

# Reduction of Jitter within Optical Tracking Data through an in-depth survey of Smoothing Techniques

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# Synopsis

- Introduction
- Background
- Objective
- Procedure
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- Conclusion
- Future Work
- Acknowledgements

# Introduction

- Purpose of Synthetic Vision System (SVS) initiative - reduce low visibility during flight by using 3d displays
- Current research - implement smoothing algorithms to reduce jitter in optical tracking data
- The behavior of the optical tracking data is considered in this study as a means of making a more intuitive smoothing algorithm selection

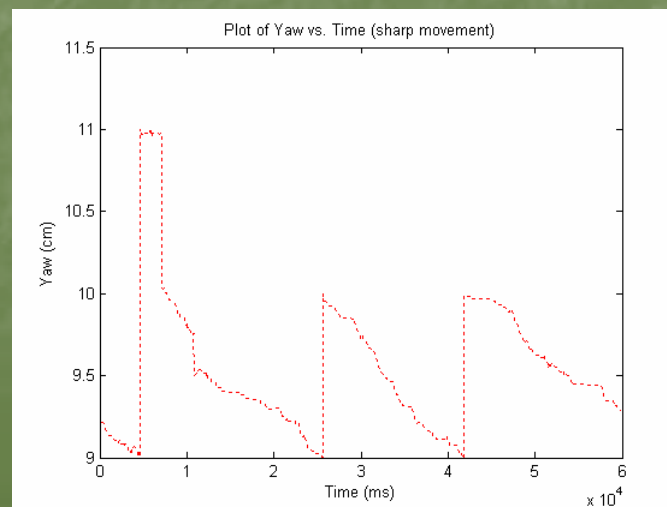
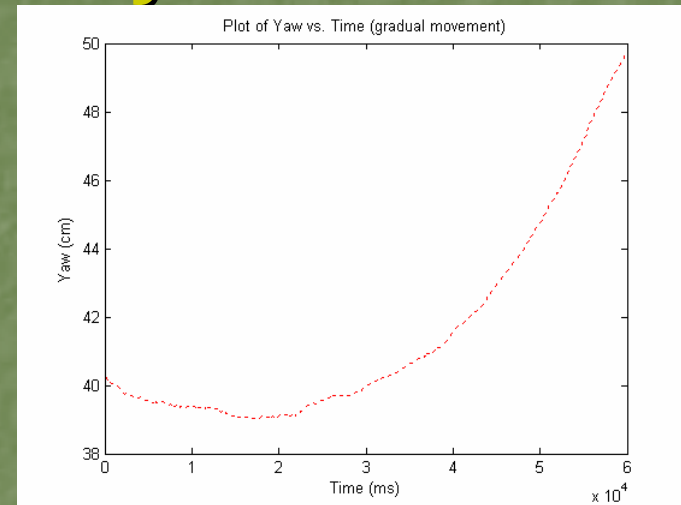
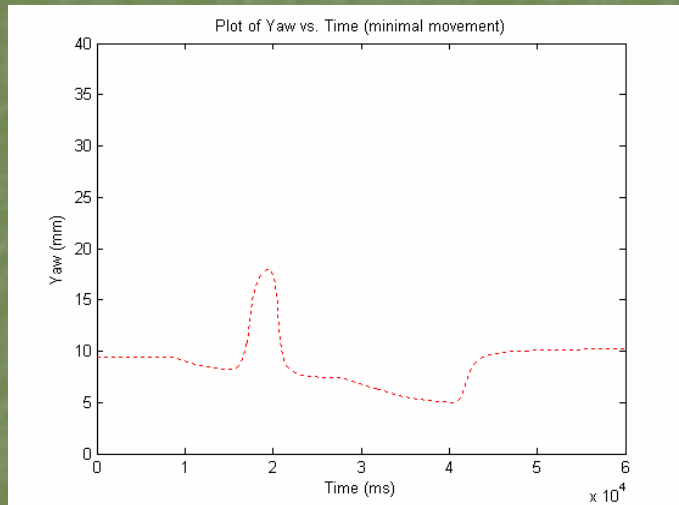
# Background

## ■ Data Characterization

- There are three major classes of optical tracking data:
  - Minimal (near stationary situations)
  - Gradual (slow but definite movements)
  - Sharp (sudden intentional movements)
- Stationary data could be considered a fourth class

# Background

## ■ Data Characterization – Major Classes



# Background

- Smoothing Algorithm Considerations
  - What is the extent of smoothness that is required?
  - Light smoothers
    - Least effect
    - Preserve trends within data
  - Heavy smoothers
    - Most effect
    - May drastically alter original data pattern

# Background

- Smoothing Algorithm Considerations
  - What smoothing method will be used?
  - Smoothing by fitting
    - Mold data into mathematical function
  - Smoothing by altering data values
    - Change the values in the data set to create smoother trend

# Background

- Smoothing Algorithm Considerations

- What types of smoothers are there?

- Linear Smoothers

- Superposition:  $S(x + y)_i = S(x)_i + S(y)_i$

- Non-Linear Smoothers

- Location Equivariance:  $S(y + a)_i = S(y)_i + a$

# Objective

- Project Goals:
  - Select smoothers based on aforementioned considerations
  - Test and compare smoothers on the optical tracking data subjected to engine vibration jitter

# Procedure

- Select smoothing algorithm properties:
  - Moderate Smoother
  - Nonlinear
  - Compound
- Add vibration jitter to three classes of optical tracking data (based on previous work)

# Procedure

- Previous smoothing algorithms:
  - Loess
  - Moving Average (most suitable)
  - Savitzky-Golay
- New smoothing algorithms considered:
  - Median Filters
    - 3RSSH
    - 4253H
    - (3RSR)2H, twice

# Procedure

- 3RSSH – Composed of:
  - 3R – repeated running median (span 3)
  - SS – Splitting (performed once)
    - Includes endpoint smoothing E
  - H – Hanning filter
    - moving average (span 3) with weights ( $\frac{1}{4}$   $\frac{1}{2}$   $\frac{1}{4}$ )
- Variant: 3RSSH, twice
  - twice – ‘rerough’ then smooth data

# Procedure

- 4253H – Composed of:
  - 42 – running median (span 4) followed by running median (span 2)
  - 5 – running median (span 5)
  - 3 – running median (span 3)
  - H – Hanning filter
- Variants: 4253EH
  - 4253H, twice
  - 4253EH, twice

# Procedure

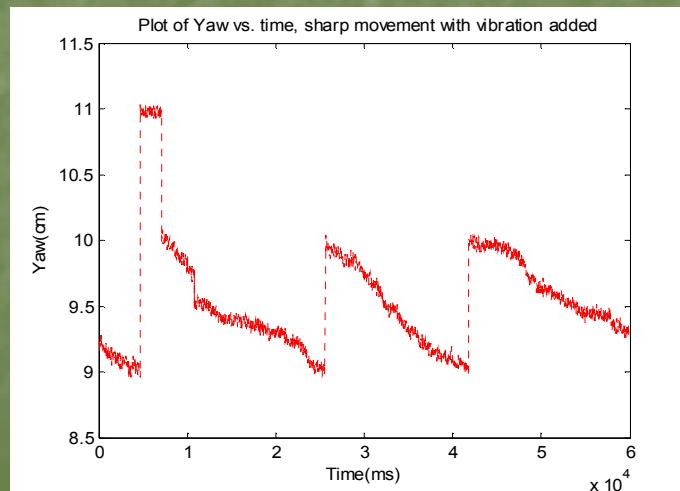
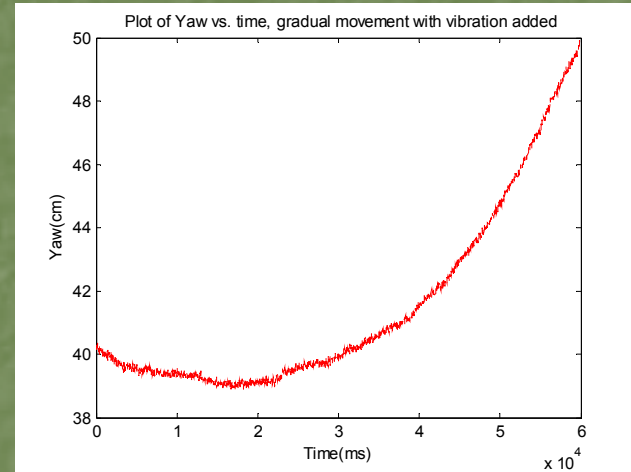
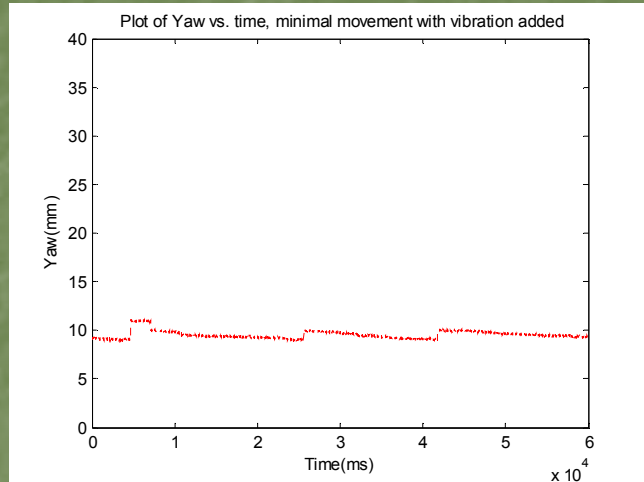
- (3RSR)2H, twice – Composed of:
  - 3R – repeated running median
  - SR – repeated splitting
  - 2H – 2 iterations of Hanning filter
  - twice – ‘rerough’ then smooth

# Procedure

- Compare 3RSSH, 4253H, (and its variants) and (3RSR)2H, twice to:
  - 3
  - 5
  - 42
  - Moving Average (span 9)

# Results

## ■ Engine Vibration Jitter on three data types



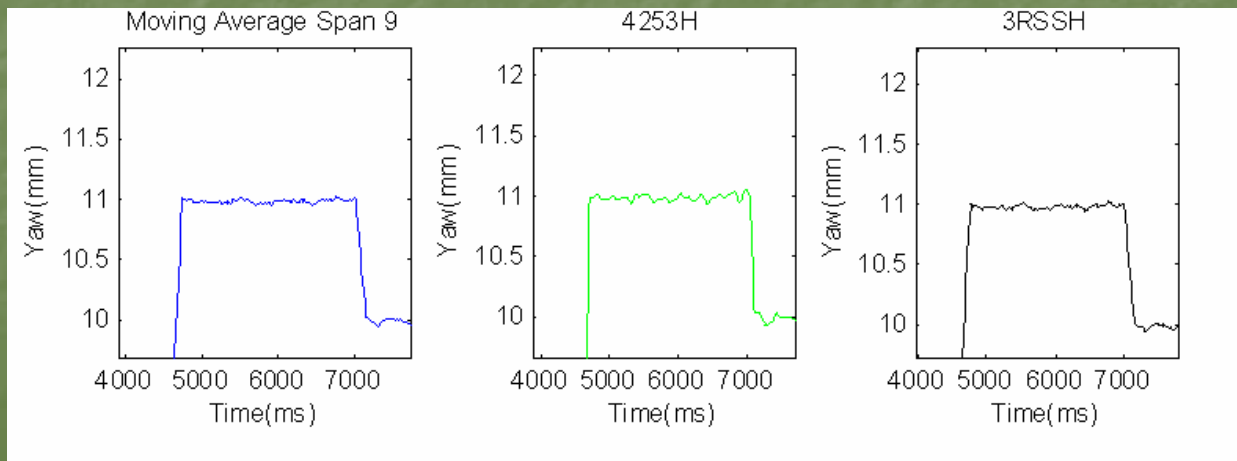
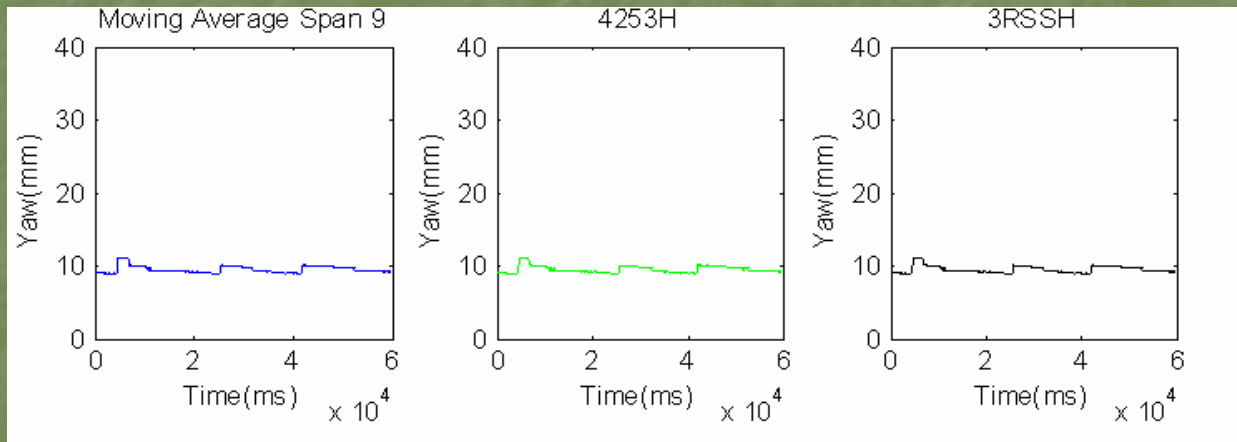
# Results

## ■ Error Ranges for Smoothers

Smoother	Minimal Error Range	Gradual Error Range	Sharp Error Range
3	12.91404483	0.361910134	0.140924054
5	12.90311557	0.258851079	0.116549757
42	12.88244504	0.253858693	1.003758094
3R	12.91404483	0.361910134	0.140924054
3RSSH	12.8647406	0.251226445	2.499846452
3RSSH, twice	12.91343862	0.294723273	2.629205211
4253H	12.85037654	0.2108082	1.258311513
4253EH	12.85037654	0.2108082	1.258311513
4253EH, twice	12.86384612	0.239807014	1.222170669
4253H, twice	12.86384612	0.239807014	1.222170669
(3RSR)2H, twice	12.94461569	0.314233389	0.853468575
Mov. Avg. (Span 9)	12.8275	0.171	1.7895

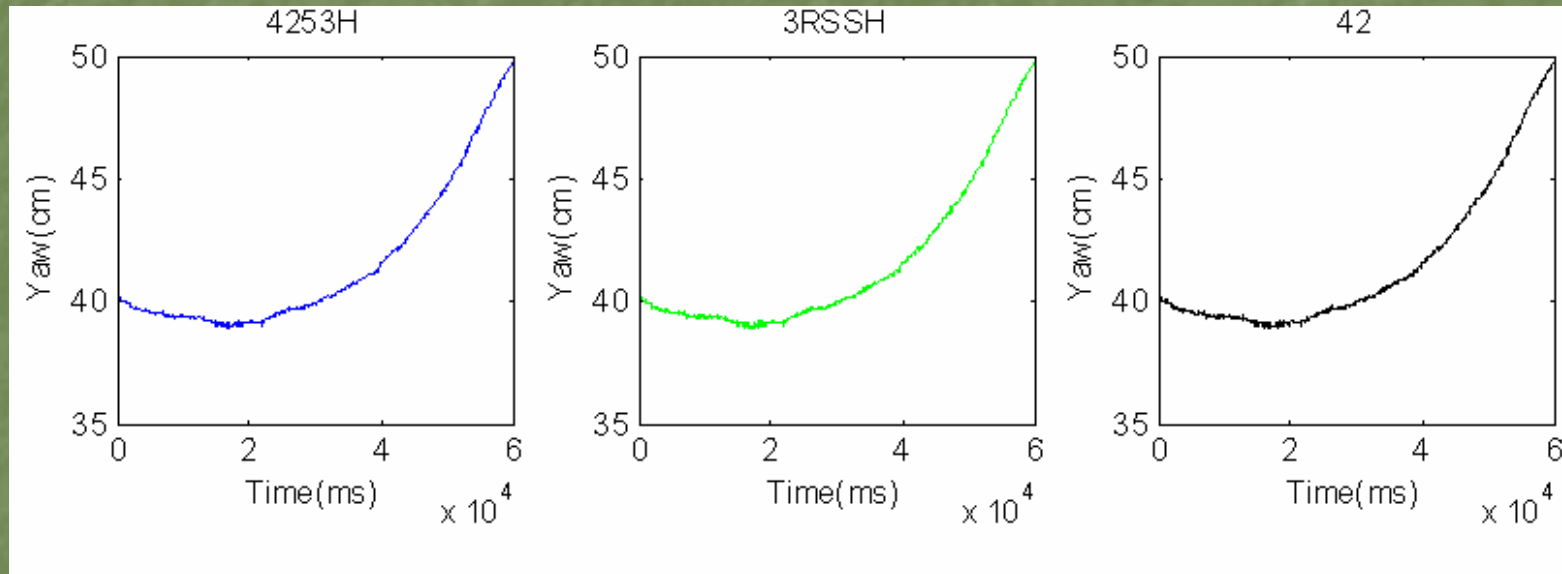
# Results

- Top 3 smoothers for Minimal Data



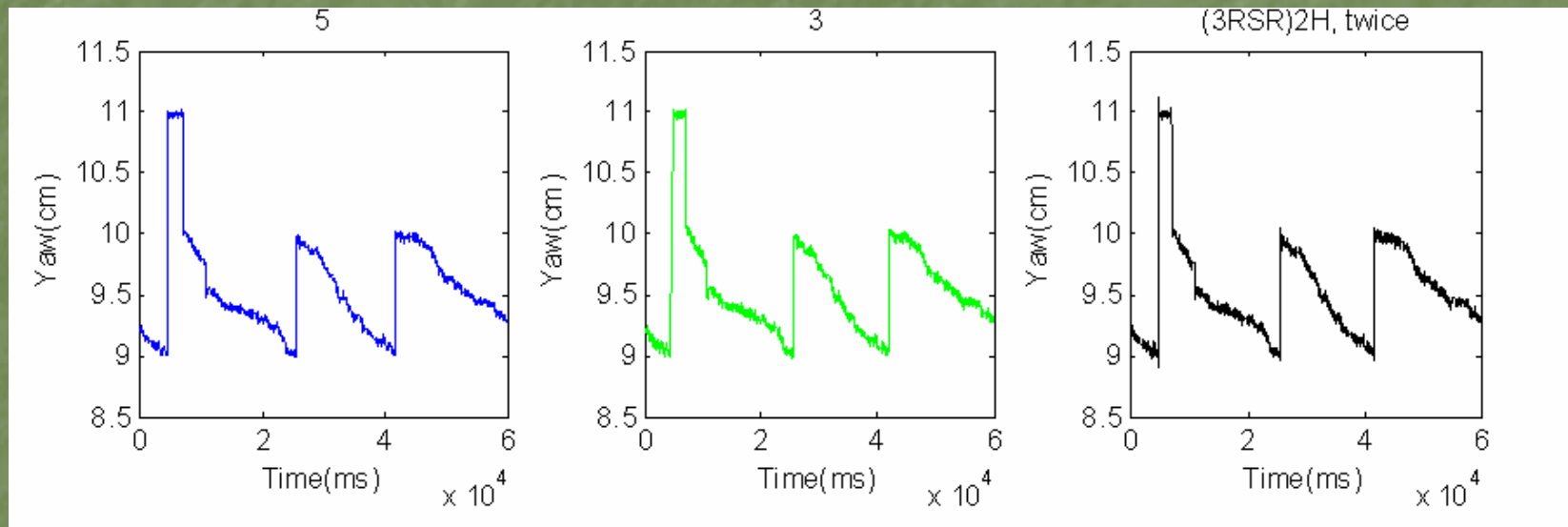
# Results

- Top 3 smoothers for Gradual Data



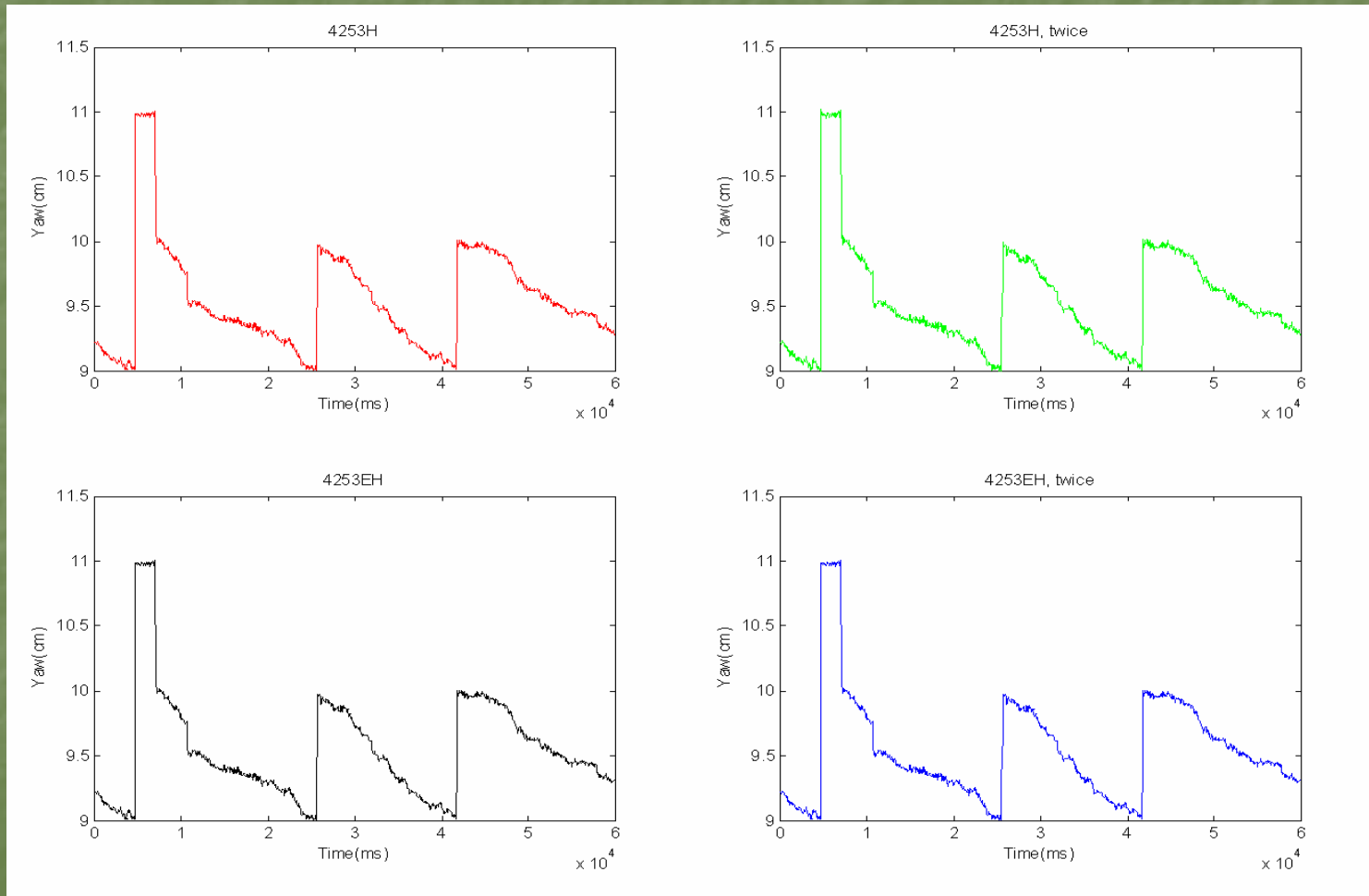
# Results

- Top 3 smoothers for Sharp Data



# Results

- Comparison of 4253H and variants



# Conclusion

- Moderate Compound Non-linear smoother were more resistant than linear smoothers
- Certain Smoothers were more suitable for specific data types
- Most consistent – 4253H

# Future Work

- Consider an adaptive smoother for jitter reduction
- Investigate significance of twicing and endpoint smoothing especially on sharp data

# Acknowledgements

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