Battery Management System

- It is increasingly apparent that Electrical Vehicles (EVs) are transitioning into one of the most important methods of transportation within 21st century; batteries are the main components that have made this progression feasible.
- A Battery Management System (BMS) is an energy management control strategy that is designed to
  - Communicate with other onboard subsystems
  - Monitor the battery states
  - Control Charge and discharge
  - Thermal management
  - Cell balancing
  - And, safety

- The following block diagram shows how real-time BMS can be facilitated by using Speedgoat® MathWorks and data collection boards.

State of Temperature (SOT) Estimation

- SOT estimation method based on the thermal model of the battery
  - The analysis of battery core temperature is critical for BMS to protect the li-ion batteries from thermal runaway reactions which can lead to potential damage, but directly it is difficult to measure.
  - Since the battery model can be affected by different temperatures, an estimation of core temperature can help us to use a more accurate battery model.
  - This approach can be implemented by defining new coefficients for the battery resistors and capacitors in ECM or simply by using lookup tables and different ECM for each.

Proposed 3rd Order SVSF

- The smooth variable structure filter (SVSF) is a model-based robust filter. This filter takes advantage of an inherent switching action to keep the estimation error within an acceptable region.
- Proposed 3rd order SVSF uses more information compared to the other SVSF-based filters leading to better performance.
- This filter is used to estimate the SoC of the battery using an equivalent circuit model (ECM).
- 3rd Order SVSF Algorithm
  - Prediction Stage:
    - The a priori state estimate vector
    - $\hat{x}_{k|k-1} = f(\hat{x}_{k-1}, u_k)$
    - $\hat{z}_{k|k-1} = H\hat{x}_{k|k-1}$
    - $\tilde{z}_{k|k-1} = z_k - \hat{z}_{k|k-1}$
    - $\tilde{z}_{k|k-1} = z_k - H\hat{x}_{k|k-1}$
  - Update Stage:
    - Proposed Corrective gain
    - $K_{k|k} = H^{-1}$
      $\dot{\hat{x}}_{k|k} = \dot{\hat{x}}_{k|k-1} - e_{RB,k}$
      $e_{RB,k} = (\hat{z}_{k|k-1} - \tilde{z}_{k|k-1}) + (\hat{z}_{k|k-1} - \tilde{z}_{k|k-1})^T(\hat{z}_{k|k-1} - \tilde{z}_{k|k-1})$

Simulation Results

- Results clearly show that the proposed 3rd-order SVSF surpasses EKF and other SVSF-based filters in terms of accuracy by 60%.
- Also, it is shown that the proposed filter converges faster than the aforementioned filter.

Conclusion and Future Works

- Robust estimation strategy and accurate model are the important issues that should be considered in order to have an accurate estimation. In this study, it is expected that the accuracy will be considerably increased by using the proposed filter with a new algorithm and new Core-temperature-based ECM. Therefore, future research will be focused on:
  - Studying observability
  - Establishing an adaptive or intelligent model
  - Considering MM and Novel IMM
  - SOT estimation
  - Studying the joint state estimation
  - Developing Advanced estimation algorithms for BMS based on SVSF

References

[7] [2]
[8] [4]