CPS: Synergy: Collaborative Research: Extracting time-critical situational awareness from resource constrained networks

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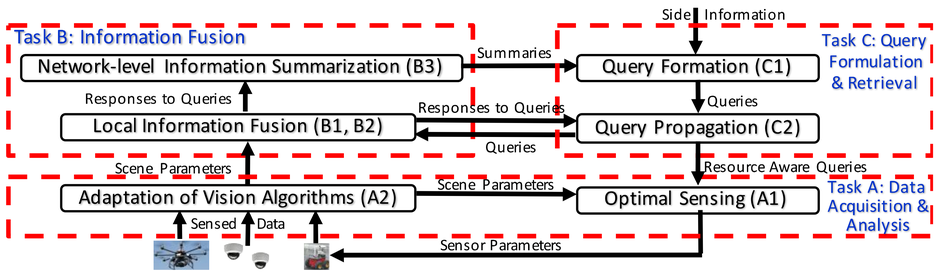
Research, Education and Outreach Objectives

- **Research Objective:** Facilitate timely retrieval of situational awareness information from rich content (including video) generated by field deployed nodes in resource-constrained, uncertain environments

- **Major research tasks:**



A. Resource-Constrained Data Acquisition and Analysis

1. Optimally and dynamically reconfigure the activation of field deployed agents to capture relevant information
2. Develop strategies to adapt video analysis algorithms based on environmental conditions and available resources

B. Information Fusion Under Resource Constraints

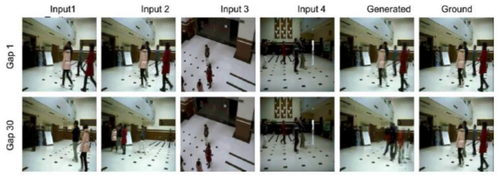
1. Locally process data, estimate its utility and decide what to transmit
2. Fuse data in a distributed manner while accounting for the directional nature of video sensors and the constraint of limited resources
3. Summarize the incoming information at the central station in the presence of missing data

C. Progressive Approach to Scalable Big Data Processing

1. Express queries using a query budget to restrict the amount of data processing time
2. Incorporate query-time analysis to reduce the redundancy of computation
3. Create an efficient workflow of user defined functions to maximize quality of an answer set within the query budget

- **Experimentation:**
  - Extensive experimentation on UCR/UCI camera network testbeds
- **Education and Outreach**
  - Develop specialized graduate and undergraduate courses at UCR and UCI
  - Make tutorials and workshops on content-aware networking and resource-constrained video analysis publicly available

Video Acquisition with Limited Computational Resources



Two examples from Office Lobby Dataset where Input 1, Input 2, Input 3, and Input 4 are the preceding and the following frames of camera 1, and the corresponding frames of camera 2 and 3 respectively.

Goal: Develop a method for multi-view frame reconstruction where multiple missing frames in one/more cameras need to be estimated using previous frames and other reference cameras.

Approach:

- Learn the spatio-temporal representation of the missing frames using conditional Generative Adversarial Networks (cGAN) with respect to other reference cameras as well as previous frames.
- Representations learned from frames within the camera compared to reference cameras are given more weight when they are close to the missing frames and vice versa.
- Experiments on a challenging dataset demonstrate that the proposed framework produces comparable results with the state-of-the-art reconstruction method in a single camera setup.

Weakly Supervised Text to Video Moment Retrieval

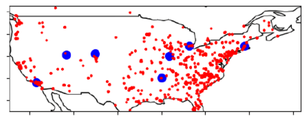
Illustration of text to video moment retrieval task

Goals: Temporally localizing video moments from text queries without requiring temporal boundary annotations of the text descriptions but using only the video-level text descriptions.

Approach:

- Utilize a joint visual-semantic embedding framework, that learns the notion of relevant moments from video using only video-level description..
- Experiments demonstrate that the proposed method, in spite of being weakly supervised, performs comparably to several fully supervised methods in the literature.

Summarization of Key Global Events from Crowd-sensed Data



A United States map of two-hour tweets of Florence dataset where red dots are tweet sources and blue dots are the producers

Date	Keywords	Textual summary	Visual summary
Sept 16	'abandon', 'hero', 'six', 'dog', '64', 'rescue', 'hurricane'	"Six dogs have been rescued from rising flood waters, after they were locked in a cage and abandoned by their owners"	

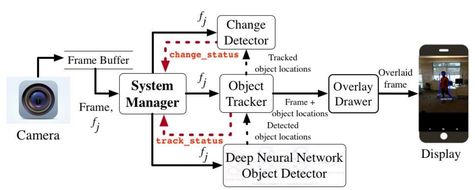
Sampled Output: Hurricane Florence Summarization

Goals: Design a novel framework that only transfers very limited data from distributed producers to a central summarizer supporting highly accurate detection and constructs concise visual summaries for key events.

Approach:

- Each producer identifies a set of local events that are likely to be of global interest via local information gain measurements
- Metadata with respect to local events are pushed to a summarizer, which pulls additional metadata if needed
- Once global events are detected, a lightweight method reconciles common events across a plurality of producers
- An intelligent algorithm parallelizes transfer of visual content to facilitate the composition of a visual summary in a very short time

Power Thrifty Application of DNNs on Mobile Devices



System Architecture

Goals: Develop a framework on mobile platforms that reduces the energy drain of Deep Neural Network (DNN)–based object detection while maintaining good tracking accuracy in videos

Approach:

- Train a DNN model to classify and localize objects in videos but only use it on a need to basis in order to save significant energy on battery-operated smartphones
- Design a lightweight change detector that triggers a DNN only when it detects significant change outside currently tracked objects while ignoring camera motion noise
- Develop an intelligent method to mediate between lightweight *incremental tracking* and DNN-based *tracking by detection* by using information from object tracker and change detector

Publications:

[1] T. Mahmud, M. Billah, and A. Roy-Chowdhury, "MULTI-VIEW FRAME RECONSTRUCTION WITH CONDITIONAL GAN", IEEE GlobalSIP, 2018
[2] N. C. Mithun, S. Paul, A. Roy-Chowdhury, "Weakly Supervised Video Moment Retrieval From Text Queries", IEEE/CVF CVPR, 2019.
[3] A. Fahim, A. Neupane, E. Papalexakis, L. Kaplan, S.V. Krishnamurthy and T. Abdelzaher, " Edge-Assisted Detection and Summarization of Key Global Events from Distributed Crowd-Sensed Data", IEEE IC2E, 2019
[4] K. Apicharttrisorn, X. Ran, J. Chen, S. Krishnamurthy, and A. Roy-Chowdhury, "Frugal Following: Power Thrifty Object Detection and Trackingfor Mobile Augmented Reality", ACM SenSys, 2019.

Collaborative Research with UC Irvine.