Simultaneous FA+ICGA enables improved accuracy of multimodal image registration

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Poster #2369 – C0432

PURPOSE

Color fundus images and angiographic fundus images are both used by clinicians to diagnose retinal diseases and monitor lesions. However, using both images require co-registration to correlate findings. Here, we assess the accuracy of co-registration of color fundus images with fluorescein angiography (FA) images, indocyanine green angiography (ICGA) images, and fused images containing information from FA and ICGA.

METHODS

- Color fundus, FA, and ICGA images were acquired using CLARUS™ 700 (ZEISS, Dublin, CA). 7 subjects were imaged using both eyes.
- Simultaneously acquired FA and ICGA images are fused by averaging the individual images.
- The ground-truth registration was acquired by manually identifying 6 landmarks, usually vessel bifurcations and optic nerve, on all images.
- We used automatic co-registration algorithm from CLARUS™ 700, based on an affine transformation, to register the color fundus image with the angiography images.
- The ground-truth landmarks on the color fundus images were transformed based on the algorithm's transformation matrix. These locations were compared with the angiography landmarks (Figure 1).
- All locations were corrected for stereographic projection (Figure 2).
- We defined the mean, standard deviation (STD), and root mean squared error (RMSE) in units of degrees subtended in air at the pupil.

CONCLUSIONS

We demonstrated that registering color fundus images with a fused FA and ICGA image improves the accuracy when compared to registering on FA or ICGA alone. This strengthens the notion that both superficial and choroidal vessels are useful in the registration process.

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Disclosures: AK (E), CL (E), KF (E), JP (C): Carl Zeiss Meditec, Inc.

RESULTS

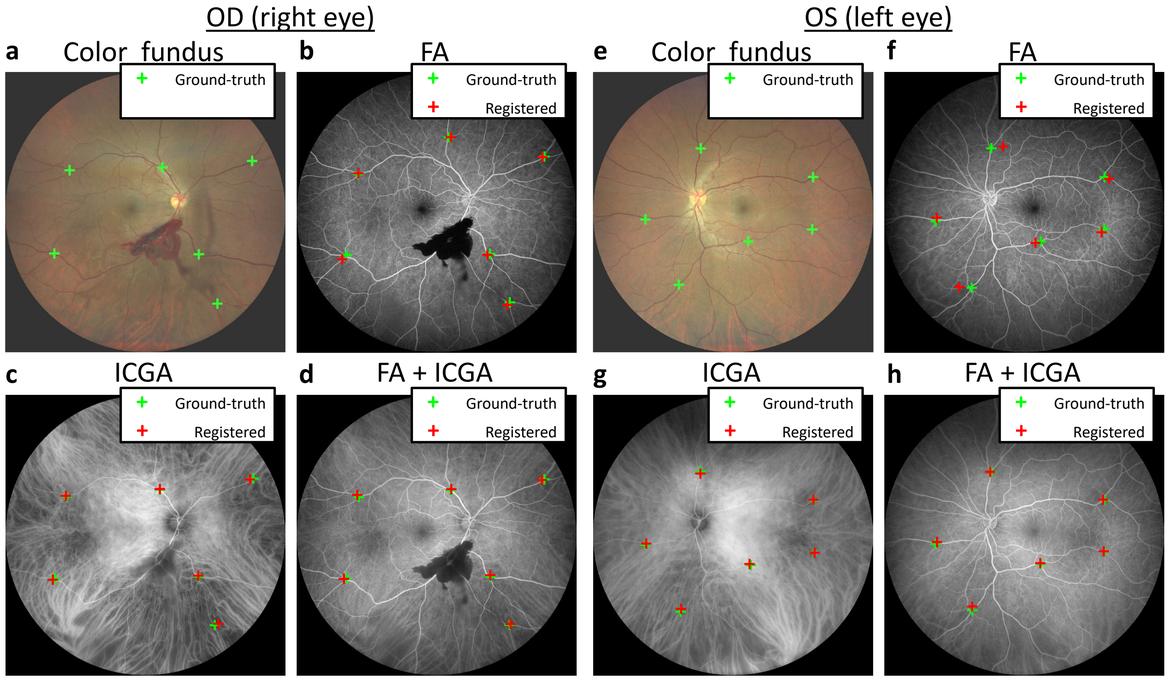

Figure 1.
Color fundus, FA, ICGA, and fused FA + ICGA images from both eyes of a subject. We found the errors between the transformed ground-truth locations and the manually identified landmark locations for each angiography image by correcting for stereographic projection and finding the shortest distance in 3D space. We then convert that distance to angle subtended in air at the pupil. We assume that the radius of curvature of the retina is 17 mm.

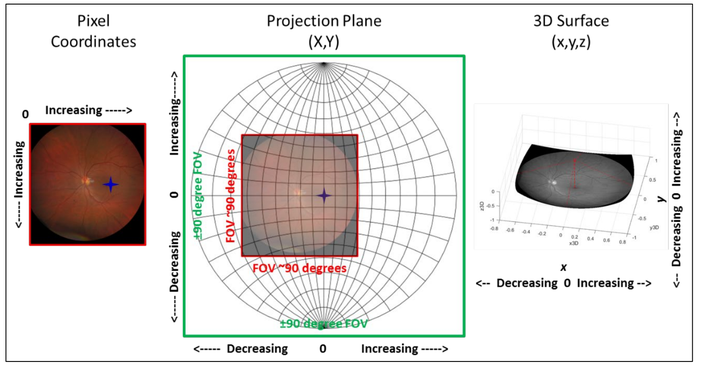

Figure 2.
Stereographic projection correction remaps the flat 2D image onto a 3D hemisphere that mimics the contours of the fundus.

	FA	ICGA	FA+ICGA
Mean error ± STD (degrees)	3.76 ± 4.05	1.00 ± 1.71	0.52 ± 0.30
RMSE (degrees)	4.05	1.96	0.60

Table 1.
Performance metrics of the registration of the FA, ICGA, and fused FA and ICGA images with color fundus images.