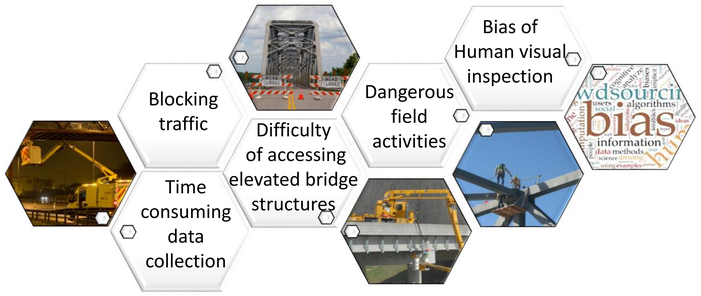
Bridge Inspection Video Data Analysis for Data-driven Asset Management

Muhammad Monjurul Karim, Missouri University of Science and Technology
Tianyi Zhao, Ruwen Qin, Genda Chen, Suzanna Long, Zhaozheng Yin, Sushil Louis

INTRODUCTION

Problem Statement:

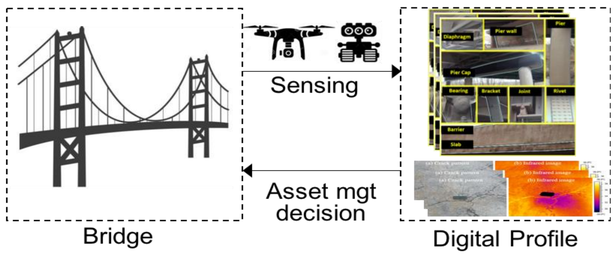
- Over 600k highway bridges in the National Bridge Inventory
- Bridges are facing the prospect of rapid deterioration (39% exceed design life of 50 years, 9% require significant repair)
- Bridges need to be inspected every two years
- The current practice of bridge inspection has many issues



Objective:

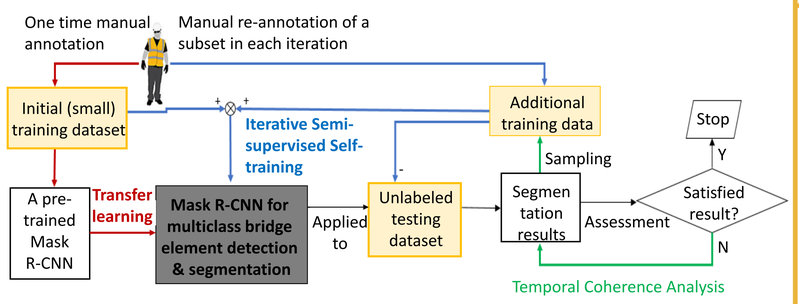
A cyber-physical system for analyze the data for an effective asset management

- Digitally profile bridge conditions as a cyber system for managing physical system (the bridge)
- Provide the decision support for preservation



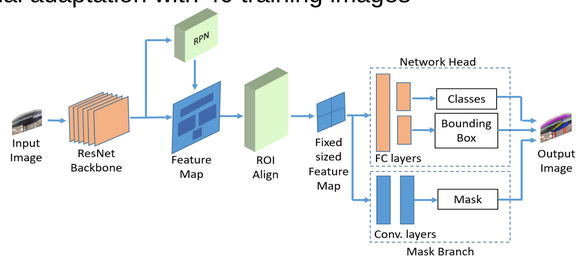
APPROACH

Engage inspectors in the development of the video data analysis AI tool.



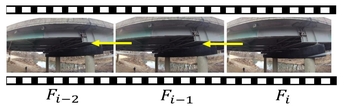
Transfer Learning:

- Mask R-CNN pre-trained on MS COCO dataset
- Initial adaptation with 40 training images



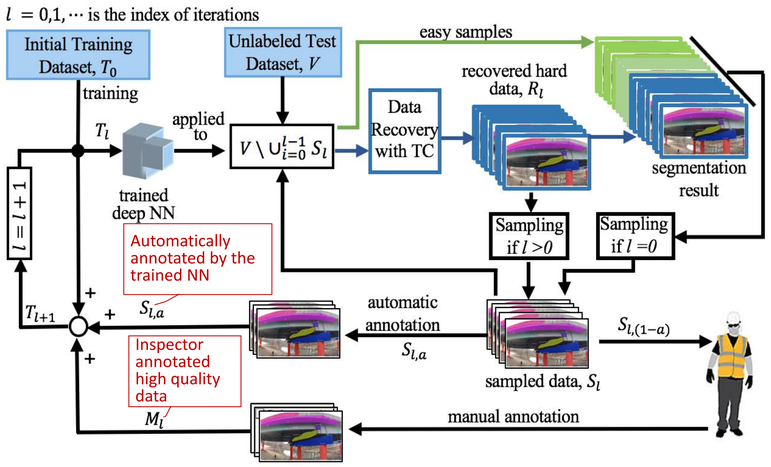
Temporal Coherence Analysis:

- Compare detection results with neighboring frames
- Recover false negative results



Iterative Semi-Supervised Self-Training (IS^{3}T):

- Select training samples from recovered hard data
- Manual annotation + automatic annotation
- Boost up the performance over iterations



RESULTS

The test dataset has 212 images, with 1872 objects in 10 classes

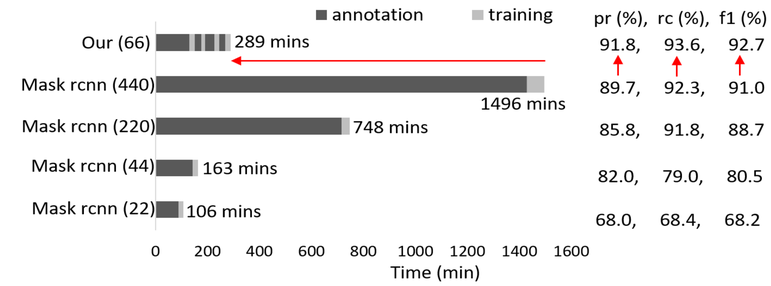
		Transfer learning	IS^{3}T		
Index of iteration, l		0	1	2	3
IoU = 0.5	Precision (%)	80.3	81.7	90.7	91.8
	Recall (%)	74.4	90.3	90.1	93.6
	f1-Score (%)	77.2	85.8	90.4	92.7

Efficiency of Transfer Learning:

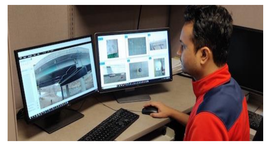
- Huge time saving and performance gain

Method	Training (min)	precision (%)	recall (%)	f1 (%)
Training from scratch	792+	32.3	18.3	23.4
Transfer learning	20	80.3	74.4	77.2

Cost-Effectiveness Achieved by Engaging Inspectors:

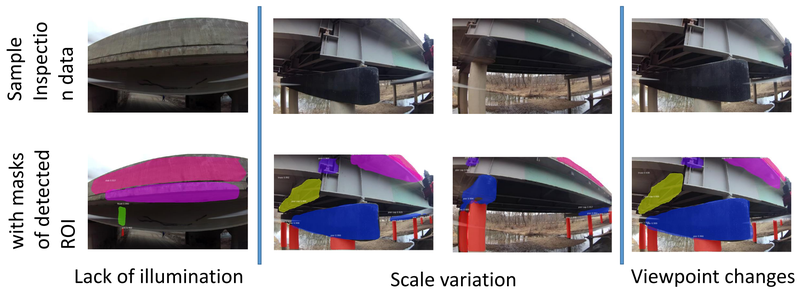


Helpfulness of the AI Tool for Inspection Image Data Analytics:



	Work time (min)	Accuracy (%)
w/o the AI tool	65	100
w/ the AI tool	0.27	93.7
change	↓99.5%	↓6.3%

Illustrative Examples:



CONCLUSIONS

Developed a semi-supervised deep learning NN for detecting and segmenting multiclass bridge elements from inspection video data

- Saves time, reduces bias, allows to focus on knowledge-intensive tasks
- Transfer learning and IS^{3}T help adapt the model to new tasks
- Keep human-in-the-loop to leverage human intelligence for AI model development

ACKNOWLEDGEMENTS

INSPIRE UTC, EMSE department, and Intelligent Systems Center