A heuristic method for automatically controlling image brightness in widefield fundus angiography sequences

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PURPOSE

Traditional fundus cameras require the operator to manually adjust flash brightness throughout an angiogram. In this work, we describe a widefield fundus imaging system that provides a very high dynamic range such that an operator does not need to adjust image brightness while capturing an ICGA image sequence. The brightness of each raw image is then adjusted for viewing, using a scheme that balances contrast enhancement with maintaining image-to-image brightness consistent with variations in the original captured fluorescent signal.

METHODS

- Angiographic sequences each comprised of ICGA images from 14 eyes acquired using CLARUS™ 700 prototype SW (ZEISS, Dublin, CA) were post-processed using three different schemes:
  - i) No enhancement
  - ii) **Balanced contrast enhancement**: relative differences of brightness between images in the sequence are compressed; low-signal images are brightened more than high-signal images. The result is a sequence that uses more of the range of brightness available for display overall, while maintaining a semblance of the original image-to-image variations in the captured fluorescent signal
  - iii) **Maximum contrast enhancement**: scale the brightness of each image until its brightest pixel reaches the saturation level
- The sequences were then randomized by brightness and graded as whole image sequences, which were comprised of early, mid, and late phases
- Grading was performed by an expert grader using a 5-point image quality grading criteria (Table 1) from 5 (excellent image quality) to 1 (very poor image quality)
- Grading was performed focusing on the importance of both image contrast and consistency with dye transit over time of the entire sequence

Image Quality Grading Scale	Definition
5	Excellent image quality. All features of interest are clearly seen with excellent contrast and image appearance is consistent with the transit phase of dye.
4	Good image quality. All features of interest are clearly seen with good contrast and image appearance is consistent with the transit phase of dye.
3	Fair image quality. Most features of interest are seen with fair contrast and overall is possible to obtain clinically useful information from the image.
2	Poor image quality. Some features of interest are obscured, poor contrast, some interpretation may be possible, but it would be desirable in a clinical situation to attempt another image or use a different method of obtaining the information.
1	Very poor image quality. Little clinical information of value could be obtained, very poor contrast, and a typical user would need to try again or use a different method to evaluate the eye.

Table 1. Definitions of image quality grading criteria over a 5-point scoring system.

RESULTS

- Image sequences over the three schemes from a sample patient are depicted (Figure 1)
- Average image quality scores for sequences (Figure 2) from 14 eyes were statistically significantly different (Wilcoxon signed rank test) between all scheme combinations ($p < 0.001$)
- The majority of sequences from scheme i were 3 (fair) and 2 (poor)
- The majority of sequences from scheme ii were 4 (good)
- All sequences of scheme iii proved to be of image quality 5 (excellent) or 4 (good)

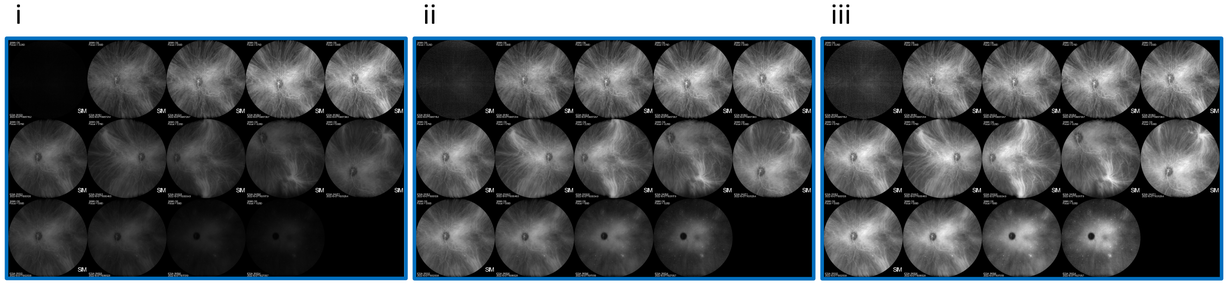

Figure 1. Sample ICGA image sequences from 1 eye over 3 brightness schemes; i) no enhancement, ii) balanced contrast enhancement, iii) maximum contrast enhancement.

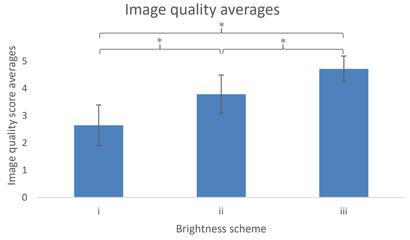

Figure 2. Average image quality scores for images sequences from 14 eyes; error bars indicate standard deviations, asterisks indicate significance.

CONCLUSIONS

Using a high dynamic range fundus camera with automatic post-acquisition contrast adjustment, angiography sequences may be captured at a fixed flash level without risk of image under- or over-exposure. Eliminating the need for manual flash adjustment in this manner may simplify the angiography workflow for the operator.

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