Foundations for Summarizing and Learning Latent Structure in Video

Problem

The growing volume of streaming and archived surveillance video in the DoD is outpacing the ability of analysts to manually monitor and view it. There is a lack of automated tools available to assist analysts in monitoring real-time video or analyzing archived video.

Solution

Inspired by the past research of CMU Machine Learning professor Dr. Eric Xing, we investigated a new unsupervised video summarization pipeline that functions on extracted clips of objects in motion, rather than whole frames. The goal of the summary is to identify the key ”object motion clips” occurring in the video.

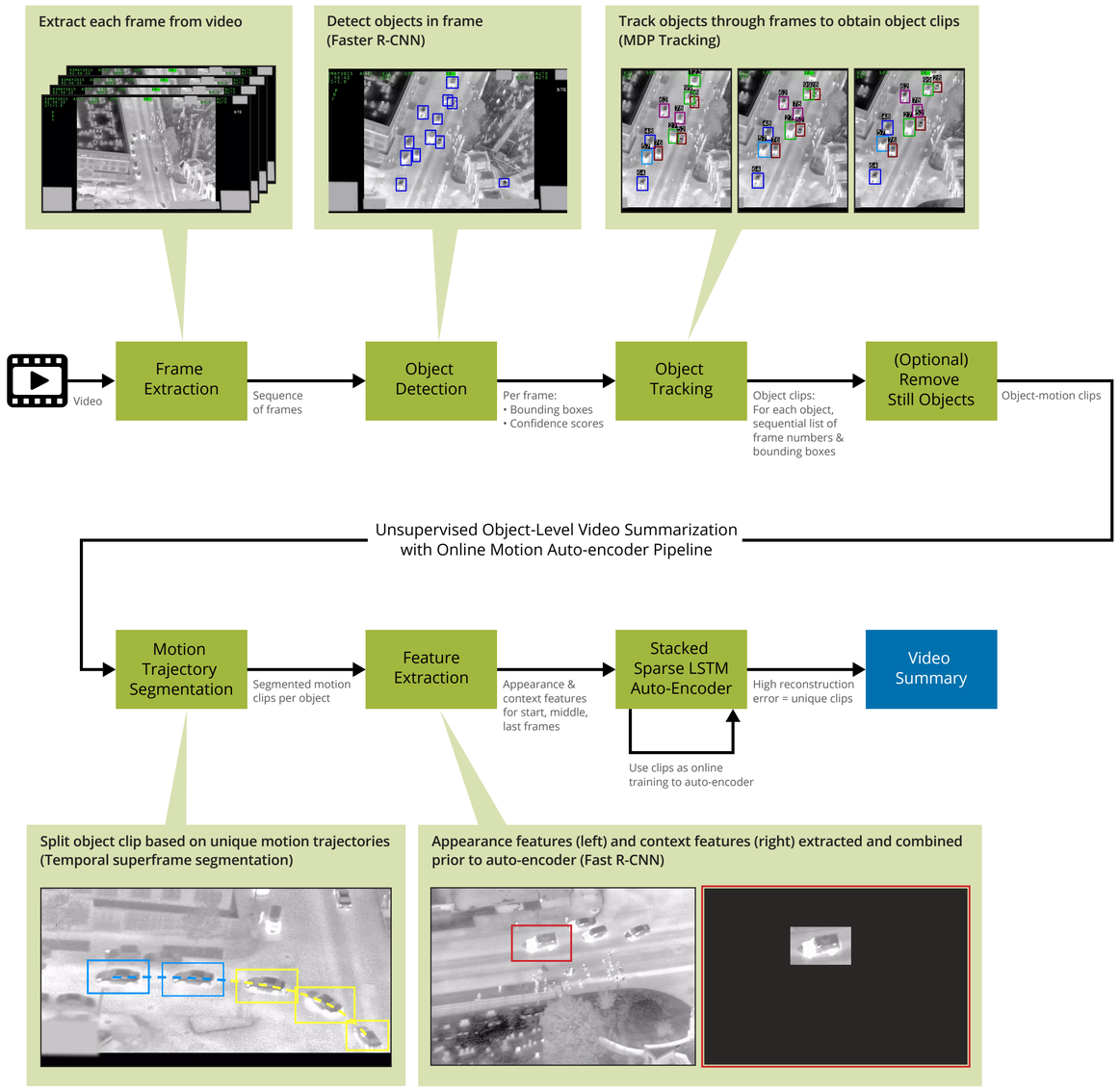
Approach

Unsupervised object-level video summarization with online motion auto-encoder

Offline Training: Initialize auto-encoder by training on random bounding boxes from representative video in order to learn a basic reconstruction capability

Online Processing & Training: For each video being processed:

1. Detect object bounds in each frame
2. Track objects through frames
3. (Optional) Remove clips of still objects
   - Useful for stationary camera
4. Segment object clips based on unique motion trajectories
5. Extract appearance and context features from the start, middle, and last frame of each clip
6. Feed the clip features through a three-layer, sparse, long short-term memory (LSTM) auto-encoder
   - Clips with high reconstruction error are collected as the ”summary”
   - As clips are processed, use them as online training for the auto-encoder



	Sparse Coding	Stacked Sparse Auto-encoder	Stacked Sparse Auto-encoder	Stacked Sparse LSTM Auto-encoder (OURS)
AUC score	0.4252	0.4354	0.5680	**0.5908**
AP score	0.1542	0.1705	0.2638	**0.2850**
F-measure	0.1284	0.1662	0.2795	**0.2901**

Table 1: Object-level summarization results between competing approaches on Orangeville dataset

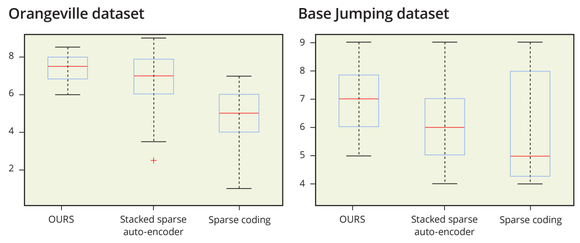


Figure 1: User study evaluation scores between competing approaches on Orangeville and Base Jumping datasets

Results

Quantitative: Our results matched or exceeded competing algorithms on benchmark datasets (see Table 1)

Qualitative: In a user study, our approach received higher and more consistent evaluation scores (see Figure 1)

Artifacts

Software

- Prototype utilizing the unsupervised, online, object-level video summarization pipeline
- Video Markup Tool for annotating spatial-temporal object clips within video

Paper

- Submission to IEEE Transactions on Cybernetics

Datasets

- “Orangeville” benchmark for object-level summarization – dataset & annotations
- Annotations & model for vehicle detection in FBI IR surveillance data

Future Work

FY18 Project: Summarizing and Searching Video

- Finish investigation of current pipeline to summarization of full-motion video (FMV) datasets
- Unsupervised activity clustering, utilizing object-motion clips as basis
- AFRL collaboration to explore applying analysis techniques to existing DoD problems
  - e.g., Nothing Significant to Report

In summary, we investigated object-level video summarization as an approach to identify the key segments in video with the final goal of applying these techniques to analyze real DoD surveillance data.

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