Optimization of Biosensor Waveform Preprocessing

Siemens Healthineers

Report Week 7

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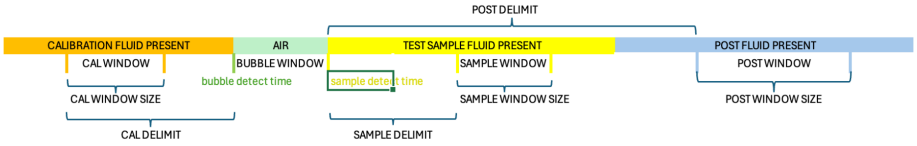
Objective 1: Window optimization

Window Optimization

Methodology

As per last week's report, we optimized the calibration window and the sample window of Sensor A and Sensor B in System 2 by creating a function that minimizes the regression slopes between System 1 and System 2 while keeping moving the current windows within certain limits. We adopted this approach because the client expected us to mitigate the flatness level of new windows to the windows in system 1.

According to the calculation formula in the below figure, the window limits like detect time and window size are constants, but the delimit value is the input we need to consider in our created function. We initially looped through both CalDelimit and SampleDelimit from 0 to 100 sec, and we found that both minimums were found further behind the current windows not before them, which was also consistent with client's expectation. Therefore, we tried moving the calibration window further in time (closer to the bubble detect time, i.e. a smaller value for CalDelimit) and the sample window further in time (further from the sample detect time, i.e. a larger value for SampleDelimit) by looping through delimit values within certain ranges to avoid windows being overlapped. The ranges are continuous with 0.2 sec interval, which is also the time unit in our datasets. However, the current sample window is possibly and slightly overlapped with the post window, so we decided to ignore this constraint and only limit the range by the post window end.



Cal window start = bubble detect time – CalDelimit
Cal window end = cal window start + cal window size

Sample window start = sample detect time + SampleDelimit
Sample window end = sample window start + sample window size

Post window start = sample detect time + PostDelimit
Post window end = Post window start + post window size

Constraint 1: CalDelimit>=Calwindow Size
Constraint 2: SampleDelimit+Samplewindow Size<=PostDelimit

	System 1			System 2		Window Size		
	CalDelimit	SampleDelimit	PostDelimit	CalDelimit	SampleDelimit	Calwindow	SampleWindow	PostWindow
Sensor A	11	15	25	8~13	13~20	8	5	5
Sensor B-Blood	20	24	27.5	18~22	24~34	18	4	5
Sensor B-Aqueous		30	37.5		28~33.5(34)			

Figure 1. Window Limits Summary for Window Optimization

Results

We plotted the optimal solution (minimization of difference) and compared it with the current window.

From all the below plots, we can tell all optimal solutions were found at specific delimit values and they both moved the current windows to further in time. This suggests those improved windows for system 2 whose flatness levels are closest to the original ones for system 1.

Specifically for sensor A, we plot the current limit and new limit for both cal and sample window in the same plot. We obtained the improved cal window by taking a smaller cal delimit value, which is 9.6. The new cal window is extremely close to the bubble window according to Figure *3.* We also obtained the improved sample window by taking a larger sample delimit value, which is 17.2. As per client's request, we provided a plot with current window and new window for both calibration and sample periods for a randomly selected test ID with the newly obtained limits applied.

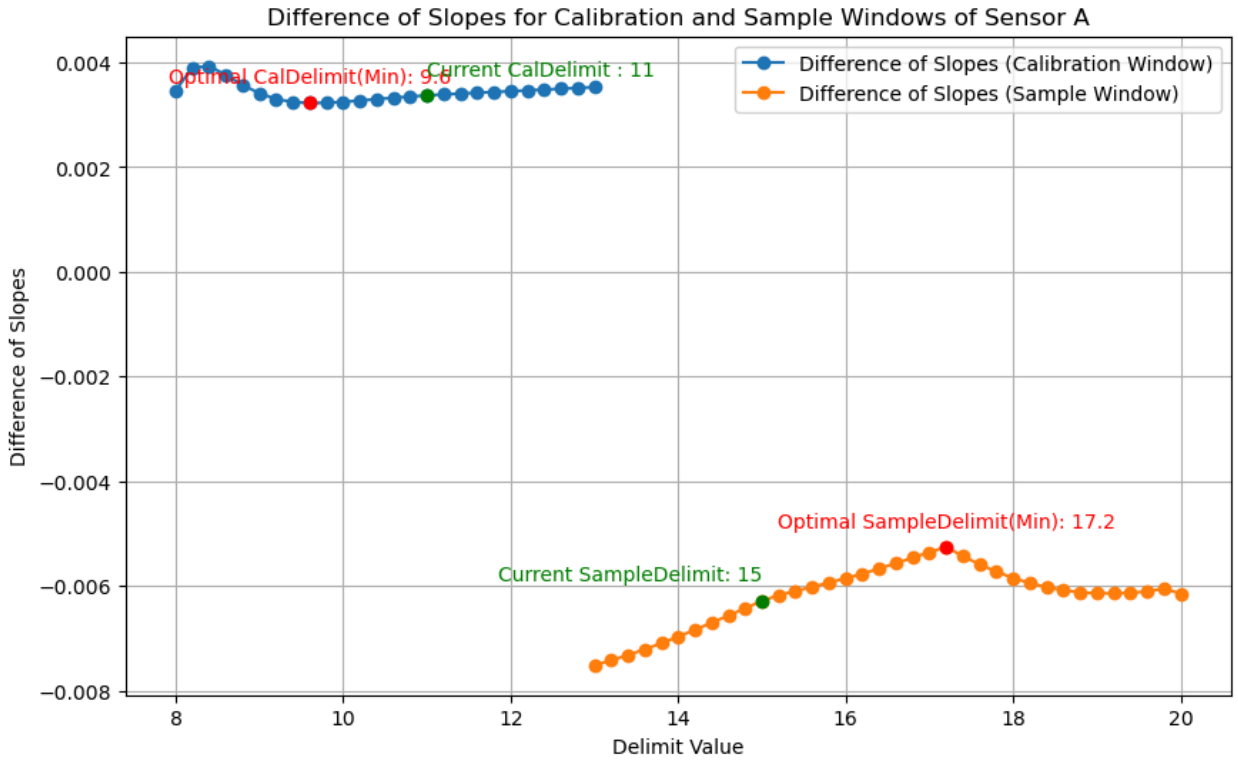


Figure 2

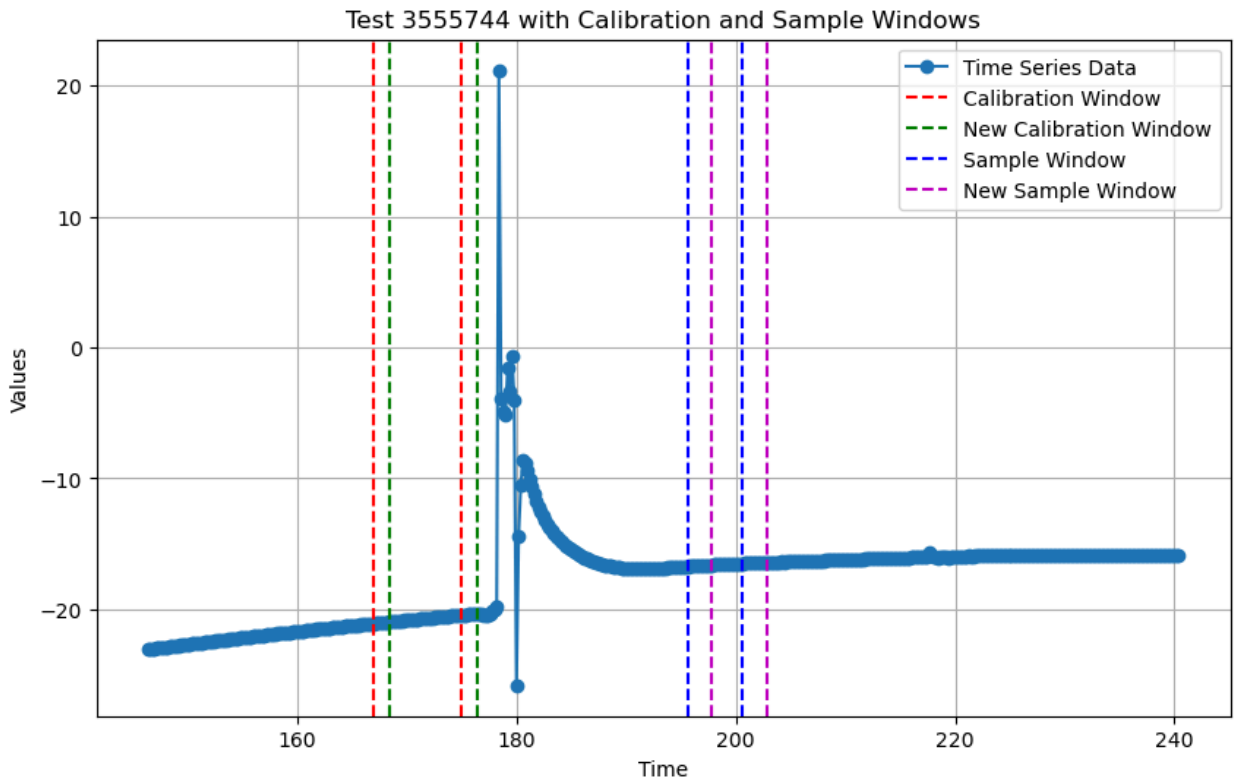
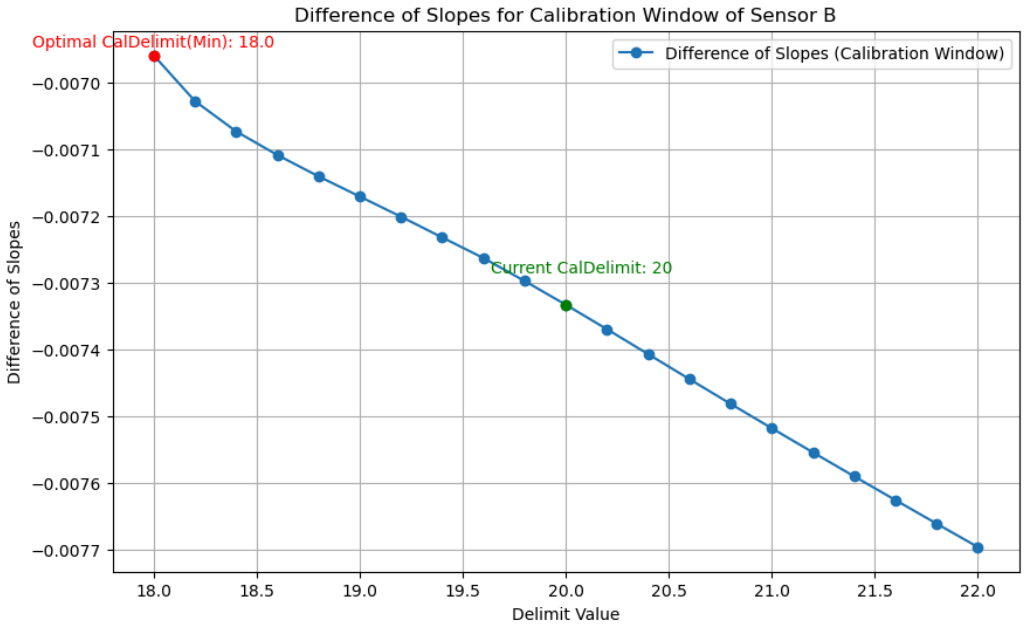
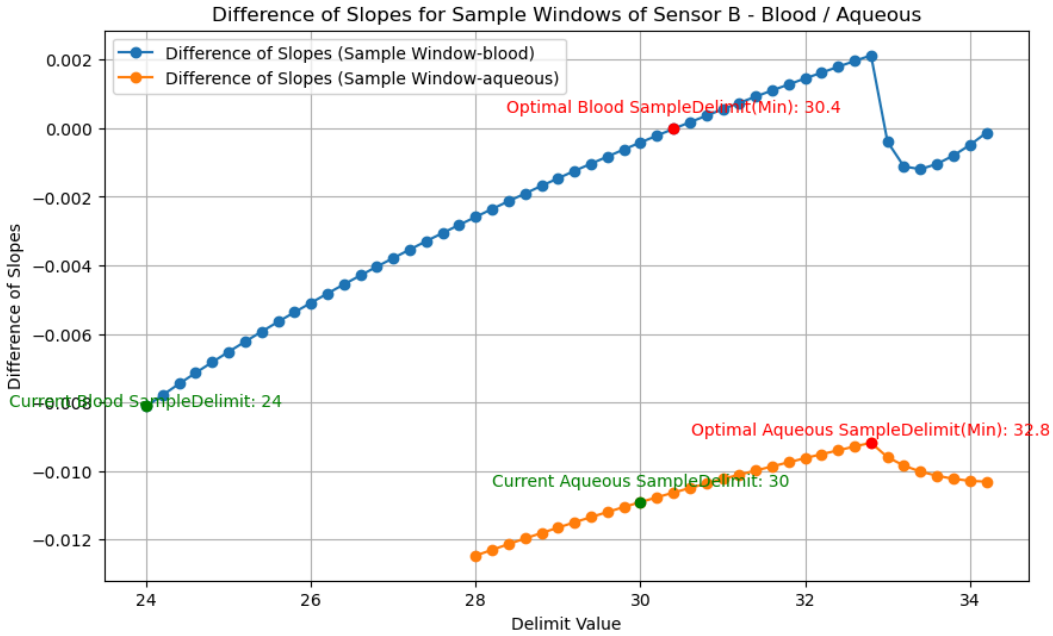


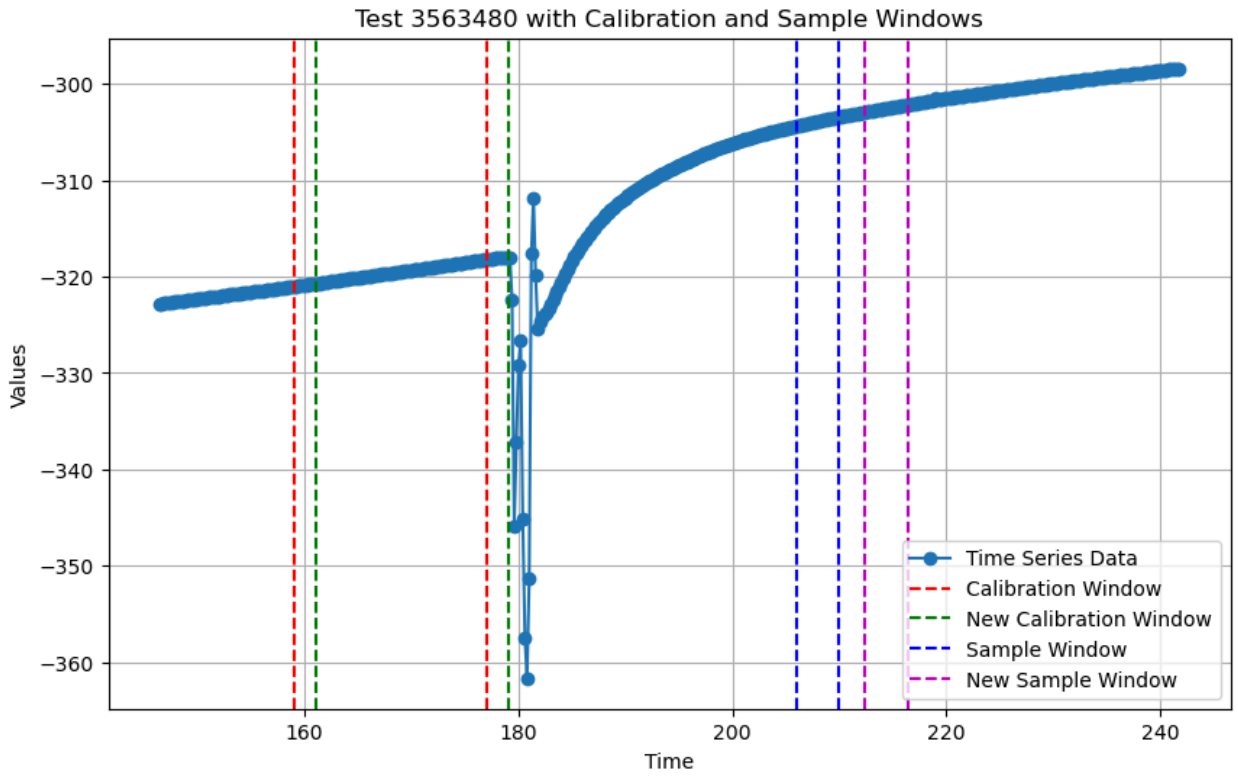
Figure 3

For sensor B, we have to plot calibration window and sample window separately because sensor B has two different sample limits for blood type and aqueous type, respectively. Similarly to sensor A, the new calibration window is close to the bubble window as well, suggesting the curve keeps getting flatter until detecting the air bubble for both sensor A and sensor B.

The new calibration window and sample window for both sensors have been optimized by imitating the flatness level to system 1 and the client was satisfied with the approach we applied and the results obtained. Additionally, they expect us to apply the new limits of windows into the FDA pipeline, and we have already finished the coding. The findings are extremely similar to ones with the old limits, only with a few changes for some specific bins by features, which we will include the detail in the final report draft.


Difference of Slopes for Calibration Window of Sensor B
Optimal CalDelimit(Min): 18.0
Difference of Slopes (Calibration Window)
Current CalDelimit: 20
Difference of Slopes
Delimit Value


Difference of Slopes for Sample Windows of Sensor B - Blood / Aqueous
Difference of Slopes (Sample Window-blood)
Difference of Slopes (Sample Window-aqueous)
Optimal Blood SampleDelimit(Min): 30.4
Current Blood SampleDelimit: 24
Optimal Aqueous SampleDelimit(Min): 32.8
Current Aqueous SampleDelimit: 30
Difference of Slopes
Delimit Value



Objective 2: Summarize waveform characterization

We finished Pipeline 1 for window characterization; the resulting code can be consulted on our public GitHub FDA Resampling.

Next Steps

- Conclude final report
- Executive report
- Slide deck for final presentation