

基于皮肤病图像的白癜风分割 弱监督方法及“AI 落地”

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目录

1 背景及意义

- 背景
- 意义

2 方法原理

- 强监督分割方法
- 弱监督分割方法

3 实验结果与分析

4 讨论与展望



目录

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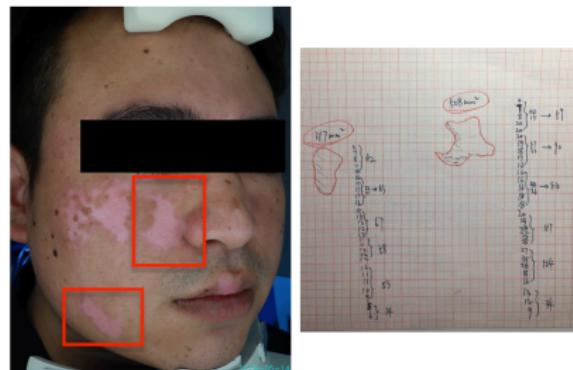
3 实验结果与分析

4 讨论与展望



背景

- ① 影响人数：全球 0.5%-1%
 - ② 影响美观
 - ③ 病情评价：面积与脱色程度
 - 方法不客观：医生估算面积
 - 操作不方便：方格纸拓写
 - 标准不统一：
VETF¹, VASI², SAVASI³



图：手工拓写

¹A. Taieb et al. The definition and assessment of vitiligo: a consensus report of the vitiligo european task force. *Pigment Cell Research*, 20(1):27–35, 2007.

²I. Hamzavi et al. Parametric modeling of narrowband uv-b phototherapy for vitiligo using a novel quantitative tool: the vitiligo area scoring index. Archives of Dermatology, 140(6):677-683, 2004.

³ L. Komen et al. The validity, reliability and acceptability of the savasi; a new self-assessment score in vitiligo. Journal of the European Academy of Dermatology and Venereology, 29(11):2145-2151, 2015.

意义

- 方法更客观 \Rightarrow 数字图像处理：分割任务
- 操作更方便 (e.g. 远程诊断，随时监控)
- 标准更统一



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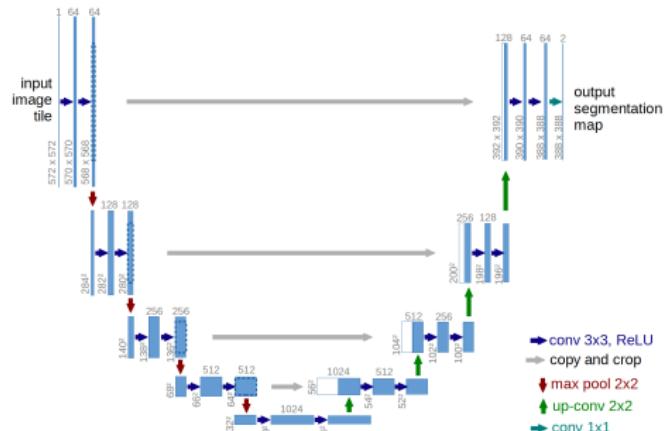
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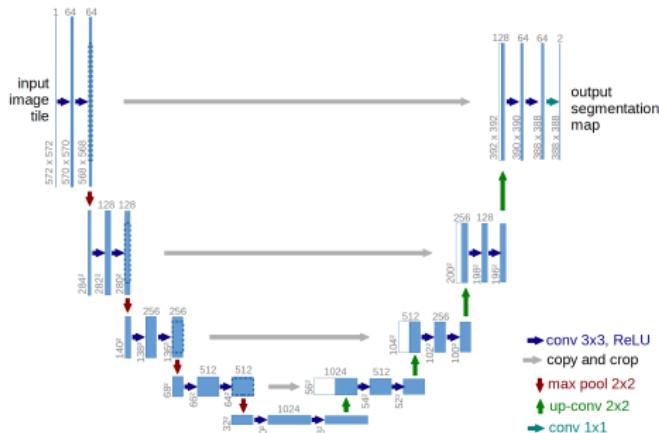
强监督分割方法

“写在前面：非原创工作均有标注引用”



强监督分割方法

“写在前面：非原创工作均有标注引用”

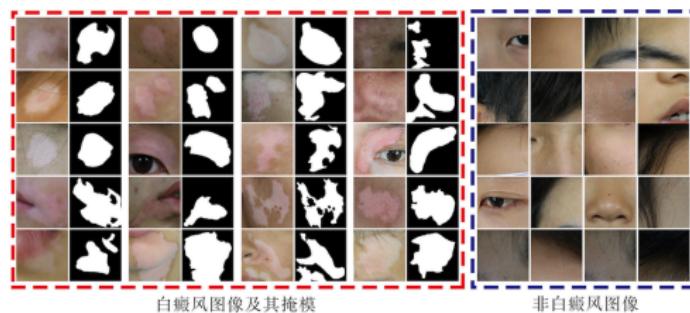


图：编码器-解码器结构⁴

⁴ O. Ronneberger, et al. U-net: Convolutional networks for biomedical image segmentation. In International Conference on Medical image computing and computer-assisted intervention, pages 234–241. Springer, 2015.



数据集 Vit2019



- 规模: 1000+1000
- 标注: 像素级标注
- 多样性: 光照、肤色、不同治疗阶段等

图: Vit2019 数据集



数据集 Vit2019 的挑战



- 肤色差别大 ((a) vs. (b))
- 对比度低 ((a), (e))
- 毛发影响 ((c), (f))
- 局部高光 (易误判) ((c))



Baseline: Unet⁵



$$\text{IoU} = \frac{\text{Area of Overlap}}{\text{Area of Union}}$$

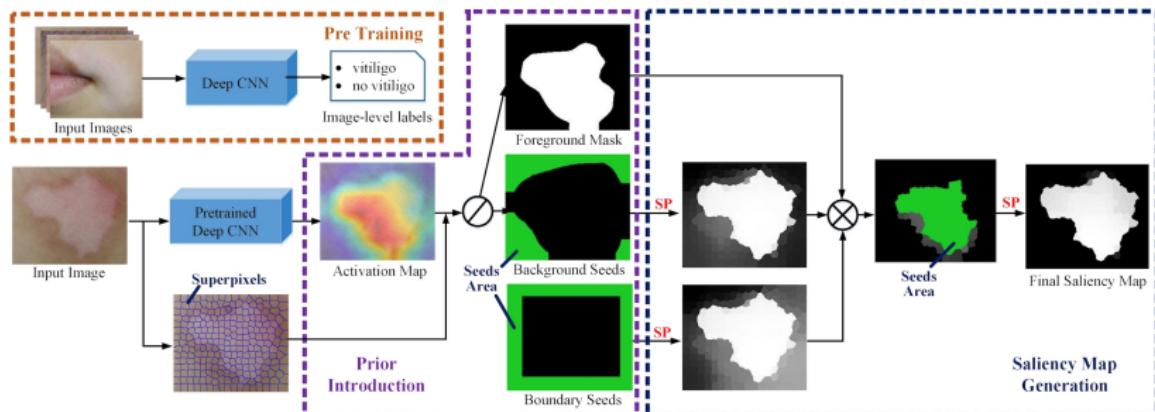
$$= 78.6\%$$

- 强监督方法局限性：
数据标注工作耗时耗力

⁵ O. Ronneberger, et al. U-net: Convolutional networks for biomedical image segmentation. In International Conference on Medical image computing and computer-assisted intervention, pages 234–241. Springer, 2015.



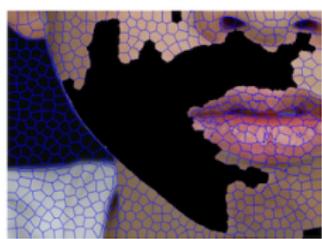
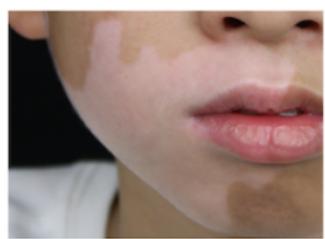
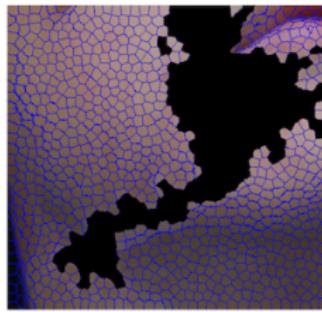
弱监督分割框架



- 超像素分割
- 高层语义特征 + 底层特征 —“既见树木，又见森林”
- 将反馈应用于显著性传播过程



超像素分割



好处：

- 降低数据维度
- 剔除异常像素点
- 保留较完整的皮损边界



“既见树木，又见森林”

定义

“森林”：高层特征 \Rightarrow 定位种子区域

“树木”：底层特征 \Rightarrow 传播



⁶Zhou, Bolei, et al. Learning deep features for discriminative localization. CVPR 2016.

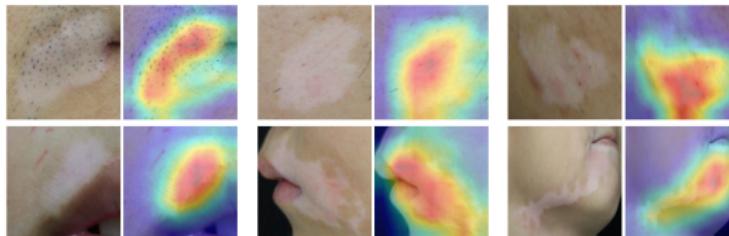
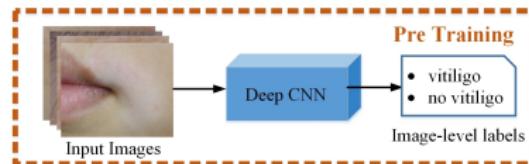
“既见树木，又见森林”

定义

“森林”：高层特征 \Rightarrow 定位种子区域

“树木”：底层特征 \Rightarrow 传播

- 定位：类激活图⁶ (Class Activation Map – CAM)



⁶Zhou, Bolei, et al. Learning deep features for discriminative localization. CVPR 2016.

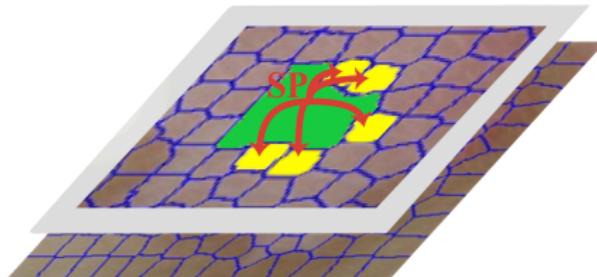
“既见树木，又见森林”

定义

“森林”：高层特征 \Rightarrow 定位种子区域

“树木”：底层特征 \Rightarrow 传播

传播：

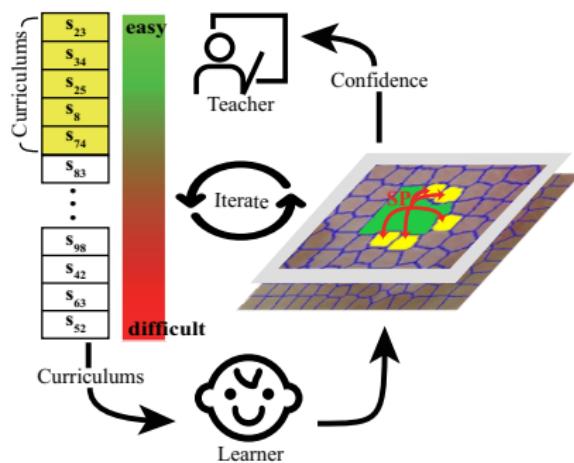


- 传播过程迭代化
- 每一次迭代需要确定传播的顺序⁷和数量

⁷ C. Gong et al. Saliency propagation from simple to difficult. CVPR 2015.



“既见树木，又见森林”-传播



图：反馈思想与传播相结合

- 传播过程 \Rightarrow “教学-学习”
- 老师：
 - 评估课程难度，从易到难布置一定数量的课程；
 - 接受学生反馈
- 学生：
 - 学习课程（传播）；
 - 反馈学习效果（confidence）

数量

$$q^{(t)} = |\# \text{Neighbor}^{(t)}| \times \text{Confidence}^{(t-1)}$$



“既见树木，又见森林”-传播

老师度量“课程”难度

$$DS_i = INF_i + IND_i + IHM_i + CON_i$$

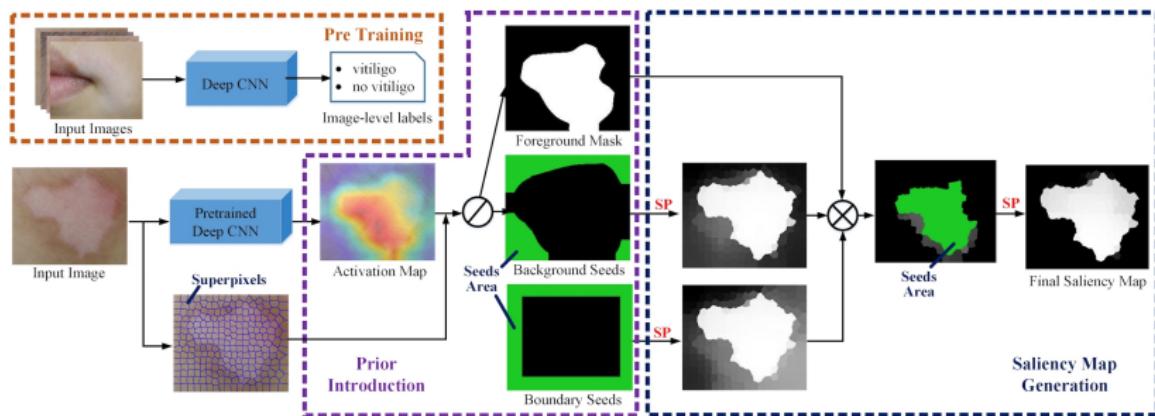
- 信息性: $INF_i = H(\mathbf{s}_i \mid \mathcal{L})$
- 个体性: $IND_i = \frac{1}{|\mathcal{N}(\mathbf{s}_i)|} \sum_{j \in \mathcal{N}(\mathbf{s}_i)} \|\mathbf{s}_i^{color} - \mathbf{s}_j^{color}\|$
- 同质性: $IHM_i = \left(\frac{2}{b^2 - b} \sum_{i=1}^b \sum_{j=i+1}^b \Theta_{ij} \right)^{-1}$
- 连通性: $CON_i = \frac{1}{l} \sum_{j \in \mathcal{L}} \text{geo}(\mathbf{s}_i, \mathbf{s}_j)$

学生反馈效果

$$\text{Confidence} = 1 - \frac{2}{q^{(t-1)}} \sum_{i=1}^{q^{(t-1)}} \min(f_i^{(t-1)}, 1 - f_i^{(t-1)})$$



方法框架



- 边界先验 (Boundary Prior): 假设边界为背景区域
- 三次显著性传播过程 (SP)



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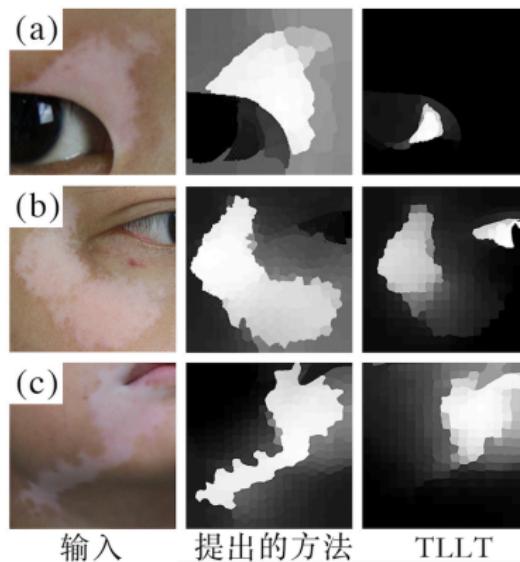
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注意力机制

- 注意力机制：Ours vs. TLLT⁸

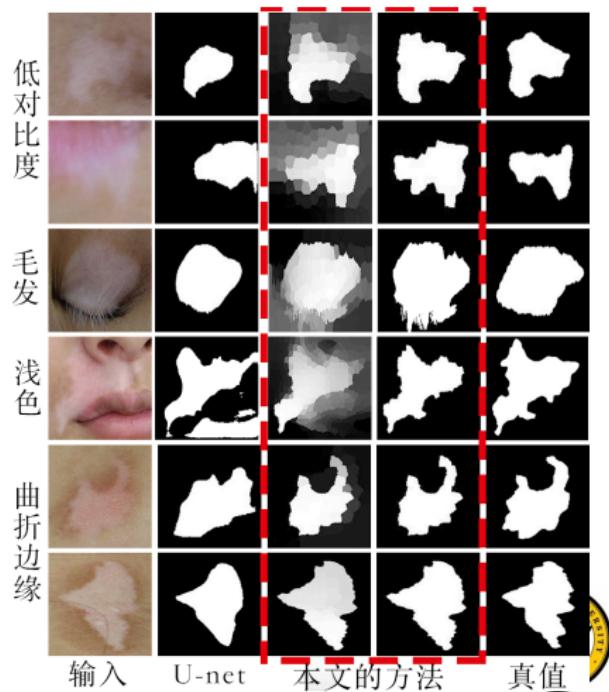


⁸ C. Gong et al. Saliency propagation from simple to difficult. CVPR 2015.

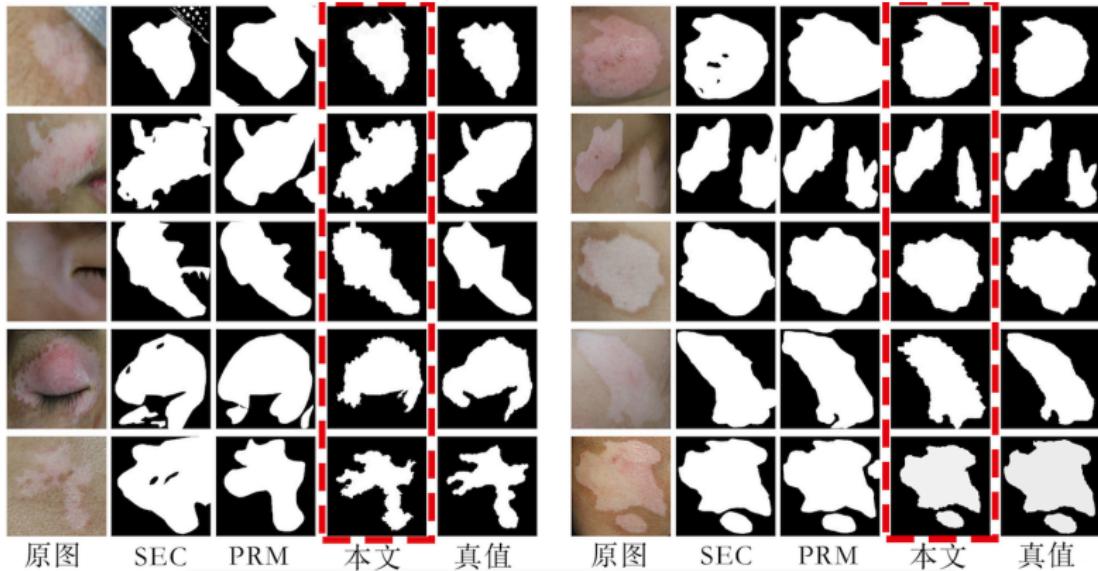
方法对比：Ours vs. Unet

表：实验结果 (Vit2019)

方法	监督方式	mIoU
FCN-VGG16	Fully	72.4
U-net	Fully	78.6
PRM		67.2
SEC	Weakly	64.7
Our Method		71.4



方法对比：Ours vs. SEC, PRM



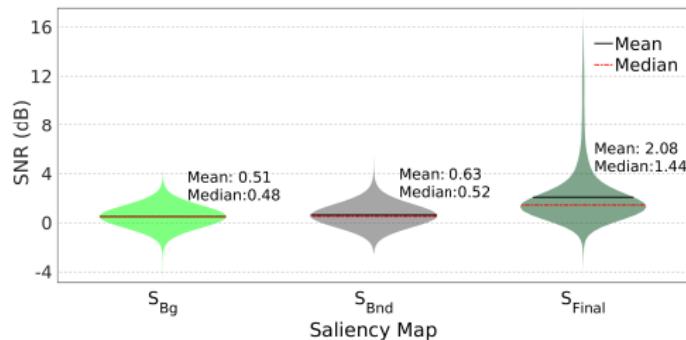
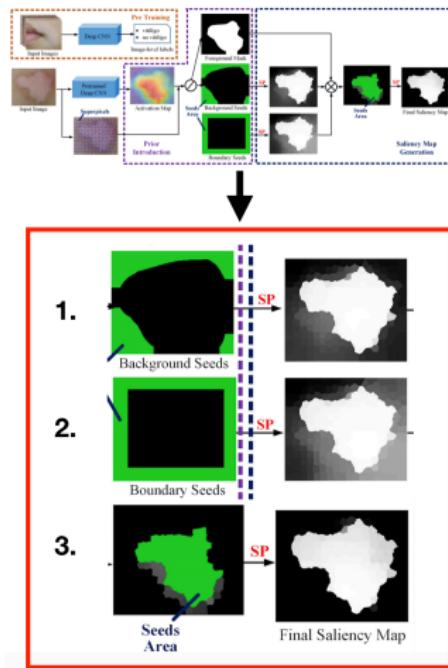
图：弱监督方法效果对比：Ours vs. SEC⁹, PRM¹⁰

⁹ A. Kolesnikov and C. H. Lampert. Seed, Expand and Constrain: Three Principles for Weakly-Supervised Image Segmentation. arXiv.org, Mar. 2016.

¹⁰ Y. Zhou et al. Weakly Supervised Instance Segmentation using Class Peak Response. arXiv.org, Apr. 2018.



显著图质量分析



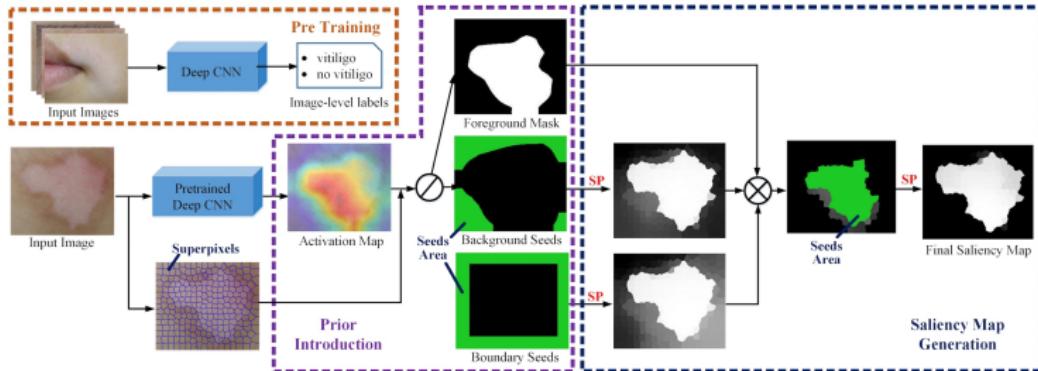
定义

信号：皮损区域内的显著性值
噪声：皮损区域外的显著性值

$$SNR_{dB} = 10 \log_{10} \left(\frac{E_{\text{signal}}}{E_{\text{noise}}} \right)$$



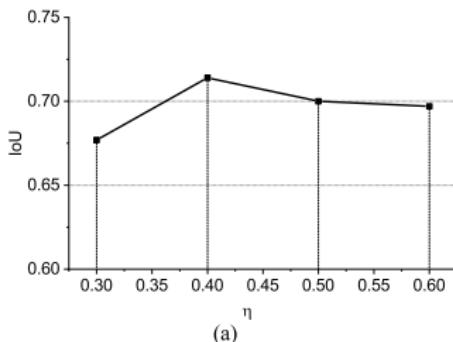
Ablation Study



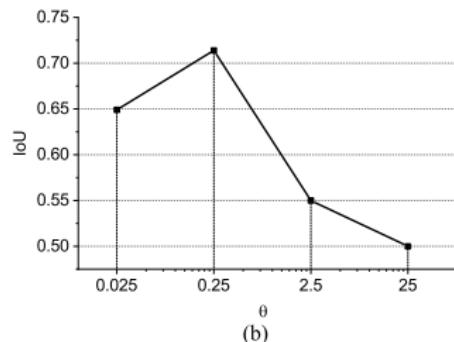
Fg Mask	✗	✓	✓	✓	✗	✗	✗	✓	
Bg Seeds	✓	✗	✓	✗	✓	✗	✓	✓	
Bnd Seeds	✓	✓	✗	✗	✗	✓	✓	✓	
Last SP	✓	✓	✓	✓	✓	✓	✗	✓	
IoU		62.5	66.7	63.1	59.5	43.5	53.0	57.7	71.4



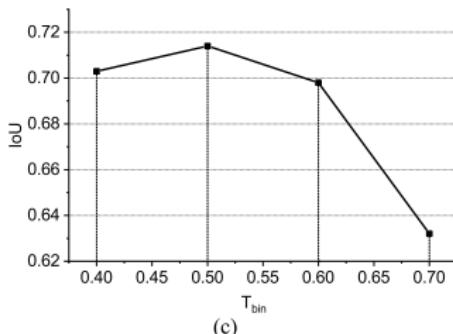
敏感度测试



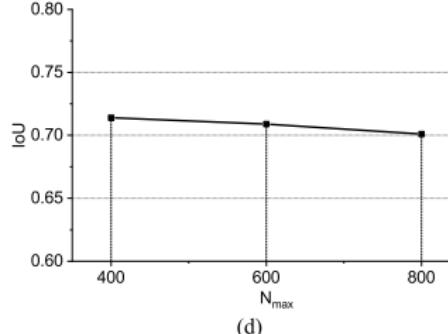
(a)



(b)



(c)



(d)



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工作总结

工作量：

- Vit2019：目前最大的白癜风分割数据集
- 大量的实验验证
- 撰写论文和专利

创新点：

- 基于显著性传播的弱监督分割方法：
 - 应用超像素技术
 - “既见树木，又见森林”策略
 - 将反馈思想与显著性传播相结合

其他工作：

- 集成分割算法到皮研所系统



工作总结

论文¹¹ (于3月投稿ICCV¹²)

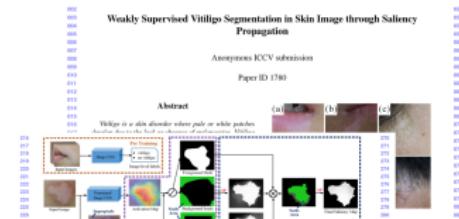


Figure 1. The framework of our algorithm. When given a raw image, it was segmented into subjects, and on the other hand, it was passed through the pre-trained network to extract features. Then, we calculated the saliency map for each subject. Finally, we performed the propagation process by using the mask area in the saliency map generation stage, we first generate a new saliency map and then refine it during the salient step. “ \oplus ” presents the propagation process detailed in the Fig. 2. More details is in the main text.



Figure 2. Sample images of VITILIGO Dataset. (a) shows the normal skin regions, (b) shows the regions where the lesions located in the patient's face and neck, (c) shows the regions where the lesions located in the patient's back and neck, (d) shows the regions where the lesions located in the patient's hands and fingers, (e) shows the regions where the lesions located in the patient's legs and feet, (f) shows the regions where the lesions located in the patient's torso and waist, (g) shows the regions where the lesions located in the patient's chest and back. (h) shows the cases with vitiligo lesions, which cause no healing skin like the eye, lip, nose and so on.

Vitiligo images are randomly extracted from the data set.

Annotation. Precisely annotating vitiligo regions in pixel-level is time-consuming and error-prone. We mainly rely on the visual inspection of domain experts. The domain experts are invited to validate and annotate the images.

Diversity. Our dataset is collected from the real clinical scene. It covers both environmental factors (such as sun exposure, diet, and exercise), and personal factors of the patient, such as the age range, ethnicity, gender, and so on. The dataset also includes images with other pigmented skin diseases, diseased parts (such as hands, feet, limbs, scalp, gender, skin tone, color, lighter, darker).



(19) 中华人民共和国国家知识产权局



(12)发明专利申请



(21)申请号: 201611481403.5
(22)申请日: 2016.12.06
(23)申请人: 东南大学
地址: 210090 江苏省南京市玄武区四牌楼2号
(24)发明人: 边张行 夏思宇 宋子涵 吴双
(25)专利代理机构: 南京经纬专利商标代理有限公司 32200
代理人: 许方
(26)摘要: 本发明公开了一种基于像素聚类与分割阈值的白癜风区域分割方法,通过将聚类中心分别与阈值分割方法结合,本发明方法能够对不同光照环境下拍摄的白癜风患病区域的照片进行快速有效的分割,而且在皮损边缘模糊,曲折,图片对比度低等条件下,仍能较为理想地分割出白斑区域,为白癜风区域的面积测量与治疗疗效评估体系提供了关键的技术支持。

权利要求书5页 说明书15页 附图2页

(54)发明名称
一种基于像素聚类与分割阈值的白癜风区域分割方法
(57)摘要



¹¹ Zhangxing Bian, Siyu Xia, Chao Xia, Ming Shao, FU YUN. Weakly Supervised Vitiligo Segmentation in Skin Image through Saliency Propagation. In Proceedings of the IEEE international conference on computer vision, 2019.

¹² 计算机视觉领域三大顶会之一

¹³ 发明人: 边张行, 夏思宇; 公布号: CN 109741336 A

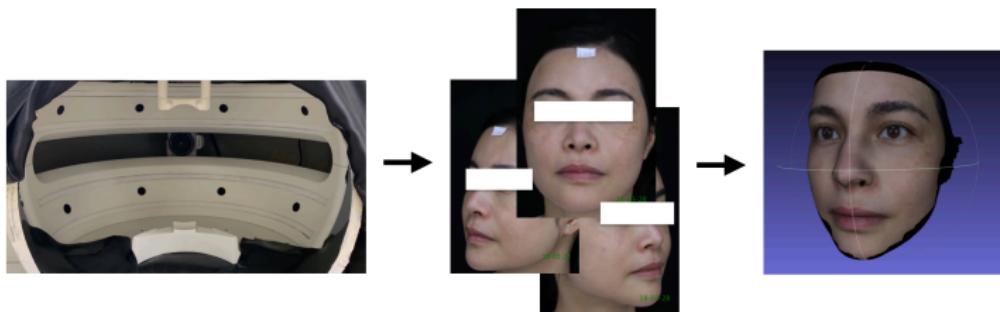


展望

- 应用：弱监督分割 + 交互式标注
- 应用：其他皮损区域的分割 e.g. 黄褐斑、雀斑、烧伤



- 计算皮损区域的绝对物理面积 \Rightarrow 3D 人脸模型



致谢

感谢夏思宇老师！

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感谢各位评审老师的聆听！

