Manipal Journal of Pharmaceutical Sciences

Volume 7 | Issue 1 Article 8

3-1-2021

# Artificial Intelligence based Point-of-Care Test Device for Urinary Dipstick Analysis for Urinary Tract Infection

Huchegowda R
*National Institute of Mental Health and Neurosciences (NIMHANS), Department of Neurochemistry, Bangalore*

Huchegowda C
*Department of Electronics and Communications Engineering, CMR Institute of Technology, Bangalore*

Research Article

# Artificial Intelligence based Point-of-Care Test Device for Urinary Dipstick Analysis for Urinary Tract Infection

Chetan Huchegowda, Ravish Huchegowda*, Jyothi R Jain

neuroravish@gmail.com

## Abstract

**Abstract:** Urine dipstick test, a basic point-of-care (POCT) diagnostic test that determines pathological changes in the analytes present in urine. The test methodology includes immersing the strip in the well-mixed urine sample for a few seconds to minutes and analyzing the strips visually for any color change. Results analyzed in such a method can be biased or may have human errors due to visual problems like color blindness. The present study uses artificial intelligence to solve the issue and help the patient and the practitioner to obtain more accurate and rapid results.

**Key words:** Artificial Intelligence, Dipstick Test, Manual Error, Point-of-Care Testing

## Introduction

Urinary tract infection (UTI), the most commonly seen bacterial infection in the elderly population is often over-diagnosed and over-treated based on non-specific clinical symptoms and due to the prevalence of asymptomatic bacteriuria (ASB) among the elderly. .[1-5] A dipstick test is a point-of-care test (POCT) for the diagnosis of UTIs, in which a paper strip is dipped into the urine sample for a few seconds to a few minutes, and the color change is compared to a standard screening chart. The strip consists of patches impregnated with chemicals, which undergo color change upon exposure to a particular concentration of urinary constituents. A standard urine test strip consists of up to 10 different chemical reagents reacting with urinary sample constituents. . The test can often be read within 60 to 120 seconds after dipping, although some tests demand a longer time. Routine urine analysis with multi-parameter strips can be the first step in the diagnosis of a wide range of diseases.[2] Although a urine dipstick analysis cannot distinguish an ASB from UTI, it is commonly a practice to diagnose UTI in elderly patients. These are frequently used as screening tests in health centers for better and early management of antibiotic treatment before the availability of time-consuming culture test reports.[6]

There are reports available regarding the use of urine dipsticks among pediatric, working adults, and pregnant women. However, the results are divorced according to the age group studied.[7,8] Nevertheless, there are not many studies on the use of urine dipsticks in the elderly population.[1] Considering the extensive use of urine dipsticks, more studies are necessary to assess the reliability of these tests. As with any endeavor involving the human element, there are chances of manual errors. The purpose of this study is to assess the reliability of the use of dipsticks in screening UTI in elderly patients, a population in which both UTIs and ASBs are highly prevalent, and to assess the possibility of implementing artificial intelligence (AI) for the

**Chetan Huchegowda[1], Ravish Huchegowda[2], Jyothi R Jain[3]**

1 *Department of Electronics and Communications Engineering, CMR Institute of Technology, Bangalore 560037, Karnataka State, India*

2 *National Institute of Mental Health and Neurosciences (NIMHANS), Department of Neurochemistry, Bangalore 560029, Karnataka State, India*

3 *JAIN (Deemed to be University), Department of Biotechnology, Bangalore 560041, Karnataka State, India*

* Corresponding Author

Date of Submission: 12-Mar-2021, Date of Revision: 16-Mar-2021, Date of Acceptance: 16-Mar-2021

**How to cite this article:** Huchegowda C, Huchegowda R, Jain J B. Artificial Intelligence based Point-of-Care Test Device for Urinary Dipstick Analysis for Urinary Tract Infection. *MJPS* 2021; 7(1): 87-90.

POCT device. AI uses sophisticated software systems which enable the computer systems to augment and emulate human intelligence and decision making. It uses algorithms to learn from previous data with known outcomes to recognize patterns and mimic the decision-making of experts. This may help in a rapid and accurate diagnostic result of urinalysis devoid of any human errors or bias involved in the normal visual analysis of the dipstick test for urinalysis.

## Materials and Methods

Dipstick test is generally a quick and inexpensive screening method that requires limited expertise. The dipstick test for urinalysis is a strip with reagent pads for semi-quantitative assessment of specific gravity, nitrite, pH, leukocyte esterase, protein, glucose, urobilinogen, ketones, bilirubin, and blood with different reading time for each..[9]

*Test for leukocyte esterase:* Leukocyte esterase is produced by neutrophils and may indicate pyuria associated with UTI. However, white blood cells (WBCs), anywhere in the GU tract, including the vaginal vault, will produce leukocyte esterase. To detect the presence of WBCs, dip the strip in urine and wait for two minutes. The change in color will detect the presence of WBCs in the urine suggests infection in the bladder, urethra, kidney, or presence of pelvic area tumor, blockage in the urinary tract, or kidney stones. . The test for leukocyte esterase is purely indicative of WBCs, and should not be solely relied on for diagnosis, as it does not replace microscopic or urine culture examinations.[10]

Test for NitritesBacterias like gram-positive or gram-negative is capable of converting urinary nitrates to nitrites which can be detected by a positive dipstick nitrite test (wait for 60 seconds after dipping the strip in urine). It generally requires more than 10,000 bacteria per ml to turn the dipstick positive. This is a screening test for asymptomatic infections caused by nitrate-reducing bacteria, which suggests a UTI.

The test for leukocytes and nitrites is frequently used to screen for possible UTIs. The test is a rapid screen for possible infections by enteric bacteria but does not replace microscopic examination, urinalysis tests, or subsequent monitoring, as other microorganisms that do not reduce nitrite can also cause urinary infections.[10]

*Urobilinogen:* Urobilinogen, is a yellowish substance and is formed from the reduction of bilirubin. It is found in the liver which helps in breaking down the red blood cells. Positive test results can indicate liver diseases such as cirrhosis, viral hepatitis, liver damage due to drugs or toxic substances, and/or conditions associated with increased RBC destruction. Dip the strip in urine and wait for 60 seconds. A negative result is indicated if urobilinogen is less than 17 µmol/l (< 1mg/dl). The test is generally carried out at room temperature, as the sensitivity of the reaction is hampered with temperature.[10]

*Protein:* The strips are checked after dipping in urine for 60 seconds. Avoid vigorous exercise before taking the urine protein (albumin) test, as this can also affect the amount of protein in your urine. Low levels of protein in urine are normal, but higher amounts may indicate a kidney problem called albuminuria or proteinuria.[10]

*pH:* The pH level indicates the amount of acid in urine. Abnormal pH levels may lead to the formation of crystals in urine or stones in the kidney which may indicate a urinary tract or a kidney disorder. Wait for 60 seconds after dipping the strip in urine for the results [10].

*Blood:* Haematuria is a condition that indicates the presence of blood in the urine. If blood is present in urine in large quantities, it can be visually detected. UTIs, medication, early stages of bladder cancer, strenuous exercise, benign (non-cancerous) tumors, bladder or kidney stones, etc., may cause haematuria. False-positive reactions due to menstrual contamination may be seen.[10]

*Specific Gravity:* Specific Gravity evaluates the body's water balance (hydration) and urine concentration, and helps evaluate kidney functions and possible kidney diseases. However, according to recent research from the University of East Anglia (UEA), urine tests should not be the only test used to measure dehydration among the elderly. To test for Specific Gravity, wait for 45 seconds after dipping

the dipstick in the urine sample. It is considered low at 1.000 but normal ranges from 1.020 to 1.030. A higher-than-normal concentration often is a result of not drinking enough fluids - water-loss dehydration happens when people do not drink enough fluid [10].

*Test for ketone bodies:* The presence of ketone bodies in the urine is a condition called ketonuria. Production of ketone bodies is a normal response to the insufficiency of glucose, meant to provide an alternate source of fuel from fatty acids. Ketones are the result of fat metabolism that is generally encountered in uncontrolled diabetes. Higher levels of ketones in the urine indicate that the body is using fat as the major source of energy. The test results can be analyzed after dipping the strip in urine for 45 seconds, and the presence of ketone in any amount indicates diabetes.[10]

*Bilirubin:* The highly pigmented compound, bilirubin is a is a by-product of hemoglobin degradation. The detection of bilirubin in the urine is an early indication of liver diseases such as hepatitis, a blockage in the structures that carry bile from your liver, or a problem with general liver function. It takes only 30 seconds to analyze the dipstick dipped in urine. It is a common test in urinalysis dipsticks, which is known to yield a high rate of false-positive results.[10]

*Glucose:* Glucose in the urine could indicate renal glycosuria or diabetes. The result can be seen within 60 seconds of dipstick analysis. The extra sugar in the bloodstream is usually only removed via the kidneys and detectable in urine at blood sugar concentrations of 10 mmol/L (180 mg/dL) and above. Any detection of sugar on this test usually calls for follow-up testing for diabetes.[10]

## Implementation of AI in POCT device

A standard urine reagent strip and analysis are depicted in Figure 1. In this project, the image was captured and the required parts (pads) were extracted and indexed. This was sent to the server, which uses a convolutional neural network, to detect the parameters and display it as shown in Figure 2.
Expected outcome

The expected outcome of the study is the creation of a setup that uses the proposed architecture to automatize the assessment of the urinary dipstick, which will minimize/eliminate the involvement of humans, thus minimizing human biases. The study aims to optimize the model to have an accurate and effective assessment of the dipstick. As a preliminary study, a pre-trained convolution neural network model has been trained for 10,000 steps, which was able to accurately predict the correct label 93.6% times (Figure 3 and Figure 4), showing the accuracy which keeps improving with an increase in the steps of training

## Applications

Manual assessment of analyzing dipsticks by technicians is a widely used method. But human error is possible in this type of analysis. Hence, there is a need for a device that gives the user accurate results. The major benefits of the proposed POCT device which uses AI are the reduction of human errors in the analysis, rapidness in generating the results, and that it is portable and cost-effective, which will help the practitioners to diagnose the disease accurately. This will reduce manpower, stress for the technician and help patients to avail better treatment.

## Conclusion

Dipstick analysis, a POCT device used in urinalysis for a range of analytes present in urine for the diagnosis of various diseases, is analyzed visually by the technician. This may have human errors due to problems in vision such as color blindness or bias. Artificial intelligence (AI) can be a solution to the issue in which the software recognizes patterns by analyzing a large amount of training data curated with known outcomes and automatically determines accurate results. The major aims of further study will be to (1) extend and improvise the model for the accuracy of the preliminary work, (2) reduce the detection errors by training a custom-built model for larger data set effectively, (3) deploy the same model in a server for easy accessibility, and to remotely serve several sub/client devices at once, and (4) to tune this prediction process for cost-effectiveness. This study will enable practitioners and patients to obtain accurate, fast, and reliable diagnostic results without any human bias or errors.



Published by Impressions@MAHE,

## Conflict of Interest

The authors declare that there is no conflict of interest


Fig. 1: A standard urine reagent strip

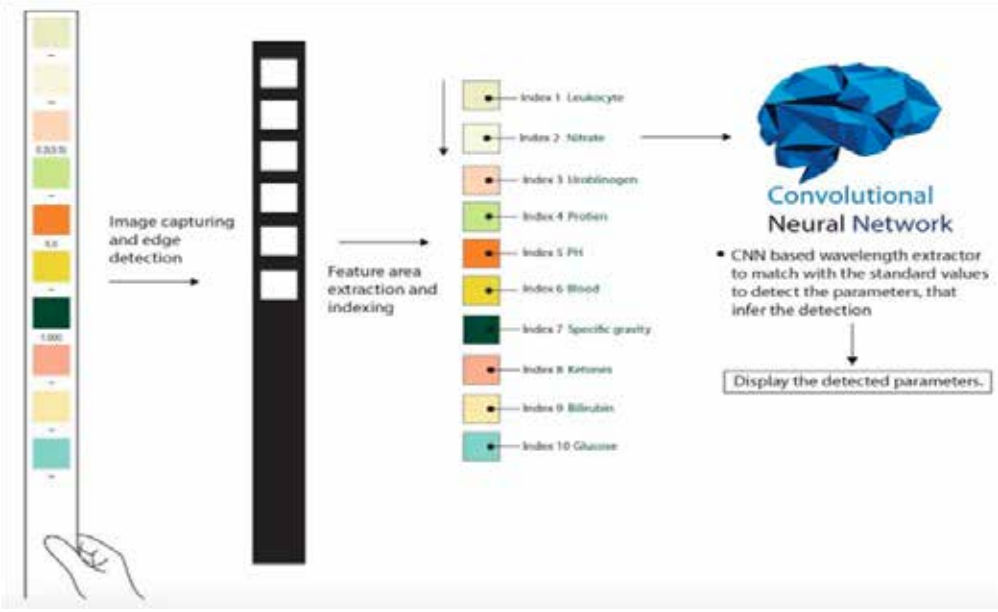


Figure 2: Implementation process

Figure 3: Accuracy v/s epochs

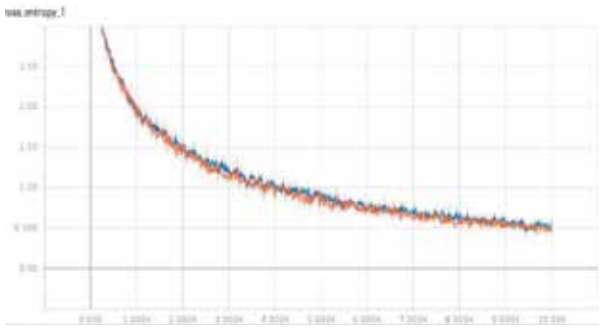

Figure 4: Loss function v/s epochs

## References

1. Beveridge LA, Davey PG, Phillips G, McMurdo ME. Optimal management of urinary tract infections in older people. Clinical interventions in aging 2011;6:173.
2. Kidshealth.org. Urine Test: Dipstick (for Parents) – Kids Health. [online]. 2019; Available at: https://kidshealth.org/en/parents/dipstick.html
3. Helsedirektoratet. Antibiotikabruk i primærhelsetjenesten. Nasjonal faglig retningslinje for antibiotikabruk i primærhelsetjenesten. Available from: https://helsedirektoratet.no/retningslinjer/nasjonal-faglig-retningslinje-for-antibiotikabruk-i-primerhelsetjenesten.
4. Fekete T, Hooton TM, Calderwood SB, Bloom A. Approach to the adult with asymptomatic bacteriuria. The New England Journal of Medicine. 2000;343: 992.
5. High KP, Bradley SF, Gravenstein S, Mehr DR, Quagliarello VJ, Richards C, Yoshikawa TT. Clinical practice guideline for the evaluation of fever and infection in older adult residents of long-term care facilities: 2008 update by the Infectious Diseases Society of America. Clinical Infectious Diseases. 2009;48(2):149-71.
6. Ducharme J, Neilson S, Ginn JL. Can urine cultures and reagent test strips be used to diagnose urinary tract infection in elderly emergency department patients without focal urinary symptoms? Canadian Journal of Emergency Medicine. 2007;9(2):87-92.
7. Sundvall PD, Gunnarsson RK. Evaluation of dipstick analysis among elderly residents to detect bacteriuria: a cross-sectional study in 32 nursing homes. BMC geriatrics. 2009; 9(1):32.
8. Krogsbøll LT, Jørgensen KJ, Gøtzsche PC (2015) Screening with urinary dipsticks for reducing morbidity and mortality. Cochrane Database of Systematic Reviews (1).
9. Klatt EC. [Internet]. Phlebotomy tutorial for medical education - WebPath. Available from: https://library.med.utah.edu/WebPath/TUTORIAL/URINE/URINE.html
10. Disabled-worldcom. Disabled-worldcom. [Online]. Available from: https://www.disabled-world.com/calculators-charts/urinalysis.php
11. Effendiinfo. Effendiinfo. [Online]. Available from: http://effendi.info/urine-test-strips-results-chart.html/urinalysis-test-strip-color-chart-learn-parallax-com-urine-strips-results.