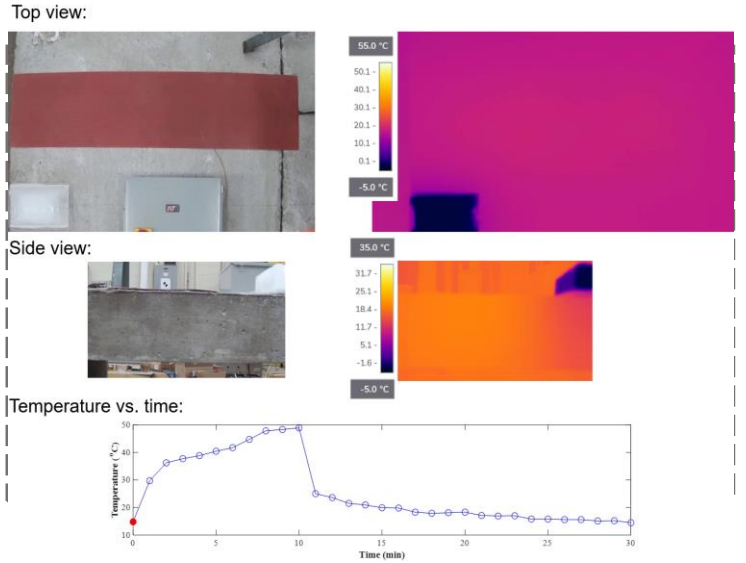
ECCS-2026357/2025929/2026445: Collaborative Research: Assistive Intelligence for Cooperative Robot and Inspector Survey of Infrastructure Systems (AI-CRISIS)

Dr. G.D. Chen, Missouri University of Science and Technology, gchen@mst.edu;
Drs. R.W. Qin and Z.Z. Yin, Stony Brook University, zyin@cs.stonybrook.edu;
Dr. D. Nembhard, University of Iowa, david-nembhard@uiowa.edu.

Active Thermography for Enhanced Subsurface Defect Survey in Bridge Deck



- Drone-based passive thermography can detect 12”×-10” embedded defects in concrete decks, and
- Active thermography using a strip heater in lab can effectively detect subsurface defects as small as 6”× 4”.
- Supply of heat in drone operation for active thermography requires further studies in bridge inspection.

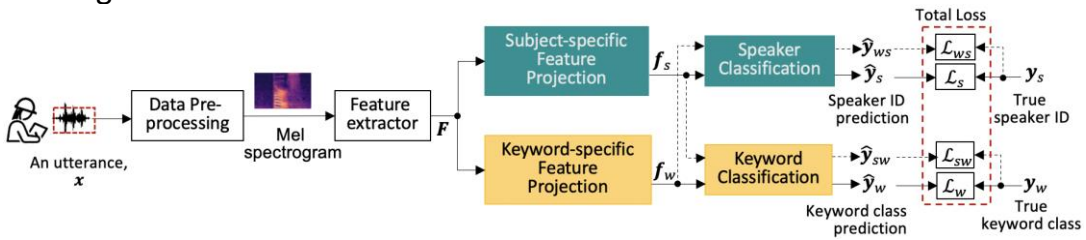
Inspector Identity and Voice Command Classification in Semi-Autonomous Drone Inspection of Bridges

Objectives:

To develop a multi-tasking model that can accurately classify the spoken words from authorized inspectors and efficiently adapt to the change of inspectors

Share-Split-Collaborate (S²C) Deep Learning Architecture:

- Two classification (inspector and voice) tasks share a feature extractor, and
- Inspector and word features are intertwined and split through collaborative training.



Model Adaption to Inspector Dynamics:

- Deactivate the classes of retired or resigned inspectors,
- Increase classes for new hires and refine the classification model,
- Collect a small dataset from the new hires and add it to training dataset,
- Refine the shared feature extractor, the two word-related networks, and retrain the two inspector-related networks.

Inspector Verification:

To separate external speakers from difficult-to-recognize internal speakers:

- The ratio between the highest and the second highest scores, $\lambda_v = \hat{y}_s^{(1)} / \hat{y}_s^{(2)}$, indicates the prediction strength of the top scorer.
- A threshold, $\lambda = k^{-1} \sum_{k=1}^{K} \mathrm{var}[\hat{\boldsymbol{y}}_s(k)]^{-1}$, is based on the training data.
- The smaller the λ value, the more capable the model to classify inspectors.
- The speaker is an authorized inspector when $\lambda_v > \lambda$ on 50% of the most recent utterances.

Word vs. Spoken Digit Dataset:

- 10 words in 3 categories, 8 subjects, and 50 utterances/word/subject are 30:10:10 splits for training, validation, and testing.
- 60 subjects, 10 spoken digits (0~9), 50 utterances/word/subject.

Effectiveness of Inspector Verification:

When λ=7.048, the chanced that an internal speaker and an external speaker are verified is 92.2% and 82.2%, respectively. The overall accuracy is 87.3%.

Concluding Remarks:

- Active thermography is effective in detecting subsurface defects in decks.
- Word and subject features are intertwined but can be split through feature projection and collaborative training.
- Pooling data from the subjects allow the model to learn more word feature representations and differentiate the features of speakers.