Robust Deep Learning Pipeline in the Presence of Runtime Sensing Uncertainties

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Sensory Challenges in the Wild

• Internet of Things (IoT) can be regarded as large-scale multi-modal sensing systems making rich inferences from big-data in the wild using intelligent techniques.

• Data in the wild has sensing and timing uncertainties:

  - Internet of Things (IoT) can be regarded as large-scale multi-modal sensing systems making rich inferences from big-data in the wild using intelligent techniques.
  - Data in the wild has sensing and timing uncertainties:

Proposed Pipeline

• Add controlled artificial misalignments across multimodal sensors.
• Add jitter in window length.
• Independent mask meta-data channel coupled with window alignment with contained samples popped ahead.
• Robust ensemble of recurrent-convolutional neural networks with conditional activation of finer-grained classifiers.

Handling Imperfect Data in the Wild

• Use sample windows with variable lengths:

  - Time-shift data augmentation:

    - Window alignment with contained samples popped ahead (treats missing samples as 0):

Evaluation and Comparison

• Independent mask channel specifying missing data location (not robust to timing uncertainties):

  \[
  X = \begin{bmatrix}
  X & X & NaN & X & NaN & NaN & X & NaN \\
  1 & 1 & 0 & 1 & 0 & 0 & 1 & 0
  \end{bmatrix}
  \]

  - Window alignment with contained samples popped ahead (treats missing samples as 0):

Conclusion

• Upto 600 ms timing error mitigation via timing and window jitter [1].
• 11 - 24% improvement in complex event recognition via proposed pipeline [2].
• Data processing pipelines require uncertainty injection and be robust to handling imperfect and missing data.