

Design and Development of a Home-based Uric Acid/ pH Level Analysis Device for Gout Patients: A Health Information Technology Application (HIT)

Neil P. Balba, Favis Joseph C. Balinado, Rio Aguilar-Escanilla, Terrence Lim, Elvin F. Gaac



Abstract—Nowadays, technology affects every distinct aspect of modern society. Hi-tech revolution invades the way people live in this technological era. As the Philippine healthcare industry crosses the threshold of digital age, the needs for a health information technology device challenges the proponents to make a possible solution in creating a system related in health care. The proponents come up with the idea of creating a device that will analyze the urine pH of a gout patient and correlate it to the uric acid level. The proponents designed and developed a home-based uric acid/ pH level analysis device for gout patients that is capable of measuring the urine pH of the user and correlate it to the uric acid level. This study is divided into two parts; the first part is the hardware part wherein the proponents used Arduino Microcontroller, Bluetooth module, pH sensor kit and power boost converter. On the other hand is the software part, which includes the Arduino IDE and B4A software. This device uses an android application in order to display the result of the test and the medical status and profile of the user. The android application has a purpose for doctor and patient interaction for the doctor's clinical recommendation. The proponents are able to build a device that measures the pH/uric acid level of a gout patient using the pH sensor and the Arduino micro controller

Keywords: Uric Acid Level, Arduino Microcontroller, HIT, B4A, pH sensor, Android

I. INTRODUCTION

A. Background of the Study

The impact of technology has seen in every aspect of life, whether in transportation, communication, education, business, agriculture, security, healthcare and many more.

Uric acid (UA) is the main end product of purine metabolism, and its excretion in urine is caused by purines that are produced in the catabolism of the dietary and endogenous nucleic acid. The production of excess uric acid may precipitate in the kidney and the lower extremities. One problem caused by the metabolism of the uric acid is gout [1]. Gout is the most prevalent form of inflammatory arthritis in men older than forty years of age and has a significant functional and social impact [2, 3]. Urine pH measures the acidity of urine to determine if it is acidic or alkaline and serves as a screening test for renal, respiratory, and metabolic disorders along with other tests.

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Neutral urine is 7, so urine with a pH below this number is categorized as acidic (the norm) and urine with a higher pH is alkaline. The kidneys acidify the glomerular filtrate from about 7.4 to about 6 when it is excreted as urine. The pH has an important role in the development of renal calculi. Acidic urine can result in xanthine, cystine uric acid, and calcium oxalate stones while alkaline urine can result in calcium carbonate, calcium phosphate, and magnesium phosphate stones. If stones are associated with acidic urine, then the diet is modified to keep the urine alkaline, and vice versa. Urine pH and Uric Acid has a great relationship in determining and analyzing gout attack. The urine pH and Uric Acid are inversely proportional with each other. [4]. In due course, the proponents designed a Health Information technology (HIT) device that will analyze the Uric Acid/ pH level of a gout patients. The device is designed for home uses so that got patients will not be having a hard time in going to clinic laboratories to monitor their pH/ Uric Acid to prevent gout attacks. The proponents also design an android application for the patient's and doctor's interaction. There is a management plan where in the doctor can login to create patient's profile and to monitor the records of pH / uric acid level testing. Within the application the user can test the uric acid if they have a profile that was created by the doctor so that they can login to the system. The system has an auto-calibration for the user to test their urine easily. This is also designed to monitor and view the result of the uric acid test. It would be a great advantage most especially for elderly because they will be able to monitor their uric acid/pH level even at home to prevent and lessen gout attack.

B. Objectives of the Study

The main objective of this study is to develop and design a Health Information Technology (HIT) Device that will analyze the Uric acid/ pH level of Gout Patients Specifically, this study aims to:

- To create a device that is capable of analyzing the uric acid level/ pH level of gout patients using pH sensor and Arduino microcontroller.
- To design and develop an application software that will display the result of the test and the medical status of the user.
- To design a low-cost and efficient health information technology device using a microcontroller for home-base used.
- To test the accuracy, reliability, functionality, user-friendliness and efficiency of the device.



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C. Significance of the Study

This study will be a significant endeavor in promoting good work environment in the workplace. It will also develop and enrich the skills and capabilities of computer engineering students to create and innovate new ideas regarding Health Information Technology (HIT). This project will be a substantial help to serve as a medical device that will analyze and predict the gout attack of gout patient. This study will benefit the following:

Patients: This study is significant and helpful for patients that is suffering from gout. The patients will be able to monitor and analyze their uric acid/ pH level even at home. This will be a great advantage in monitoring the uric acid/ pH level of the patient to lessen and avoid gout attacks.

Future the Study: The outcome of this study is advantageous to present and future researchers. This study can encourage and motivate researchers to create and innovate more medical devices that can be useful in maintaining the good health of an individual. It can also provide one of the foundation of the new theory about Health Information Technology (HIT).

II. REVIEW OF RELATED LITERATURE

A. Related Literatures

According to Margaret Rouse, Health information technology (HIT) is a part of Information Technology (IT), which where the improvement, foundation, design, usage and maintenance of the healthcare system are involve. HIT improves the medical system, efficiency of medical tools and patient's necessity. In Health Information Technology (HIT) includes Electronic Health Records (EHRs) where the information of the patient are already stored electronically and it is the improved version of the old method that still using by some doctors where the storing of patients' records is still in paper files. Using EHRs, the doctors can easily monitor the health information of their patients and the patient's records are can still be access even though the office is closed. EHRs also make it easier for the doctor to share information with other specialists so they can had the necessary information easily [5].

Arduino, an open source electronic platform for creating electronic based projects. It is a configurable physical circuit that can be also programmed using a computer interface. Arduino platform became popular with people which starting in electronics, and with good intention. Compared to preceding programmable circuit boards it does not need a separate hardware to upload new code but instead it only uses USB cable [6].

Gout is a form of arthritis that occurs when there is too much buildup of uric acid on the body. These buildups can cause: severe uric acid crystals deposited in the joints (usually in big toe), Uric acid deposits (tophi) that is under the skin looks like lumps, and Uric acid crystals in the kidneys that will cause kidney stones. Gout can cause: pain, swelling, redness, heat, stiffness in joints (NIAMS, 2014). [7]. Gout usually happens in attacks. Attacks usually advances rapidly over few hours. The victim will feel severe pain in one joint. If the attack is left untreated it may last for several days but will usually go away completely within 10 days. Less painful attacks can be mistaken for other type of arthritis when occurred. Attacks will occur again between

weeks, months, or even years some victims maybe only experience one attack (Tidy, 2017). [8]

According to the Urology P.C when the urine is acidic (pH 5.5 or less) uric acid stones are formed and they often dissolve in vivo when the pH of the urine is raised via administration of alkali. It is now clear that if the urine is acidic the uric acid stones are more likely to form. Determining the pH of the urine can help the gout patient to control their diet. If the gout patients' pH level in urine is 5.5 and below the patient are most likely to have gout attack and uric acid stones. And if the pH level in the urine is higher or alkaline the uric acid stone and gout attack will dissolve. [9]

According to a study if a urinary pH is less than 5.5 the uric acid becomes insoluble and forms crystal of anhydrous or dihydrate uric acid. The uric acid stones are being formed if uric acid is substantial. The patients with a pH less than 5.5 are more prevalent to have uric acid crystals than those who has higher urinary pH. In this study they used pH meter and dipstick to validate if their device is functioning well. This device has an auto calibration system that allowing the user to measure immediately the urinary pH after pushing a button. This study is beneficial to the patients in controlling their urinary pH so that they can prevent uric acid stones and kidney stones. A pH sensor is used in this study in measuring the urine pH [10].

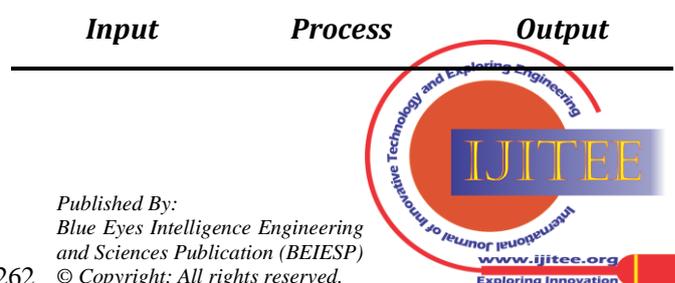
B. Synthesis

Health Information Technology is one of the trending topics this 2017, it is now being applied to health and health care. It supports health information organization across computerized systems and it secure the exchange of health information. There are also several studies related to pH level, uric acid level and gout. With all those studies the researchers therefore acquires a lot of information and knowledge regarding the research study. The information and data that was within the related literature shows the relationships between the uric acid, pH and gout. From all those studies the researchers also based the hardware components that they will be using for a reliable system. Each researches has different uses, proposed design, functionality, objectives, scope and limitation and significance of the study. The proponents gathered related literatures and tabulated reviews as shown in table. It shows the simplified and summarized related literatures. With all the gathered related studies the proponents has decided to come up with a decision to pay attention in the health and health care of the people. The related literatures help the proponents to gain more knowledge and ideas on how they will contribute a study about health information technology (HIT) and come up to create and develop a uric acid/ pH level analyzing device for gout patients to monitor and analyze the pH level of the patient to avoid gout attacks.

III. CONCEPTUAL FRAMEWORK

A. Conceptual Framework

TABLE I. CONCEPTUAL FRAMEWORK



| | | |
|-----------------------------|---|--|
| Urine sample | *pH sensor will measure the pH of the Urine sample *Arduino | *The result will displayed in the "android device" |
| User Inputs | | |
| * Calibrate function | Microcontroller will analyze and compute the pH of the Urine sample | *The clinical recommendation |
| * Analyze Function | *Bluetooth is used to connect to the "android device" wirelessly | and advice from the doctor will be displayed in the android device |
| * User Profile | | |
| *Doctor's Advice | | |

Table 1 shows the IPO chart of the system. The input of the system is the urine sample, user inputs, calibrate function, analyzed function, user profile and doctor’s advice. The system will measure the pH of the Urine Sample and the Bluetooth is used to connect to the android device. The output will be displayed in the android device and the clinical recommendation from the doctor.

IV. METHODOLOGY

A. System Block Diagram

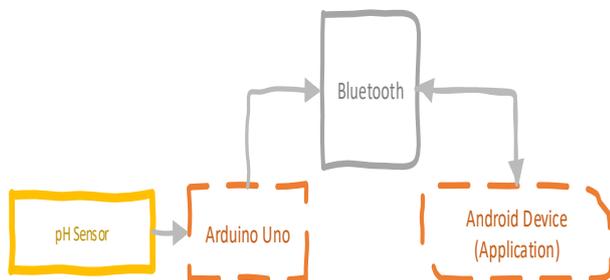


Figure 1. System Block Diagram

1. pH Sensor: This is the process of measuring the pH level of the “sample urine” to send it to the Arduino Nano micro controller. The pH sensor takes analog measurement which will be interpreted by the Arduino controller.
2. Arduino Nano: The device that gathers data from the ph sensor and processes it to usable information. The results will we sent to the Android device via Bluetooth.
3. Bluetooth: This is the type of connection the device will use.
5. Android Device: A smart phone that will control the action of the Arduino device. It is connected to the arduino using the Bluetooth connection built in it. This is also where the information will be store.

V. RESULT AND DISCUSSION

The proponents discussed and illustrated the results of the various test and experiments in this chapter. The test and experiments determine the functionality of the system, accuracy of giving a precise output, reliability of giving a consistent data output, user-friendliness and efficiency of the system through interpretation and analysis of data based from numerous testing and experiments. Presented are the data gathered from the series of tests conducted by the proponents. To test the accuracy, reliability and stability of error of the system, the proponents used test method a method for a test in science or engineering such as physical, chemical or statistical test which is a definitive procedure

that produces a test result. The data gathered from the test are essential in answering the problems considered in achieving the objectives of the study.

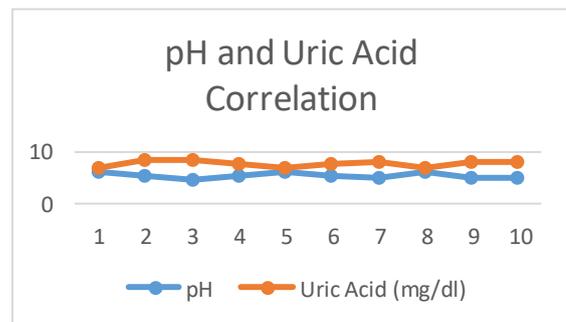


Figure 2. pH and Uric Acid Correlation

Fig 2 shows that there is a correlation between the pH of the urine sample and the Uric Acid. As the pH level gets low meaning acidic the uric acid gets high.



Figure 3. pH/Uric Acid Analysis Device

Figure 3 shows the actual prototype of the system. It is composed of the Arduino Nano microcontroller as the brain of the system, E-201C pH sensor module kit for measuring the Urine pH, HC-05 Bluetooth module for the android phone and Arduino microcontroller connection and XL6009 DC to DC Step up down Boost Buck Voltage Power Converter Module for the power supply of the system. This system is used in measuring the urine pH of the gout patients through the pH sensor and correlate it to the Uric Acid

VI. CONCLUSION

After the execution, the system is able to analyze the pH/uric acid level of gout patients that can be accessed through an android application. Also, the proponents are able to achieve their specific objectives and these are the following:

- The proponents are able to build a device that measures the pH/uric acid level of a gout patient using the pH sensor and the Arduino micro controller.
- The Device uses an android application to display the result of the test and the medical status (profile) of the user.
- The device is able use health information technology using the Arduino microcontroller for home use.



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• The pH/Uric Acid Analyzer Device is able to have similar measurement with the typical device used to measure pH levels in a solution. The device has more function than its other comparable device, it not only measures the pH level of the solution but also correlate the result to know the uric acid level of the user. Thus, reducing the work for obtaining information about the user's current health.

(2014). A new device for simple and accurate urinary pH testing by the Stone-former patient. Springer Plus.

VII. RECOMMENDATIONS

The proponents are recommending the following for the future researchers:

I. The proponents to use a power supply with similar power specification to an USB port.

II. The pH Sensor rely on voltage to measure the pH level, therefore the sensor can be affected with varying voltage supplies. A certain "module" must be able to detect this change to compensate for the changes of voltage.

III. The proponents also recommend a cloud server because currently the database is only in the android device making it inaccessible from different devices.

IV. The device uses an android based GUI but, it's not adaptable to different devices due to problem in resizing the interface. Therefore limiting its compatibility with multiple android devices.

V. The proponents strongly recommend having a proper "buffer solution" to calibrate the pH sensor to its neutral 7 pH level.

VI. The proponents also recommend exploring different type of algorithm to increase the accuracy of the information processed.

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