Mobile Image Analysis for Urinalysis Strips Using a Backpropagation Neural Network

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INTRODUCTION

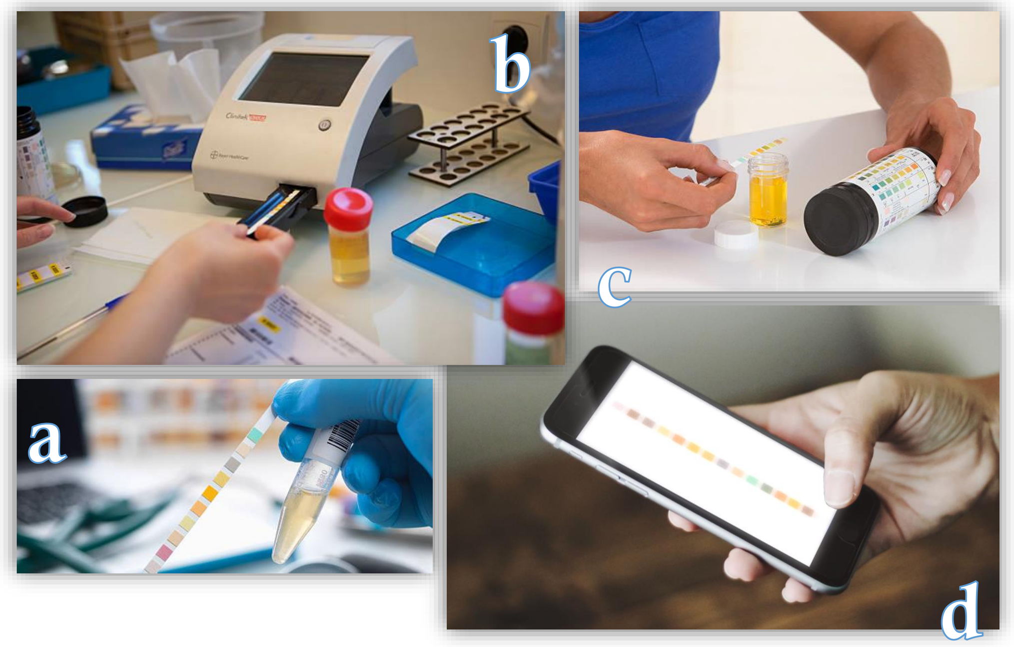
Urinalysis has great potential in personalized care, considering its biological richness and its capacity to be a convenient and cost-effective medium for continuous health monitoring of urinary tract infections, kidney function, diabetes, pregnancy, hydration testing, etc. Mobile devices incorporate image sensors, offering a practical, accurate, and low-cost mHealth-based solutions for initial self-diagnosis of disease, self-monitoring of health conditions, or to augment preliminary remote clinical examinations.

OBJECTIVES

(1) Compare the performance of different algorithms to classify non-uniform illumination of urinalysis strip images for color recognition, and (2) evaluate the feasibility of image processing on mobile devices in the context of urinalysis.

RESULTS

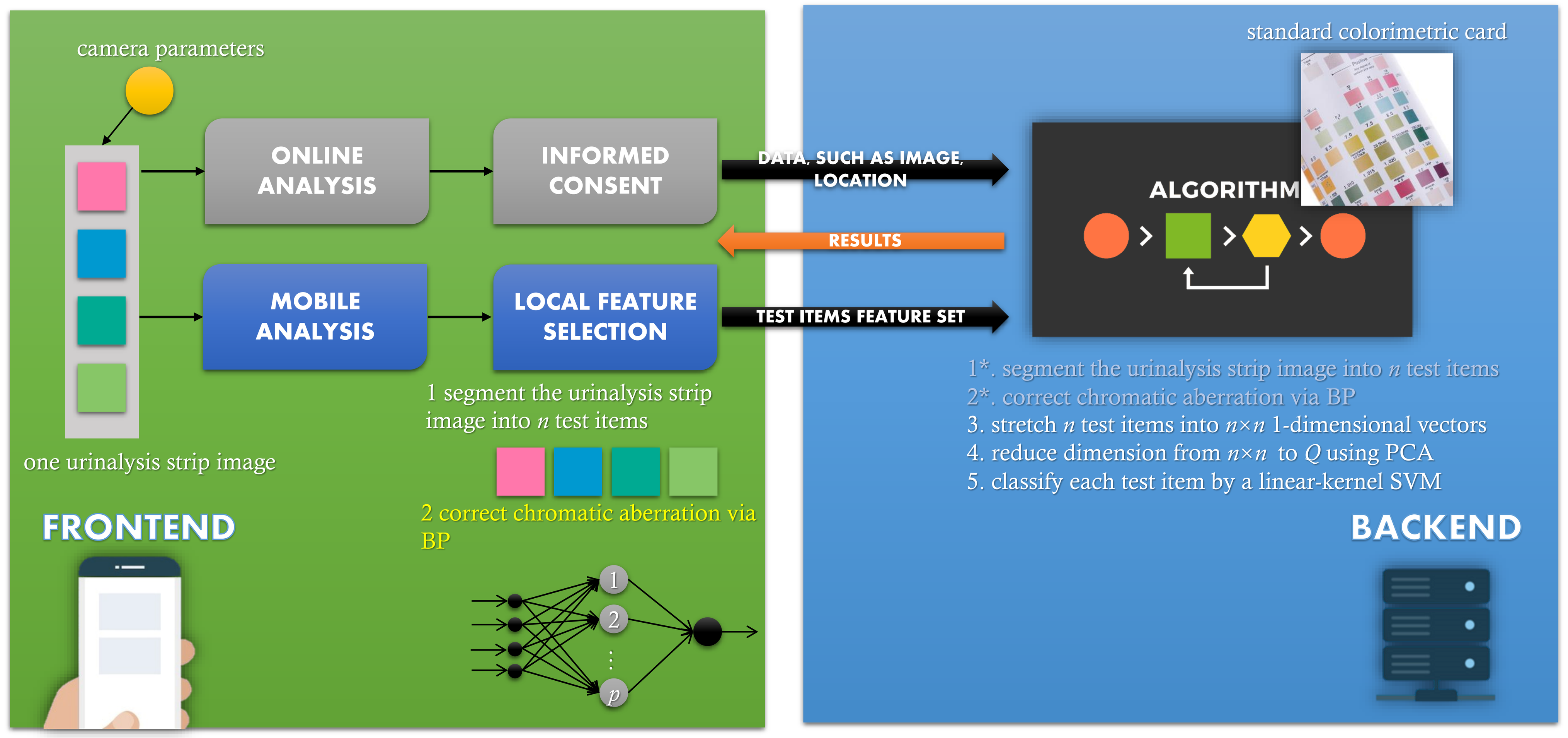
The result indicates that our algorithm performs stably (average accuracy as 90.9%) and is higher than the four baselines with a maximum improvement rate of 28.2% and an average improvement rate of 16.9%. There is no evidence that algorithm performance decreases when processing mobile analysis.

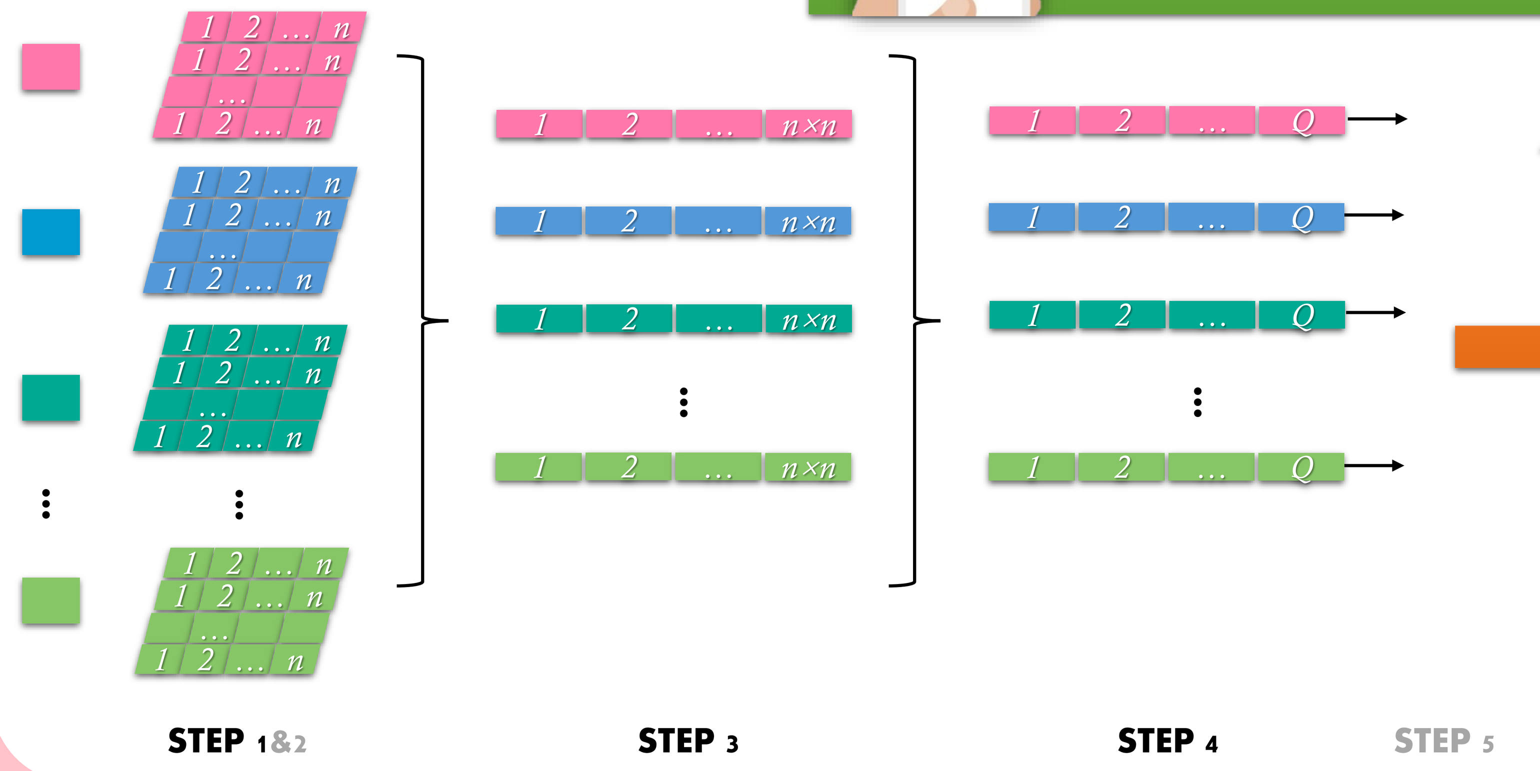


(a) the original image (b) ours-without-BP (STEP2 excluded) (c) ours

5,620 labeled urinalysis strip images were split into a training set (5,163, 91.8%) and hold-out validation set (457, 8.2%).

We propose a backpropagation neural network-based algorithm to identify color similarity between urinalysis images originating on mobile devices and a standard colorimetric card that will process images on the mobile device itself (novel workflow) or on the server (baseline workflow).





Three existing image recognition models, run on the server, serve as additional baselines. Algorithm performance is evaluated using the metrics of average accuracy and improvement rate.

DISCUSSION AND CONCLUSIONS

The main finding is that (1) adapting the backpropagation neural network to chromatic aberration detection under non-uniform lighting is apposite as it allows us to correct chromatic aberration directly in RGB color space rather than needing to convert color into LAB or HSV space and (2) it is feasible to create an accurate mHealth app to augment urinalysis workflows. We compared two workflows and found it is feasible to run image processing algorithms on the mobile devices themselves for accurate urinalysis.

It is feasible to run image processing algorithms on mobile devices themselves for accurate urinalysis. Mobile urinalysis enables patients to control their own personal data and get vital lab results quickly while enabling them to share that data with their care team.

Limitations: We only used one type of urinalysis strips as the source of labeled images, and that these were collected from a single hospital, and therefore may not generalize to other paper-based urinalysis strips produced by other vendors, as the reagents are preloaded onto the paper in the manufacturing process, which may differ across vendors. Another limitation is related to the methods of feasibility used in this study. While we assessed the opinion of laboratory technicians, physicians, and nurses, we did not assess the opinion of other providers and patients.