Comparative Evaluations of Selected Tracking-by-Detection Approaches: Supplemental Material

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APPENDIX

A.1 - Introduction

This document serves as the supplemental material for the main submission to IEEE TCSVT [1]. It principally lists the parameters tuned for the DPF and RJMCMC trackers, in addition to some parameters associated with the detectors. These two particle based trackers, DPF and RJMCMC, are our implementations (in C++). For the other trackers, namely: Tracker Hierarchy [2], SORT [3] and MDP [4], we rely on the parameters provided by the authors (please see the associated publications for details). Nevertheless, the detector and data association parameters remain the same as the ones used with DPF and RJMCMC.

A.2 - Tuned Parameters for DPF and RJMCMC

- Detection Thresholds
  - θ_{RCNN}: detection threshold used for RCNN.
  - θ_{DeepPed}: detection threshold used for DeepPed.
  - θ_{LDCF}: detection threshold used for LDCF.
  - θ_{ACF}: detection threshold used for ACF.
  - θ_{DPM}: detection threshold used for DPM.
  - $\theta_{\text{HOG-SVM}}$: detection threshold used for HOG-SVM.
- Detector Covariance Matrices
  - Σ_{RCNN}: sampling covariance matrix used for RCNN.
  - Σ_{DeepPed}: sampling covariance matrix used for DeepPed.
  - Σ_{LDCF}: sampling covariance matrix used for LDCF.
  - Σ_{ACF}: sampling covariance matrix used for ACF.
  - Σ_{DPM}: sampling covariance matrix used for DPM.
  - $\Sigma_{\text{HOG-SVM}}$: sampling covariance matrix used for HOG-SVM.
- DPF Specific Parameters
  - β: probability of sampling a particle from a target's dynamics.
  - α: probability of sampling a particle from a detector proposal.
  - γ: probability of sampling a particle from prior distribution.
  - λ: Bhattacharyya coefficient normalizing coefficient.
  - α_h: the rate used to update a target's color histogram.
  - N: total number of particles used per a particle filter (single target tracker).
  - N_T: maximum number of template histograms stored per target.
  - N_{birth}: the number of consecutive correctly associated detections of a target required before starting to track a target.
  - N_{death}: the number of consecutive missed associated detections of a tracked target required before terminating the track.
  - Σ_{dyn}: the covariance matrix used to model the uncertainty of a random walk.
- RJMCMC Specific Parameters
  - q_m: the detector specific move proposal distribution used by the RJMCMC tracker.
  - M: the total number of effective (without burn-in and thin-out particles) used by the RJMCMC tracker.
  - M_b: the number of burn-in particles in the RJMCMC tracker.
  - M_{th}: the number of thin-out particles in the RJMCMC tracker.
  - λ_{lmrf}: the distance normalizer used in the Markov Random Field (MRF) interaction model.
- Data Association
  - λ_d: parameter used to normalize the distance between a detection and a tracked target center point.
  - λ_s: parameter used to normalize the scale difference between a detection and a tracked target.
  - λ_{app}: parameter used to normalize the Bhattacharyya color histogram similarity coefficient between a detection and a tracked target.

REFERENCES

[1] A. A. Mekonnen, F. Lerasle, Comparative evaluations of selected tracking-by-detection approaches, in: Submitted to IEEE TCSVT, 2017.
[2] J. Zhang, L. L. Presti, S. Sclaroff, Online multi-person tracking by tracker hierarchy, in: IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS'12), Beijing, China, 2012.
[3] A. Bewley, Z. Ge, L. Ott, F. Ramos, B. Upcroft, Simple online and realtime tracking, in: IEEE International Conference on Image Processing (ICIP'16), 2016, pp. 3464–3468.
[4] Y. Xiang, A. Alahi, S. Savarese, Learning to track: Online multi-object tracking by decision making, in: IEEE International Conference on Computer Vision (ICCV'15), 2015.

Category	Symbol	Description	Set Value
Detectors	θ_{RCNN}, θ_{DeepPed}, θ_{LDCF}, θ_{ACF}, θ_{DPM}, $\theta_{\text{HOG-SVM}}$	Detection thresholds	$.00, 1.25, 37.64, 20.51, -.30, .00$
	Σ_{RCNN}	Detector covariance matrices	$diag(7.28, 17.24, .006)$
	Σ_{DeepPed}		$diag(6.25, 17.00, .007)$
	Σ_{LDCF}		$diag(6.57, 17.51, .007)$
	Σ_{ACF}		$diag(7.82, 15.90, .007)$
	Σ_{DPM}		$diag(12.86, 24.04, .007)$
	$\Sigma_{\text{HOG-SVM}}$		$diag(6.00, 14.81, .003)$
DPF Related	β, α, γ	Sampling proposal distribution parameters	.5, .5, 0
	λ	Bhattacharyya coefficient normalizer	.65
	α_h	Color histogram update rate	.04
	N	Number of particles	130
	N_T	Maximum number of templates (MT)	10
	N_{birth}	Required number of associated detections before tracking	11
	N_{death}	Required number of unassociated tracks before termination	11
	Σ_{dyn}	Random walk covariance matrix	$diag(19.08, 7.19, .003)$
RJMCMC Related	q_m	Move proposal distribution	RCNN: $\{.25, .0, .025, .0, .724, .001\}$ DeepPed: $\{.3, .0, .005, .0, .694, .001\}$ LDCF: $\{.3, .0, .005, .0, .694, .001\}$ ACF: $\{.15, .0, .1, .0, .749, .001\}$ DPM: $\{.1, .0, .1, .0, .849, .001\}$ HOG-SVM: $\{.05, .0, .1, .0, .849, .001\}$
	M	Number of effective RJMCMC particles	300
	M_b, M_{th}	Number of burn-in and thin-out particles	45, 4
	λ_{lmrf}	MRF interaction model distance normalizer	.00017
Evaluation	s_o	Tracked region overlap threshold (for correct match)	.5
Data Association	$\lambda_d, \lambda_s, \lambda_{app}$	Data association score component normalizers	.0044, 25.0, 44.4

Table A.1: Values of DPF and RJMCMC parameters tuned using PETS-S1L1 for evaluation on the PETS-S2L1 dataset.

Category	Symbol	Description	Set Value
Detectors	θ_{RCNN}, θ_{DeepPed}, θ_{LDCF}, θ_{ACF}, θ_{DPM}, $\theta_{\text{HOG-SVM}}$	Detection thresholds	$.15, 0.0, 55.0, 15.25, -.30, .00$
	Σ_{RCNN}	Detector covariance matrices	$diag(7.33, 17.15, .007)$
	Σ_{DeepPed}		$diag(6.15, 16.50, .007)$
	Σ_{LDCF}		$diag(7.55, 18.12, .007)$
	Σ_{ACF}		$diag(6.96, 16.24, .007)$
	Σ_{DPM}		$diag(12.33, 23.44, .007)$
	$\Sigma_{\text{HOG-SVM}}$		$diag(6.74, 15.94, .003)$
DPF Related	β, α, γ	Sampling proposal distribution parameters	.5, .5, 0
	λ	Bhattacharyya coefficient regularizer	.65
	α_h	Color histogram update rate	.075
	N	Number of particles	130
	N_T	Maximum number of templates (MT)	10
	N_{birth}	Required number of associated detections before tracking	8
	N_{death}	Required number of unassociated tracks before termination	8
	Σ_{dyn}	Random walk covariance matrix	$diag(18.05, 6.55, .005)$
RJMCMC Related	q_m	Move proposal distribution	RCNN: $\{.30, .0, .025, .0, .674, .001\}$ DeepPed: $\{.25, .0, .055, .0, .694, .001\}$ LDCF: $\{.3, .0, .005, .0, .694, .001\}$ ACF: $\{.20, .0, .1, .0, .699, .001\}$ DPM: $\{.175, .0, .05, .0, .774, .001\}$ HOG-SVM: $\{.05, .0, .1, .0, .849, .001\}$
	M	Number of effective RJMCMC particles	300
	M_b, M_{th}	Number of burn-in and thin-out particles	45, 4
	λ_{lmrf}	MRF interaction model distance regularizer	.00017
Evaluation	s_o	Tracked region overlap threshold (for correct match)	.5
Data Association	$\lambda_d, \lambda_s, \lambda_{app}$	Data association score component normalizers	.0044, 25.0, 44.4

Table A.2: Values of DPF and RJMCMC parameters tuned using ETH-Crossing dataset for performance evaluation on the ETH- datasets.