Calibration as Parameter Estimation in Sensor Networks

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Agenda

- Localization and Calibration Problems
- Literature Review
  - Calibration function with linear regression
  - Iterative calibration
  - Mean calibration
- Proposed Macro-calibration
  - Joint calibration
- Generalization as Parameter Estimation
  - Reflection on RBS
  - Relative Calibration
- Conclusion
Localization and Calibration Problem

- Awareness of location is important in ad-hoc sensor networks
  - Infrastructure to provide position and distance
  - GPS module and ultrasonic receivers
- Radio Frequency (RF) and acoustic pulse transmission introduce large variation
  - Simple hardware
  - Heavy duty calibration
Literature Review

- **Device Calibration**
  - Hardware tuning
  - Calibration Function
  \[ r^* = f(r, \beta) \]

- **Linear Regression**
  - Valid to ONE TX/RX pair
  - Complexity of \( n^2 \)
  - Separation Problem
  \[ r^* = \beta_1 + \beta_2 \times r \]

- **Iterative Calibration**
  - Declare one TX as reference to calibrate
  - Iterate with RX as reference

- **Mean Calibration**
  - Assume Gaussian distributed variation in device
  - Calibrate all TX/RX as mean value
Joint Calibration

The model

\[ d^* = B_T + B_R + G_T \times d + G_R \times d + |F_T - F_R| \times d + f_o (O_T, O_R) \times d \]

- Omit non-linear terms
- Complexity 4n var. in n^2-n equations
-Parameter estimation avoids separation problem yet keeps TX/RX models
What if NOT distance we are concerned?

- Time/Sync [OSDI 2002]
- Phase offset: Offset Matrix according to pair of receivers with Gaussian dist. parameters
- Clock Skew: least square linear regression
- Multi-hop time sync

\[ Offset(i, j) = \frac{1}{m} \sum_{k=1}^{m} (T_{j,k} - T_{i,k}) \]
Conclusion

- Existing Methods
  - Traditional linear regression: Separation Problem
  - Iterative calibration: Error Propagation
  - Mean calibration: Ignore the errors with Gaussian model

- Joint calibration
  - System model
  - Parameter estimation

- Generalization
  - Time Varying Model?
  - Extension to synchronization scenario…