Energy Harvesting, Storage and Management for Automated Environment Monitoring in the East African Region

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May Progress Report

May Plans...as per last presentation

- Finish LIC paper and submit - **Done**. paper was finished and sent to Elsevier Journal of Power Sources (Self-discharge of Li-ion capacitors in High Environmental Temperatures)
- Data pre-processing to achieve point to point - **Done** (more later)
- Deploy node to collect insolation data: UNMA THIS DATA !!!!!! Collected every 15 minutes
- Select re-analysis algorithm to use - No Need for this anymore!
- Run preliminary validation (using same data) - **Done** (more later)
- Share dissertation format with supervisors - **Not yet Done**

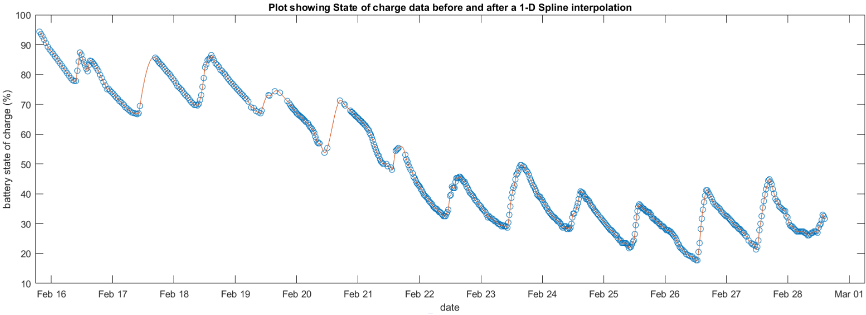
Details

- Solar Insolation data from UNMA was obtained from Mr. Milton Waisswa for Jan - April. One main challenge is the input and output data points are sampled at different times. For example:

1 Date	2 Insolation	3 SOC
22-Feb-2018 12:19:00	NaN	39.7461
22-Feb-2018 12:30:00	7.5000	NaN
22-Feb-2018 12:40:00	NaN	42.4141
22-Feb-2018 12:45:00	6.6620	NaN
22-Feb-2018 13:00:00	2.8200	NaN
22-Feb-2018 13:01:00	NaN	42.0039
22-Feb-2018 13:15:00	2.0910	NaN
22-Feb-2018 13:23:00	NaN	42.0039
22-Feb-2018 13:30:00	1.5870	NaN
22-Feb-2018 13:44:00	NaN	42.0039

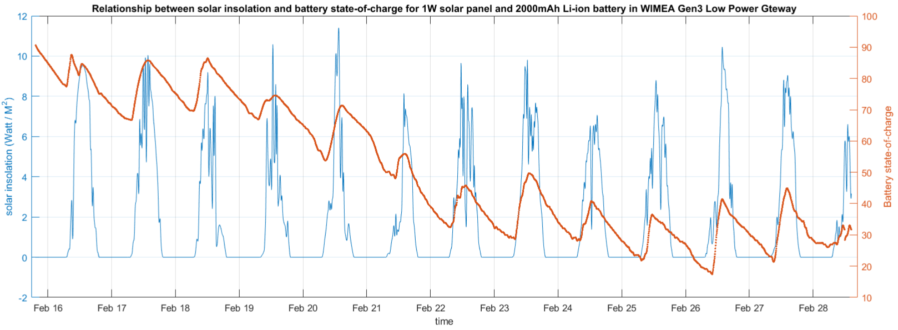
Solution

- One Solution is to perform higher resolution 1-D data interpolation (e.g every 5 minutes). Spline interpolation retains the exact shape of the curve while ensuring point to point matching



- Futher Reading Ongoing: Bekiroglu et al. (2017) System Identification Algorithm for Non-Uniformly Sampled Data

Matched input and output data

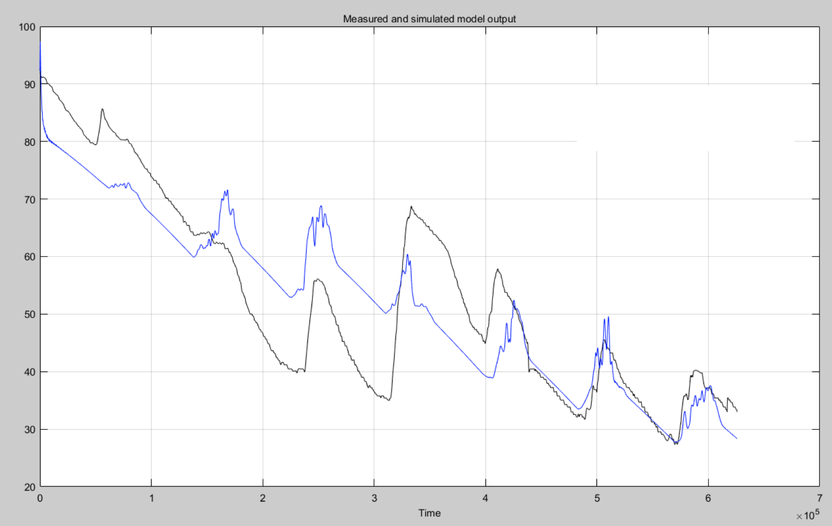


- Figure shows solar insolation and battery SOC for Feb 16 to Feb 28
- The two datasets are used in the MATLAB system Identification toolbox to estimate the system transfer function

Preliminary System Indentification Results

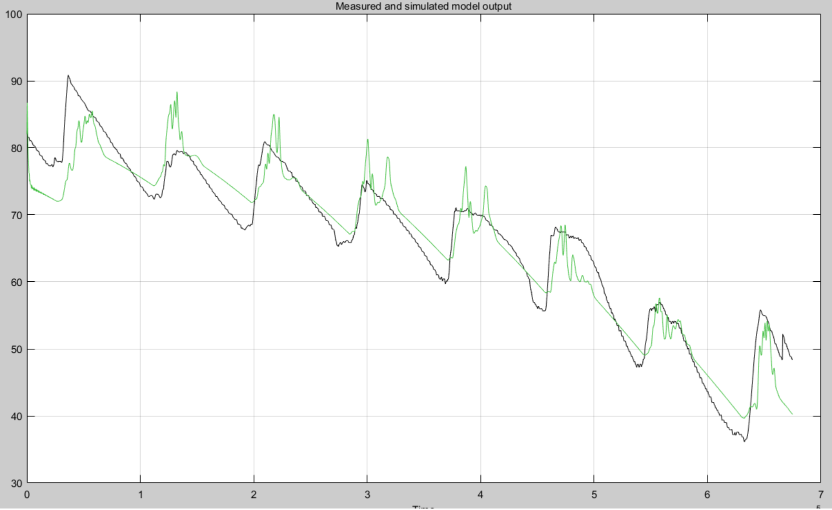
- The transfer function is then tested against another set of input-output data to obtain the best fit between actual output and simulated output
- In this particular example, Using 6 poles and 3 zeros gives a best fit of 80.61 % and a RMSE of 4.07 % the transfer function is derived as
  $$H(z) = \frac{1.478z^{-1} - 2.933z^{-2} + 1.454z^{-3}}{1 - 0.9208z^{-1} - 1.409z^{-2} + 0.888z^{-3} + 1.099z^{-4} - 0.6228z^{-5} - 0.03472z^{-6}}$$
- best fits are measured against the estimation data itself

March 13-20 data



Actual data - black, simulated output - blue

March 27- April 03 data



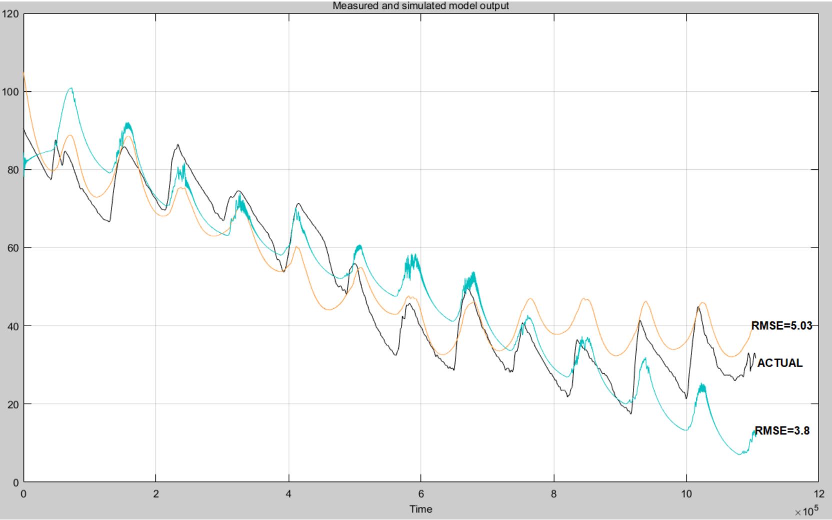
Actual data - black, simulated output - green

Here, we use the feb 16-28 dataset as the validation data and the other 2 sets was working data in 2 simulations. The Actual battery state of charge profile is shown in black. The simulated output using the march 13-20 data is shown in orange-brown and the simulated output using the march 27-april 03 data in blue-green.

Observation

The simulated outputs gives low RMSE values (3.8-5.0). The plots indicate that our initial assumption that the system can be modeled as a Linear Time Invariant system is largely accurate. Transfer function estimations are only for linear system. The system has some non-linearity that could arise from a number of factors. e.g. changing motes frequently (hence variable data coming in hence variable power consumption)

Reverse simulation



June Plans

- Compare results with Non-linear models such as GRNN (Generalized Regression Artificial Neural Network). Got idea from **Khatib and Elmenreich (2016)** - *A Model for Hourly Solar Radiation Data Generation from Daily Solar Radiation Data Using a Generalized Regression Artificial Neural Network* and State-Space Models
- Perform iterations with various solar panel sizes
- Current deployment was changed to 3W to test model with actual data for larger panel
- At that point, I think we shall be ready for Paper 4: **"Solar Panel Sizing Models for Environment Monitoring Wireless Sensor Networks"** Target is : Hindawi - Journal of Control Science and Engineering (Response 40 days)
- Share Thesis format! (Early June)