

Design and development of automatic urine analyzer suitable for public toilets and transmission of vital composition to user's registered cell phone

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ABSTRACT - A sample of urine holds number of key information about the health of a person. The online urine analyzer is about the quantitative analysis of urine in real time. The automated urine analyzer is a proposed instrument for analyzing the contents of urine samples during the process of urination.

This paper describes the design of a system that can be used to monitor the urine contents such as pH, specific gravity, glucose and protein. The system consists of an automation unit inside the analytical chamber, bio-chemical sensor to determine the level of the constituent of urine, electronic hardware circuit comprising voltage regulator IC, serial ADC for signal conditioning, an eight bit microcontroller circuits for signal processing, ATM card reader system, GSM based data transmitter unit and auto flushing system. The vital composition of urine will be automatically sent to the ATM registered mobile/cell phone. This whole system never draws the intelligences and attention of user and hence, very convenient for use. The system is to be calibrated to the acceptable standard before practically implementing it. The proposed system is intended to be used in public toilet system on a nominal cost per use basis. Though the initial cost of design and installation is costly, in a long run it will prove to be economically feasible. This will also create health awareness among the public. The prelims medical suggestions for the user, in case of acute findings, can also be made possible with a standard medical data storage and retrieval process.

Key words: Urine analyzer, protein, bilirubin, glucose, microcontroller, ATM card reader, GSM.

INTRODUCTION

Urine analysis is primarily requested for the diagnosis of renal disorders. Urine analysis is used in chemical medicine

diagnosis method. It is also called as urine chemical analyzer. It is kind of automated instrument to test some chemical composition in the urine which is done with test strips.

The urine analyzer uses original urine as a urine sample directly for the analyzer that automatically completes the full process for testing and cleaning. The instrument quantitatively or semi quantitatively test the level of the bilirubin, ketone body, blood, protein, nitrite, glucose, vitamin c, micro albumin in the urine, according to some changes in the colours. Simplicity in obtaining urine specimens and relatively lesser cost of test makes urine analysis as important component of diagnosis in all developing countries.

1. CHEMICAL COMPOSITION OF URINE:

A normal adult discharges approximately 1500 ml of urine in 24-hour period. Water is main constituent of urine (95%) and contains the soluble waste products urea, uric acid, creatinine and excess electrolytes. Most hormones and drugs after carrying out their specific functions are normally discharged through the urine which makes this an ideal specimen for diagnosis of hormonal disorders and drug overdose.

Real time urine analysis is about the paper that speeds the process of urine analysis without causing any hindrance in day to day routine of the person. It updates the person about the health. A sample of urine holds prominent key information about the health of the person. Insight of a patient's health can be estimated by monitoring various information of urine [1]. This information includes:

1.1 Color: Many things affect urine colour, including fluid balance, diet, medicines and diseases. The amount of water content in urine makes how dark or light it is. Vitamin B supplements can turn urine bright yellow. Some medicines, beets, blackberries, rhubarb, or blood in the urine can turn urine red-brown.

1.2 Specific gravity: This checks the amount of substances in the urine. It also shows how well the kidneys balance the amount of water in urine. This test is used to measure tubular function.

1.3 pH: The pH is a measure of how acidic or alkaline (basic) the urine is. Dipsticks measure pH using methyl red, bromthynol blue or phenolphthalein indicator dyes. These reagents react rapidly and result in a color change.

1.4 Protein: Protein normally isn't found in the urine. Fever, hard exercise, pregnancy, and some diseases, especially kidney disease, may cause protein to be in the urine. The protein portion of the dipstick reagent strip measures the protein and it is based on pH dye indicator method using bromphenol blue.

1.5 Glucose: Glucose is the type of sugar found in blood. Normally there is very little or no glucose in urine. When the blood sugar level is very high glucose is present. Reagent strips measure glucose levels using the glucose oxidize method. This method is the sequential enzymatic reaction. Glucose reacts with glucose oxidize to produce hydrogen peroxide, which oxidizes the indicator chemical to produce a color change. The color change is related to the amount of glucose present in the urine sample.

1.6 Nitrites: Bacteria that cause a urinary tract infection (UTI) make an enzyme that changes urinary nitrates to nitrites. Nitrites in urine show a UTI is present.

1.7 Ketones: When fat is broken down for energy, the body makes substances called ketones (or ketone bodies). These are passed in the urine. Large amounts of ketones in the urine may mean a very serious condition, diabetic ketoacidosis is present. A diet low in sugars and starches (carbohydrates), starvation, or severe vomiting may also cause ketones to be in the urine.

1.8 Red or white blood cells: Blood cells aren't found in urine normally. The occult blood test will react positively in the presence of red blood cells, free hemoglobin or free myoglobin. Hemoglobin usually is bound and is too large to pass through the glomerular filter. If the renal threshold is exceeded, the hemoglobin can pass into the urine. Myoglobin can be detected in urine before a change in plasma color is apparent. White blood cells may be a sign of infection or kidney disease.

1.9 Bilirubin: Bilirubin is produced from the breakdown of hemoglobin, transported to the liver bound to albumin and conjugated with carbohydrates by hepatocytes. Only conjugated bilirubin is found in urine. Conjugated bilirubin is detected in urine if the renal threshold is exceeded. The bilirubin level makes a person suffer from "Jaundice".

2. AVAILABLE METHODS OF ANALYSIS:

There are various methods of urine analysis in practice [2], [3]. These methods are mostly confined to analytical laboratories or patholabs. Some methods include:

1. Physical examination method
2. Urinometer method

3. Refractometer method
4. Reagent- strips method

2.1 Physical examination method: Physical examination of urine includes measurement of volume of urine discharged, examination of colour and appearance, detecting the odour and recording the specific gravity. Measurement of volume of urine discharged by the patient is only done for the 24-hour urine specimen and where glomerular filtrate rate (GFR) or clearance rate is to be determined. These are the degraded products of urobilinogen after the latter is exposed to air.

2.2 Urinometer method: The urinometer method of measuring specific gravity of urine is based on principle of buoyancy. As increased solute concentration or specific gravity increases the up-thrust of the solution correspondingly increases. The increased up-thrust is reflected by the scale of urinometer as the latter is pushed up.

2.3 Refractometer method: This is a dependable optical instrument that can conveniently determine the specific gravity with a drop of urine specimen. Hence it is ideal for pediatric patients. It needs no temperature correction as the instrument is compensated to the variation of temperature. The instrument is also capable of measuring the protein concentration of serum. It is however expensive and needs delicate handling.

2.4 Reagent-strips method: The recent introduction of plastic reagent strips has practically eliminated the wet tests for the quick screening of urine chemistry. The method is simple, reliable, fast and often more specific and sensitive. Because of the ease of performing the test, the technician tends to develop carelessness in performing the test, or store the test strips in a way that render them ineffective. The test- strips are available in a form to run a single test (e.g. glucose), or to run a multiple tests that is glucose, protein, pH, haemoglobin, ketones, bilirubin and urobilinogen.

3. EXISTING URINE ANALYZER

There are several companies and agencies which manufacture offline urine analysers which are suitable for in vitro application. These systems are used extensively in hospitals and other medical care centres. But, these systems require some preparation, operator's intervention, and time for analysis. However, the initial and installation cost of such systems are relatively less compared to the online/automatic type. The cost of online/automatic urine analyser can always be justified and returned in terms of its repetitive use and hence at the end, the cost per use will drastically reduce.

There are few companies and inventions which are related to automated analysis of urine and possible use of such methods for sending urine data to the concerned person over the cell phone. But, none of these systems are proved to

be practically acceptable and hence not implemented for public use.

3.1 US Patent:

A US patent has discussion on the modern toilet system which comprises of urine component analysis and at least one of body physiological parameter such blood pressure, heart rate, and temperature. This system consists of urine sampler for sampling a portion of urine. The sampled urine is fed to a urine receiver and analyser. for measuring the proportion of a particular constituent of the urine, a measuring unit for measuring at least one of the blood pressure, heart rate, and temperature of a user of the urine receiver, and a display unit for displaying the results of measurement by the urine sampler, the urine analyzer, and the measuring unit [4].

3.2 Toto's invention:

A Japanese company TotoGroup has created intelligence toilet system, which can measure sugar levels in urine, blood pressure, heart rate, body fat and weight [5]. The results are sent from the toilets to a doctor by an internet capable cellular phone built into the toilet. Through long distance monitoring, doctors can chart a person's physical well-being. The Toto's inventions uses dipstick for analysis of a urine sample which is not viable and feasible for automatic method. Also, the Toto's invention is not implemented for public usage.

3.3 The urinometer:

The urinometer is a device which measures the specific gravity of urine samples. The specific gravity of normal urine depends on the amount of solids in solution. It is also affected by fluid intake versus fluid loss through skin, lungs, and bowels. The measurement of urine- specific gravity is important in determining the ability of the kidneys to concentrate or dilute the urine. The inability of the kidneys to perform this function could be indicative of renal structural damage, metabolic disorder, or endocrine disturbance. An accurate urinometer can provide rapid, reliable, and convenient determinations of specific gravity. Greater accuracy can be obtained with a pycnometer or with weighing bottles; however, these are rarely required in routine urinalysis, and are far less convenient to use[6]. Urinometer is used only to test specific gravity and pH, but not for other urine components

3.4 Intelligent colour classifier for urine analysis:

Eom Sang Hoon *et al.* have discussed colour sensor based classification of urine samples using a unique classifier method. This method uses a new classification algorithm. This algorithm is required for accurate classification and urine colour collection. The method is implemented using neural network algorithm. RGB parameters gathered by colour sensor are pre-processing using normalization. The

fuzzy inference and neural network were constructed. The experiment results were calibrated against 9 tests. Of many test items, experimental results showed a satisfactory agreement with test results of reference system [7].

4. PROPOSED METHOD

An intelligent toilet performing an extensive health check while being as simple to use as a conventional toilet is discussed by Thomas Schlebusch *et al* [8]. An intelligence toilet system, created by Japan's largest toilet company, Toto, can measure sugar levels in urine, blood pressure, heart rate, body fat and weight. The results are sent from the toilet to a doctor by an internet-capable cellular phone built into the toilet. Through long distance monitoring, doctors can chart a person's physical well-being. Main focus of the system is to support the treatment of diabetes and chronic heart failure, but additional applications are possible [9].

The method presented here is based on optical detection of various colours on the urine test strips. There are some electronic methods of detecting composition of urine. Sabeel T.M.A *et al.* have discussed the use of electronic nose for the detection of volatile components of urine [10]. There are methods of detection of red blood cells in urine image captured under microscope by image processing, Sobel operator and Hough transform to provide a reliable and convenient detective method for medical research [11]. In the Indian perspective these are financially not viable. Also, much awareness about such state of the art toilets is to be created. The method discussed here and its practical implementation is much simpler and cost effective.

5. WORKING MECHANISM

The user has to swipe his/her ATM card. The card reader, after authentication and balance check, deducts prescribed fee (say Rs.50 per use). Meanwhile microcontroller stores the registered mobile/cell number from the card and also flushes out the urine pit. A small quantity of urine will be sampled for urine analyzer. Urine analyzer will be fitted with many physical and bio-chemical sensors required for the detection of concentration of vital parameters of urine such as specific gravity, colour, glucose, bilirubin, ketones, blood cell and other. The number and type of sensor to be used depends on the application. These parameters are fed to microcontroller/ processor unit. The controller/ processor will make thorough comparison with standard set of data and these parameters are sent to the registered mobile/cell phone (cell phone number registered with ATM card). Some medical interpretation can also be made and sent the benefit of user. The urinal basin is located at the first end of the system unit.

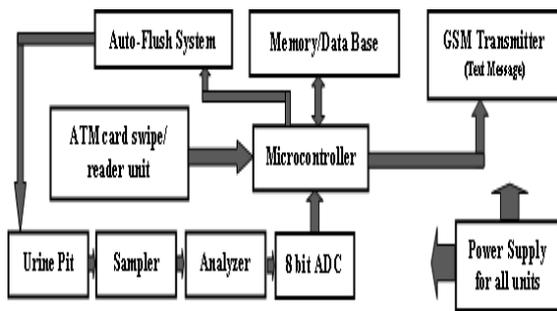


Fig-1: The block diagram of the system.

6. DETECTION INTERPRETATIONS

Protein: Protein content present in the urine indicates some unhealthy symptoms like fever, kidney diseases, pregnancy.

Glucose: Extreme concentration of Glucose present in the urine indicates the person is diabetic.

Bilirubin: Excess Bilirubin content in the urine indicates symptoms of liver diseases, jaundice

We can also use reservoir to hold the urine sample temporarily. Here we have used motor just to support urine strip roller in providing one by one urine strips. Motor rotation in turn is controlled by microcontroller with built in ADC. The ADC converts the analog signal received into digital signal. The signal is fed to the microcontroller unit.

The microcontroller coordinates and guides various units of the analyzer. It supervises all the sensors attached in the reservoir. It also guides the pump and the motor attached to the automation unit. Besides it compares the various signals of the different constituents of urine with the standard signals.

7. CONCLUSION

The modern era of science and technology is ever trying to increase the living comfort and health attainment of human being. The electronic engineering inventions have profound impact on the better living standards. This paper discusses an innovative, intelligent and hassle free confidential way of urine analysis where in it draws no attention from the user and no operators intelligence. It is a unique way of knowing important composition of urine in a highly confidential way. The microcontroller can always be replaced with dedicated processor such as ARM processor for better processing and larger data handling.

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