Algorithm 2 Original Connected Component Analysis

Input: $\mathbf{S} \in \mathbb{R}^{C \times H \times W}$ {Segmentation mask}
Input: $\mathbf{L} \in \mathbb{R}^{C \times H \times W}$ {Segmentation logits}
Input: τ {Coarse threshold}
Input: $A_{\min}$ {Minimal area threshold}
Input: split_last $\in$ {True, False}

$\mathcal{R} \leftarrow \emptyset, \mathcal{B} \leftarrow \emptyset, \mathcal{S} \leftarrow \emptyset, \mathcal{P} \leftarrow \emptyset$
for $c \leftarrow 0$ **to** $C - 1$ **do**
  if $\neg$split_last $\wedge\ c = C - 1$ **then**
    continue
  end if
  $\mathcal{R}[c] \leftarrow \emptyset, \mathcal{P}[c] \leftarrow \emptyset, \mathcal{S}[c] \leftarrow \emptyset, \mathcal{B}[c] \leftarrow \emptyset$
  $\mathbf{M}_c \leftarrow \mathbf{S}[c]$ {Class mask}
  $\mathbf{L}_c \leftarrow \mathbf{L}[c]$ {Class logit}
  if $\max(\mathbf{L}_c) < \tau$ **then**
    continue
  end if
  $\mathbf{M}_{\text{labeled}} \leftarrow \mathcal{F}_{\text{label}}(\mathbf{M}_c, 2)$ {2-connected labeling}
  $N_{\text{regions}} \leftarrow \max(\mathbf{M}_{\text{labeled}})$
  for $r \leftarrow 1$ **to** N_{regions} **do**
    $\mathbf{M}_r \leftarrow \mathbb{I}[\mathbf{M}_{\text{labeled}} = r]$ {Region indicator mask}
    if $\sum_{i,j} \mathbf{M}_r[i,j] < A_{\min}$ **then**
      continue
    end if
    $s_r \leftarrow \frac{1}{|\Omega_r|} \sum_{(i,j) \in \Omega_r} \mathbf{L}_c[i,j]$ {Ω_r is region r}
    $\mathbf{L}_r \leftarrow \mathbf{L}_c \odot \mathbf{M}_r$
    $(i^*, j^*) \leftarrow \arg\max_{i,j} \mathbf{L}_r[i,j]$
    $\mathcal{P}[c] \leftarrow \mathcal{P}[c] \cup \{(j^*, i^*)\}$
    $\mathcal{R}[c] \leftarrow \mathcal{R}[c] \cup \{\mathbf{M}_r\}$
    $\mathcal{S}[c] \leftarrow \mathcal{S}[c] \cup \{s_r\}$
  end for
  if $|\mathcal{R}[c]| > 0$ **then**
    $\mathcal{R}[c] \leftarrow \text{stack}(\mathcal{R}[c])$ {Stack region masks}
    if $\mathcal{R}[c] = \emptyset$ **then**
      $\mathcal{B}[c] \leftarrow \mathcal{R}[c]$
    else
      $\mathcal{B}[c] \leftarrow \mathcal{F}_{\text{masks\_to\_boxes}}(\mathcal{R}[c])$
    end if
  end if
end for

Output: $\mathcal{R}, \mathcal{B}, \mathcal{S}, \mathcal{P}$ {Regions, boxes, scores, points}

Algorithm 3 Optimized Connected Component Analysis

Input: $\mathbf{S} \in \mathbb{R}^{C \times H \times W}$ {Segmentation mask}
Input: $\mathbf{L} \in \mathbb{R}^{C \times H \times W}$ {Segmentation logits}
Input: τ {Coarse threshold}
Input: $A_{\min}$ {Minimal area threshold}
Input: split_last $\in$ {True, False}

$\mathcal{R} \leftarrow \emptyset, \mathcal{B} \leftarrow \emptyset, \mathcal{S} \leftarrow \emptyset, \mathcal{P} \leftarrow \emptyset$
$\mathcal{D} \leftarrow \text{device}(\mathbf{L})$ {Device information}
$\mathbf{L}_{\max} \leftarrow \max_{h,w} \mathbf{L}_{c,h,w} \quad \forall c \in \{0, 1, \ldots, C-1\}$ {Class-wise max values}
$\mathcal{C}_{\text{valid}} \leftarrow \{c \mid \mathbf{L}_{\max}[c] \geq \tau\}$ {Pre-filter valid classes}
for $c \leftarrow 0$ **to** $C - 1$ **do**
  if $\neg$split_last $\wedge\ c = C - 1$ **then**
    continue
  end if
  $\mathcal{R}[c] \leftarrow \emptyset, \mathcal{P}[c] \leftarrow \emptyset, \mathcal{S}[c] \leftarrow \emptyset, \mathcal{B}[c] \leftarrow \emptyset$
  if $c \notin \mathcal{C}_{\text{valid}}$ **then**
    continue
  end if
  $\mathbf{M}_c \leftarrow \mathbf{S}[c]$ {Class mask (CPU memory)}
  $\mathbf{L}_c \leftarrow \mathbf{L}[c]$ {Class logit}
  $(\mathbf{M}_{\text{labeled}}, N_{\text{labels}}, \mathbf{\Gamma}) \leftarrow \mathcal{F}_{\text{CC}}(\mathbf{M}_c, 8)$ {8-connected components with stats}
  if $N_{\text{labels}} \leq 1$ **then**
    continue
  end if
  $\mathcal{V} \leftarrow \emptyset$ {Valid masks}
  for $r \leftarrow 1$ **to** $N_{\text{labels}} - 1$ **do**
    $\mathbf{M}_r \leftarrow \mathbb{I}[\mathbf{M}_{\text{labeled}} = r]$ {Region indicator mask}
    $A_r \leftarrow \mathbf{\Gamma}[r, \text{AREA}]$ {Region area from component stats}
    if $A_r < A_{\min}$ **then**
      continue
    end if
    $\mathbf{M}_r^{\mathcal{D}} \leftarrow \mathcal{F}_{\text{to\_device}}(\mathbf{M}_r, \mathcal{D})$ {Transfer to device}
    $s_r \leftarrow \frac{1}{|\Omega_r|} \sum_{(i,j) \in \Omega_r} \mathbf{L}_c[i,j]$ {Ω_r is region r}
    $\mathbf{L}_r \leftarrow \mathbf{L}_c \odot \mathbf{M}_r^{\mathcal{D}}$
    $(i^*, j^*) \leftarrow \arg\max_{i,j} \mathbf{L}_r[i,j]$
    $\mathcal{P}[c] \leftarrow \mathcal{P}[c] \cup \{(j^*, i^*)\}$
    $\mathcal{R}[c] \leftarrow \mathcal{R}[c] \cup \{\mathbf{M}_r\}$
    $\mathcal{S}[c] \leftarrow \mathcal{S}[c] \cup \{s_r\}$
    $\mathcal{V} \leftarrow \mathcal{V} \cup \{\mathbf{M}_r\}$ {Track valid masks}
  end for
  if $|\mathcal{R}[c]| > 0$ **then**
    $\mathcal{R}[c] \leftarrow \mathcal{F}_{\text{to\_device}}(\text{stack}(\mathcal{V}), \mathcal{D})$ {Stack valid masks}
    $\mathcal{B}[c] \leftarrow \mathcal{F}_{\text{masks\_to\_boxes}}(\mathcal{R}[c])$ {Convert masks to boxes}
  else
    $\mathcal{B}[c] \leftarrow \mathcal{R}[c]$ {Empty collection for invalid classes}
  end if
end for

Output: $\mathcal{R}, \mathcal{B}, \mathcal{S}, \mathcal{P}$ {Regions, boxes, scores, points}