Part I. Definitions of main symbols.

Symbols	Descriptions
Γ	bilateral grid
Γ_t	the grid size corresponding to the temporal axis
t_l	time layer
v_i	grid cell
$\lvert v_i^f \rvert$ ($\lvert v_i^b \rvert$)	the number of pixels that are foreground (background) within v_i
$\alpha_{v_i}^f$ ($\alpha_{v_i}^b$)	the percentage of the foreground (background) pixels within v_i
$p_{t_l}^f$ ($p_{t_l}^b$)	foreground (background) appearance model for time layer t_l
p_{t_l}	normalized appearance (foreground) model for time layer t_l
$P(v_i)$ ($p_{t_l}(v_i)$)	probability of v_i to be the foreground
$S_{t_l}^f$ ($S_{t_l}^b$)	foreground (background) grid cells at time layer t_l
$S_{t_l}^a$	set of ambiguous colors at time layer t_l
$S_{t_l}^u$	set of unconstrained colors at time layer t_l
S^a	sets of ambiguous colors over all time layers
S^u	sets of unconstrained colors over all time layers
$p_{t_l}^a$	GMM trained from $S_{t_l}^a$ for time layer t_l
$p_{t_l}^a(v_i)$	probability of v_i be misclassified
$T_{t_l}^f$ ($T_{t_l}^b$)	minimum foreground (background) probability thresholds for time layer t_l
$\{(\pi_k^f, \mu_k^f, \Sigma_k^f)\}_{k=1}^K$	parameters of appearance model $p_{t_l}^f$
$\{(\pi_k^b, \mu_k^b, \Sigma_k^b)\}_{k=1}^K$	parameters of appearance model $p_{t_l}^b$

Part II. The main steps to construct the DAM with reliability measurements are summarized in Algorithm 1.

Algorithm 1 Reliable and Dynamic Appearance Modeling

Input: all non-empty grid cells $\{v_i \in \Gamma\}$

/* (1) constructing the dynamic appearance model $P=\{p_{t_l}\}_{t_l=1}^{\Gamma_t}$ ***/**

for $t_l \in \Gamma_t$ **do**

  step 1: compute the weight of each grid cell v_i using $|v_i^f|$, $\alpha_{v_i}^f$ (see details in eq. (4))

  step 2: build a foreground appearance model $p_{t_l}^f$

  step 3: repeat step 1 using $|v_i^b|$, $\alpha_{v_i}^b$ and step 2, and obtain the background appearance model $p_{t_l}^b$

  step 4: compute the normalized appearance (foreground) model p_{t_l} using $p_{t_l}^f$, $p_{t_l}^b$

  for v_i in time layer t_l **do**

    step 5: estimate the probability (to be the foreground) $P(v_i)=p_{t_l}(v_i)=p_{t_l}^f/(p_{t_l}^f+p_{t_l}^b)$

  end for

end for

/* (2) reliability measurements */

for $t_l \in \Gamma_t$ **do**

  /* (2.1) defining the ambiguous colors */

  step 6: validate the appearance models $p_{t_l}^f$ and $p_{t_l}^b$ using $S_{t_l}^f$ and $S_{t_l}^b$, and determine the misclassified colors $S_{t_l}^a$

  step 7: train an additional GMM $p_{t_l}^a$ from $S_{t_l}^a$

  /* (2.2) defining the unconstrained colors */

  step 8: compute the minimum probability thresholds $T_{t_l}^f$ and $T_{t_l}^b$ using the parameters $\{(\pi_k^f,\mu_k^f,\Sigma_k^f)\}_{k=1}^K$ and $\{(\pi_k^b,\mu_k^b,\Sigma_k^b)\}_{k=1}^K$ of $p_{t_l}^f$ and $p_{t_l}^b$, respectively. (see details in eq. (5))

  /* (2.3) discrimination */

  for v_i **in time layer** t_l **do**

    step 9: compute the probability $p_{t_l}^a(v_i)$

    if $p_{t_l}^a(v_i)>p_{t_l}^f(v_i)$ and $p_{t_l}^a(v_i)>p_{t_l}^b(v_i)$ **then**

      v_i is ambiguous ($v_i \in S_{t_l}^a$)

    end if

    if $p_{t_l}^f(v_i)<T_{t_l}^f$ and $p_{t_l}^b(v_i)<T_{t_l}^b$ **then**

      v_i is unconstrained ($v_i \in S_{t_l}^u$)

    end if

    if $v_i \in S_{t_l}^a$ or $v_i \in S_{t_l}^u$ **then**

      step 10: assign v_i a trivial likelihood $P(v_i)=0.5$

    end if

  end for

end for

Output: the probability of each grid cell $P(v_i)$
