Supplementary Materials of ”SI-Cut: Structural Inconsistency Analysis for Image Foreground Extraction”

1 Comparion Using a Structural Scene Dataset

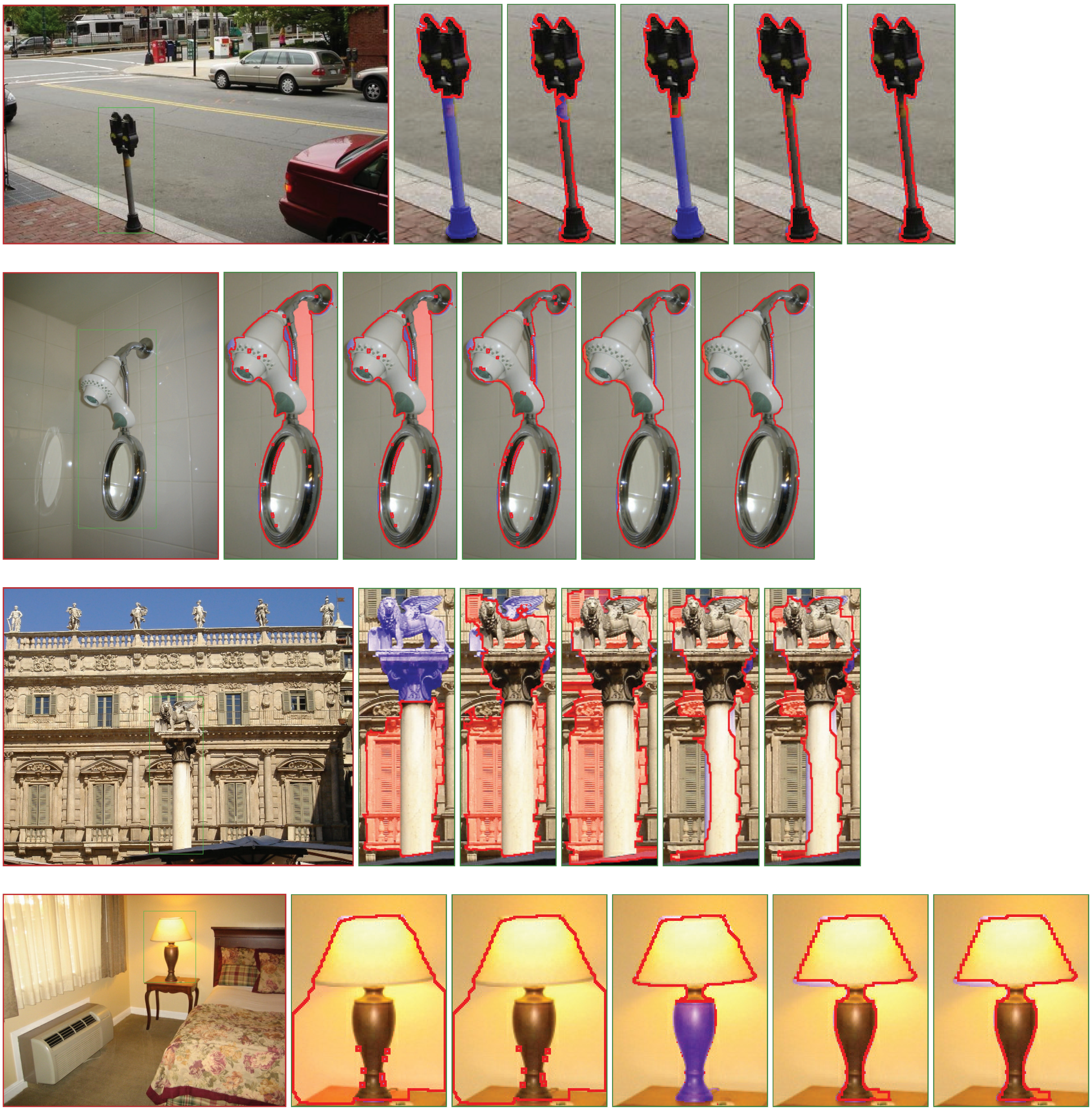

Fig. 1. Supplementary comparison for the structural scene dataset (part I). From left to right: (*left*) Input images and rectangles, (*mid-left 1*) GrabCut results, (*mid-left 2*) Box-prior results, (*mid-right 1*) One-cut results (individually optimal weights), (*mid-right 2*) the proposed results (auto-estimated iterations), and (*right*) the proposed results (user-assigned iterations).

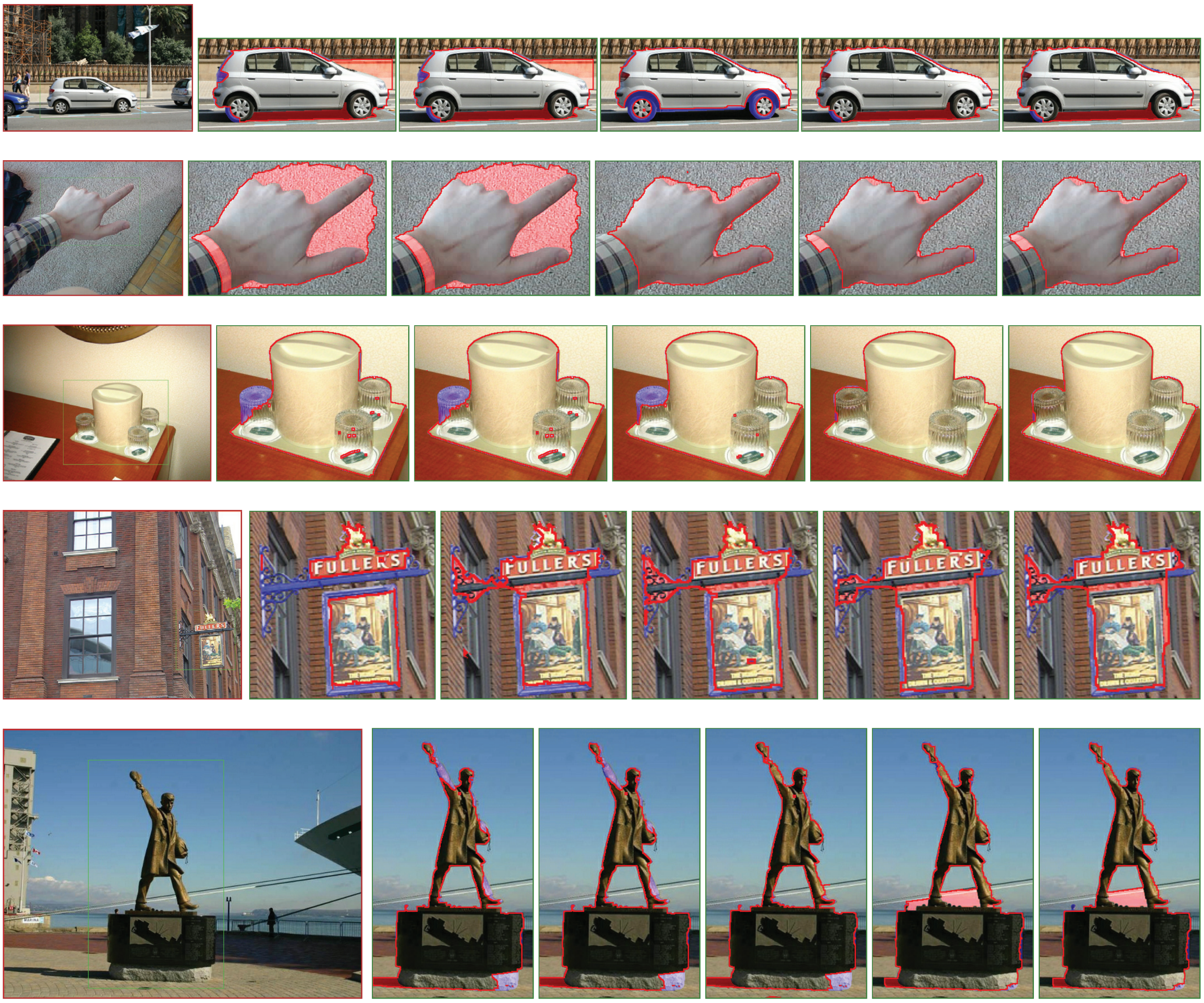

Fig. 2. Supplementary comparison for the structural scene dataset (part II). From left to right: (*left*) Input images and rectangles, (*mid-left 1*) GrabCut results, (*mid-left 2*) Box-prior results, (*mid-right 1*) One-cut results (individually optimal weights), (*mid-right 2*) the proposed results (auto-estimated iterations), and (*right*) the proposed results (user-assigned iterations).

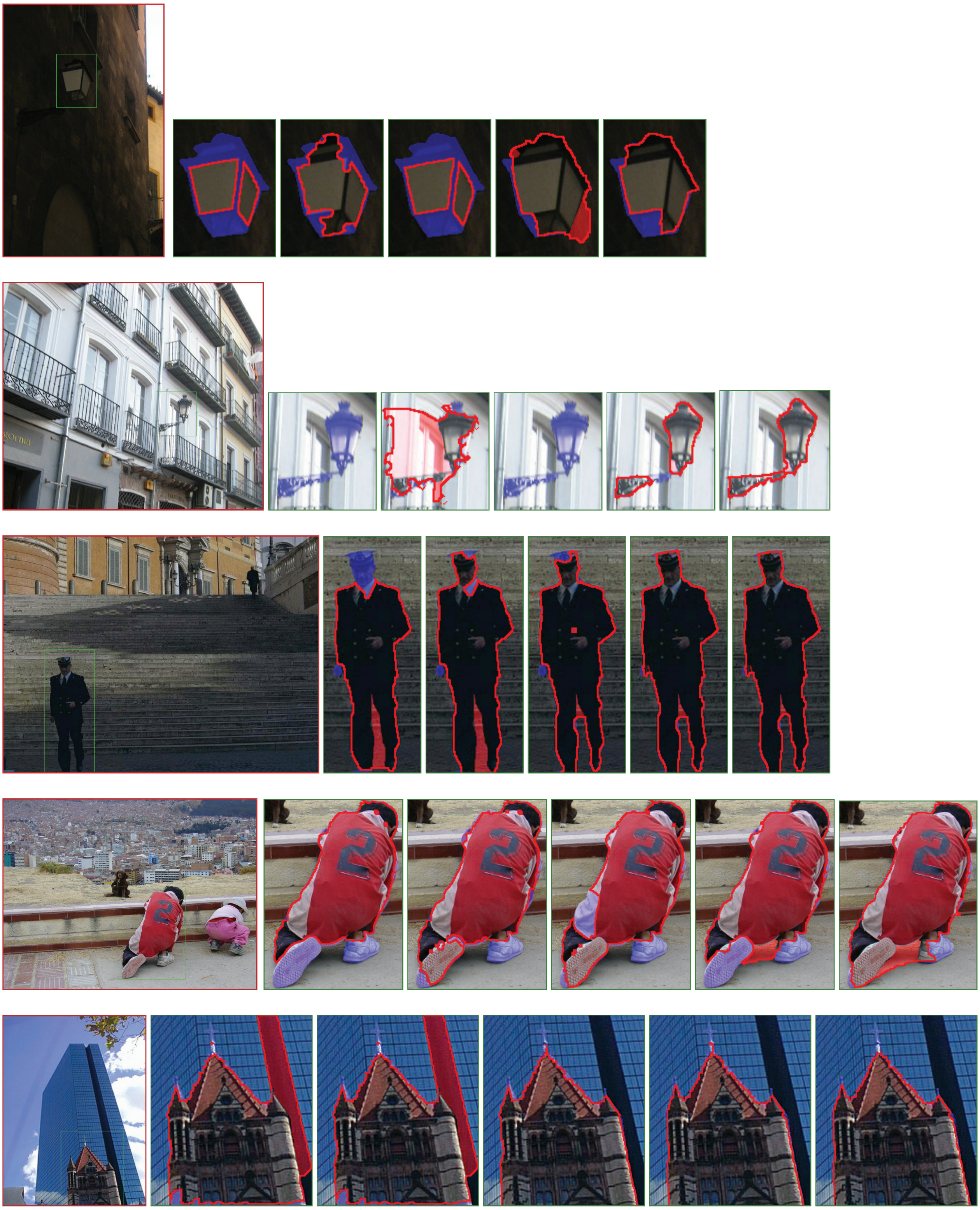

Fig. 3. Supplementary comparison for the structural scene dataset (part III). From left to right: (*left*) Input images and rectangles, (*mid-left 1*) GrabCut results, (*mid-left 2*) Box-prior results, (*mid-right 1*) One-cut results (individually optimal weights), (*mid-right 2*) the proposed results (auto-estimated iterations), and (*right*) the proposed results (user-assigned iterations).

2 Comparison Using the Grabcut Dataset

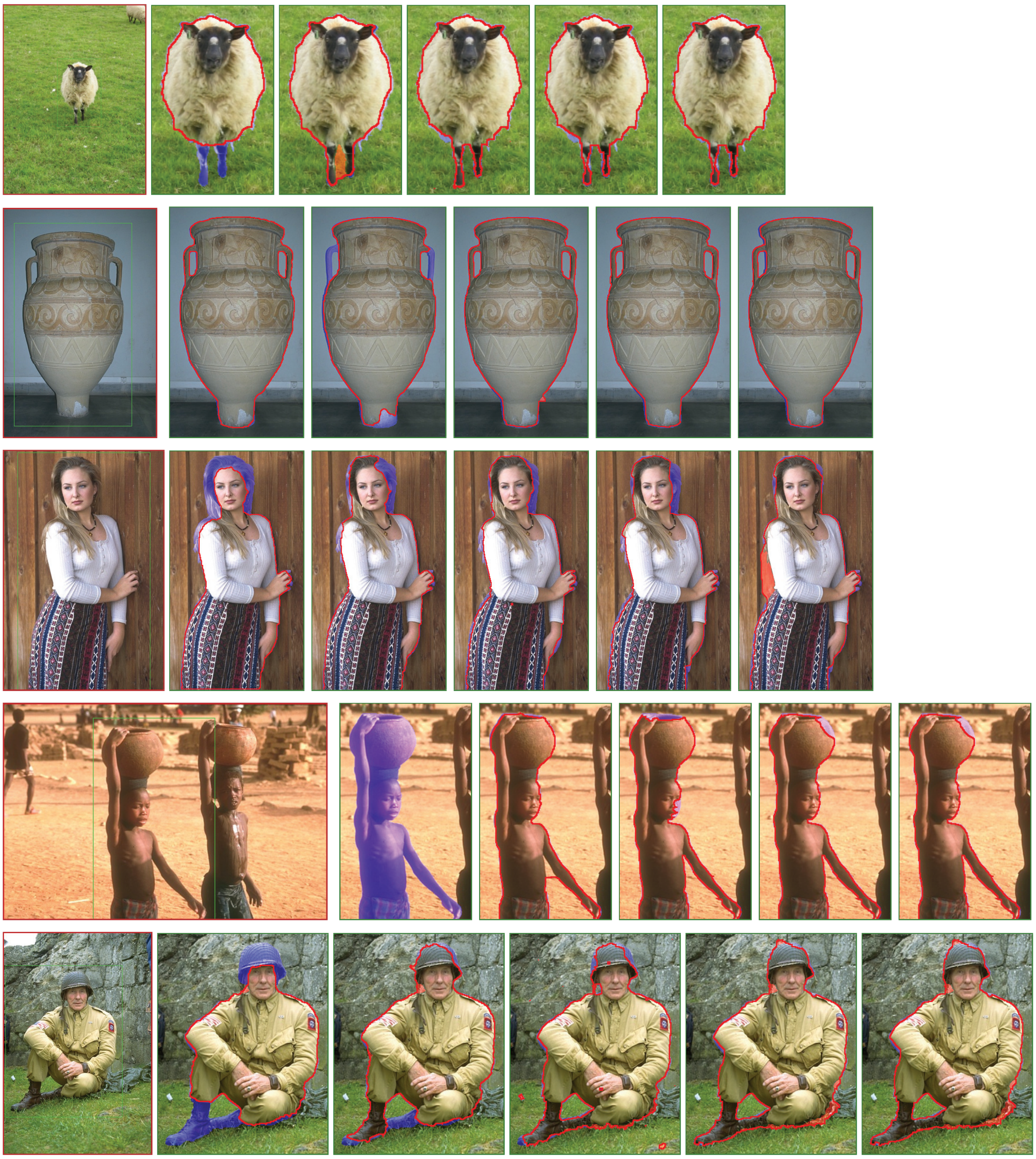

Fig. 4. Supplementary comparison for the Grabcut dataset (part I). From left to right: (*left*) Input images and rectangles, (*mid-left 1*) Grabcut results from [6], (*mid-left 2*) Box-prior results from [6], (*mid-right 1*) One-cut results (individually optimal weights), (*mid-right 2*) the proposed results (auto-estimated iterations), and (*right*) the proposed results (user-assigned iterations).

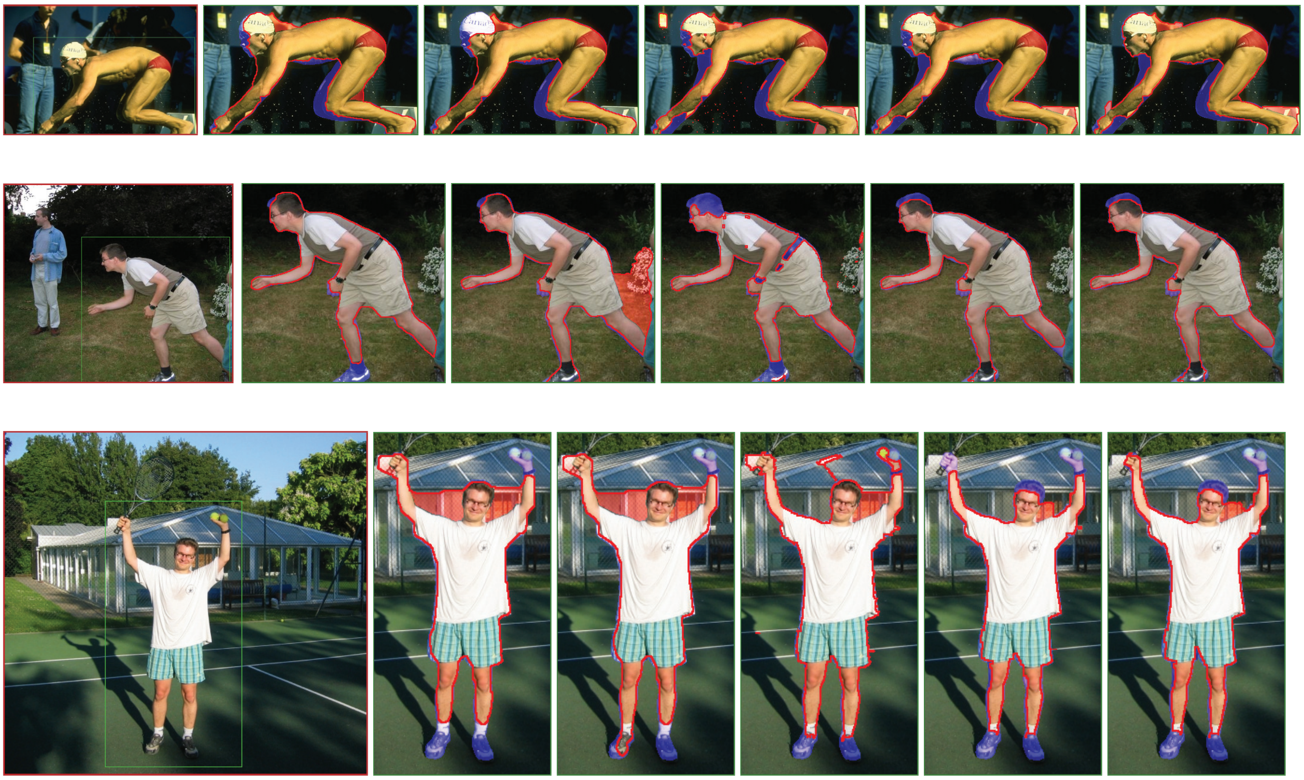

Fig. 5. Supplementary comparison for the Grabcut dataset (part II). In these cases, the One-cut has to use different bin, beta and weight numbers for satisfactory results. From left to right: (*left*) Input images and rectangles, (*mid-left 1*) Grabcut results from [6], (*mid-left 2*) Box-prior results from [6], (*mid-right 1*) One-cut results (individually optimal weights)(The One-cut result of Tennis is from [7]), (*mid-right 2*) the proposed results (auto-estimated iterations), and (*right*) the proposed results (user-assigned iterations).

3 Comparison on Examples with Extended SI-Cut

Fig. 6. Supplementary comparison for the GrabCut dataset (with extended SI-Cut). From left to right: (*left*) Input images and rectangles, (*mid-left 1*) Grabcut results from [6], (*mid-left 2*) Box-prior results from [6], (*middle*) One-cut results (individually optimal weights), (*mid-right 1*) our results (auto iterations without the bounding box constraint), (*mid-right 2*) the proposed results (auto iterations with extension), and (*right*) the proposed results (user-assigned iterations with extension).

4 Examples about Limitations and Failure Cases of the Proposed Method

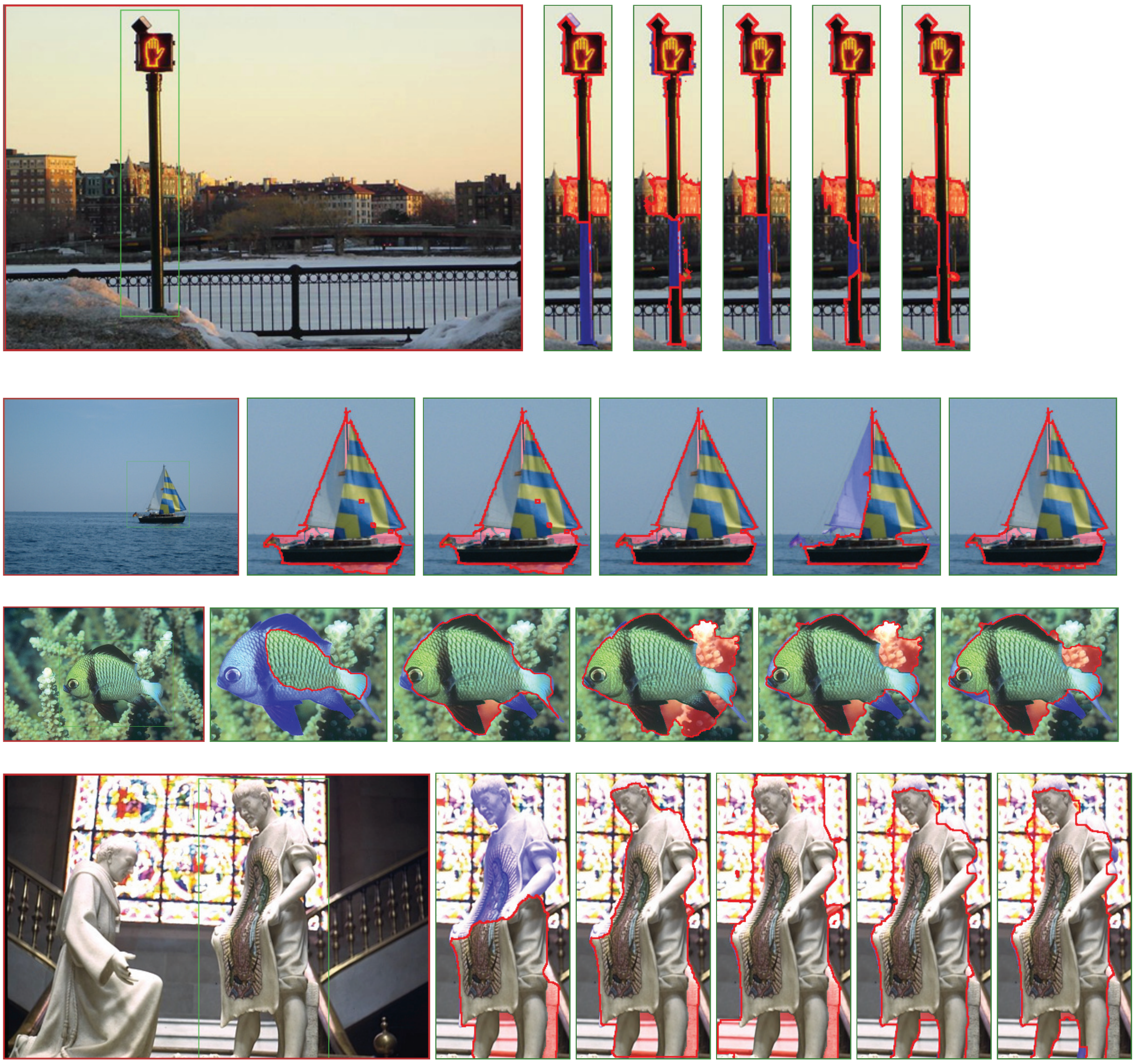

Fig. 7. Supplementary comparison for examples about limitations and failure cases of the proposed method. From left to right: (*left*) Input images and rectangles, (*mid-left 1*) GrabCut results (Fish and marble statue results are from [6]), (*mid-left 2*) Box-prior results (Fish and marble statue results are from [6]), (*mid-right 1*) One-cut results (individually optimal weights), (*mid-right 2*) the proposed results (auto-estimated iterations), and (*right*) the proposed results (user-assigned iterations).

Traffic light: With the bounding-box-distance constraint, the results generated by the proposed and Box-prior method do not excessively shrink. However, the illuminated facade behind the pole is of high inconsistency with respect to the predicted structure.

Boat: As shown in the proposed UA result, one iteration actually captures the boat shape. However, the iteration analyzer selected the contour fitting for the right sail, since its inconsistency value change is more conspicuous on the vtc_k curve. It is possible to use an additional region-size penalty to alleviate this situation.

Fish: Without sufficient references, the intricate coral structure within the rectangle is difficult to be accurately predicted and it results in an imperfect contour.

Marble statue: The various pictures on stained glass slowed the progress of background exclusion. By contrast, around the head and left shoulder of the statue, the boundary is blurry and colors are similar to the bright background. These two parts were excluded earlier than the window frame near the right arm. In this case, it is possible to use background prediction with a symmetry property to improve the prediction and segmentation.

5 Segmentation with Different Rectangle Sizes

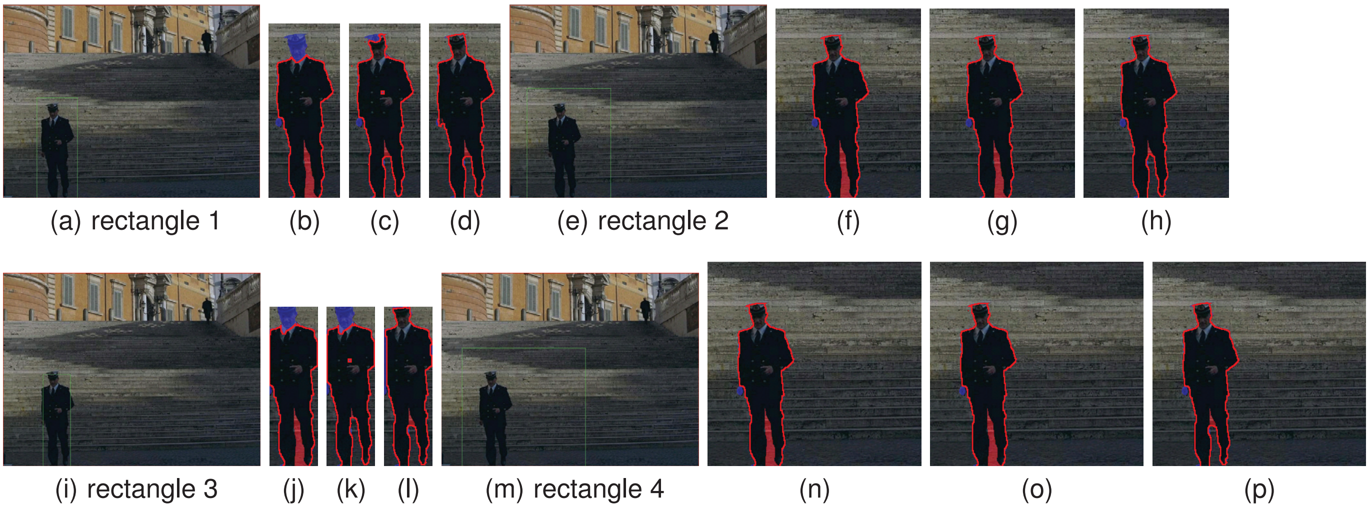

Fig. 8. Segmenting images with different sizes of indicated rectangles (part I). (a)(e)(i)(m) Input images and indicated rectangles. (b)(f)(j)(n) One-cut results (generally optimal weights). (c)(g)(k)(o) One-cut results (individually optimal weights). (d)(h)(l)(p) the proposed results (auto-estimated iterations). The bounding-box-distance constraint was turned off.

Rectangle 1: the original rectangle. **Rectangle 2**: a wider and higher rectangle.
Rectangle 3: a smaller rectangle (parts of the arms and hat are excluded). **Rectangle 4**: a much larger rectangle.

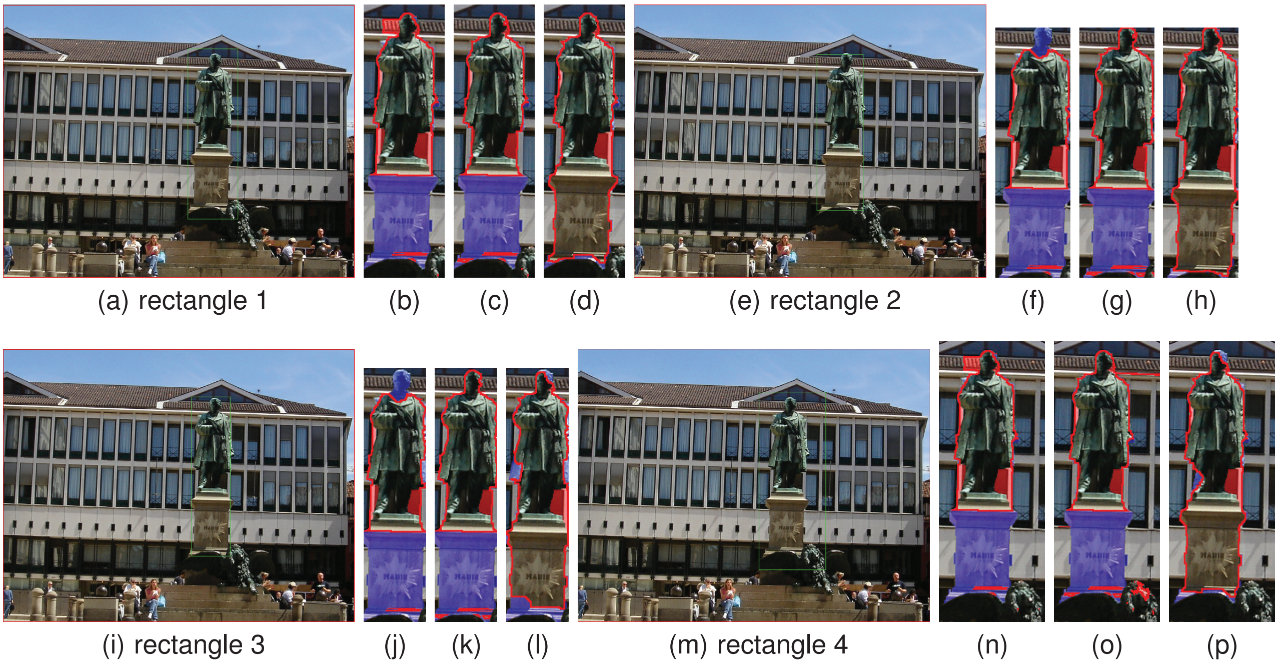

Fig. 9. Segmenting images with different sizes of indicated rectangles (part II). (a)(e)(i)(m) Input images and indicated rectangles. (b)(f)(j)(n) One-cut results (generally optimal weights). (c)(g)(k)(o) One-cut results (individually optimal weights). (d)(h)(l)(p) the proposed results (auto-estimated iterations). The bounding-box-distance constraint was turned off.

Rectangle 1: the original rectangle. **Rectangle 2**: a smaller rectangle (parts of the arm and head are excluded).
Rectangle 3: a smaller rectangle (parts of the arm and pedestal are excluded). **Rectangle 4**: a larger rectangle.

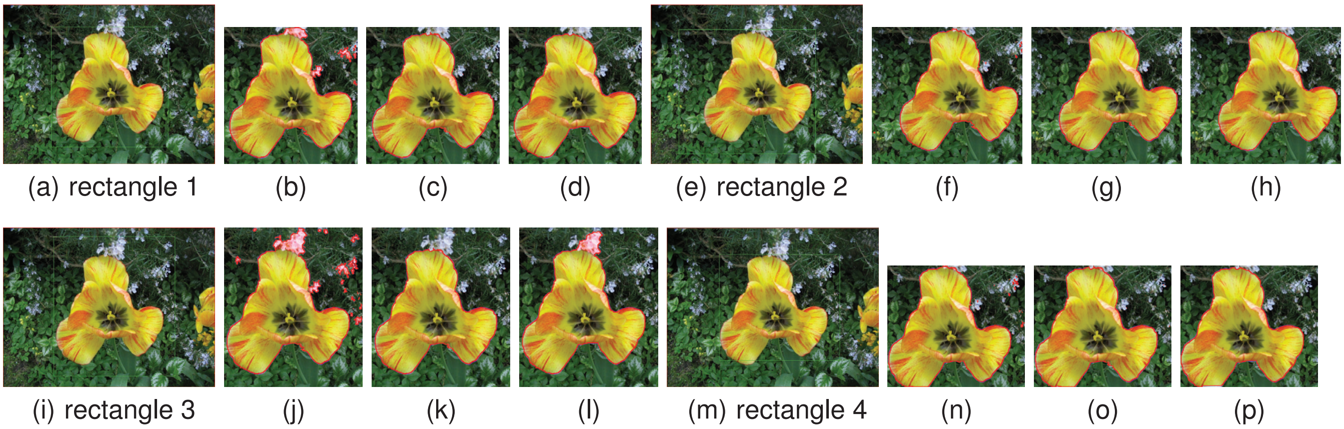

Fig. 10. Segmenting images with different sizes of indicated rectangles (part III). (a)(e)(i)(m) Input images and indicated rectangles. (b)(f)(j)(n) One-cut results (generally optimal weights). (c)(g)(k)(o) One-cut results (individually optimal weights). (d)(h)(l)(p) the proposed results (auto-estimated iterations). The bounding-box-distance constraint was turned off.

Rectangle 1: the original rectangle. **Rectangle 2**: a wider rectangle.
Rectangle 3: a taller rectangle (white flowers above are included). **Rectangle 4**: a smaller rectangle (parts of a petal are excluded).

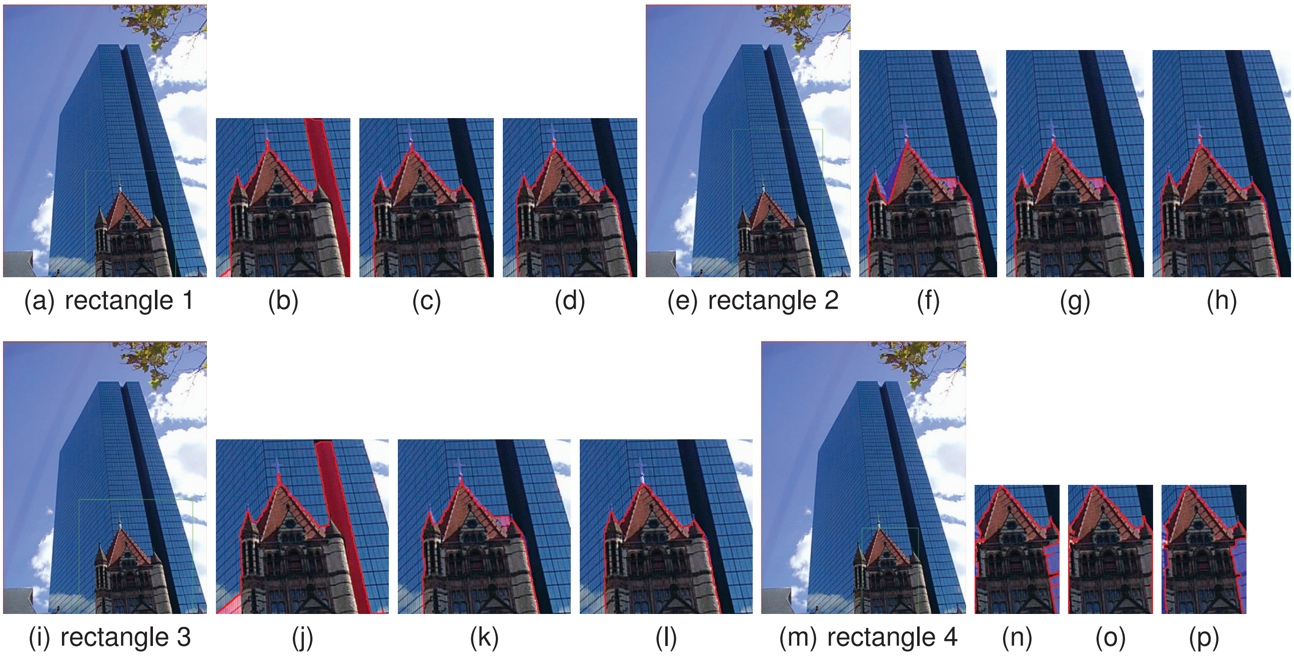

Fig. 11. Segmenting images with different sizes of indicated rectangles (part IV). (a)(e)(i)(m) Input images and indicated rectangles. (b)(f)(j)(n) One-cut results (generally optimal weights). (c)(g)(k)(o) One-cut results (individually optimal weights). (d)(h)(l)(p) the proposed results (auto-estimated iterations). The bounding-box-distance constraint was turned off.

Rectangle 1: the original rectangle. **Rectangle 2**: a taller rectangle.
Rectangle 3: a larger rectangle. **Rectangle 4**: a narrower rectangle (halves of the columns are excluded).

6 PSEUDO CODE OF THE ITERATION ANALYZER

Algorithm 1 The iteration analyzer

Input: Iteration ID cur_t, the top k% background consistency value cur_vtc_k, the residual target region cur_T, the indicated rectangle $BBox\_ind$, and (optional) user iteration assignment $user\_asg$.

Output: Whether the iterations stop $iter\_stop$, the best iteration interval t_{fb} and t_{bb}, and the corresponding regions F_{fb} and F_{bb}.

/* Store the cur_vtc_k and cur_T into lists. */
$vtc_k(cur\_t) \leftarrow cur\_vtc_k$;
$T(cur\_t) \leftarrow cur\_T$;

/* If users prefer the $T(cur\_t)$, stop the iterations and export the foreground region for optimization. */
if $user\_asg$ == TRUE **then**
    $t_{fb} \leftarrow cur\_t$
    $t_{bb} \leftarrow cur\_t$;
    $F_{fb} \leftarrow T(t_{fb})$;
    $F_{bb} \leftarrow T(t_{bb})$;
    $iter\_stop \leftarrow$ TRUE;
    return ;
end if

/* For the minimum variation criterion, evaluate the ratio $\frac{|T(cur\_t-1)-T(cur\_t)|}{|T(cur\_t-1)|}$ */
$var\_percent \leftarrow$ RegionVariationPercent($T(cur\_t-1)$, $T(cur\_t)$);

$BBox\_T \leftarrow$ BoundingBox($T(cur\_t)$); /* Evaluate the bounding box of $T(cur\_t)$ */

/* For the bounding-box-distance (excessively shrunk) criterion, ...*/
/*, evaluate the orthogonal distances between the horizontally and vertically closest sides of two boxes */
$(hor\_dist, ver\_dist) \leftarrow$ ClosestSideDistances($BBox\_ind$, $BBox\_T$);

/* Check the three essential stop criteria */
if $\big((cur\_t > maxiter\_th)$ or $(var\_percent < minvar\_th)$ or $(hor\_dist > maxhor\_th)$ or $(ver\_dist > maxver\_th)\big)$ **then**
    $(t_{fb}, t_{bb}) \leftarrow$ BestInterval(vtc_k); /* Evaluate the best interval from the vtc_k curve */
    $F_{fb} \leftarrow T(t_{fb})$;
    $F_{bb} \leftarrow T(t_{bb})$;
    $iter\_stop \leftarrow$ TRUE;
else
    $iter\_stop \leftarrow$ FALSE;
end if

Algorithm 2 BestInterval(): The best interval from the vtc_k curve

Input: Input vtc_k list.
Output: The best interval t_{fb} and t_{bb}.

/* v_{max}, c and th are constants or thresholds */
$f \leftarrow$ BilateralFilter(vtc_k); /* t represents the iteration index */
$t_h \leftarrow$ BackwardFindHighestValueIter(f); /* $f(t_h)$ is max($f(t)$) */
$t_m \leftarrow$ ForwardFindMiddleValueIter(f); /* $f(t_m)$ is just smaller than $\frac{f(t_h)+f(1)}{2}$ */

/* If the slope of f curve is too flat, t_h and $t_h - 1$ are assigned t_{bb} and t_{fb}. */
if $\frac{f(t_h)-f(1)}{t_h-1} < th_{flat}$ **then**
  $t_{bb} = t_h$;
  $t_{fb} = t_h - 1$;
  return ;
end if

/* In the backward search, t_{bb} is the first iteration below the tangent line L_{tng} of t_h. */
$t_{bb} = t_h$; /* Initialize the t_{bb} */
v_{bw} = min$\big(v_{max}, \big(f(t_h) - f(t_h - 1)\big)\big)$; /* The local slope of L_{tng} */
$y = f(t_h)$; /* y is the height of L_{tng} at iteration t */
for iteration $t = t_h \rightarrow (t_m + 1)$ **do**
  if $(f(t) + c) < y$ **then** /* If the distance between $f(t)$ and L_{tng} is larger than a small c, */
    $t_{bb} = t$; **break**;
  end if
  $y = y - v_{bw}$; /* Update the current height of L_{tng} */
end for

/* In the forward search, t_{fb} is the first iteration whose left derivative is much larger than the right one. */
$t_{fb} = t_{bb}$; /* Initialize the t_{fb} */
for iteration $t = \big(t_m + 1\big) \rightarrow t_h$ **do**
  if $\big(f(t) - f(t-1)\big) > \big(f(t+1) - f(t) + th\big)$ **then**
    $t_{fb} = t$; **break**;
  end if
end for

/* When $t_{fb} > t_{bb}$, exchange their values. */
if $t_{fb} > t_{bb}$ **then**
  $t_{tmp} = t_{fb}$;
  $t_{fb} = t_{bb}$;
  t_{bb} = min$(t_{tmp}, \big(t_{fb} + 1\big))$;
end if