



INSPECTING AND PRESERVING
INFRASTRUCTURE THROUGH
ROBOTIC EXPLORATION

A Training Framework of Robotic Operation and Imaging Analysis for Decision-Making in Bridge Inspection and Preservation

INSPIRE UTC 2018 Annual Meeting, Rolla, August 14-15

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Region of Interest Detection in Bridge Inspection



Outline

- Background
- Multi-scale convolutional neural network feature extracting and matching
- Multi-scale Siamese neural network and one-shot learning
 - One-shot learning
 - Siamese neural network
 - Region of interest detection
 - Multi-scale Siamese neural network
 - Results
- Method comparison
- Conclusion and future work



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Problems with bridge inspections currently performed

- Access is difficult, dangerous, and disruptive



Problems with bridge inspections currently performed

- Requires heavy lifting equipment



Problems with bridge inspections currently performed

- Manual inspection is time-consuming & costly



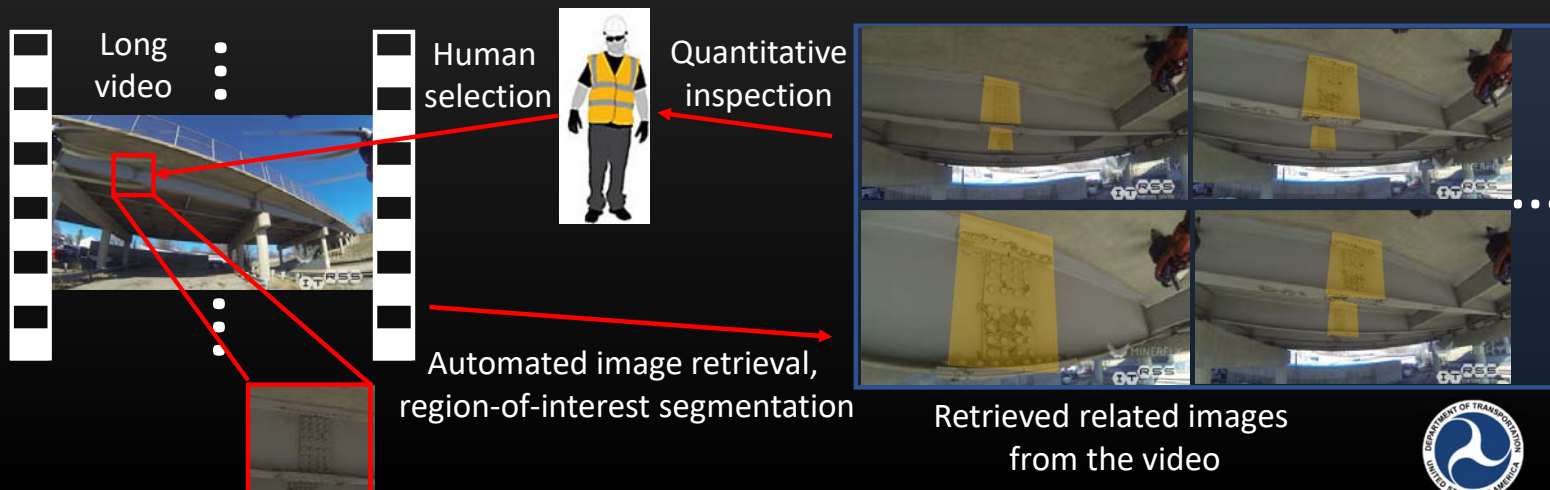
Inspect bridges using robotics

- Faster, safer, better, and less expensive
- Big data of inspection videos are collected



Image analysis to provide decision-making support

- 30 frames/second \times 3600 seconds/hour = 108,000 frames/hour
- Boring and inefficient to watch long videos collected for bridge inspection
- What can we help?



Challenges in processing the videos

- Different viewpoints of camera
- Different scales of an object in images
- Camera vibration
- Different models or types of an object to be inspected

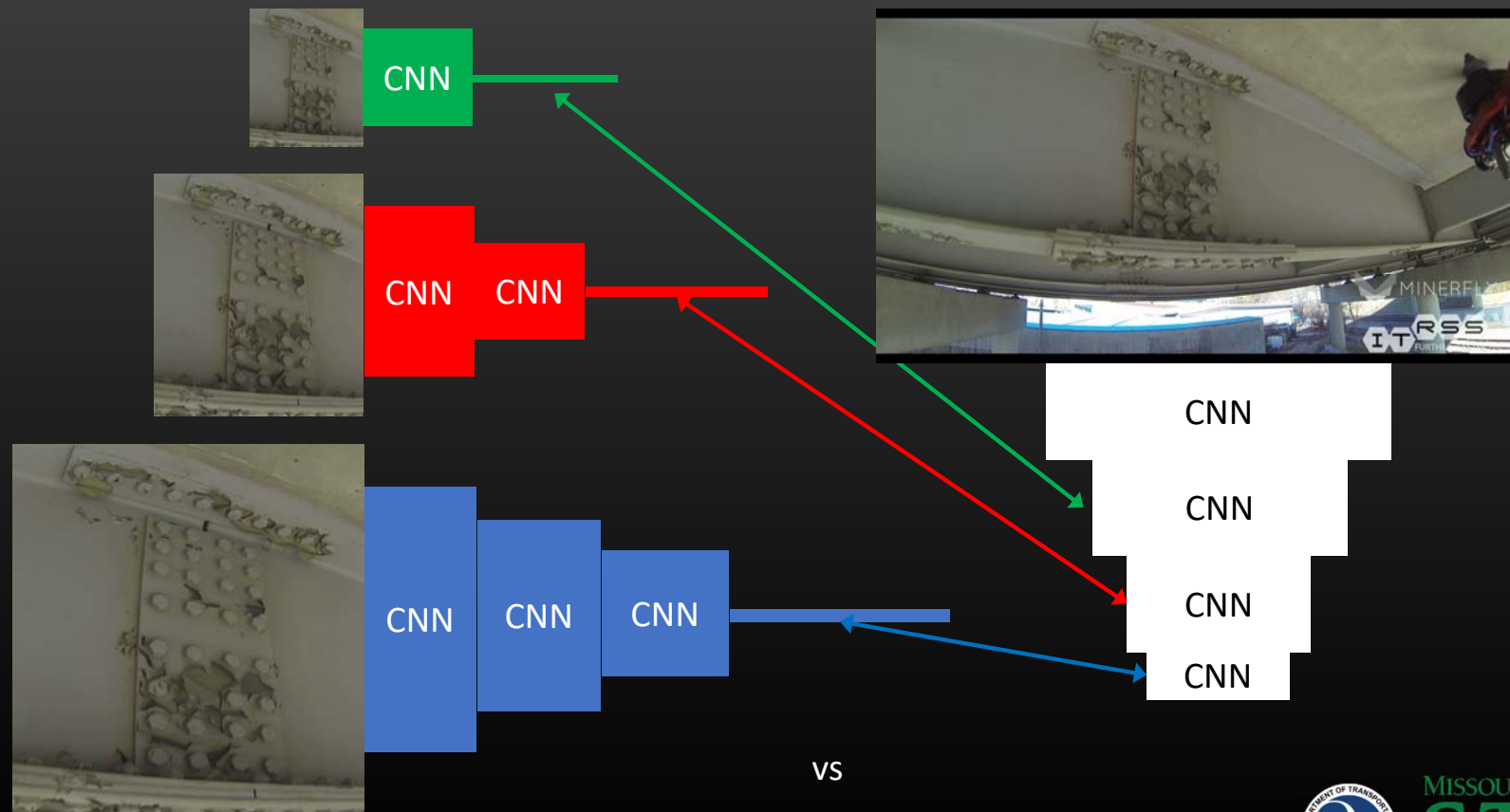


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Multi-scale convolutional neural network (CNN) feature extraction and matching



Multi-scale convolutional neural network (CNN) feature extraction and matching



Issues with the current CNN model

- Deployed from other dataset whose domain is different than bridges
- Generates false-positive noise

Improve the image retrieval algorithm



Outline

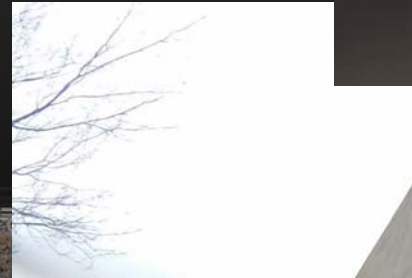
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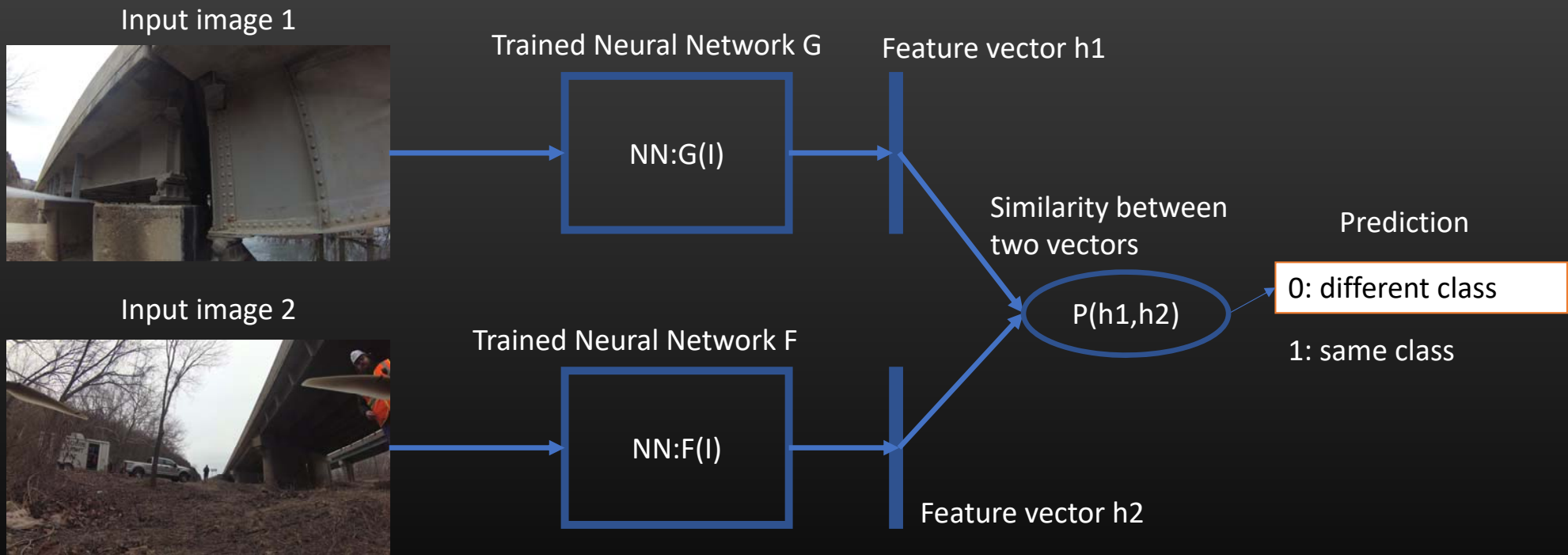
One-shot learning

- To correctly make predictions given only a single example of each new class

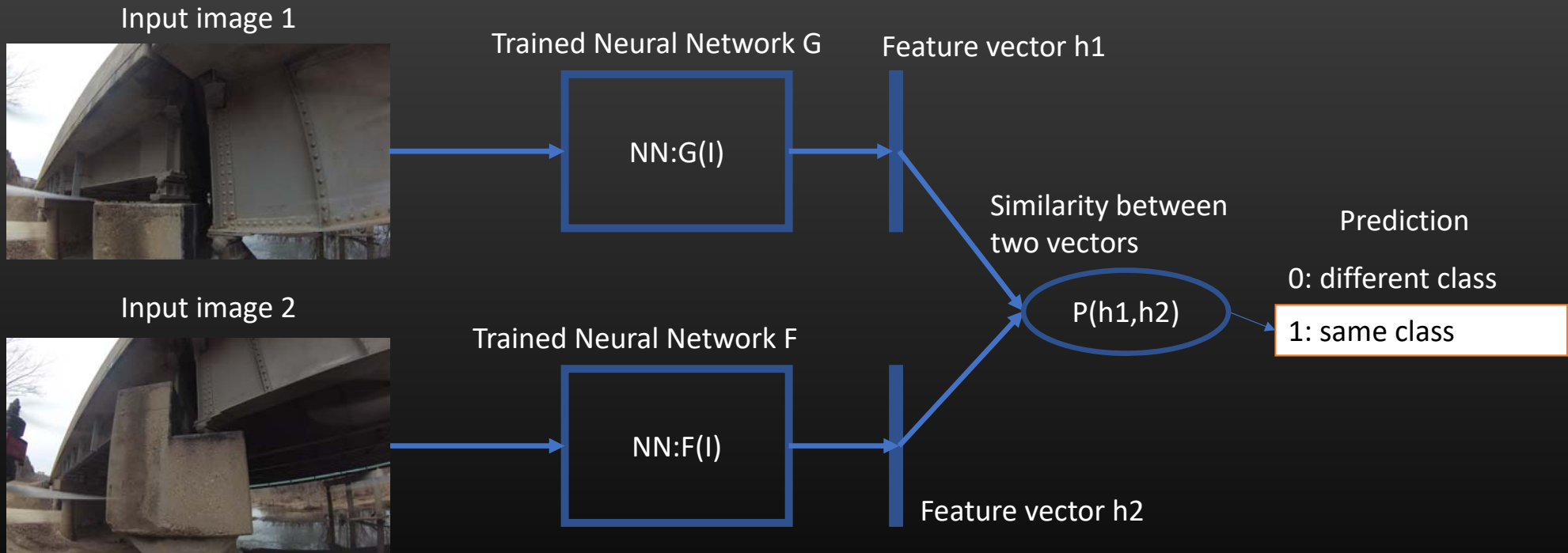
Region of Interest → **VS** ← Background



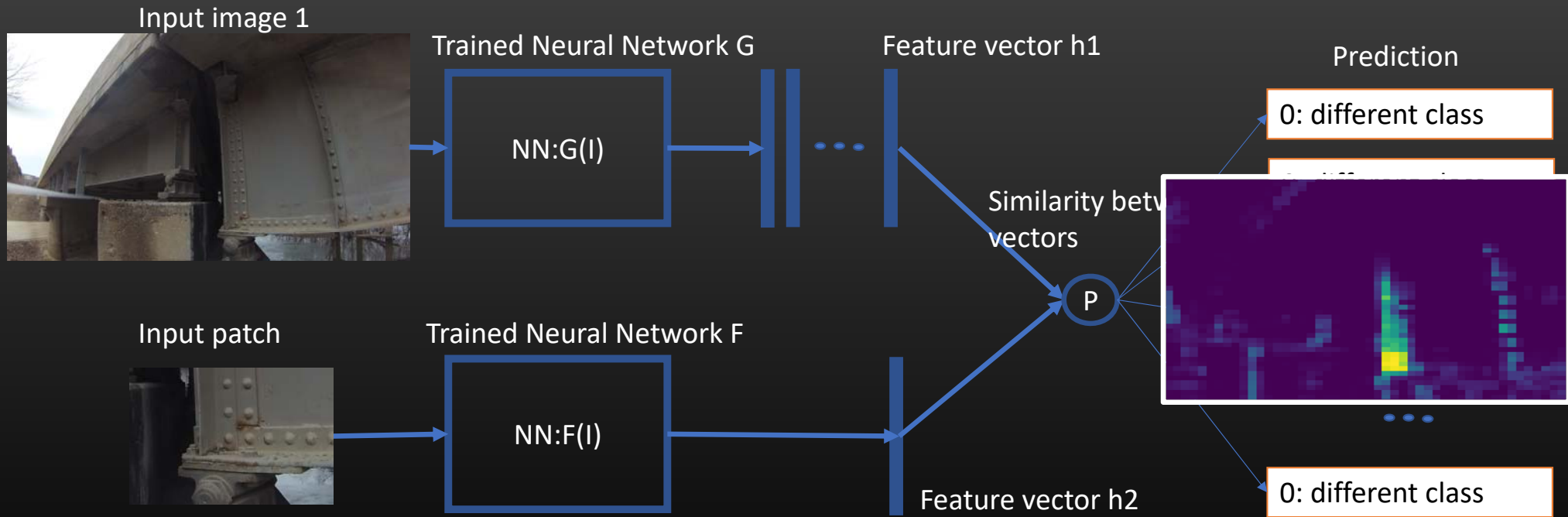
Siamese neural network



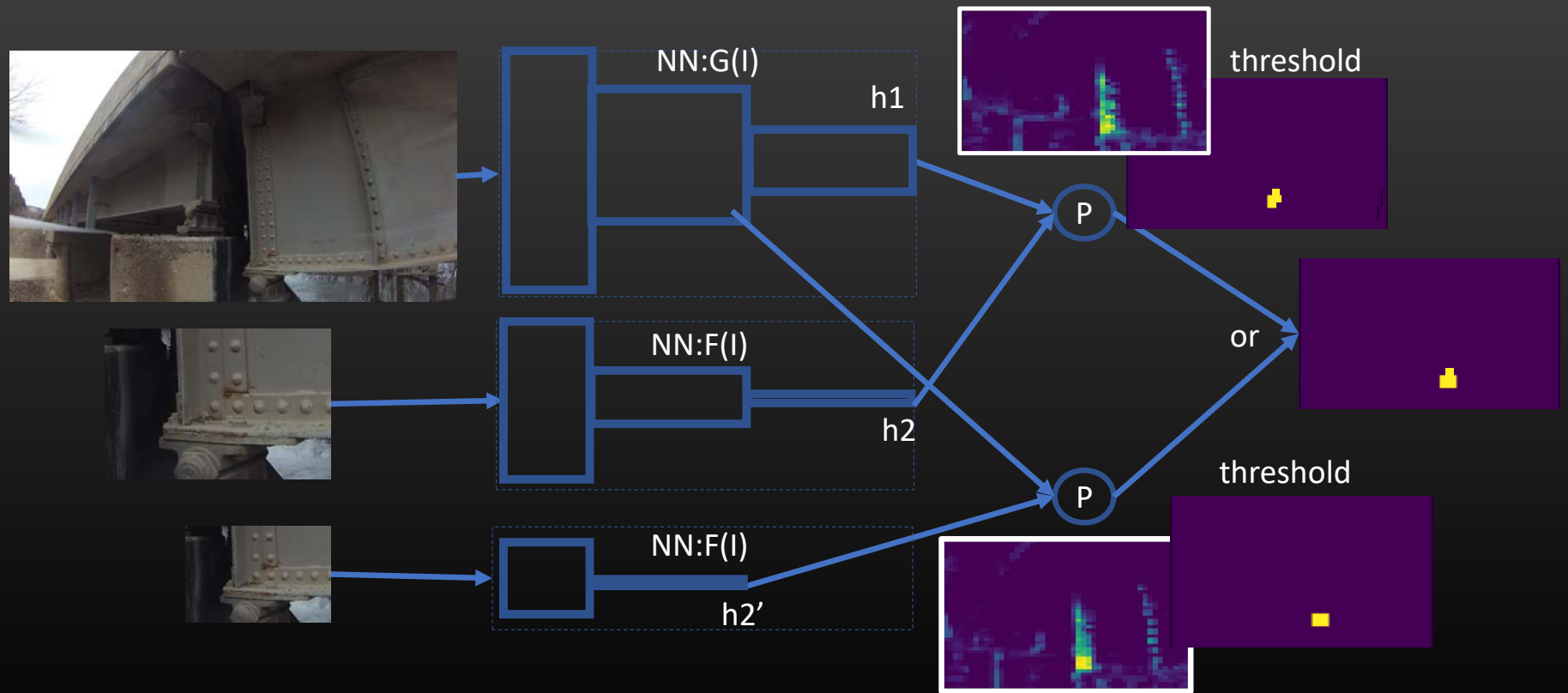
Siamese neural network

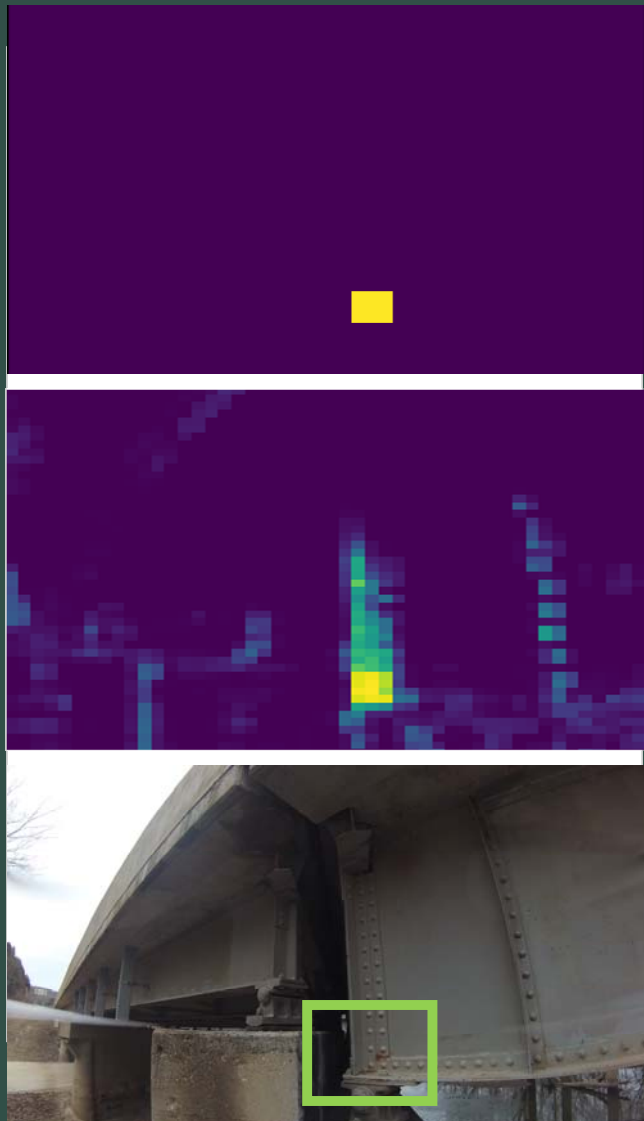


Region of interest detection (region vs image)



Multi-scale Siamese neural network





Multi-scale Siamese neural network

- Formula
 - $P(h1, h2) = \text{Sigmoid}\left(\frac{h1 \cdot h2}{|h1| |h2|}\right)$
 - $Loss = -y \log(P) + \alpha(1 - y) \log(P^2)$
- Training:
 - Stochastic gradient descent (SGD)
 - Learning rate = 0.01
 - $\alpha=0.05$
 - Fine-tune from Alexnet



Result

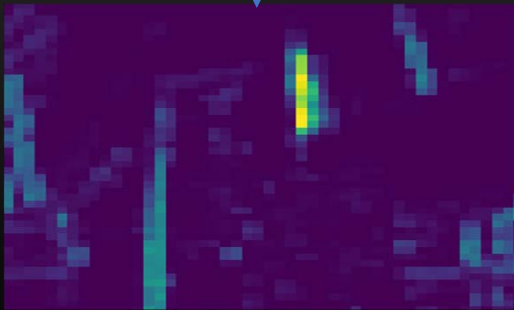
region of interest



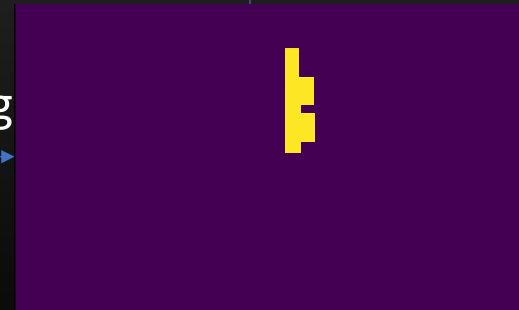
input image



Mask overlap on original image



thresholding

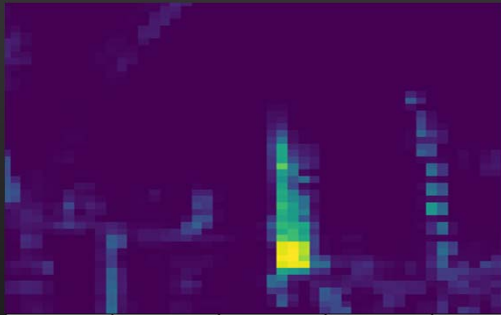


similarity map

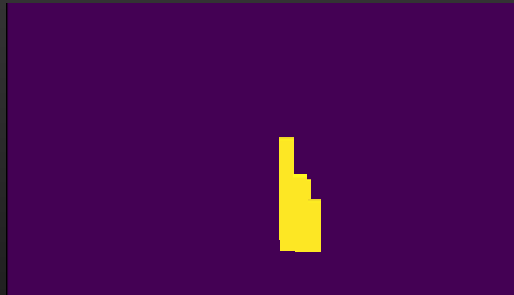


Result

similarity map



thresholding



Mask overlap on original image



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Method comparison

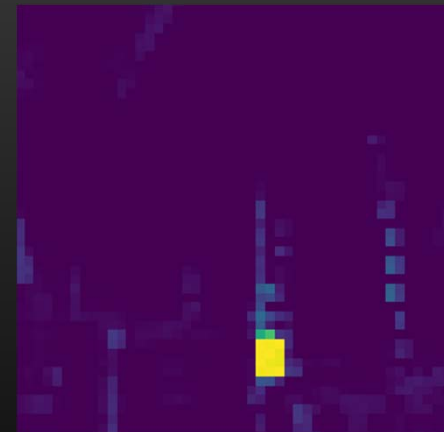
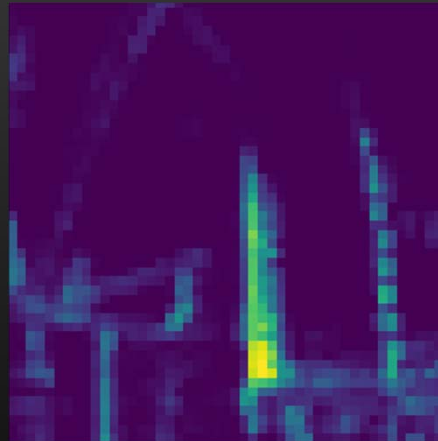
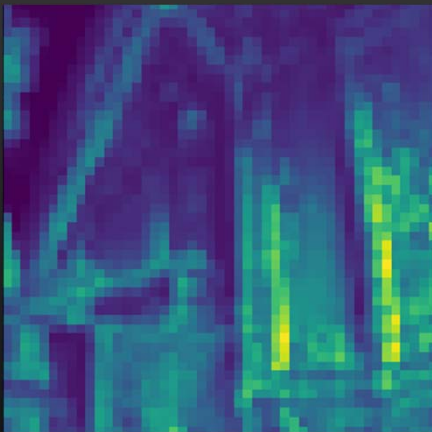
Iteration 0



15000



30000



- After learning, the result become more stable and accurate



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Conclusion

- A video analysis framework that keeps engineers in the loop of inspection
 - Multi-scale convolutional neural network for feature extraction and matching
 - Multi-scale Siamese neural network and one-shot learning



Future work

- Problem: One-shot learning has data limitation
 - Limited amount of data
 - Unrelated background inside the region leads to false-positive detection and thus may detect background as region of interest
- Proposed: post-process to smooth the result and denoise



Acknowledge

- Financial support provided by INSPIRE UTC, and CS and EMSE departments
- Video Data of Bridge Inspection provided by Dr. Genda Chen



Q&A

