Comparative Analysis of Biomechanical Normalization Schemes for Iris Recognition

Jiayi Li and Antwan D. Clark

Johns Hopkins University | Whiting School of Engineering | Baltimore, MD

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Introduction

- Iris recognition is prevalent in today's high-tech market; however, variations in pupil size still pose a great challenge to this technology.
- Although recent studies have shown that integrating biologically-based iris deformation models into the iris image (also known as *biomechanical normalization*) have shown to handle these nonidealities, some of these models are highly nonlinear which can add additional computational overhead.

Objective

- To perform comparative assessment of two families of biomechanically-based normalization schemes: approximate large deformations and infinitesimal also known as small) deformations.
- The benefit of incorporating infinitesimal deformations is that it's a simple model with a *closed form solution*.

Approach

Our approach investigates this from theoretical and empirical perspectives which include the following:

1. **Theoretical** – Theoretical comparisons are made between approximate large deformation (ALD) and small deformation (SD) formulations for both isotropic and orthotropic cases, where these will be used to produce biomechanical iris image normalization schemes.
2. **Empirical** – Empirical comparisons are made on the West Virginia University Pupil Light Reflex Ramp (WVU-PLR Ramp) dataset. This dataset contains videos of 54 subjects with categories of light and dark colored irises under gradual changes in illumination for 20, 30, and 45 seconds. Our empirical analysis assumes perfect segmentation to focus on the direct changes in dilation.

Results

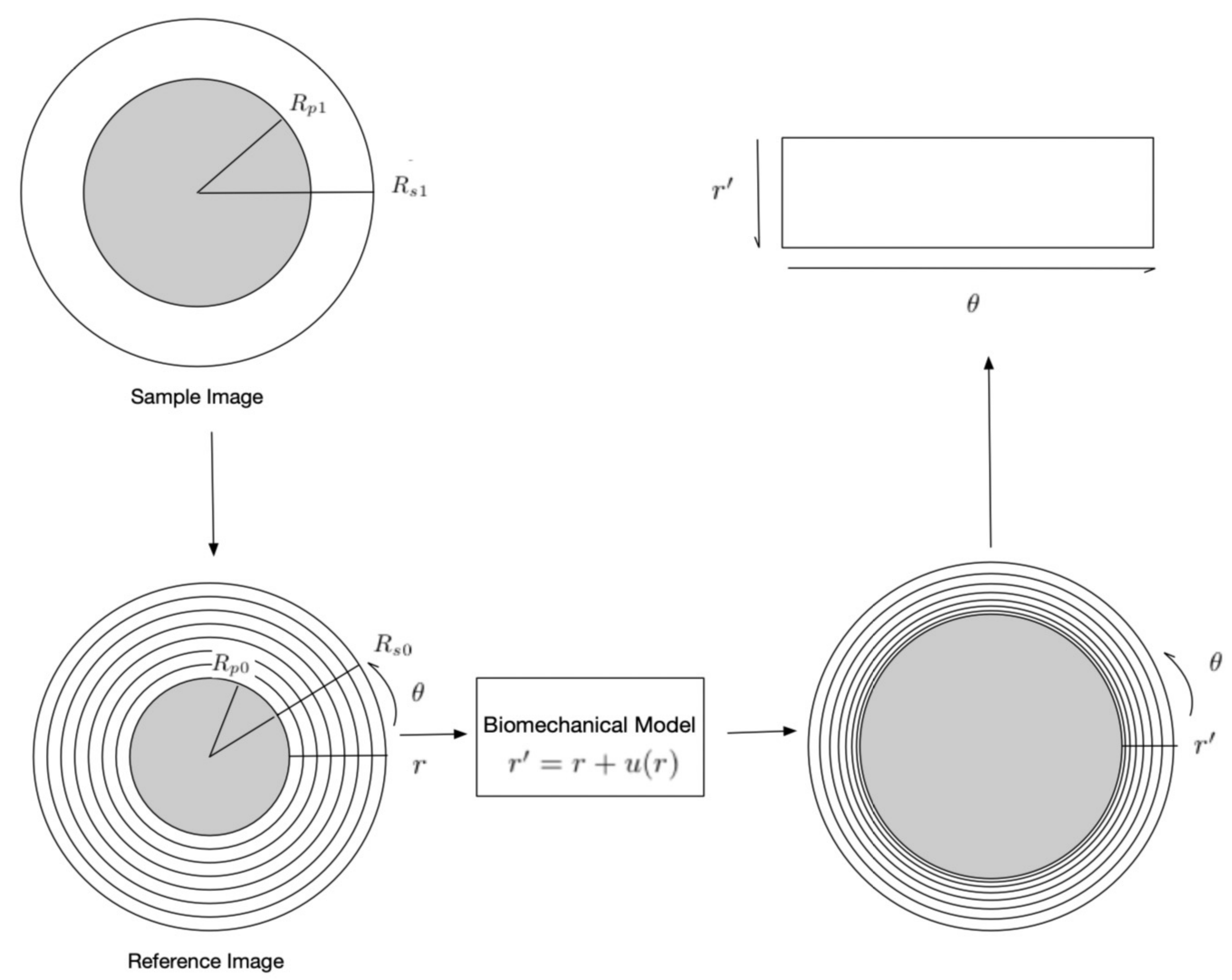

Figure 1— Generalized Biomechanical Normalization Process

Flow chart of our proposed process. Deformation comparisons are made between the reference and acquired (sample) images in order to compute the appropriate level of tissue distortion, which include ALD and SD formulations. Baseline numerical comparisons for both isotropic and orthotropic cases show promise with dissimilarities falling within $O(10^{-3})$ and $O(10^{-7})$.

Dilation Level	Number of Images	Genuine Comparisons	Impostor Comparisons	Total Comparisons
Low	135	14,292	597,722	612,014
Medium	111	10,997	501,266	512,263
High	119	20,556	882,347	902,903

Table 1 — Dilation Level and Number of Comparisons (Dark Colored Irises)

Example of the statistical comparisons made from the WVU-PLR Ramp dataset for 20 second timeframe, where the total number of subjects is 38. The dilation level Δ is computed as a normalized ratio between the pupil and iris, where $\Delta < 0.425$ is a low dilation level, $\Delta \in (0.425, 0.525)$ is a medium dilation level, and $\Delta > 0.525$ is a high dilation level.

Biomechanical Deformation Method	Identification Accuracy (%)
Approx. Large Deformation (Orthotropic)	99.79
Approximate Large Deformation (Isotropic)	99.75
Small Deformation (Orthotropic)	98.07
Small Deformation (Isotropic)	98.35

Table 2 – Identification Performance Summary

Identification performance of each biomechanical normalization scheme for dark colored irises.

Conclusion

Our comparative analysis shows that incorporating small deformations into the normalization process achieves equivalent performance with the state of the art in handling these nonidealities, where the difference in accuracies is less than 2%.