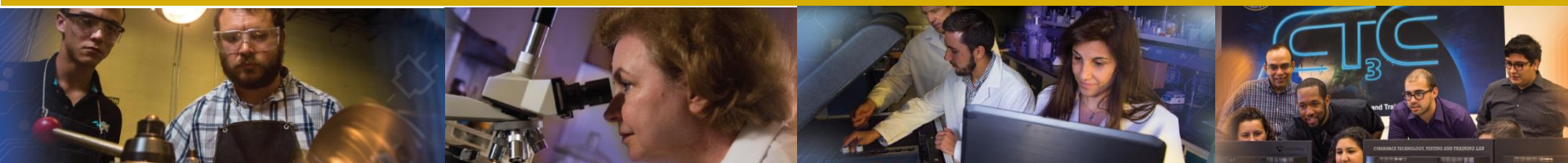
DOE-FIU Science and Technology Workforce Development Program
Applied Research Center
Florida International University

FLORIDA INTERNATIONAL UNIVERSITY



Summer 2017 Internship at SNL

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Project Description/Background

FIU Applied Research Center

Challenge: How to extract valuable insights from the vast quantities of diverse data that are generated across the DOE complex?

- Current systems record large amounts of information for environmental monitoring, tank and pipe inspections, etc:
  - Video
  - Sensor data (temperature, radiation, etc.)
  - Records/documents
- Currently rely on human operators for analysis and decision-making
  - Too much information to parse
  - Limited reaction time
  - Not easily scalable

Scope/Objective

- Develop a system for automatically detecting and handling anomalies in multimodal, spatial and temporal data
  - Determine a sequence of actions to search for anomalies
  - Able to interpret sensor data and extract meaning

Method / Approach

- Inspection Tool/Process Selection
  - Hierarchical Task Network (HTN) to make decisions
  - Goal-oriented
  - Adaptive (incorporates current world-state)
  - Extensible (new actions are easily incorporated)
- Detection
  - Shared representations for multimodal data
  - Long Short Term Memory (LSTM) Neural Networks to detect anomalies

Automated Task Planning

PRELIMINARY RESULTS/DISCUSSION

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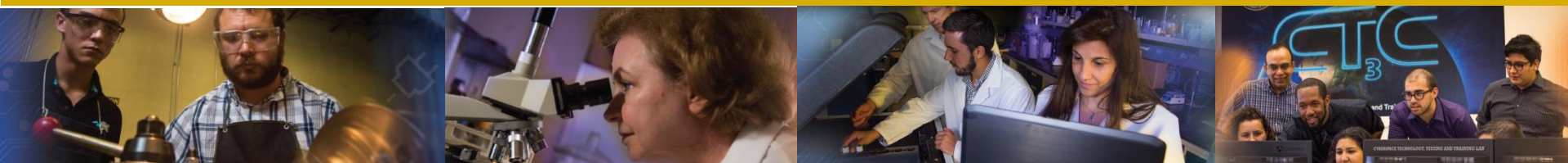
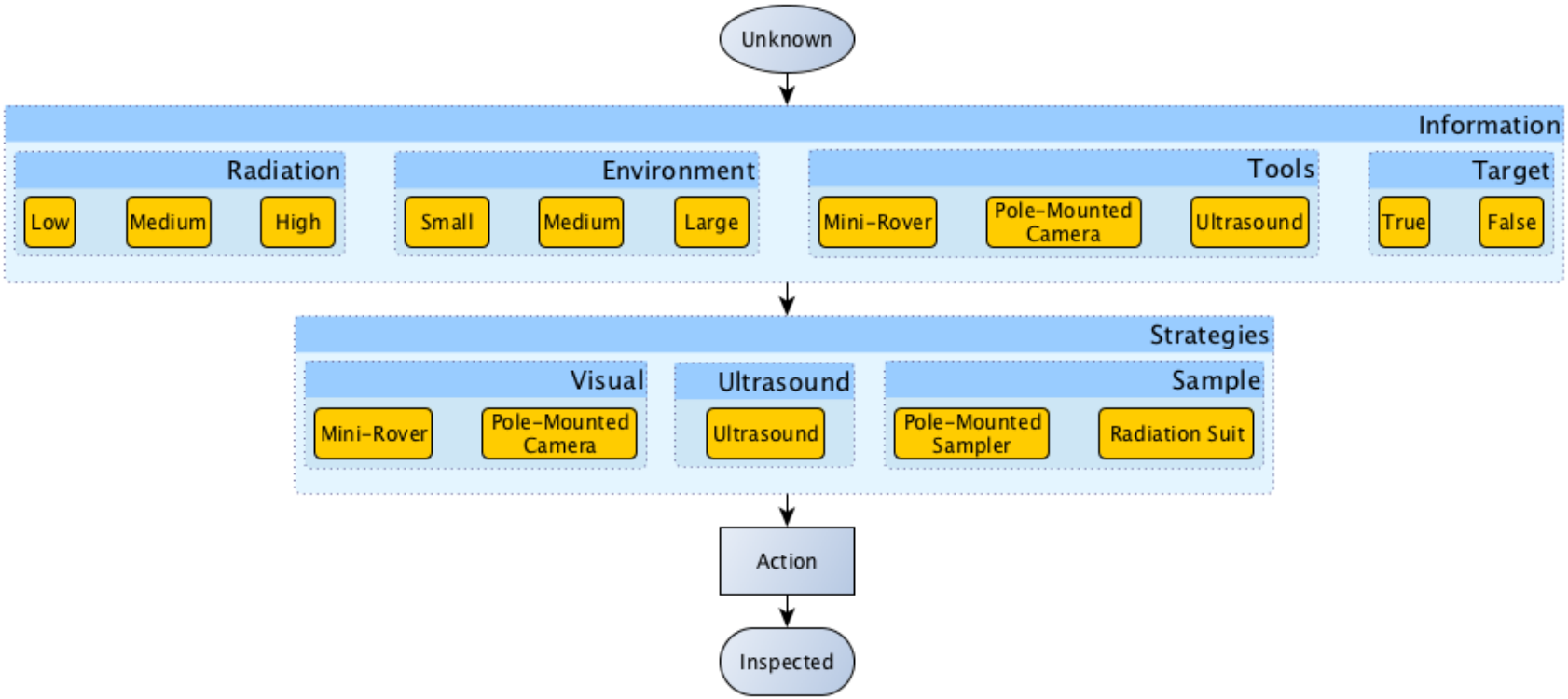


Automated Inspection Planning



Automated Inspection Planning

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World State

- status: unknown
- tools = mini-rover, pole-mounted camera, ultrasound
- environment: large
- radiation: low
- target: true

Response

- status: inspected
- tool = ultrasound
- strategy = ultrasound

Automated Inspection Planning

FIU Applied Research Center

World State

- status: unknown
- tools = mini-rover, pole-mounted camera, ultrasound
- environment: large
- radiation: low
- target: false

Response

- status: inspected
- tool = pole-mounted camera
- strategy = visual

Automated Inspection Planning

World State

- status: unknown
- tools = mini-rover, pole-mounted camera, ultrasound
- environment: small
- radiation: low
- target: false

Response

- status: inspected
- tool = mini-rover
- strategy = visual

Image Captioning

PRELIMINARY RESULTS/DISCUSSION

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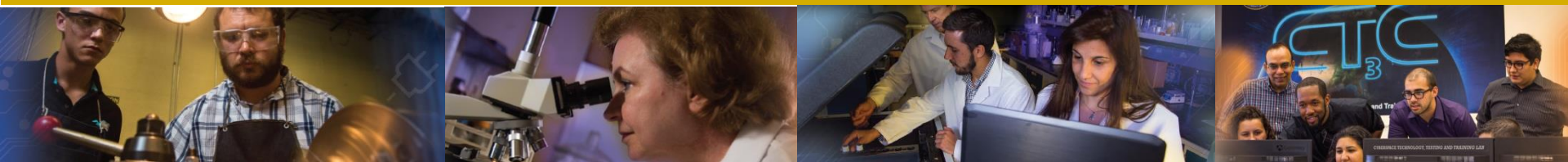
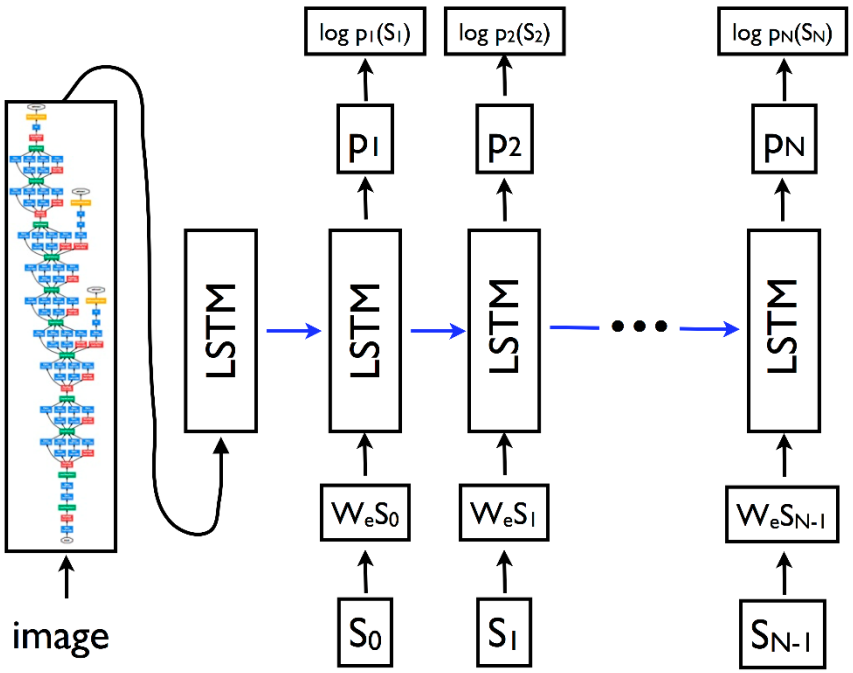


Machine Learning using LSTM



- Learning a prediction model using LSTMs and ConvNets
- Input : time series multimodal, spatially correlated data
- Output : predicted error vectors

Anomaly Detection

PRELIMINARY RESULTS/DISCUSSION

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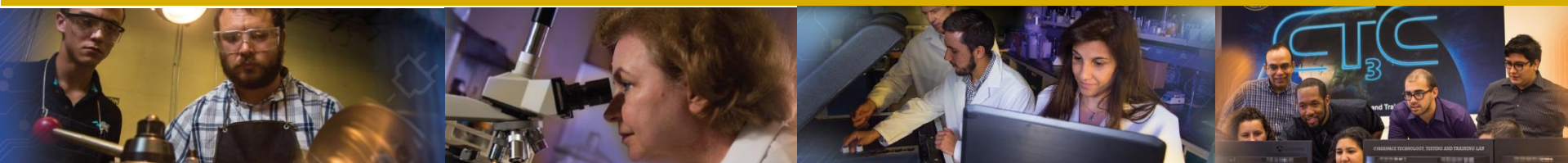
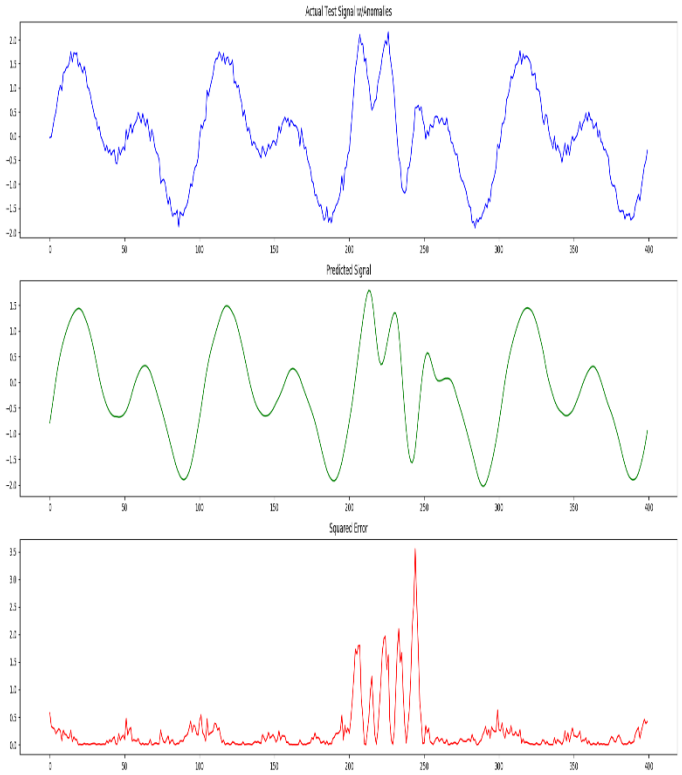


Anomaly Detection



Example :

- Train on sine wave
- Expect a repeating sine-like wave
- Inject an anomaly
- Error when measured value does not match predicted value

Preliminary Results/Discussion

- Elements in place for a comprehensive inspection system
  - Select inspection method and tool
  - Interpret data
  - Determine if data is anomalous
  - Respond to environment

Conclusions

- Neural networks have been studied extensively for image captioning
- Some work has been done for anomaly detection
  - Little work on multimodal data fusion via shared representations
- Preliminary results indicate that the system presented is capable of addressing pressing inspection and monitoring concerns
  - Easily extensible towards other areas

Future Work

- Collect multimodal, spatio-temporal correlated training data
- Fuse sensor data into a shared representation
- Expand LSTM to work with multimodal data
- Modify LSTM to work with continuous data stream vs sliding window
  - Tune and train LSTM
- LSTM research is expected to continue after returning to FIU from Sandia

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