Digital Urimeter

Epocheon

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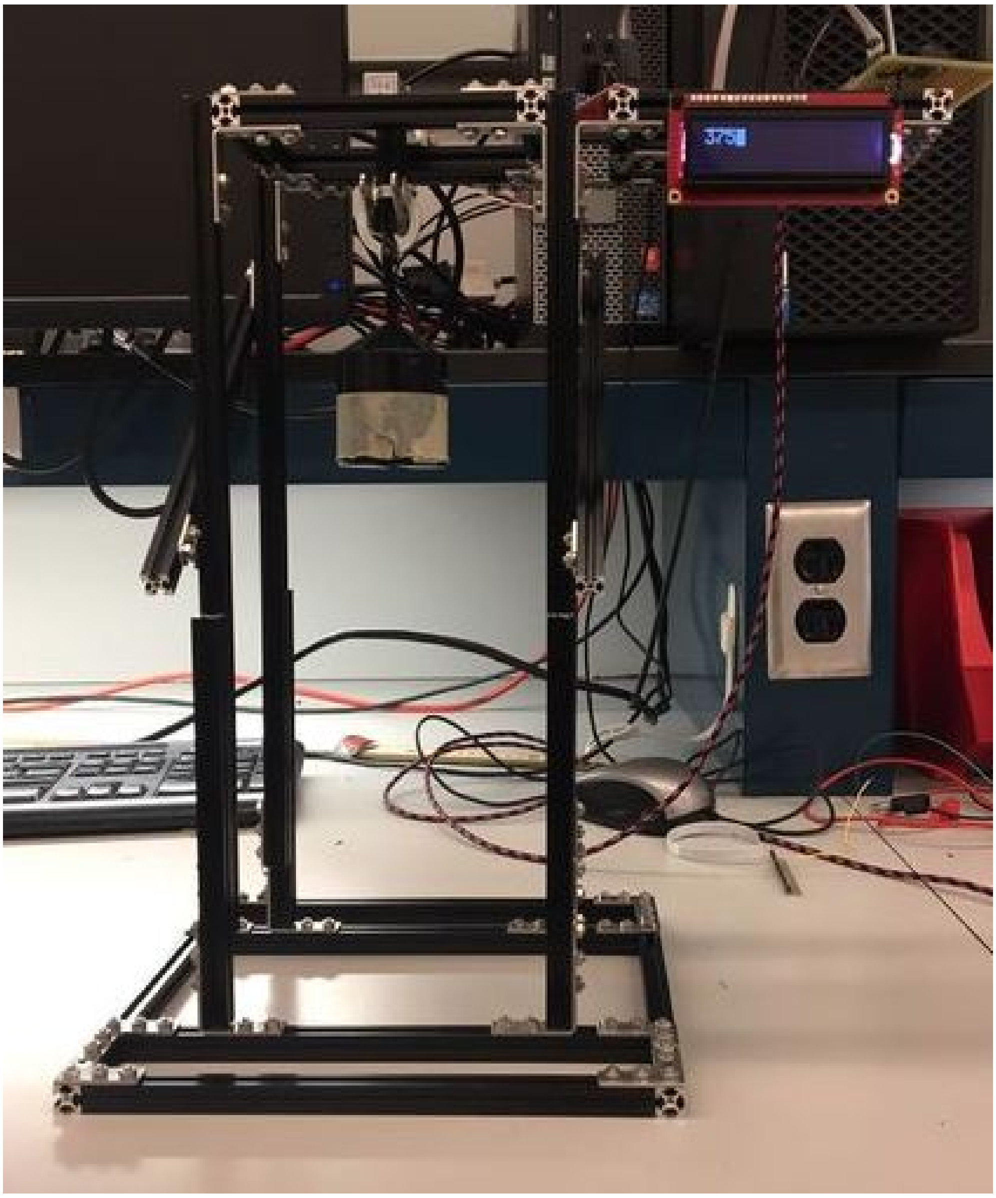

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Motivation

Measuring and monitoring the volume of urine patients produce is crucial to doctors and nurses in monitoring the health of those under their care. Even though fluid volume is a quantity which is relatively straightforward to obtain, the current requirement for nurses to manually note down the quantity of urine along with other information on an hourly basis for every patient makes this task not only time consuming, but tedious as well.

Despite the strenuous nature of a nurse's job and the multitude of things they have to tend to, nurses still have to manually and repeatedly re-enter urine volume data every hour, when we have watches that automatically track our heartrates.

The team identified the real need of a solution and being passionate on process orchestration decided to adopt this as the final project. The team approached the issue from a different angle, i.e., by weight.

Goals & Methodology

We aim to provide a solution in the form of a device which automatically measures and updates the quantity of the urine on an hourly basis without the nurse having to physically be present at the bedside for checking. The only manual task involved now is the necessity to replace the urine container every 24hrs.

In order to make sure our device addresses the hospital's concern and is configured to be easily implemented in the patient rooms and integrated with the hospital's on-site patient monitoring system, a hospital visit was carried out where we took down the following points:

1. A main monitor at the ICU waiting lounge which has summary of vitals of all patients in ICU - EKG, Heart rate, Blood pressure, number of times breathing per minute
2. A monitor at each ICU with patient's vital information
3. Nurse manually checks the urine measurement from the bag which hangs in the bottom of the bed and goes to her nurse desk to enter the value he/she viewed. Drawbacks: Highly prone to human errors, sometimes nurses miss checking measurement due to busy shift.
4. Currently everything needs to be manually checked and approved by the nurse before saves are made (Overriding option) to the medical record. Else it maintains local saves.
5. Often the beds are moved around
6. Nurses do not have any form of alarm when the urine value is in the critical region.

Goals

As such our requirements are:

1. The device must have a 2cc minimum resolution requirement for fluid volume resolution.
2. The device needs to perform its function without the need for constant recalibration.
3. In the event where numerous re-calibration are unavoidable for the sake of accuracy, the device needs to be easy to calibrate without the need for the user to provide various reference weights.
4. The device must be able to reliably transmit collected data and receive user inputs without the need to be physically wired to a PC.
5. Responsive system: Visual feedback on connectivity to WIFI, Battery backup

Methodology

1. We used Load cell peripheral to find quantity of urine
2. Calibrate load cell to achieve high accuracy(About 1g): Temperature compensation technique with overnight testing in different temperature conditions, Physical data acquisition, regression testing with mock patient setup.
3. An independent power supply will be installed so as to allow the device to function without the need of being wired to a PC.
4. Wireless transmission protocol will be designed, implemented and tested for Particle Photon microprocessor which will be used to facilitate transmission of patient data and user commands with a host PC.
5. Implement protocol to export data into a local database and backup .txt file
6. Design and build web application that mocks the patient monitoring system which communicates with device on the same wifi network.
7. Design and print 3D printed model of enclosure for the electronics which is both portable and strong.
8. Implement RFID based login system for nurses.

Architecture

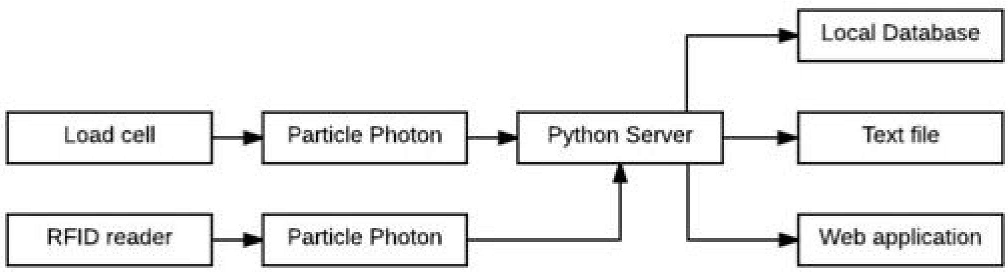


Figure 1: System Architecture for Load Cell Based Urimeter Device

1. Particle Photon microprocessor communicates with the load cell peripheral to read current weight measured and converts it to a fluid volume using parameters obtained from calibration.
2. The data collected from the Urimeter is stored into both local and cloud databases.
3. The Urimeter sends the data to a Python written server code which then updates the databases as per the patient information provided.
4. The server establishes connection with the client and proceeds with data collection only after the first basic handshake where the client sends the Patient Info:IP to the server.
5. The database refreshes the data every 24hrs. We are maintaining a *PatientInfo_Date.txt* file for each day which not only logs the data but also keeps track of date, time, connection established/lost etc.

Setup and Testing

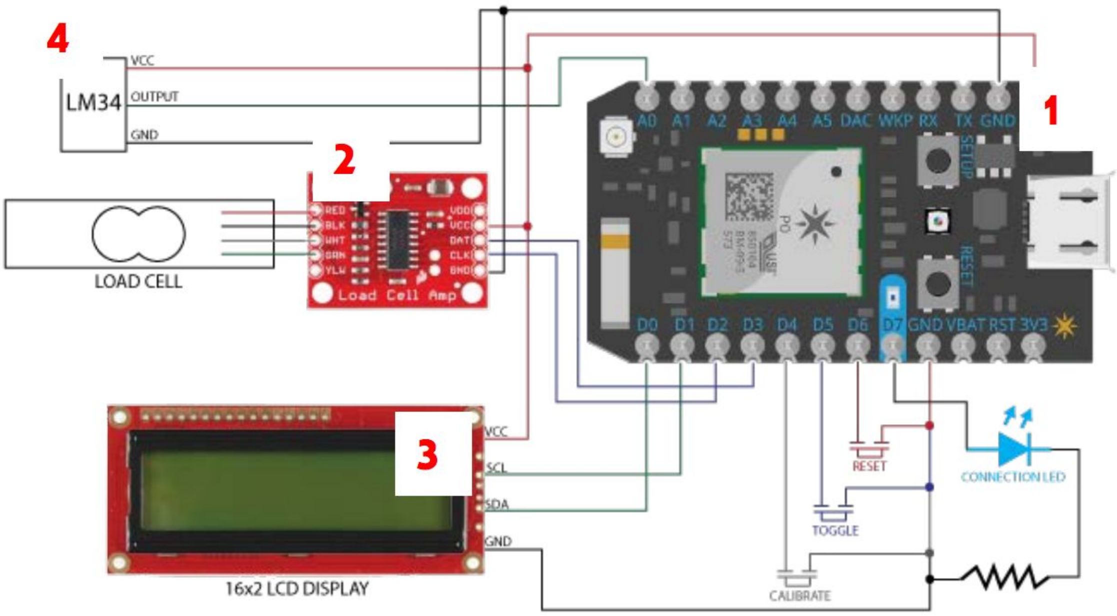


Figure 2: Load Cell and Temperature Sensor Setup with Photon and LCD Display

Materials:

1. Particle Photon Microprocessor
2. Atmega328p Sparkfun Load cell amplifier- Hx711 24-bit ADC
3. Uxcell Load cell 0-5 kg
4. LM34 temperature sensor

In addition, three toggle buttons are connected to the Photon microprocessor's digital pins and are used to 'Reset', 'Toggle', and 'Calibrate' the load cell unit respectively.

Backend and User Interface

Figure 3: Web UI

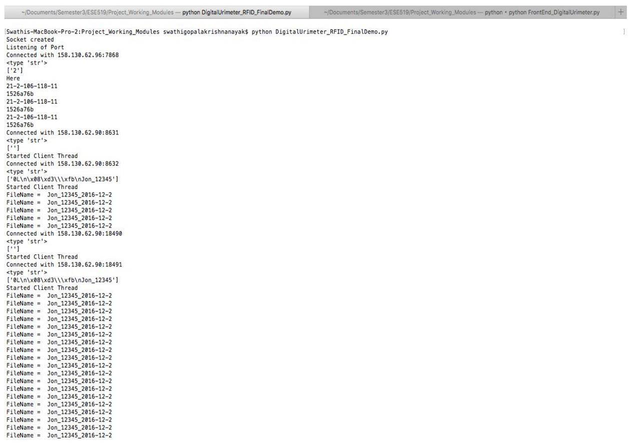
Figure 3 above shows the web-based user interface for our device, which is a mock of the hospital's patient monitoring system.

The user front-end application for our device is launched using python+flask. The python server is multithreaded and manages the 3 types of clients - Urimeter client, RFID based login module, and web application.

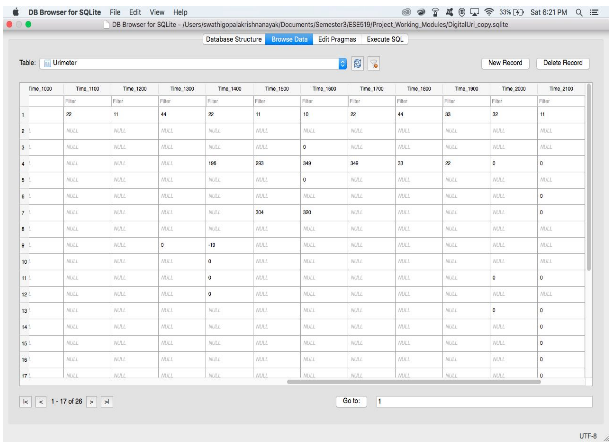
The Urimeter client is of client_ID:1 and on connection, sends data in the form - "Date:Time:UrineQuantity:PatientInfo". This data is then broken down, analyzed and required data is saved into the local databases according to the date, time and patient.

RFID based login module is of client_ID:2, on connection sends tagID received from the receiver of the reader. This on match with the user data in the database redirects the web application from "login page" to "logged in homepage".

Server for running Web Application



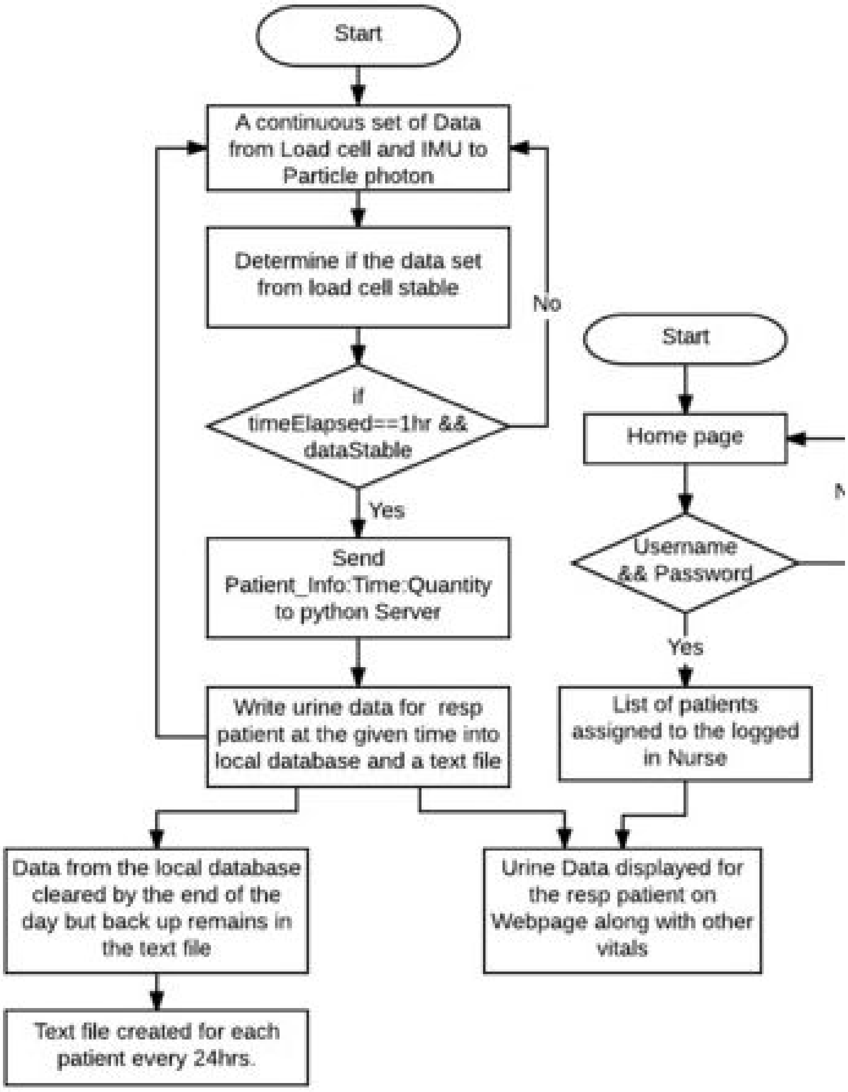
Multithreaded server for Urinmeter and RFID clients



Local Database

Mock Patient Monitoring System

System Flowchart



Compensation

For Load Cell Temperature Drift Even though the load cell's conversion factor remains constant, the 'zero' of the scale changes (this is one reason why scales have a tare feature). This can be caused by changes in temperature as the metal in the load cells goes through thermal expansion, the strain gauges attached to the load cells is also affected as a result. In fact, drift due to temperature is the main cause of inconsistencies in load cells.

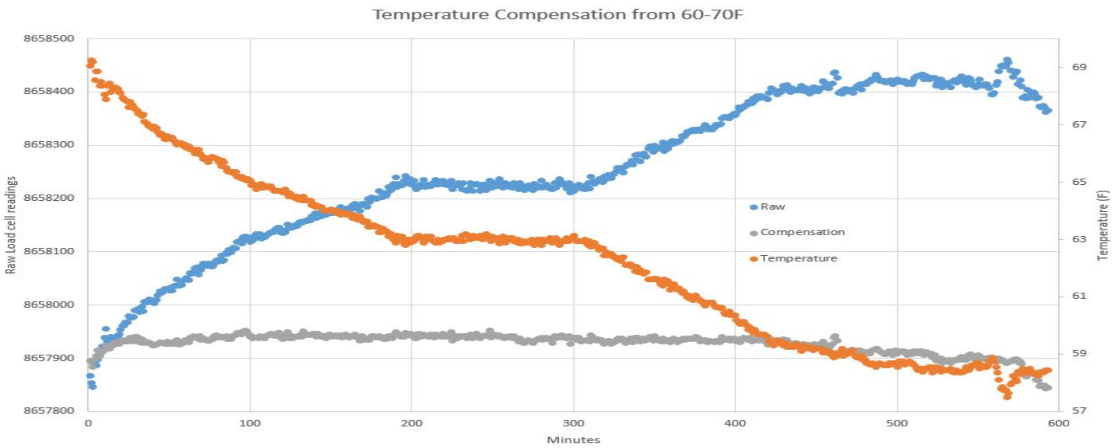


Figure 5: Temperature Drift on Load Cell

Figure 5 above shows the weight data collected overnight using the Uxcell load cell unit. This was done with 1 kg load on the scale. We can see that temperature and the scale output is related.

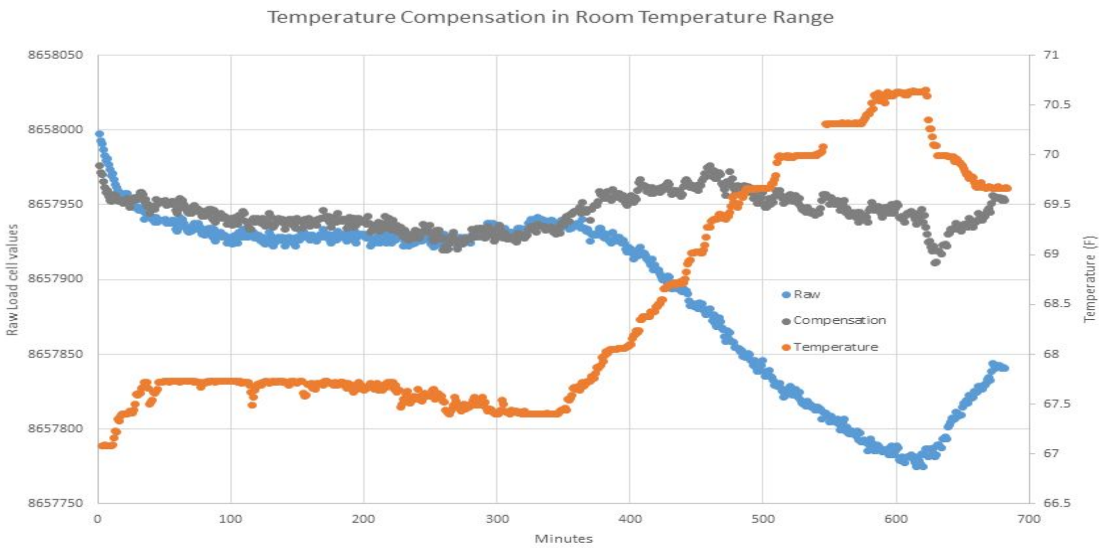


Figure 6: Compensated Load Cell Weight data

Using a simple linear transformation using the raw output and temperature, we can get rid of most of the temperature drift as shown in Figure 6 above.

We went from about 400 units of drift to about 150 units a drift, a 60% decrease. Weight wise, the range went from 1.8 g to 0.7 g. Thus it can be seen that the load cell can achieve a +/- 2 mL accuracy despite changes of temperature, and can be a good choice for this application.

Mechanical Design

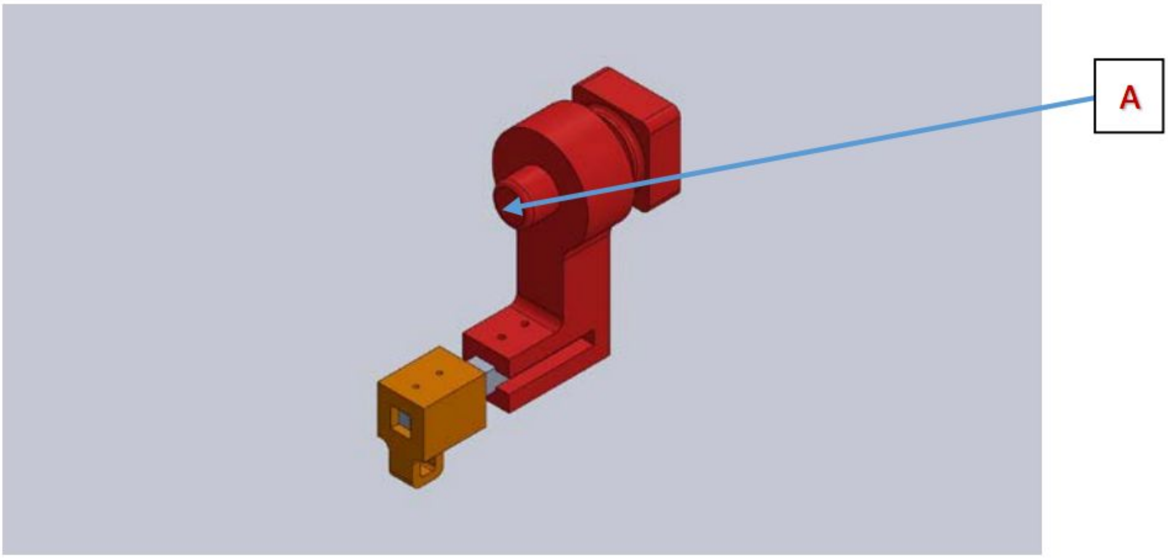


Figure 7: Device Mechanical Design

A hook-based design encasing the load cell was designed using SolidWorks and 3D Printed. As seen in Figure 7 above, the device has a hook at its end where a urine bag can be hung from, permitting the use of the existing urine bags used by the hospital, so as to be easily implemented.

In addition, the device has a swivel-based bed-attachment incorporating a roller bearing so that it can be easily strung to a hospital bed leg at any angle and still remain vertical to the ground, making it easily transferred from one hospital bed to another.

A separate container unit which is currently being designed, houses all the electronic components and will be attached to surface A as labelled on Figure 7.