Target Identity-aware Network Flow for Online Multiple Target Tracking

Problem:
- Multi Object Tracking

Key Contributions:
- Solving detection (SSVM) and data association (Network Flow) simultaneously
- A new target identity-aware network flow graph
- Used as Inference of our structured learning
- Finding most violated constraints during training
- Finding tracks during testing
- An efficient Lagrange relaxation solution

Target Identity Aware Network Flow (TINF):
- Traditional Network flow cannot be used directly in our Inference function:
  - No notion of parameter W
  - Different objective function
- min ∑ \( C(f) \) s.t. \( \xi \geq 0 \)

Optimization:
- Lagrange Relaxation: We relax the bundle constraints
  \[ C(f) = \sum_{k=1}^{K} \sum_{(i,j) \in E} (\epsilon_{ij}^k + \lambda_{ij})f_{ij}^k - \sum_{(i,j) \in E} \lambda_{ij} \]
- Sub-gradient optimization: Alternate between the following two steps:
  - Solve the minimum cost flow for each identity using cost coefficient \( \epsilon_{ij}^k + \lambda_{ij} \)
  - Update the Lagrange multipliers according to:
  \[ \lambda_{ij}^{k+1} = \left[ \lambda_{ij}^k + \theta \sum_{j=1}^{K} f_{ij}^k - 1 \right] \]

Spatial Constraint:
- Lagrange multiplier will take care of the shared detections
- Tracks may highly overlap which is not plausible
- Replace NMS
- Our overlap constraint -> Discourage targets to take paths which highly overlap

Experiments:
- Evaluation metrics: MOTA, MOTP, MT, ML and ID-Switch (IDS)

Training:
- Goal: Prediction function: Learn a prediction function that predict location of all the targets in a set of frames
- Score Function:
  \[ f_o(X) = \arg \max_{X} \sum_{i=1}^{K} w_i \phi(x_i, y_i) \]
  - One object – One Frame
  - Multi object – Multi Frame

Parameter w:
- \( \min \frac{1}{2} ||w||^{2} + C \xi \) s.t. \( \xi \geq 0 \)

Loss Function:
- \( \Delta(Y, Y') = \frac{1}{2} \sum_{(i,j) \in E} (1 - (y_i^j \land y'_i^j)) \)