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

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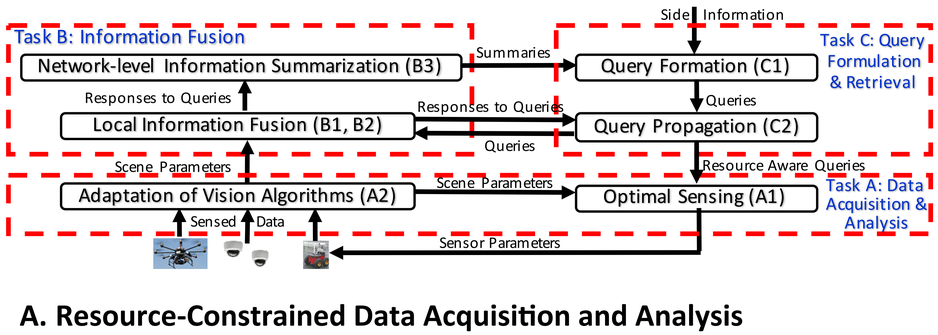
Research, Education and Outreach Objectives

- **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

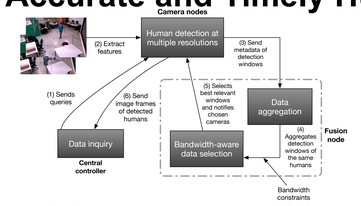
1. Locally process data, estimate its utility and decide what to transmit
2. Fuse data in a distributed manner while accounting for the directional nature of video sensors while adhering to the constraint of limited resources
3. Summarize the incoming information at the central station in the presence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

C. Cost-Aware Query Formulation and Retrieval

1. Design queries with an opportunity cost associated with each action, and prioritize queries based on desired importance criteria
2. Effectively disseminate the queries to retrieve relevant information from the field nodes

- **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

Accurate and Timely Human Detection in Bandwidth Constrained Wireless Camera Networks



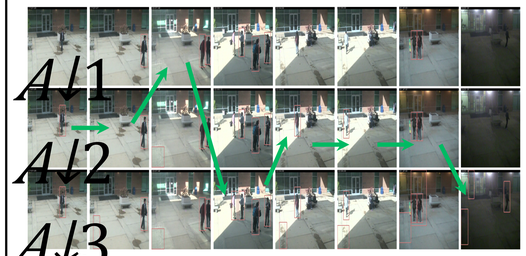
ACTION framework for human detection

Goal: Accurately detect the presence of humans by leveraging video feeds captured by multiple cameras with overlapping views on the field.

Approach:

- Effectively detect humans at individual cameras.
- Detection metadata from multiple cameras is fused to improve accuracy.
- Human images that satisfy a detection criteria are chosen for transfer while adhering to bandwidth constraints.

Adaptive algorithm selection for pedestrian detection applications



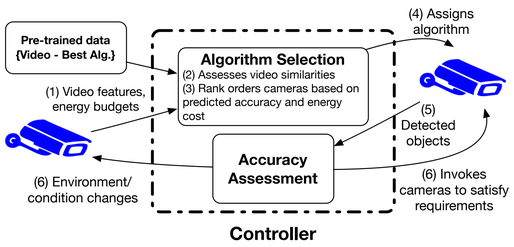
The best algorithm varies in different time windows

Goals: (i) For every part of an unknown video feed, automatically select an algorithm among all available algorithms that achieves the best result, and (ii) for the entire unknown video feed, determine the best strategy to switch between algorithms.

Approach:

- Exhaustively apply every algorithm A_k on the training set $T=\{T\downarrow 1, \ldots, T\downarrow M\}$ to learn the best algorithm for each T_i.
- For a test item $R\downarrow j$, find the most similar training item $T\downarrow i$ based on the similarity $S(T\downarrow i, R\downarrow j) = e^{-d(T\downarrow i, R\downarrow j)}$, where the feature distance $d(T\downarrow i, R\downarrow j)$ is computed via domain adaptation.
- The adaptive algorithm selection cost depends on the similarity between two consecutive time windows, and can be optimized by dynamic programming.

Adaptive algorithm selection for multi-camera settings



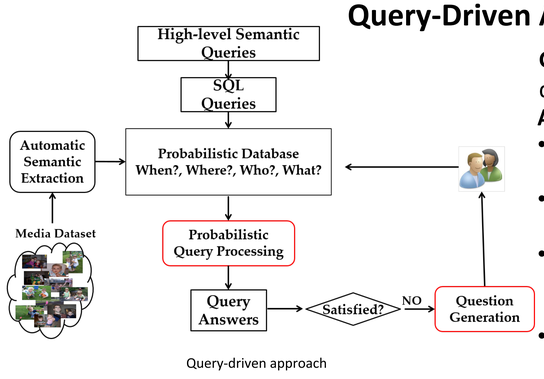
Adaptive algorithm selection in multi-camera settings

Goal: Invoke the best algorithm to each camera so as to achieve a globally desired detection accuracy while adhering to energy constraints.

Approach:

- Cameras upload video features and energy budgets to the controller node, where pre-trained data with training video feeds and associated best detected algorithms are available.
- The controller node rank orders cameras based on the trade-offs between estimated accuracy and energy cost.
- Cameras with the best trade-offs are chosen. Detection accuracy is assessed periodically; additional cameras are invoked on demand until the desirable accuracy is met.
- Re-calibration happens when the environment or constraints change.

Query-Driven Approach to Face Clustering and Tagging



Query-driven approach

Goal: Accomplish visual tagging depending on the user queries or application requirements in big data settings, wherein traditional image processing is not feasible.

Approach:

- *Query-driven active learning*: Rather than asking a human for the label of the entire dataset, the system asks for a label that reduces the uncertainty in answers of their own query.
- Since the queries are probabilistic, probabilistic database is constructed by extracting semantic attributes using visual concept detectors.
- When a high level semantic query arrives, the database manager processes and answers the query. If the users are not satisfied with the answer, the *human-in-the-loop* component will be activated.
- Questions are automatically generated to ask users for feedback, based on which the final answer will be updated. The process continues until the users are satisfied.

Publications:

[1] T. Dao, A. K. Roy-Chowdhury, N. Nasrabadi, S. V. Krishnamurthy, P. Mohapatra, L. Kaplan, " ACTION: Accurate and Timely Situation Awareness Retrieval from Bandwidth Constrained Wireless Cameras", submitted to IPSN 2017.
[2] S. Zhang, Q. Zhu, A. K. Roy-Chowdhury, "Adaptive Algorithm selection, with applications in pedestrian detection", ICIP 2016.
[3] L. Zhang, X. Wang, D. V. Kalashnikov, S. Mehrotra and D. Ramanan, "Query-Driven Approach to Face Clustering and Tagging," in *IEEE Transactions on Image Processing*, vol. 25, no. 10, pp. 4504-4513, Oct. 2016.
[4] T. Dao, A. K. Roy-Chowdhury, H. V. Madhyastha, S. V. Krishnamurthy, T. LaPorta, "Managing Redundant Content in Bandwidth Constrained Wireless Networks", accepted to IEEE/ACM Transactions on Networking, 2016.