Estimating CO using the Parlikar Estimator

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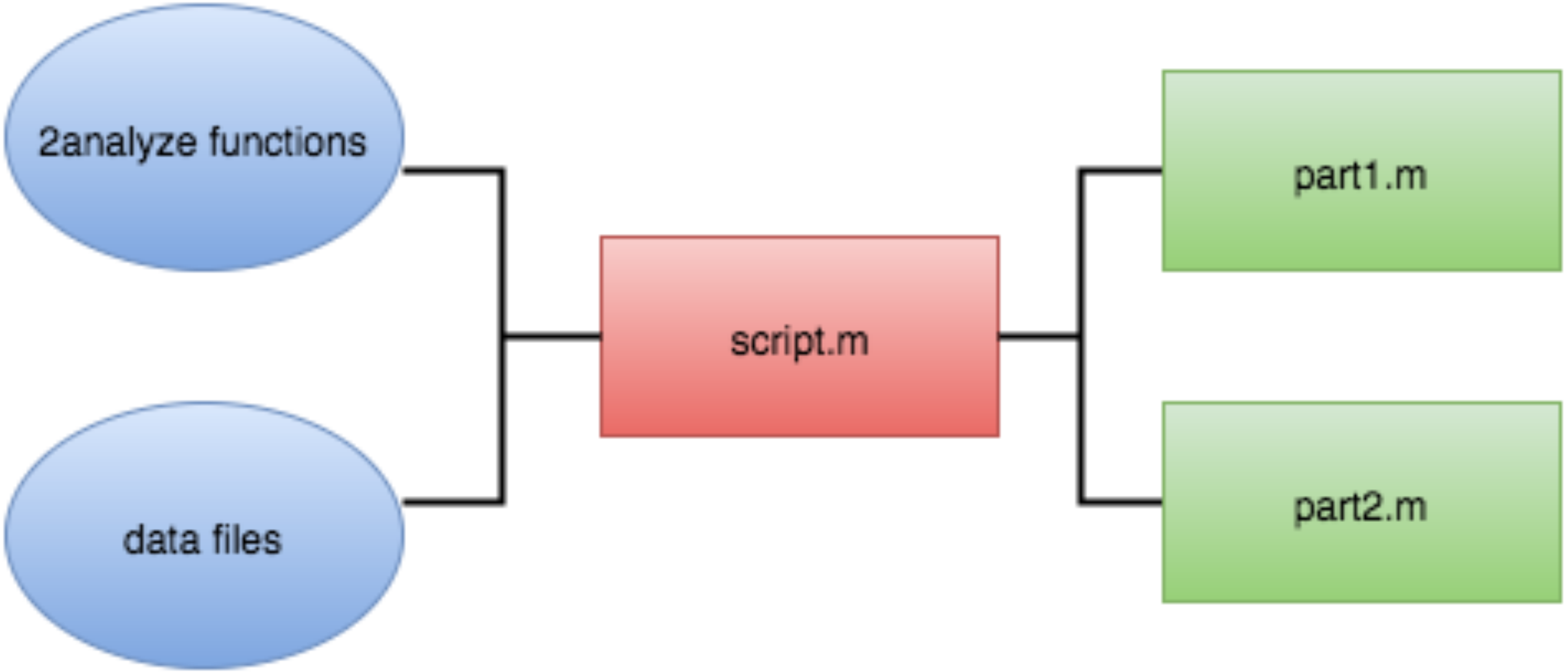
Cohort Comparison: Married vs. Unmarried

- Scripted a search mapping i2b2 exported values to MIMIC files available
  - on i2b2: 279 patients with CO
  - on OneDrive: 22 patients from i2b2 set
- Use very large categories to obtain large sections: married and unmarried
  - on i2b2: 150 married, 129 unmarried
  - on OneDrive: 12 married, 10 unmarried

Cohort Comparison: Analysis

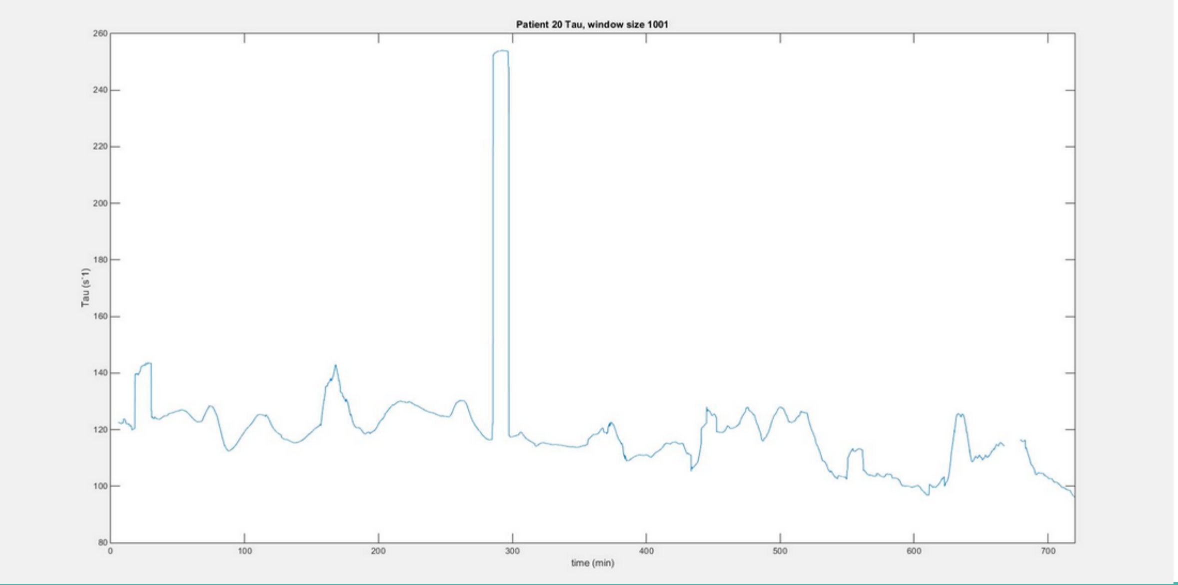
- Testing the original 3 estimators with 22 patients
- Quantitative
  - Mean and RMS error
    - Using C2 calibration introduces too much noise/error to get useful results from such a subtle difference
  - Total Peripheral Resistance to provide additional insight
- Qualitative
  - Observe more of what makes constitutes estimator performance eg sensitivity, stability
  - A more subjective comparison
  - Analyzing and representing 66 graphs can be clumsy

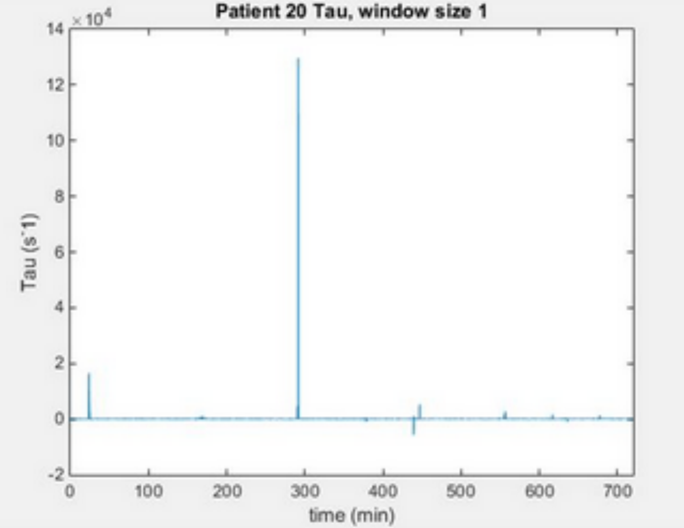
Code Overview

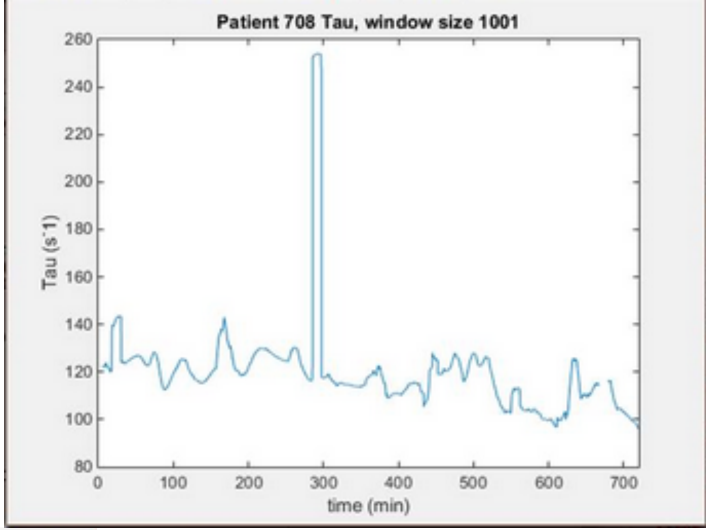


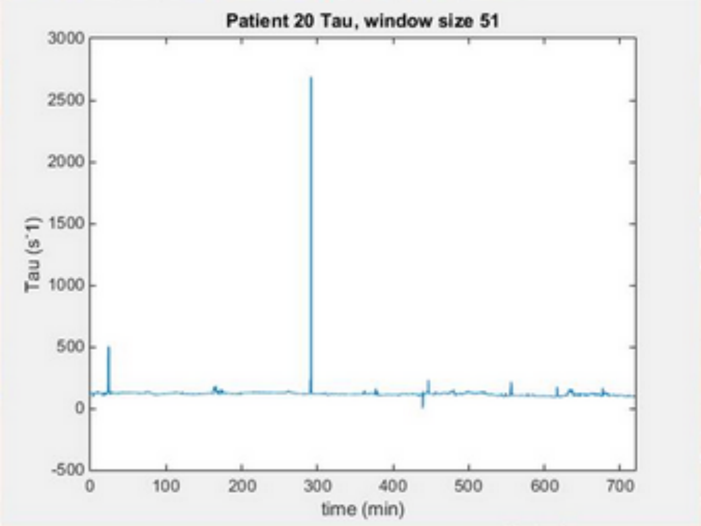
Parlikar Estimator - Tau$_n$ Calculation $CO_n = C_n\left(\frac{\Delta P_n}{T_n} + \frac{\overline{P}_n}{\boxed{\tau_n}}\right)$

- Use a window for calculation of tau$_n$
  - tau$_n$ ≈ mean(tau$_{n-x}$ + … + tau$_{n+x}$), window from -x to x
  - Smoother beat-to-beat estimation of tau




Patient 20 Tau, window size 1
Tau (s^-1)
time (min)


Patient 708 Tau, window size 1001
Tau (s^-1)
time (min)


Patient 20 Tau, window size 51
Tau (s^-1)
time (min)

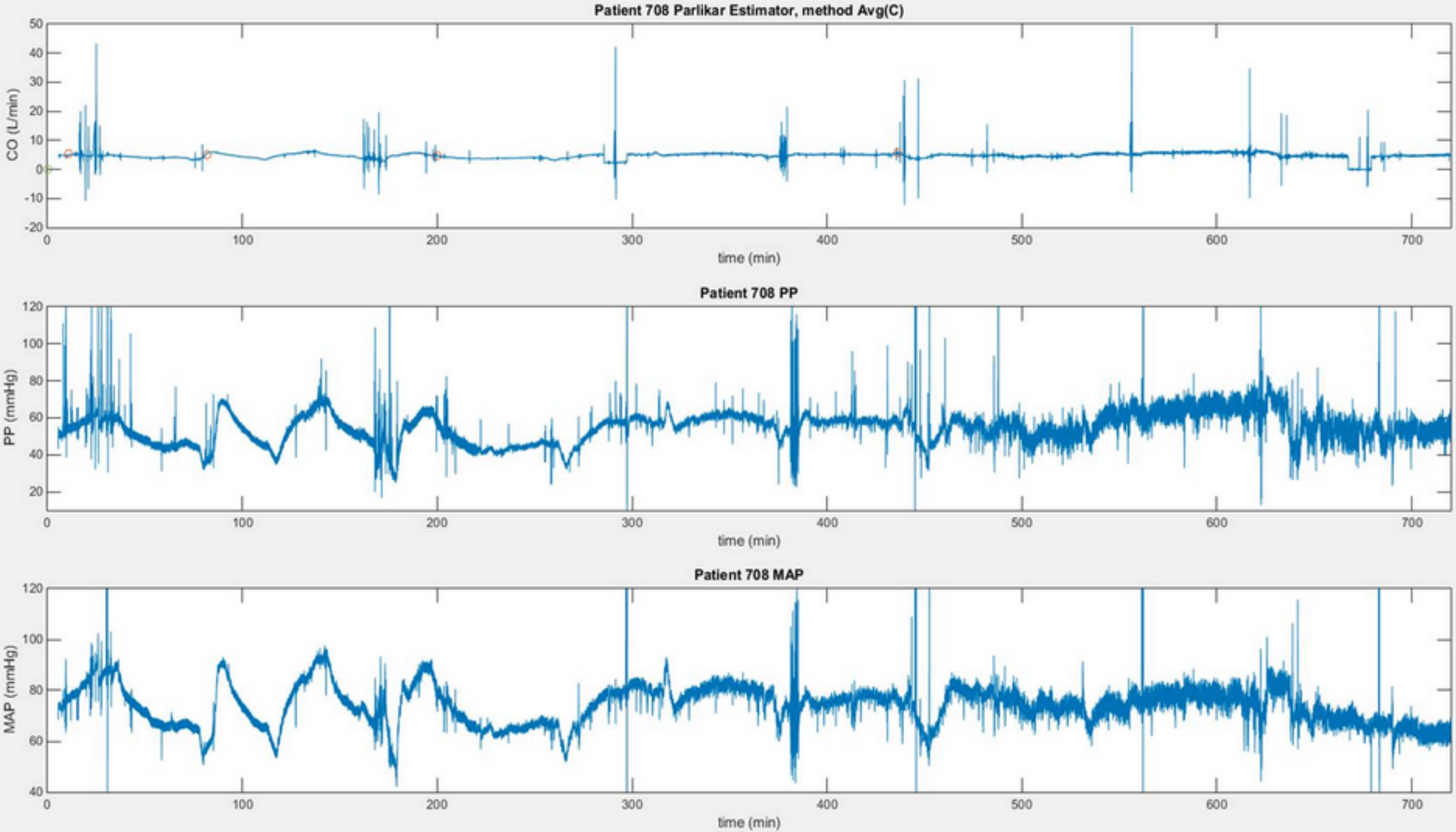
Parlikar Estimator - Compliance Calibration

$$\mathrm{CO}_n = \boxed{C_n}\left(\frac{\Delta P_n}{T_n} + \frac{\overline{P}_n}{\tau_n}\right)$$

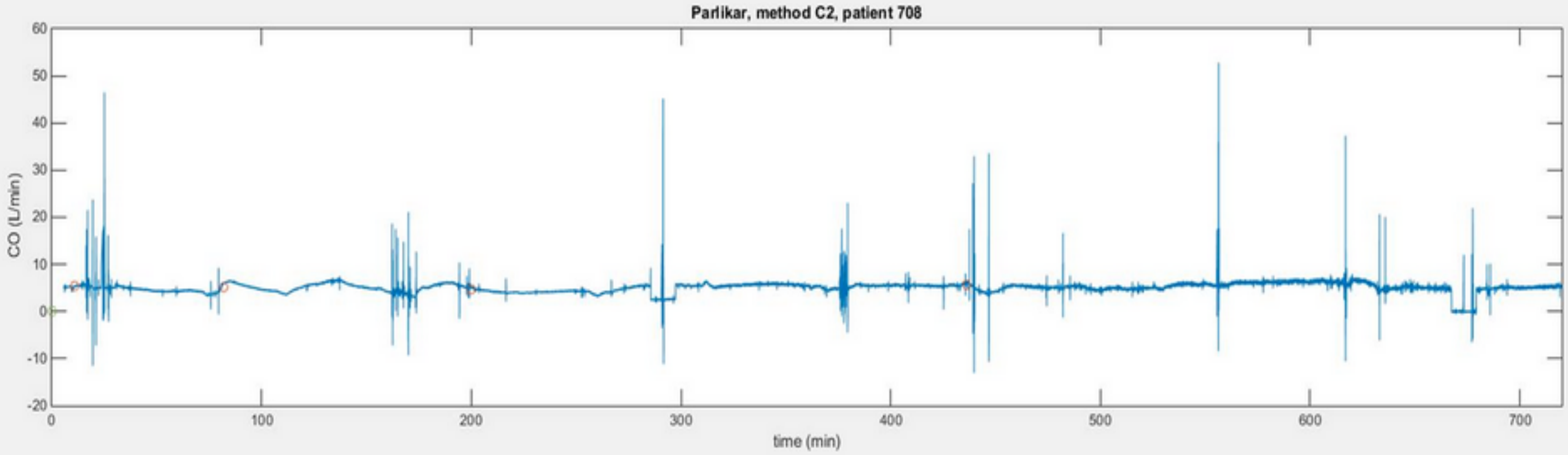
- Goal: normalize estimated CO values
- Methods:
  - Average C from TD
  - Using only first TD (C2)
  - Using Least Squares with

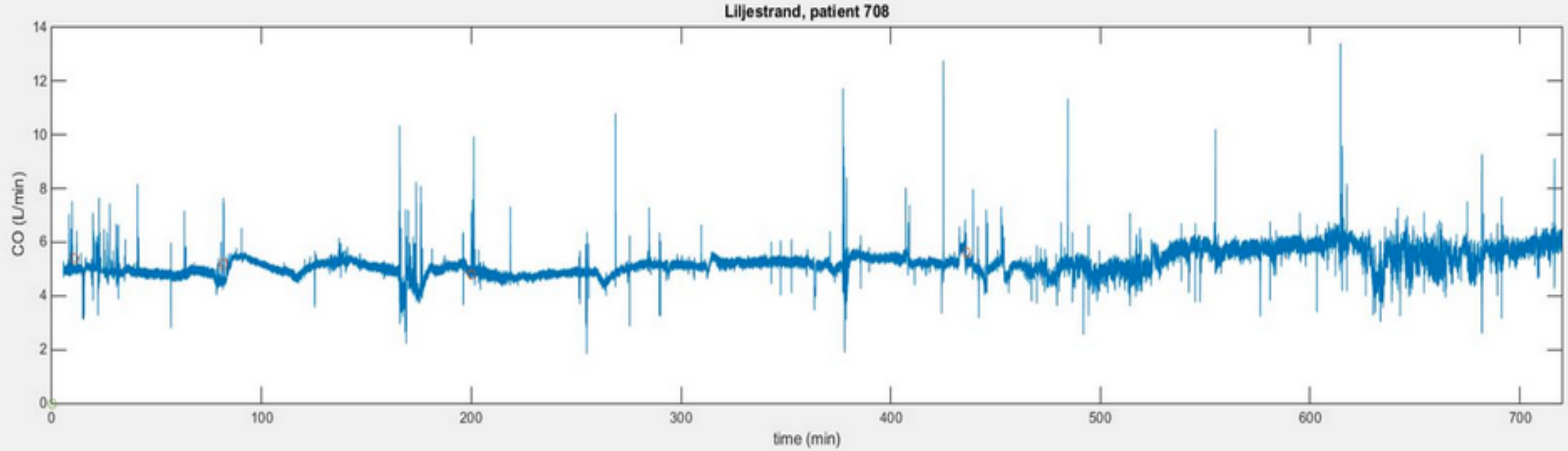
$$C_n = \gamma_1 + \gamma_2 \overline{P}_n \,.$$

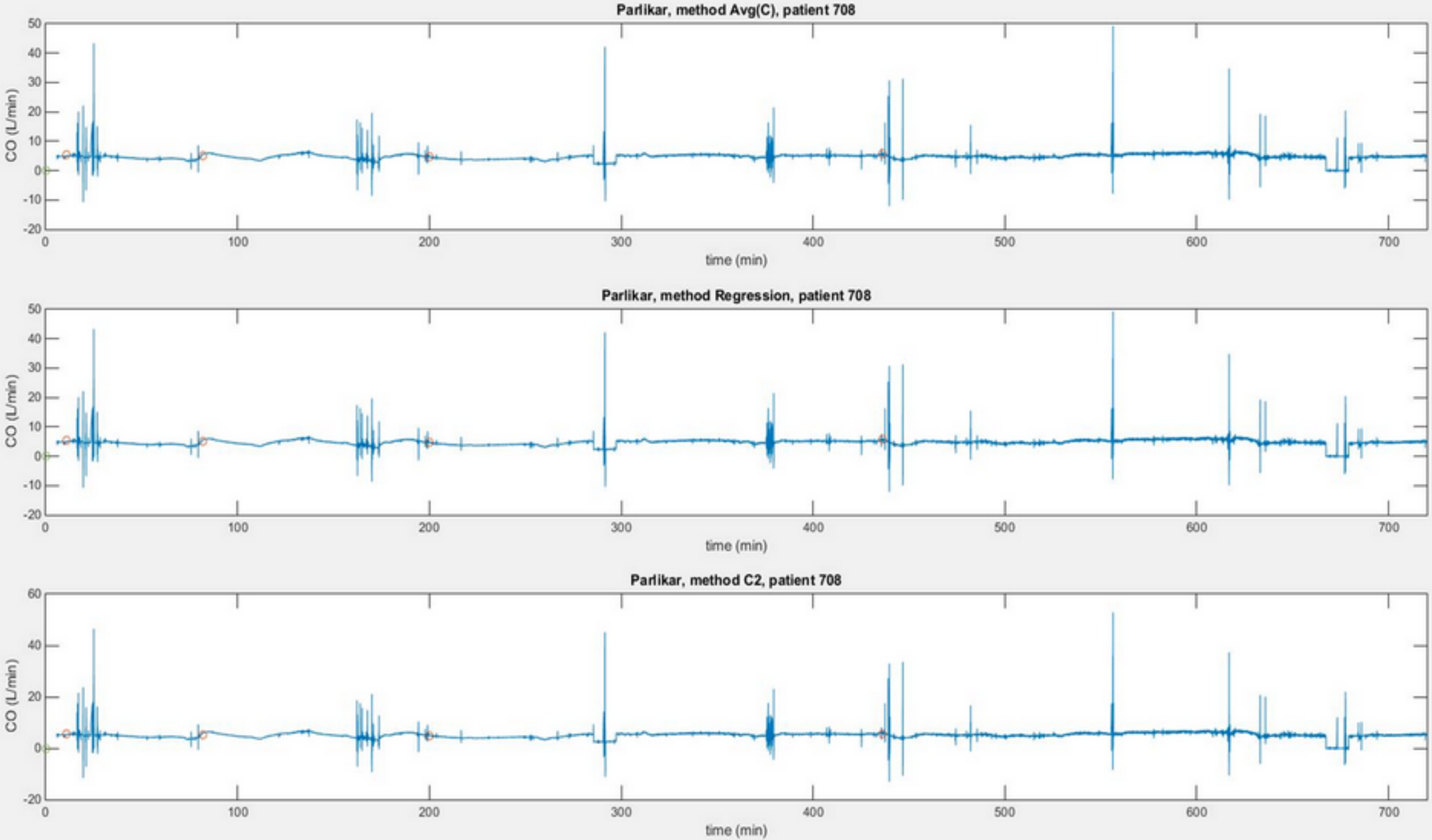
- Use known CO_{TD} values to create known C_{TD} values.
- Create linear regression with C_{TD} against MAP values to find gamma values and find the affine relation and then solve for compliance values at each heartbeat.
- Use the newly created C values to estimate for CO across all heartbeats.



Patient 708 Parlikar Estimator, method Avg(C)
CO (L/min)
time (min)
Patient 708 PP
PP (mmHg)
time (min)
Patient 708 MAP
MAP (mmHg)
time (min)


Parlikar, method C2, patient 708
CO (L/min)
time (min)
60
50
40
30
20
10
0
-10
-20
0
100
200
300
400
500
600
700


Liljestrand, patient 708
CO (L/min)
time (min)
14
12
10
8
6
4
2
0
0
100
200
300
400
500
600
700



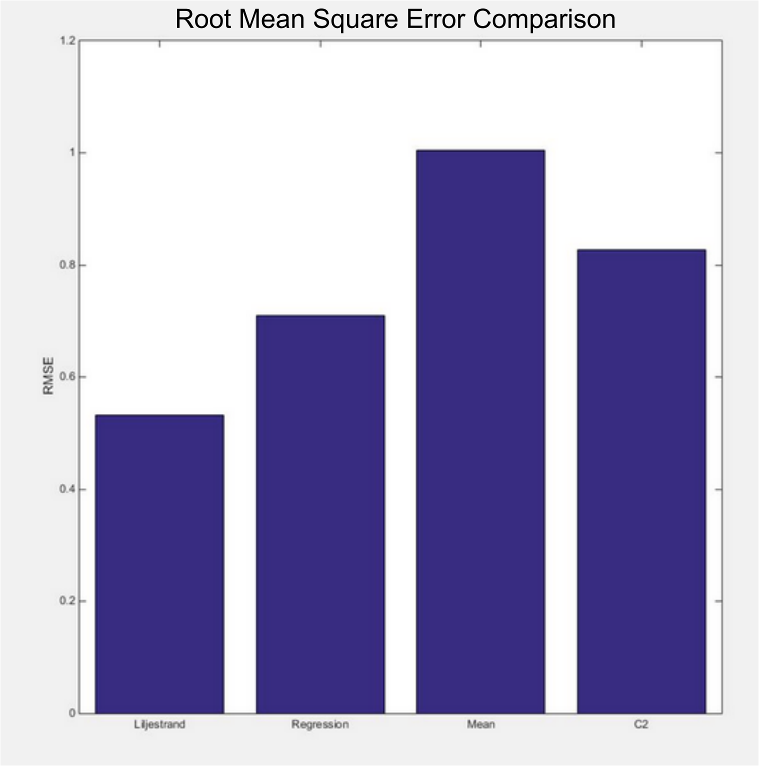
Parlikar, method Avg(C), patient 708
CO (L/min)
time (min)
Parlikar, method Regression, patient 708
CO (L/min)
time (min)
Parlikar, method C2, patient 708
CO (L/min)
time (min)

Comparison of Compliance Methods

> Regression: State-dependent

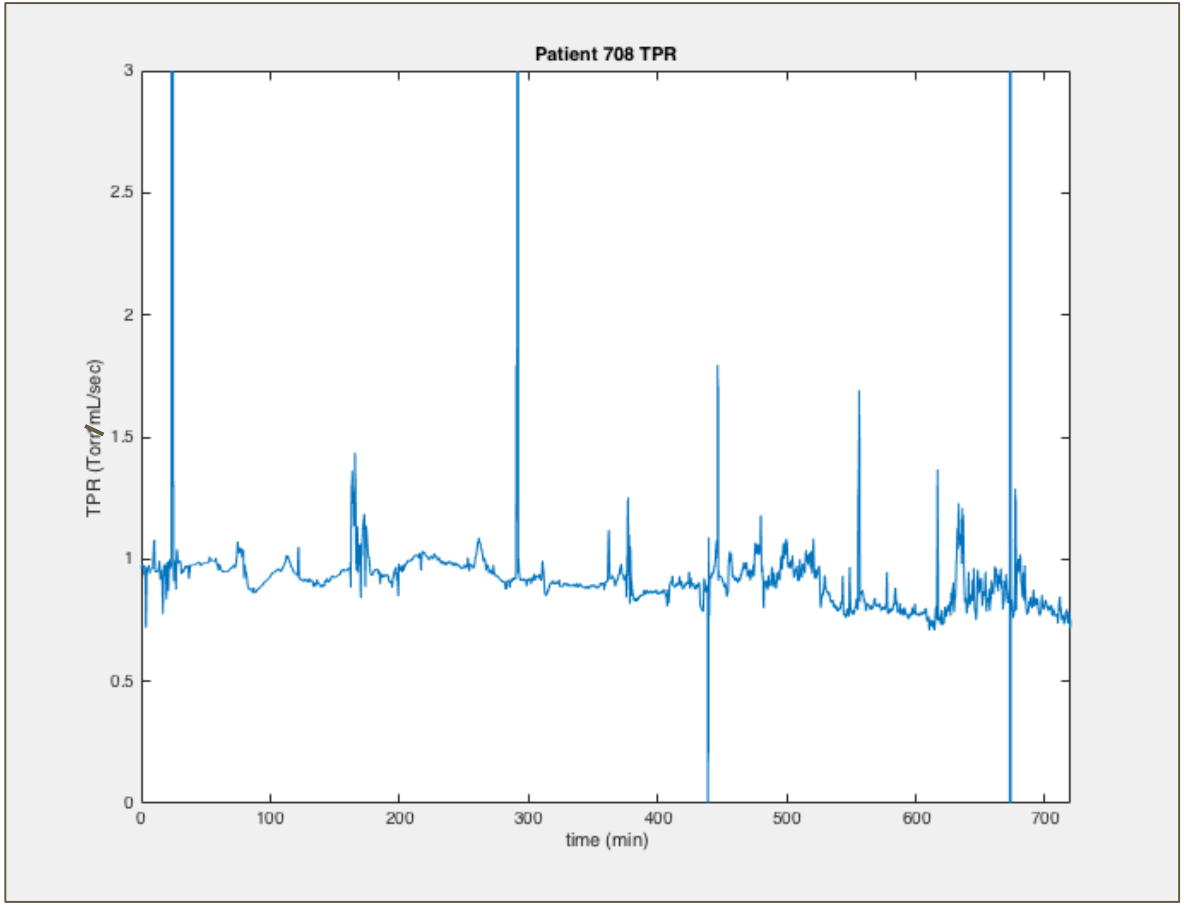
> Mean

> C2



TPR GRAPH

$$R_n = \frac{\overline{P}_n}{\mathrm{CO}_n - C_n \frac{\Delta P_n}{T_n}} \,.$$



Reflection

- Implementing a mathematical algorithm into MATLAB poses non-mathematical issues
    - Syncing up time-scales and matrix sizes
    - Logistics
- Distributing work amongst ourselves to work on separately and then come together at the end was not the most efficient method.

Conclusions

Liljestrand had the least RMS errors between the CO estimated values and the CO_{TD} values. Therefore, unless there is a special case that requires beat-to-beat analysis or when the TPR needs to be calculated considering compliance, Liljestrand is a better estimator than Parlikar.

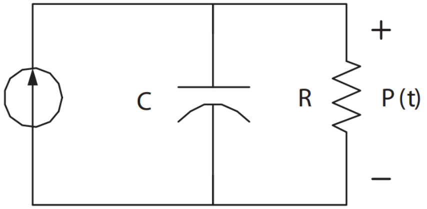
For finding compliance, deriving an affine relationship between the compliance and the mean arterial pressure from a linear regression of known values yielded the least RMS error.

Appendix

$$C\frac{dP(t)}{dt} + \frac{P(t)}{R} = Q(t)$$

$$C_n\frac{\Delta P_n}{T_n} + \frac{\overline{P}_n}{R_n} = \mathrm{CO}_n$$

$$\mathrm{CO}_n = C_n\left(\frac{\Delta P_n}{T_n} + \frac{\overline{P}_n}{\tau_n}\right)$$



$$\frac{\Delta P_n}{T_n} + \frac{\overline{P}_n}{\tau_n} = \frac{\mathrm{PP}_n}{T_n} \quad ,$$

$$\mathrm{PP}_n = \alpha\left(\overline{P}_n - \mathrm{DAP}_n\right)$$

$$R_n = \frac{\overline{P}_n}{\mathrm{CO}_n - C_n\frac{\Delta P_n}{T_n}} \; .$$