Walk the Lines: Object Contour Tracing CNN for Contour Completion of Ships

André Peter Kelm, Udo Zölzer
Department of Signal Processing and Communications,
Helmut-Schmidt-University, Hamburg,
andre.kelm@hsu-hh.de

HELMUT SCHMIDT UNIVERSITÄT
Universität der Bundeswehr Hamburg

Abstract

We develop a new contour tracing algorithm to enhance the results of the latest object contour detectors. The goal is to achieve a perfectly closed, single-pixel wide and detailed object contour, since this type of contour could be analyzed using methods such as Fourier descriptors (FD). Therefore, we present the Walk the Lines (WtL) algorithm: a standard regression CNN trained to follow object contours. Convolutional Neural Networks (CNNs) are rarely used for contour tracing, and we see great potential in using their capabilities for this task. As initial step, we train the CNN only on ship contours, but the principle is applicable to other objects. In contrast to the comparable Non-Maximum Suppression (NMS) method, our approach produces connected contours with finer details.

Introduction

Complete object contours extracted from an image contain relevant information about the shape of the photographed objects and are used in many areas of computer vision. Driven by the recent success of deep learning methods, the object contour detection has made great progress. The outputs of these detectors are so-called soft contour maps. The most commonly used post-processing method, the NMS, breaks the soft contour when thinning out.

Figure 1: Example of an object contour prediction (left) and its post-processing by the NMS (right). Red circles indicate where disconnections of the object contour are introduced.

There is no easy way to synthesize and analyze them with methods like FD, because these normally require complete contours. For this we propose an alternative to the NMS.

Walk the Lines

Input data are the image and the associated object contour prediction of the recently published RefineContourNet (RCN). The WtL is located on a center point that defines an input section. After cropping this, the patch is rotated so that the CNN to be fed with it always receives the input aligned as defined by the previous step itself. The WtL predicts its steps pixelwise in a selfrouting way and ideally moves along the contour. The core is a standard regression CNN.

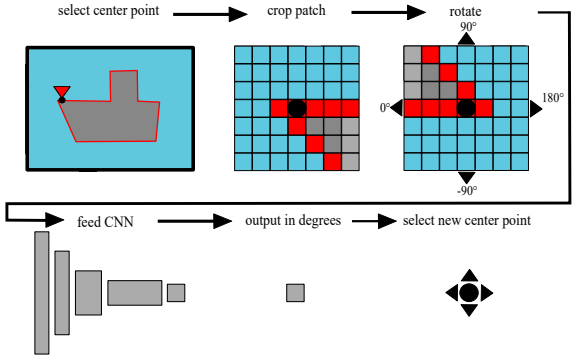

Figure 2: Algorithm steps

Dataset and Training

To train the CNN to follow contours, a workflow and training data with very detailed contours, the Detailed Ship Contour (DSC) dataset, are used.

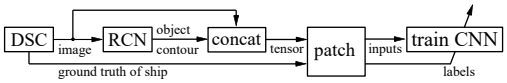

Figure 3: Workflow to generate training data

Object Contour Completion

A single tracer has many possibilities to deviate from the correct object contour. Therefore, we want to use many tracers at different image locations, so that a closed object contour is drawn. Finally, we sum up all walked lines and return the WtL contour.

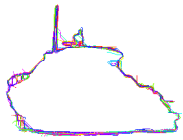

Figure 4: Several tracers

Object Contour Binarization

The WtL contour is a grayscale image and must now be converted into a binary, single-pixel wide and detailed object contour. A third procedure is implemented to obtain as much detail as possible, by searching for the highest threshold that closes the object contour.

Results and Conclusion

The algorithm is applied to ten randomly selected test images of our dataset. The object contour completion by WtL draws excellent object contour maps on which many specific details of the original object can be seen. Compared to the results from the NMS, the contour is a bit more detailed and wider. The main advantage, however, is that WtL contours are connected and can be converted into a closed binary contour without losing many details. The binarization is completely automatic, but so far it only works for a limited number of images. For these, we produce excellent segmentations with very high IoUs and reveal details that are easily omitted, such as antennas and ship superstructures.

Method	Metric	1	2	3	4	5	6	7	8	9	10	∅	$\varnothing_{1,2,6,8}$
Binary WtL	1. cl. sh.	**yes**	**yes**	OL	DL	WL	**yes**	OL	**yes**	OL	DL	-	-
NMS	1. cl. sh.	no	no	no	no	no	no	no	no	no	no	-	-
WtL-seg	P	94.23	**93.66**	77.04	91.90	84.11	86.88	72.67	82.56	73.10	91.47	82.66	88.54
	R	**99.60**	**99.05**	**99.98**	**98.99**	**99.88**	**99.82**	50.13	**99.25**	72.13	11.65	50.13	**99.52**
	IoU	**93.87**	**92.83**	77.03	91.04	84.02	86.75	42.17	82.05	57.00	11.52	70.36	**88.17**
RN	P	**98.52**	87.76	**95.97**	**97.32**	**96.68**	**96.52**	**95.07**	**93.37**	**87.64**	**96.86**	**94.55**	**95.00**
	R	88.27	94.16	95.34	93.92	92.93	90.86	**88.69**	89.63	**93.68**	**78.41**	**90.98**	90.25
	IoU	87.11	83.23	**91.67**	**91.55**	**90.06**	**87.98**	**84.79**	**84.26**	**82.75**	**76.46**	**86.45**	86.16

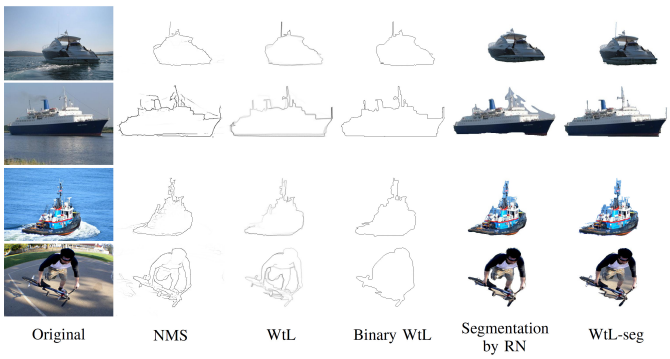

Figure 5: Visualization of the relevant algorithms

The WtL shows that contour tracing is a new and unexplored application for CNNs.