Embedded Multi-Person Pedestrian Tracking and Detection

MSCV19 Capstone Project, Internal(CMU)

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Introduction

- Problem
  - Detect and track multiple people
  - Deal with occlusion, large appearance changes
- Motivation
  - Real-time multi-person pedestrain tracking
  - Visual analysis, automatic driving, robotics
- Solution
  - Track by detection - SiameseRPN (Single Object)
  - Multiple object extension

Siamese RPN for Single Object Tracking

Li, Bo et al. "High Performance Visual Tracking with Siamese Region Proposal Network." 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition 2018
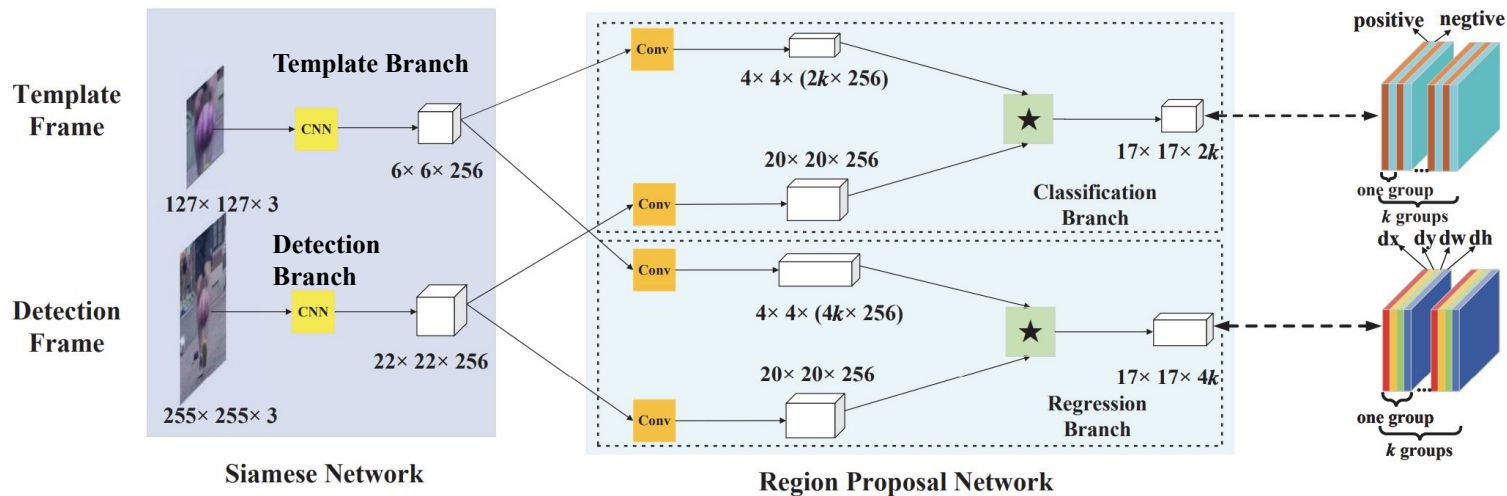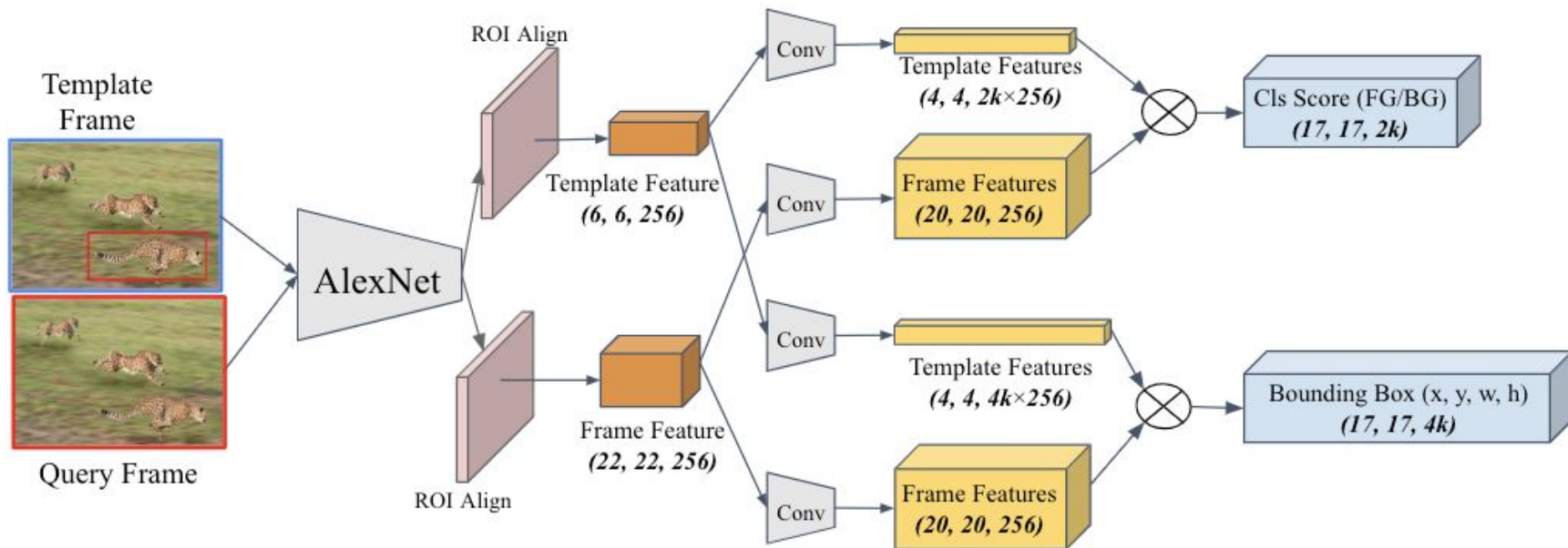
Siamese RPN

Figure 2: Main framework of Siamese-RPN: left side is Siamese subnetwork for feature extraction. Region proposal subnetwork lies in the middle, which has two branches, one for classification and the other for regression. Pair-wise correlation is adopted to obtain the output of two branches. Details of these two output feature maps are in the right side. In classification branch, the output feature map has $2k$ channels which corresponding to foreground and background of k anchors. In regression branch, the output feature map has $4k$ channels which corresponding to four coordinates used for proposal refinement of k anchors. In the figure, $\star$ denotes correlation operator.

Siamese RPN

- Re-implementating Siamese RPN
  - Training & Testing have been implemented
    - note: this is migrated from an unofficial reimplementation of SiameseRPN
  - Testing results (finetune from pretrained weights on VOT dataset)
    - Training EAO (Expected Average Overlap): 0.5240
    - Testing EAO: 0.3085

Siamese RPN with RoI Align

Siamese RPN with RoI Align

- Siamese RPN with RoI Align
  - Training & Testing have been implemented
  - Results (finetune from pretrained weights on VOT dataset)
    - Training EAO: 0.6045
    - Testing EAO: 0.0785
- Will be used for MOT tracking to save computation

Some Visualizations

Red - SiamRPN (finetuned)   Black - Official DaSiameseRPN
Blue - SiamRPN RoI (finetuned)   Green - Ground Truth

What's next

- Training code for official SiameseRPN implementation
- Improving test performances
    - Investigate into low test performance using RoI
    - Use official SiameseRPN implementation
    - NMS with size penalty, distance penalty
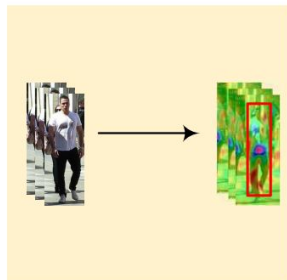- Consider how to merge with Multi-Object Tracking

SiamRPN Extention for Multiple Object Tracking

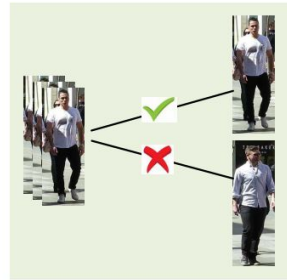# Extend SiamRPN for Multi Object Tracking

- Single Object Tracking
  - Given a template, do tracking
- Multiple Object Tracking
  - 1. Given several templates, do tracking
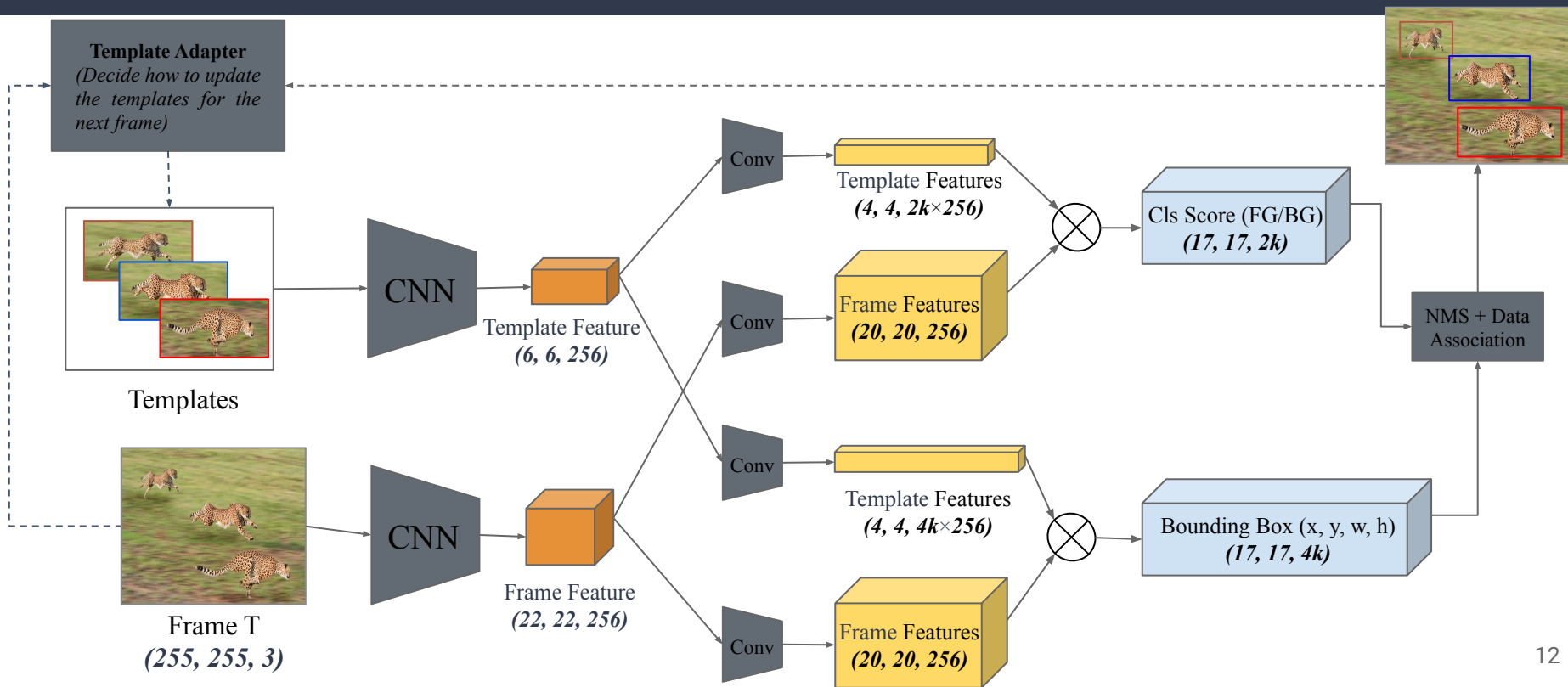 - 2. Decide when to add new templates
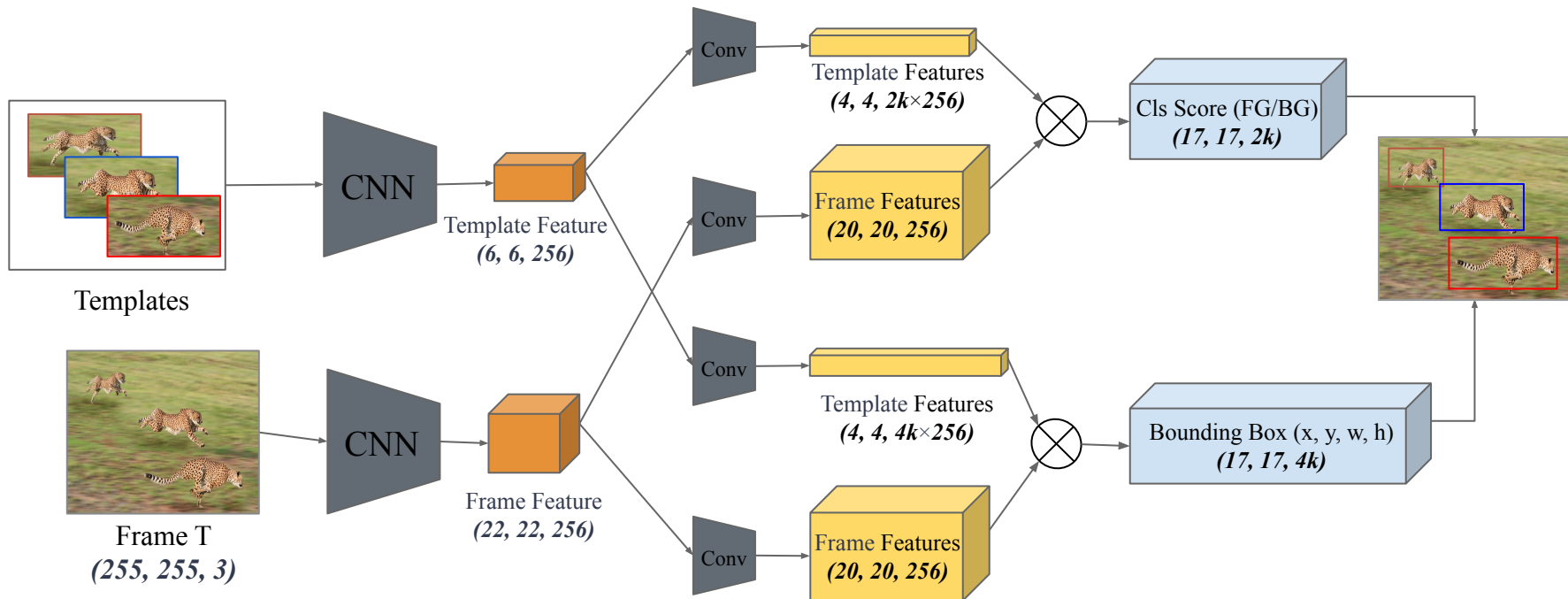

Detection   Single object tracking   Data association

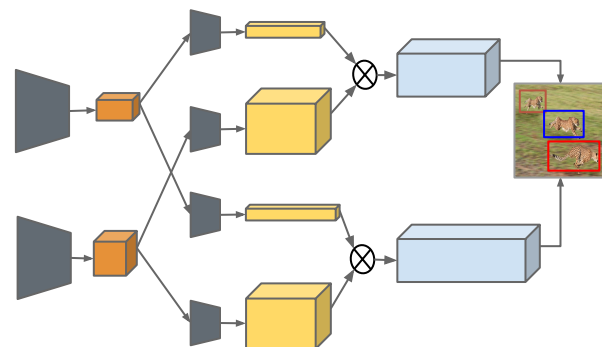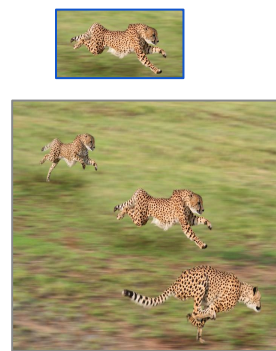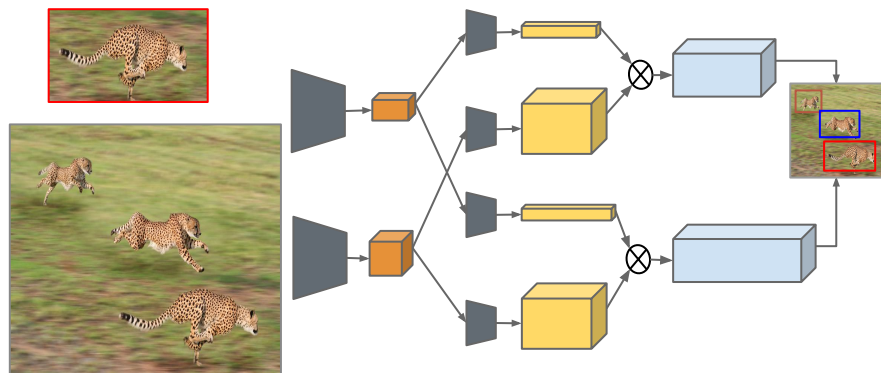# Extend SiamRPN for Multi Object Tracking

Extend SiamRPN for Multi Object Tracking

Ideas for Tracking

- Basic Idea: For loop
  - Initialize different single object tracker for each object
  - Time and memory complexity increase linearly
- All single object tracker share the same network weight
  - Pre-compute correlation filters and save
  - Fix the memory issue
- Introduce Communication between templates
  - Add Distractor-aware loss and fine-tune
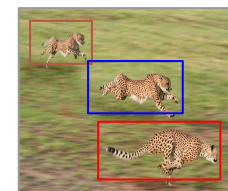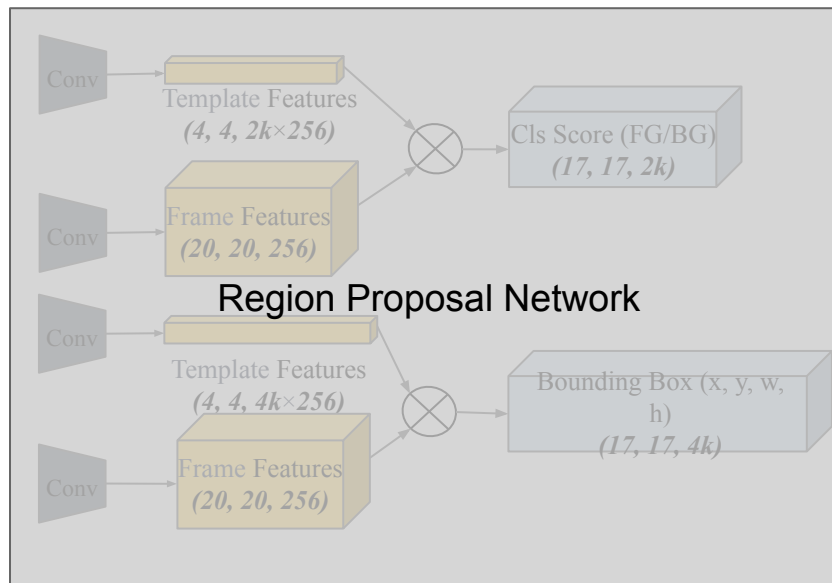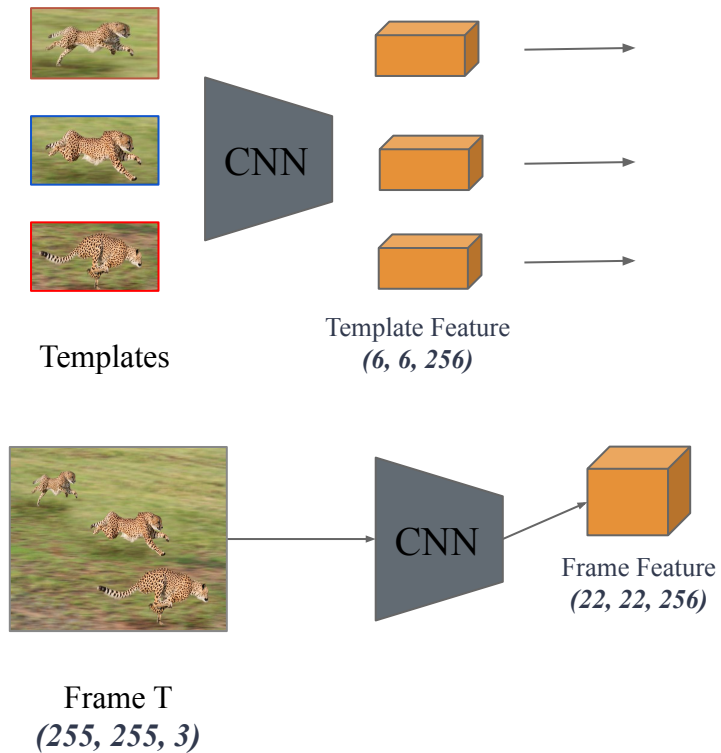- More Ideas
  - ROI Pooling

Pipeline 1: For loop

Ideas for Tracking

- Basic Idea: For loop (Done)
    - Initialize different single object tracker for each object
    - Time and memory complexity increase linearly
- **All single object tracker share the same network weight**
    - **Pre-compute correlation filters and save**
    - **Fix the memory issue**
- Introduce Communication between templates
    - Add Distractor-aware loss and fine-tune
- More Ideas
    - ROI Pooling

Pipeline 2:

Templates

Template Feature
(6, 6, 256)

Frame T
(255, 255, 3)

CNN

Frame Feature
(22, 22, 256)

Conv

Template Features
(4, 4, 2k×256)

Frame Features
(20, 20, 256)

Cls Score (FG/BG)
(17, 17, 2k)

Conv

Region Proposal Network

Conv

Template Features
(4, 4, 4k×256)

Frame Features
(20, 20, 256)

Bounding Box (x, y, w, h)
(17, 17, 4k)

Conv

Visualization Results

Visualization Response

Template:

Visualization Response

Template:

Visualization Response
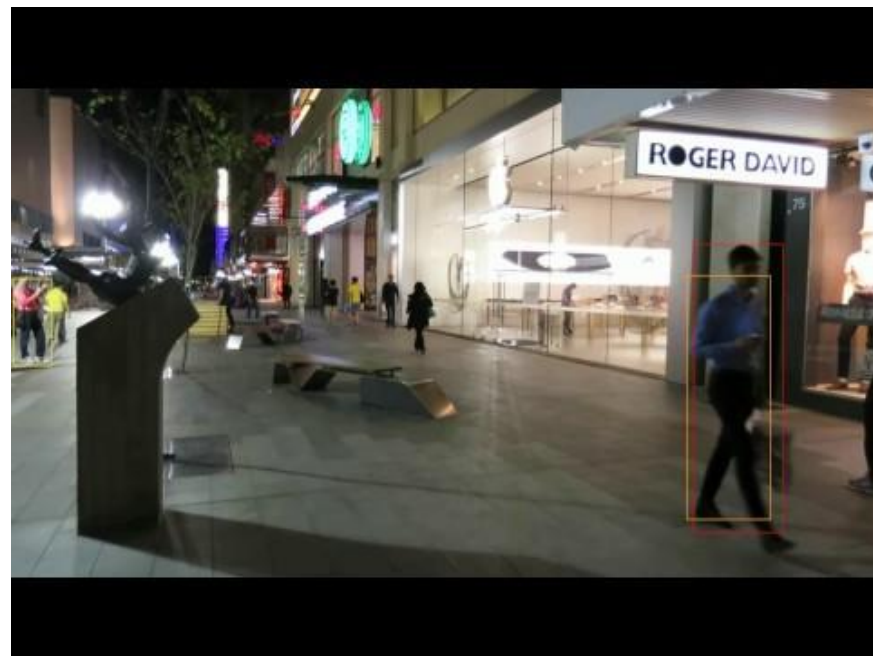
Template:

Template:
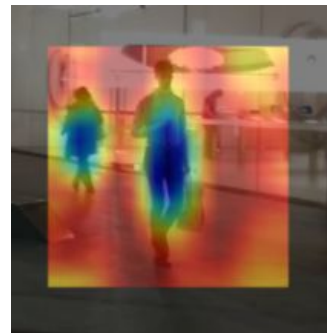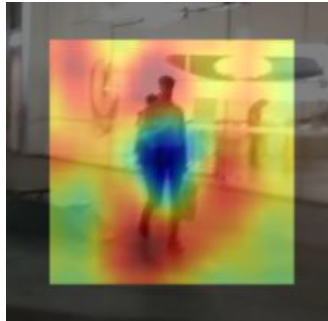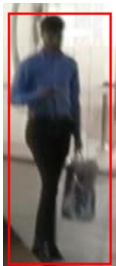
Ideas for Tracking

- Basic Idea: For loop (Done)
  - Initialize different single object tracker for each object
  - Time and memory complexity increase linearly
- All single object tracker share the same network weight (Done)
  - Pre-compute correlation filters and save
  - Fix the memory issue
- Introduce Communication between templates
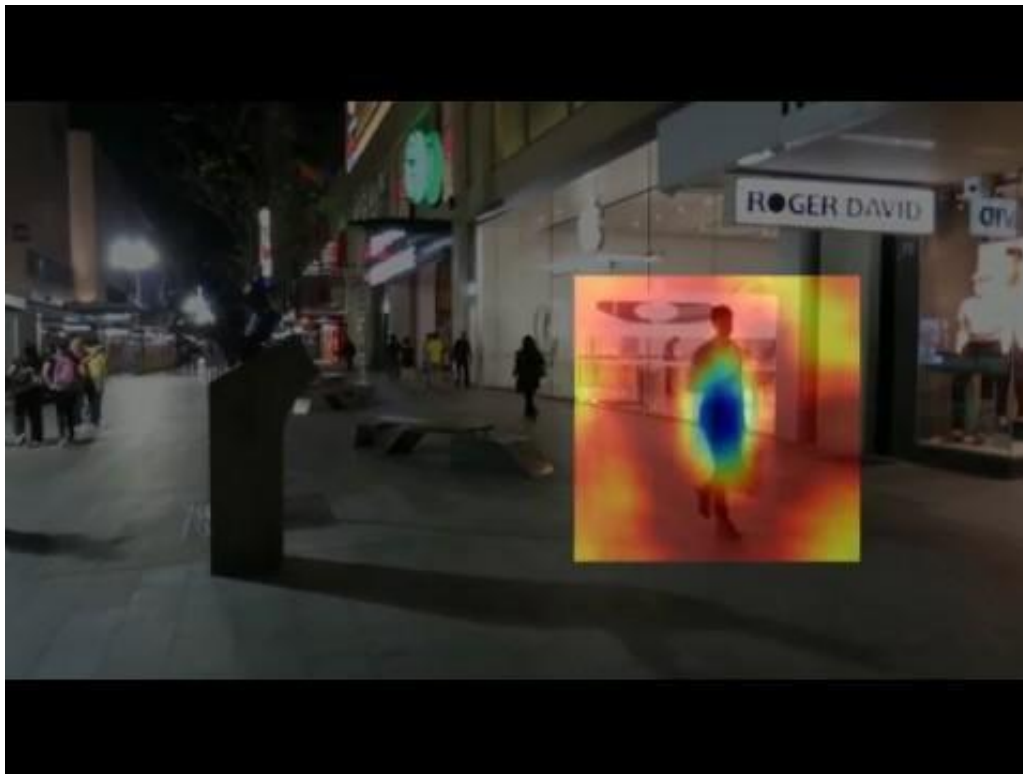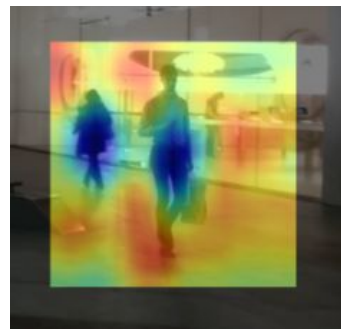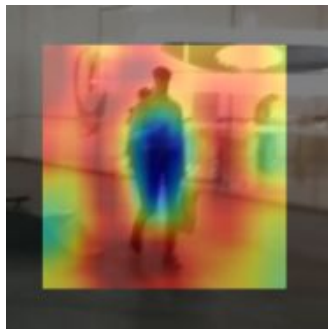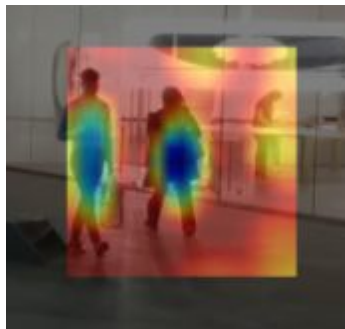 - Add Distractor-aware loss and fine-tune
- More Ideas
  - ROI Pooling

Pipeline 3: Connect all templates

n Templates

Template Feature
(6, 6, 256n)

Template Features
(4, 4, 2nk×256)

Frame Features
(20, 20, 256)

Template Features
(4, 4, 4nk×256)

Frame Features
(20, 20, 256)

Cls Score (FG/BG)
(17, 17, (n+1)k)

Bounding Box (x, y, w, h)
(17, 17, 4k)

Frame T
(255, 255, 3)

Frame Feature
(22, 22, 256)

Pipeline 4: Connect all templates

Templates

Template Feature
(n, 6, 6, 256)

Frame T
(255, 255, 3)

Frame Feature
(22, 22, 256)

RPN

Cls Score (FG/BG)
(17, 17, 2k)

Cls Score (FG/BG)
(17, 17, 2k)

Cls Score (FG/BG)
(17, 17, 2k)

SoftMax

Cls Score (FG/BG)
(17, 17, nk)

Bounding Box (x, y, w, h)
(17, 17, 4k)

24

Pipeline 4: Connect all templates

Templates

Template Feature
(n, 6, 6, 256)

Frame T
(255, 255, 3)

Frame Feature
(22, 22, 256)

CNN

RPN

Cls Score (FG/BG)
(17, 17, 2k)

Cls Score (FG/BG)
(17, 17, 2k)

Cls Score (FG/BG)
(17, 17, 2k)

Bounding Box (x, y, w, h)
(17, 17, 4k)

SoftMax

Cls Score (FG/BG)
(17, 17, nk)

Visualization (not working, still in progress)
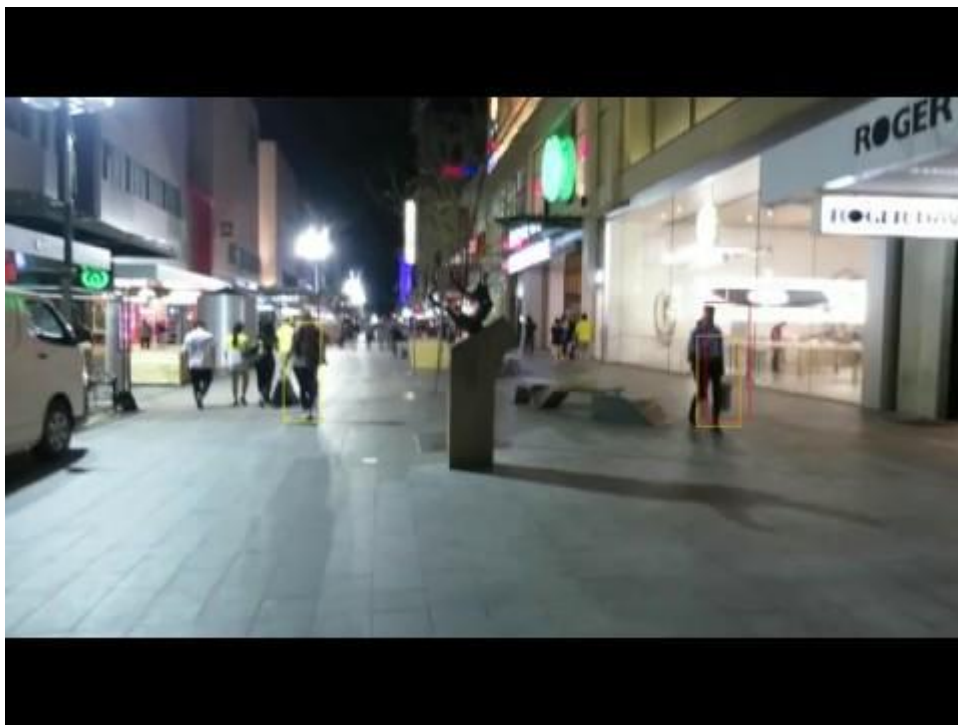
Ideas for Tracking

- Basic Idea: For loop (Done)
  - Initialize different single object tracker for each object
  - Time and memory complexity increase linearly
- All single object tracker share the same network weight (Done)
  - Pre-compute correlation filters and save
  - Fix the memory issue
- Introduce Communication between templates (In Progress)
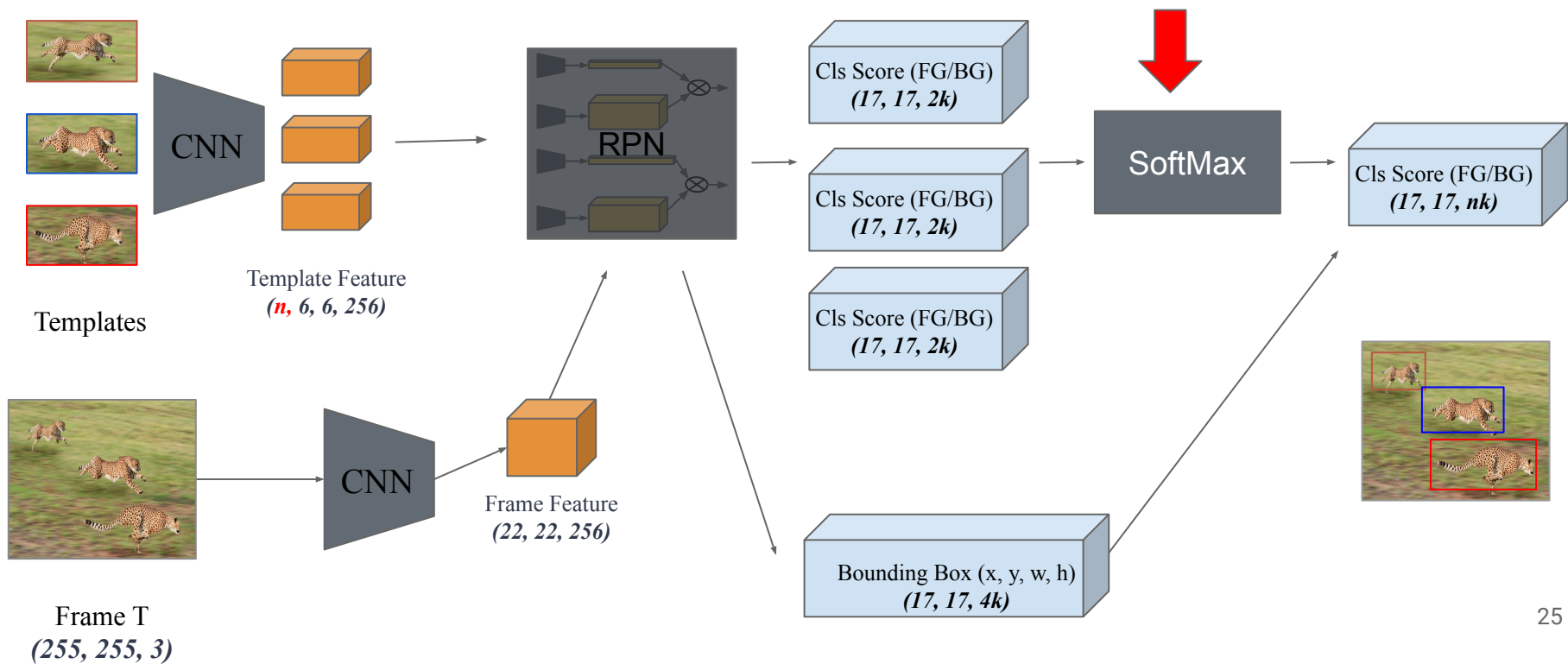 - Add Distractor-aware loss and fine-tune
- More Ideas
  - ROI Pooling to speed up

Timeline

Task	Person	Time	Result
SiamRPN test on VOT using official Code, Verify numbers	Richard		Done
Finetune SiamRPN on VOT, Verify numbers	Richard	4.11	In Progress
Finetune SiamRPN with ROI Pooling, Verify numbers	Richard	4.11	Code Done, need EXP
Two-template SIamRPN: A uniform architecture	Chunhui	4.11	In Progress
Two-template SIamRPN with ROI Pooling	Chunhui	4.18	
Data Association: concept design + implement		4.25	
Evaluation on MOT benchmark		5.3	