A Flow Model for Joint Action Recognition and Identity Maintenance

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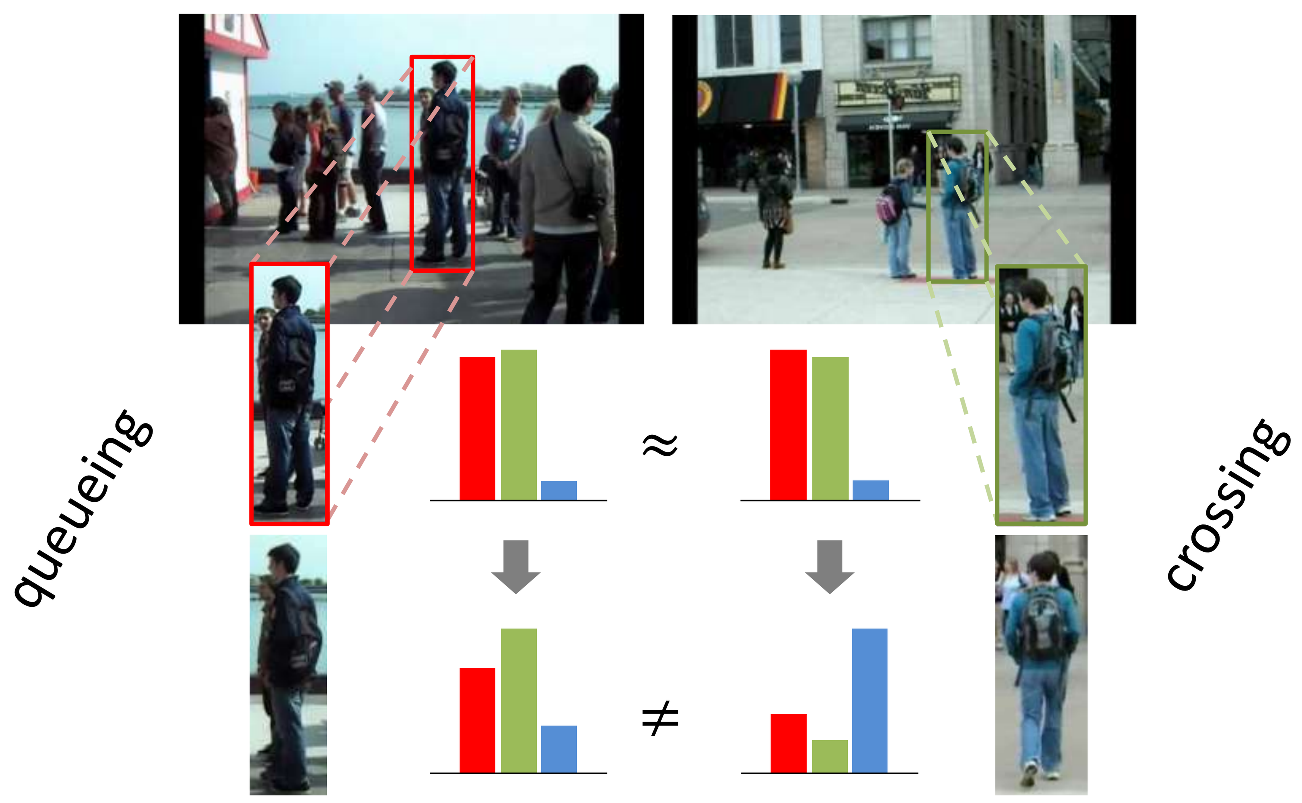
Motivation

- Different actions might have matching feature responses if they have visually similar bounding boxes.



- Action recognition can benefit from tracking, but tracking can also benefit from action recognition!
- We seek to improve action recognition performance by simultaneously solving both problems.

Proposed Approach

- Our goal is to formulate the problem as a tractable optimization function.
- The function should minimize
  - The action classification costs.
  - The identity association costs.
- The action classification cost is based on the Action-Context (AC) descriptor [3] using HOG as the underlying representation.
- The identity association cost penalizes appearance and action transition inconsistencies.
  - Appearances are modeled by a distance matrix learned using LMNN [4] between the blurred downsampled detection boxes as raw features.
  - Action transitions are modeled by a transition matrix learned by counting action pairs on the same track.
- We can leverage recently proposed formulations of tracking as network flow [5].

Model Formulation

- Our formulation can be represented as an integer linear program of a constrained minimum cost flow problem.

$$\min_{\{\mathbf{e},\mathbf{t},\mathbf{x}\}} \sum_i \sum_a \Big[(u_a(i) + \lambda_0) e_a(i) + \sum_{j \in \mathcal{P}(i)} \sum_b (u_a(i) + \lambda_d d(i,j) - \lambda_c \log(p_{ab})) t_{ab}(i,j) \Big]$$

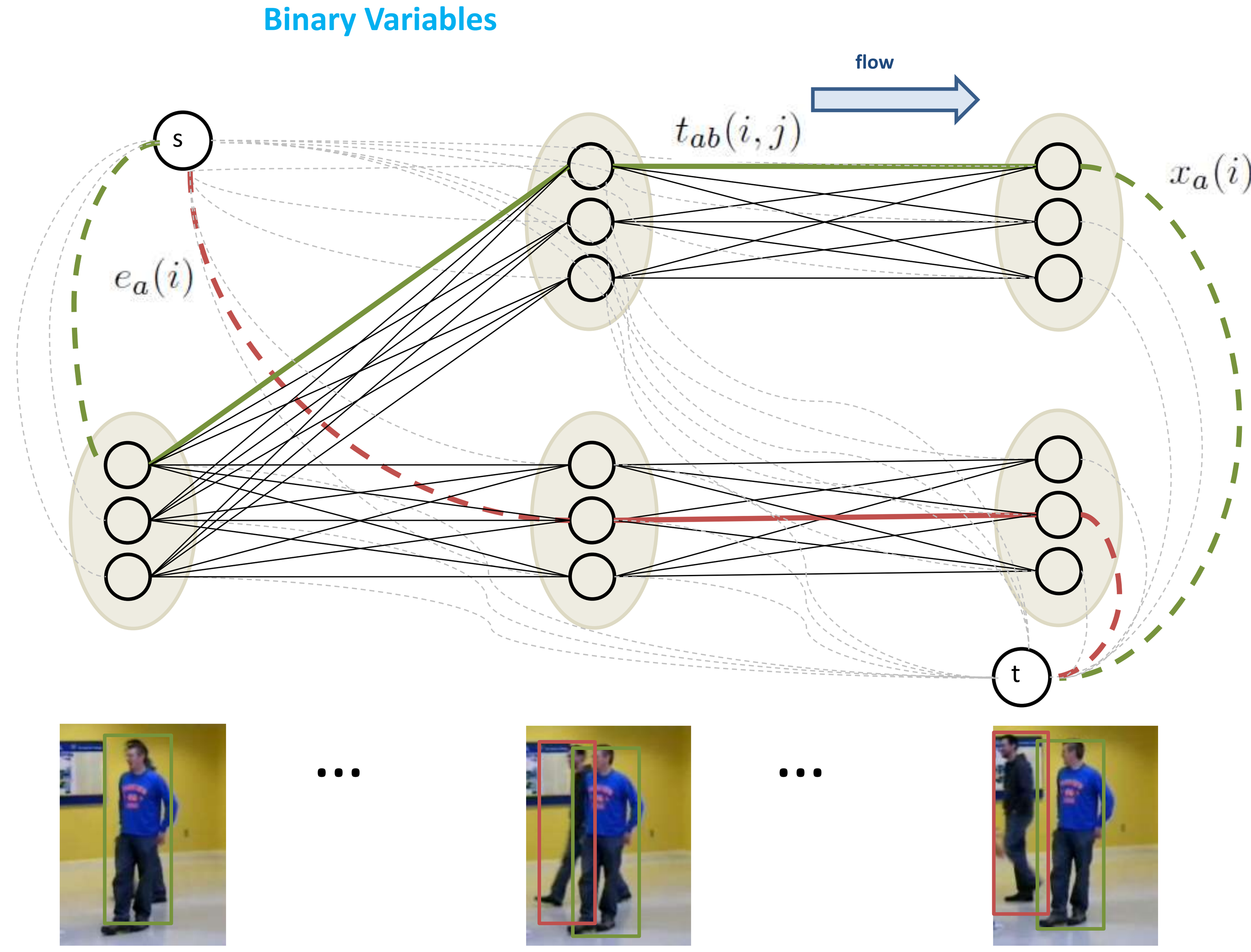
Appearance Consistency Weight, No Match Penalty, Action Transition Weight, Classification Cost, Appearance Consistency Cost, Action Transition Cost

$$\text{s.t.} \quad e_a(i) + \sum_{j \in \mathcal{P}(i)} \sum_b t_{ab}(i,j) = x_a(i) + \sum_{k \in \mathcal{S}(i)} \sum_c t_{ca}(k,i) \quad \forall i, a$$

$$\sum_a \Big[e_a(i) + \sum_{j \in \mathcal{P}(i)} \sum_b t_{ab}(i,j) \Big] = 1 \quad \forall i$$

$$\{\mathbf{e},\mathbf{t},\mathbf{x}\} \in \mathbb{B}^n$$

Enter Event, Transition Event, Exit Event, Flow Conservation Constraint, Explanation Constraint, Binary Variables



- Our ILP is constrained to the submodular polyhedron, therefore the constraint matrix is totally unimodular [2].
- Relax and solve!

Experimental Results

- We experimented on two public multi-person action recognition datasets [1]
- Our results improve on using unary potentials only and achieve state-of-the-art performance on both datasets

Approach	5-class	6-class
Classifier (AC Only)	68.8%	81.5%
Ours (AC + Tracking)	**70.9%**	**83.7%**

	crossing	waiting	queueing	walking	talking
crossing	67.9%	4.9%	2.0%	19.3%	1.7%
waiting	2.7%	58.1%	14.1%	10.4%	0.9%
queueing	4.2%	28.5%	78.5%	2.9%	5.9%
walking	24.6%	5.7%	1.4%	61.9%	3.6%
talking	0.5%	2.8%	4.1%	5.4%	87.9%

	crossing	waiting	queueing	talking	dancing	jogging
crossing	87.8%	5.8%	1.6%	4.0%	0.8%	0.5%
waiting	7.3%	57.5%	16.6%	1.5%	0.0%	0.1%
queueing	3.0%	30.3%	77.4%	4.6%	0.3%	4.1%
talking	0.4%	6.4%	4.1%	89.2%	1.4%	1.8%
dancing	0.3%	0.0%	0.2%	0.4%	97.0%	0.1%
jogging	1.2%	0.0%	0.0%	0.3%	0.4%	93.4%

References

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