INTERACTIVE IMAGE

SEGMENTATION USING PARTICLE COMPETITION AND COOPERATION



The International Joint Conference on Neural Networks



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Abstract - Many interactive image processing approaches are based on semi-supervised learning, which employ both labeled and unlabeled data in its training process. In the interactive image segmentation problem, a human specialist labels some pixels of an object while the semi-supervised algorithm labels the remaining pixels of the segment. The particle competition and cooperation model is a recent graph-based semi-supervised learning approach. It employs particles walking in a graph to classify the data items corresponding to graph nodes. Each particle group aims to dominate most unlabeled nodes, spreading their label, and preventing enemy particles invasion. In this paper, the particle competition and cooperation model is extended to perform interactive image segmentation. Each image pixel is converted into a graph node, which is connected to its nearest neighbors according to their visual features and location in the original image. Labeled pixel generates particles that propagate their label to the unlabeled pixels. The particle model also takes the contributions from the adjacent pixels to classify less confident labeled pixels. Computer simulations are performed on real-world images, including images from the Microsoft GrabCut dataset, which allows a straightly comparison with other techniques. The segmentation results show the effectiveness of the proposed approach.

Particle Competition and Cooperation

An undirected and unweight graph is generated from the image. Each pixel becomes a graph node. Each node is connected to its *k*-nearest neighbors according to some pixel features.



Proposed Method Segmentation Example: (a) original image to be segmented (16x16 pixels); (b) original image with user labeling (green and red traces); and (c) graph generated after the original image, where each image pixel corresponds to a graph node. Labeled nodes are colored blue and yellow, and unlabeled nodes are colored grey. Each labeled node will have a particle assigned to it.



A particle gets strong when it selects a node being dominated by its own team, but it gets weak when it selects a node being dominated by another team.











A particle is generated for each labeled node. Particles initial position are set to their corresponding nodes. Particles with same label play for the same team and cooperate with each other. Particles with different labels compete against each other.



Each particles randomly chooses a neighbor to visit at each iteration. Nodes which are already dominated by the particle team and closer to particle initial node have higher probabilities of being chosen.

Computer Simulations



(a) Original image, (b) Trimap providing seed regions, and (c) Close-up foreground segmentation results by the proposed method.



$$v_i^{\omega_c} = \begin{cases} 1 & \text{if } x_i \text{ is labeled } y(x_i) = c \\ 0 & \text{if } x_i \text{ is labeled } y(x_i) \neq c \\ 1/c & \text{if } x_i \text{ is unlabeled} \end{cases}$$
$$v_i^{\omega_c}(t+1) = \begin{cases} \max\left\{0, v_i^{\omega_c}(t) - \frac{0.1 \rho_j^{\omega}(t)}{C-1}\right\} \end{cases}$$

 $v_i^{\omega_c}(t+1) = \begin{cases} \max\left\{0, v_i^{\omega_c}(t) - \frac{0.1 \, \rho_j(t)}{C-1}\right\} & \text{if } c \neq \rho_j^c \\ v_i^{\omega_c}(t) + \sum_{r \neq c} v_i^{\omega_r}(t) - v_i^{\omega_r}(t+1) & \text{if } c = \rho_j^c \end{cases}$

(a) Nodes have a domination vector. Labeled nodes have ownership set to their respective teams (classes). Unlabeled nodes have ownership levels set equally for each team. (b) When a particle selects a neighbor to visit: it decreases the domination level of the other teams while it increases the domination level of its own team. Exception: labeled nodes domination levels are fixed.

(b) (a) Original images from the GrabCut dataset, and (b) The trimaps providing seed regions. Close-up foreground segmentation results from the proposed method.

Image	DINH	PCC
208001 (mushroom)	3,65%	6,19%
271008 (children)	5,12%	7,67%
person7	2,82%	1,53%
sheep	5,85%	1,24%
124084 (flowers)	3,51%	1,09%

Comparison of the error rates obtained by the Directed Hypergraph Model (DINH) and those obtained by our proposed Particle Competion and Cooperation Method (PCC)

