**Multilevel Object Closure Detection By Superpixels**

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**1. Abstract**

**2. Introduction:**

**2.1 Background and Literature Review**

The closure of any object in an image sets the scope for the pixels for the object, and those pixels within the closure can be used for further application, for example neural network models for recognition tasks. Finding a good closure for an object thus can be thought as a preprocessing to focus the recognition on a specific object instead of finding a main object among a few possible objects. While the definition of objects can be vague and abstract, if we treat objects in different level, we will be able to have priority in detecting objects in an image. For example, an image may contain a car, a tree, and a person. This might be the most outer level of objects. Then, in the car, there are the front windshield, wheels, front hood, headlights, and so on. These are the objects in the next level constrained by the closure of the car, and they can also be detected by their closures. In our project, we develop a hierarchical structure that can separate the image depending on the need of the user, for instance how specific for objects and in what range.

However, there are many challenges in obtaining contour closure, linking together a set of fragmented contours into a cycle that separates an object from its background. Early perceptual grouping researchers [61] identified a set of non-accidental contour relations, such as symmetry, parallelism, collinearity, co-curvilinearity, etc., that can be used to link together causally related contours. However, the space of possible closures is still overwhelming, particularly when one allows larger and larger boundary gaps in a closure. Finding an optimal solution is intractable without somehow reducing the complexity of the problem.

In our project, we used Alex’s method that reformulates the problem of searching for cycles of contours as the problem of searching for a subset of superpixels whose border has strong contour support in the contour image; the assumption we make here is that those salient contours that define the boundary of the object (our target closure) will align well with superpixel boundaries. In this method, parametric maxflow is used to yield the top k solutions. In every layer of the hierarchy, the user can choose one of the result that best fits his demand and do the deeper layer.

**Objective:**

We develop a hierarchical structure that can segment image based on the user’s demand. In the structure, the user apply superpixels to detect objects’ closures in different levels. And in each level, superpixels are used to both set a scope for object-searching and find the closures for the possible objects in that scope. At different level, the extracted parts can be used for more specific further usage.

**Resources Needed:**

* Papers of different applications of superpixels.
* Existing code for implementing the superpixels and finding the basic closures for an image.
* Images that have been tagged for multiple objects within each of the images.

**Related Readings (unsorted):**

[1] The representation and matching of categorical shape, 2006, by Ali Shokoufandeh, Lars Bretzner, Diego Macrini, M. Fatih Demirci,Clas JoÅNnsson, Sven Dickinson.

[2] View-based object recognition using saliency maps, 1998, by Ali Shokoufandeh, Ivan Marsic, Sven J. Dickinson.

[3] Closing the Loop for Edge Detection and Object Proposals, 2017, by Yao Lu and Linda Shapiro.

[4] Efficient Closed Contour Extraction from Range Image’s Edge Points, 2005, by Angel D. Sappa.

[5] Segmentation of Multiple Salient Closed Contours from Real Images, 2003, by Shyjan Mahamud, Lance R. Williams, Karvel K. Thornber, and Kanglin Xu.

[6] SLIC Superpixels, 2010, by Radhakrishna Achanta, Appu Shaji, Kevin Smith, Aurelien Lucchi, Pascal Fua, and Sabine Susstrunk.

[7] Superpixel Hierarchy, 2016, by Xing Wei, Qingxiong Yang, Yihong Gong, Ming-Hsuan Yang, Narendra Ahuja.

[8] Superpixel Benchmark and Comparison, by Peer Neubert and Peter Protzel.

[9] Superpixel Segmentation using Linear Spectral Clustering, 2015, by Zhengqin Li, Jiansheng Chen.