Utilising AI based Image processing for Disease Identification

(Analysing Urine Strips via Computer Vision based Colour isolation and Contouring)

Abstract:

Novel methods were developed in this research exercise to analyse and identify colour changes on urinalysis strips accurately and with ease. The research extensively used Urinalysis strips and colour correction cards. The colour correction cards help to detect images and ultimately aid image processing in any lighting condition. A python program was written and utilised to detect colour thresholds and give results that include an accurate analysis of the urine strip test, and the diseases that apply to the results.

Research question

How can we utilise image processing to analyse urine strips faster, efficiently and without any human intervention? Do the use of home printed colour correction cards have any impact on the accuracy and efficiency of urine analysis as compared to PANTONE colour correction cards?

1. Introduction

1.1 Issue of Urine Analysis: Patients in India and across the world face issues with testing for health check-ups. One way to get a urinalysis related check up is a detailed urine analysis test that takes place in hospitals and clinics. This test involves 3 stages - visual, microscopic and dipstick examination - and takes about 24 hours. Furthermore, it is costly starting at around INR 2500 and going up to INR 20000 for more detailed testing .

Labs provide another option to use automated urine analyzers, which can cost upwards of INR 50,000. Therefore, these two methods are quite impractical for a base examination.

The alternative to these are home urine analysis strip tests, which only cost about INR 350 for 100 strips.

A urinalysis strip has 10 blocks on it, each corresponding to a different parameter and having a different reagent, each of which changes colour on reaction with the urine. The parameters that are tested in this are for leukocytes, nitrites, proteins, bilirubin, urobilinogen, ketones, glucose, blood, specific gravity, and pH level.

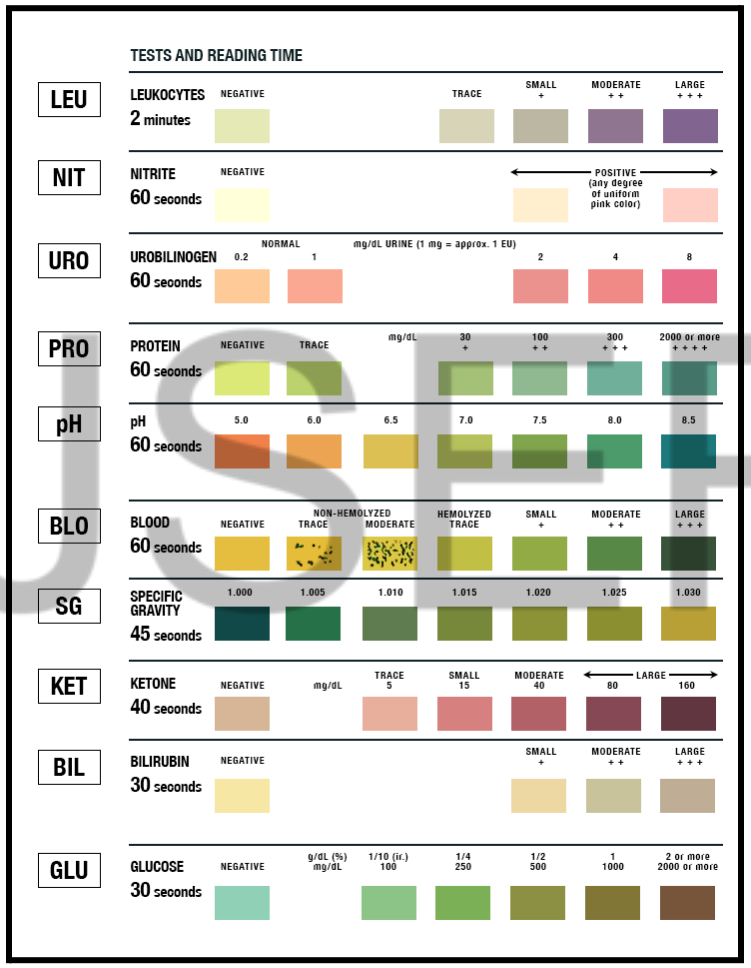
However, one major problem with this test is that it is prone to human error. Often while analysing the colour changes on these strips, medical staff or even the patients themselves can make errors in correctly identifying the shade of colour. This poses a significant problem as it often leads to incorrect diagnoses and hence the wrong treatment.

In fact, statistics at the global level reveal an alarming fact.

- 1 in every 4 samples of urine is inaccurate due to errors of the patient while giving the urine
- 50% of tested urine is deemed to be inaccurate due to human errors of doctors while analysing

This calls for a simple yet effective and accurate way of home testing.

1.2 Diseases detected with Urine Analysis:



All of the parameters on the urinalysis strip are indicators of at least one disease. The most common disease detectable are UTI's, or urinary tract infections.

- Glucose content can indicate glucosuria, diabetes mellitus and renal glycosuria.
- The bilirubin concentration can detect hepatitis(along with other liver diseases) and jaundice.
- Ketones are indicators of ketonuria and diabetic ketoacidosis, and the specific gravity parameter can help detect diabetes insipidus.
- Protein concentration can detect proteinuria, kidney disease, nephrotic syndrome, etc.

- The presence of blood can indicate hematuria or myoglobinuria and the pH level can detect kidney stones, metabolic acidosis, renal tubular acidosis, etc.
- The nitrite and leukocyte test help detect urinary tract infections, and leukocytes can also indicate pyuria, kidney stones and acute inflammation renal calculus.
- Lastly, urobilinogen concentrations can point toward hemolytic anaemia as well as liver diseases like cirrhosis.

1.3 Frequency of Urine Analysis

A urinalysis test can be frequently done depending on the kind of diseases and the kind of patient. Diseases that work similar to diabetes, liver disease and kidney disease (UTIs) are usually more sensitive and hence require daily monitoring.

This, if done at the lab, would be a very costly affair for the already under stress patient.

1.4 AI based Image processing can help mitigate human error

Inaccuracies due to human errors of both patients and doctors can create massive problems while generating a urinalysis report. This includes incorrect diagnosis, which can lead to incorrect treatment, all which will just compound the patient's problem.

The main example of a human error is when the colour change on the strip is not correctly detected, as the colour on the strip may be very faint and hard to ascertain.Therefore, there is a great need for a method that can accurately analyse a strip and hence eliminate human errors.

Such a method includes the use of computerised testing that captures images well and generates the report after image processing, ultimately increasing both the accuracy and precision of urinalysis tests.

2. Methodology

The research process consisted of 3 stages :

- Data collection,
- Colour correction
- Thresholding/contouring

2.1 Data Collection :

Work was done with over 200 images of the urinalysis strips alongside the colour correction cards in multiple lighting conditions to best simulate the actual image that would be clicked by a patient or user.

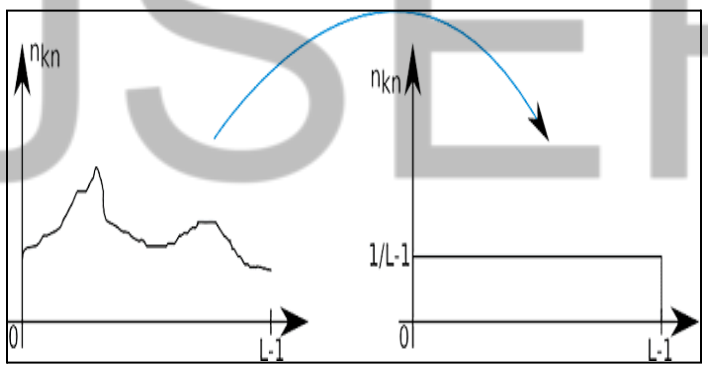
In order to simulate different conditions, the pictures utilised were both with home-printed colour correction cards as well as professional-grade ones.

2.2. Colour Correction

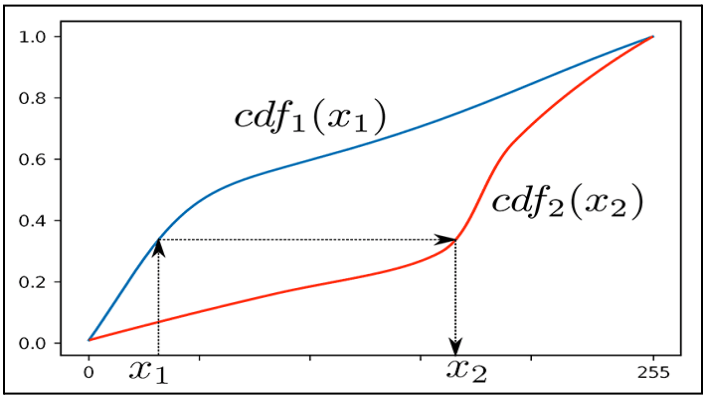
The colour correction cards had an ArUCO marker on them, and so these markers were detected by OpenCV.

This part was divided into 2 stages viz.

- Histogram equalisation &
- Histogram matching

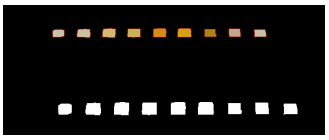


HISTOGRAM EQUALISATION

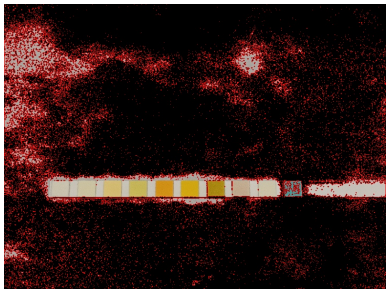


HISTOGRAM MATCHING

2.3 Thresholding



The last stage was thresholding. After the images were colour corrected, manual adjustment of thresholds of various individual images in a lookup table consisting of more than 56 shades of colours was done. Post this, a contouring-based technique was used to isolate different blocks on the strip so that it would become easier to analyse them separately.



This was followed by printing our own colour correction cards using an off-the-shelf colour printer. Since the accuracy of a colour printer depends on the calibration done to the cartridges,an additional morphological transform correction was done to get rid of the extra contours.

Post analysing the strip, the test results were displayed on the screen.

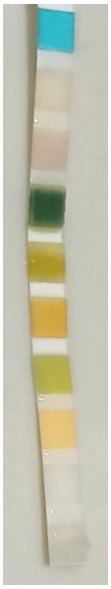
3. Results

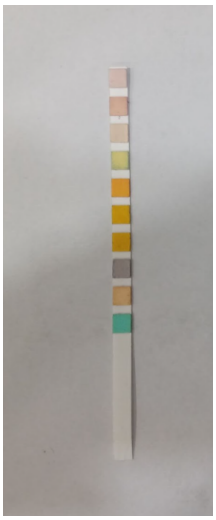
The results that obtained showed that the program could

- Accurately detect the colours present in the tested and untested urinalysis strips.
- Furthermore, the accuracy of the results from the home-printed colour correction cards were similar to the professional-grade PANTONE colour correction cards.

This is an important observation as professional-grade colour correction cards like PANTONE are relatively expensive - more than INR 1000 . So, by printing our own cards rather than buying them, the costs come down significantly.

The results were also cross-verified by a doctor.





UNTESTED STRIP

H_{LOW}(°)	H_{HIGH}(°)	S_{LOW}(%)	S_{HIGH}(%)	V_{LOW}(%)	V_{HIGH}(%)
15	19	13	17	78	82
17	27	22	32	76	86
26	30	16	20	77	81
48	54	35	41	73	79
32	42	73	83	74	84
39	47	89	97	68	76
40	44	90	94	63	67
20	28	8	16	44	52
29	35	43	49	64	70
160	172	43	55	50	62

THRESHOLD LOOKUP TABLE FOR UNTESTED STRIP

4. Conclusion

The project developed is very effective in eliminating human error and increasing the accuracy and precision of urinalysis strip test results.

Furthermore, it helps make the test more convenient and easy to perform, as users can conduct it accurately at their own homes without having to go to a hospital or clinic. It also helps replace its expensive and time-consuming alternatives such as automated urine analysers and detailed urinalysis tests for base examinations.

This program also has a lot of future scope, as it can be developed into a web or mobile app which can then be even more easily used by patients or even hospitals and clinics. Not only this, but urinalysis strip manufacturers can also provide their own colour correction card along with the strips as part of a self-test kit, so that the users do not have to search for professional-grade cards.

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