Clinical utilization of automated image analysis software for improving retinal reader’s performance

V Joshi, C Agurto, ES Barriga, S Nemeth, P Soliz
VisionQuest Biomedical, LLC, Albuquerque, NM, USA | Contact email: vjoshi@visionquest-bio.com

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**Purpose**

To present a fully automated software system for detection of hypertensive retinopathy abnormalities using digital fundus images. The proposed system will assist retinal readers in identifying such abnormalities and predicting the associated risk of cardiovascular diseases.

**Background**

In the US, there are 720,000 annual incidences of heart attack; 795,000 people experience a stroke. Risk factors for cardiovascular disease (CVD) and stroke are well known, yet many individuals are not aware of their risk.

Signs of hypertensive retinopathy (HR) such as retinal lesions and vessel abnormalities present an early indication of increased risk of CVD. Regular screening for HR can predict long-term risks for CVD or stroke.

The telediagnosis systems utilize manual or semi-automatic methods for retinal vessel analysis and detection of HR abnormalities. These systems are highly qualitative, lack accuracy and consistency, and require extensive reader interaction.

**Methods**

- Automated retinal abnormality analysis
- Graphical user-interface

**System Description**

- The software consists of 3 processing levels (Fig. 2):
  - Retinal vessel network analysis and abnormality detection
  - Integration of algorithms into a graphical user interface (GUI)
  - Software assistance to a retinal reader

**Datasets** (Table 1):

- VisionQuest’s VQ-I dataset of N=230 images extracted from our own retinal screening database.
- Publicly available retrospective retinal color image datasets: 1) INSPIRE, 2) Tortuosity dataset from the University of Padova.
- Ground truth: Images annotated for retinal abnormalities by a certified ophthalmic medical technician (COMT).

**Results**

**Detection of AV nicking, CS wiring, retinal emboli**

- Tested on 100 images randomly selected from VQ-I dataset.
- The performance was measured in terms of detection sensitivity per vascular abnormality and false positives per image (FPPR).

**Table 3. Vascular abnormality detection**

<table>
<thead>
<tr>
<th>Abnormality</th>
<th>Sensitivity</th>
<th>FPPR</th>
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<tbody>
<tr>
<td>AV nicking</td>
<td>78%</td>
<td>0.15</td>
</tr>
<tr>
<td>CS wiring</td>
<td>82%</td>
<td>0.28</td>
</tr>
<tr>
<td>Emboli</td>
<td>94%</td>
<td>0.23</td>
</tr>
</tbody>
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**Discussion and Conclusion**

- The software was effective in improving retinal reader’s performance when used as a grading aid.
- Reduction of reading time per image by 32%, which provides increased efficiency for graders.
- Improvement in disease detection sensitivity by ~30%, reducing significantly the false negatives.
- Improvement in Inter-reader agreement for disease detection by 54%, which eliminates variability in retinopathy diagnosis and associated CVD risk.

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