Retinal Vessel Segmentation Using Minimum Spanning Superpixel Tree Detector

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***Abstract*—Abstract goes here.**

***Index Terms*—Keyword 1, keyword 2, keyword 3.**

I. Introduction

INTRODUCTION goes here. 1. The research topics are very popular, very useful, and have great impact and research value

2. The existing methods all have problems, the problems that you are going to solve in the paper

3. Our methods have the theory, therefore our approach can solve the problems in theory as we have the designed

4. Describe the advantages, features, logic, methods, processes, etc. of our methods

5. List explicitly 3 to 4 our contributions/advantages like: Our work makes the following three main contributions:

- **Efficient Structure Restoration** The mixed use of different sizes of patches capture the structural information efficiently, avoiding the absorption of irrelevant information which causes abnormal structures;
- **Balanced Computational Workload** Multiscale solution with dynamic patches adjusts the computational workload in the operation. It significantly reduces the computation in low pyramid level without sacrificing the visual effects, and accelerates the completing process at the same time;
- **Parallel Search & Competitive Mechanism** Parallel search for different size patches is conducted with GPU acceleration. A competitive mechanism is included to select the patch with minimum unit energy.

II. Related Work

Related Work One XXXXXXXXXX
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Related Work Two XXXXXXXXXXX
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Related Work Three XXXXXXXXX
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III. Approach Overview

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Fig. 1 shows XXXXX
Fig. 2 shows XXXXX
Cite paper like this [1] or like this [1], [2].
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IV. Method Part I (at least 7 formulas)

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Calculate $a + b = c$ is OK.

$$I(p) = \sum_{q \in \Omega} S(p, q) I(q) = \sum_{q \in \Omega} exp(-\frac{D(p, q)}{\sigma} I(q) \quad (1)$$

Algorithm 1 Dynamic Patch-based Image Completion

Input: Image I , cavity C, source $S = I - C$, Number of different size patches v, Pyramid level L
Output: Final Image F

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Initialize F through filling patches randomly
Compute image pyramid I_{l_i}, C_{l_i}, K(l_i), l_i = L, L − 1, ..., 0
for each pyramid level l_i do
    Define the patch sizes with Eq. 1
    repeat
        for All q ∈ C do
            Parallel Search for v different size patches
            Retrieve the patch P that satisfies Eq. 1
        end for
        Calculate the minimum cost boundary
        Combine all the patches
    until convergence
    Propagate solution to the next level
end for
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A. Test Apple One

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B. Test Apple Two

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C. Test Apple Three

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V. Method Part II (at least 7 formulas)

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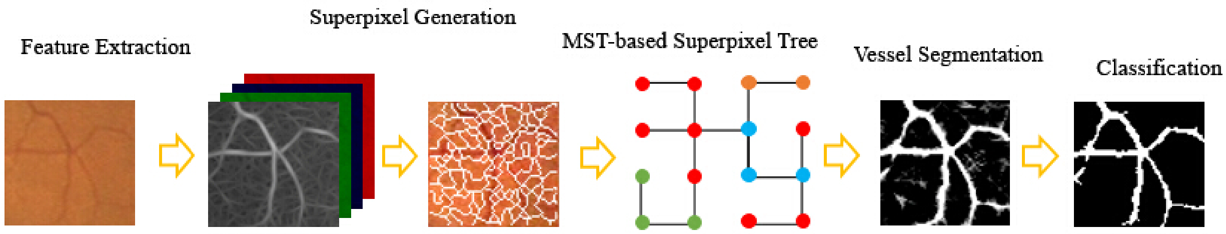

Fig. 1: Overview of the proposed minimum spanning superpixel-based tree detector for retinal vessels.

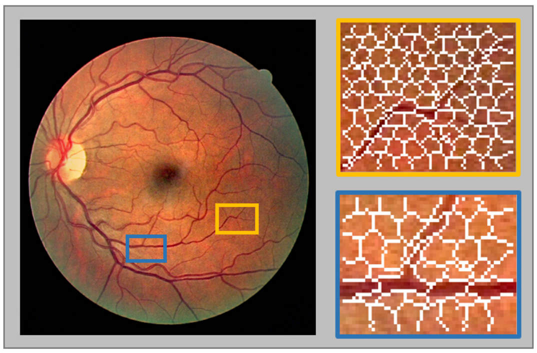

Fig. 2: Patches showing the superpixel region after clustering.

TABLE I: Performance Comparison of Vessel Segmentation

Methods	*Connectivity*	*Area*	*Length*	*C*A*L*
2nd Observer	1	0.9398	0.9347	0.8784
Marin [3]	0.9990	0.8327	0.8314	0.6916
Soares [4]	0.9952	0.8920	0.8889	0.7891
Nguyen [5]	0.9895	0.8727	0.8687	0.7502
Zhang [6]	0.9988	0.8097	0.8108	0.6557
Our method	**0.9996**	**0.9002**	**0.8982**	**0.8082**

A. *Test Banana One*

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B. *Test Banana Two*

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C. *Test Banana Three*

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VI. Experimental Results

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VII. Conclusion and Future Work

Conclusion goes here.

References

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[5] U. T. Nguyen, A. Bhuiyan, L. A. Park, and K. Ramamohanarao, "An effective retinal blood vessel segmentation method using multi-scale line detection," *Pattern Recognition*, vol. 46, no. 3, pp. 703–715, 2013.

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TABLE II: Computation time statistics of the evaluations of large CSGs (seconds)

No.	Model	Face Num.	Mesh Num.	CGAL	Cork	Carve	QuickCSG	Our Approach†				
								Total	Step 1	Step 2	Step 3	Step 4
1	Organic	219k	6	-	14.3	63.1	0.580	2.75	0.892	1.32	0.397	0.118
2	T1	80k	50	1.00k	18.5	10.4	0.388	14.4	0.691	2.71	8.11	2.87
3	T2	7k	50	2.81k	-	16.0	0.804	5.52	0.162	1.11	3.29	0.746
4	Sprocket	11k	52	211	-	4.26	(0.132)*	0.386	0.093	0.105	0.149	0.034
5	Ring & Ball	146k	801	-	-	187	(1.10)	20.0	1.04	3.55	8.61	6.68