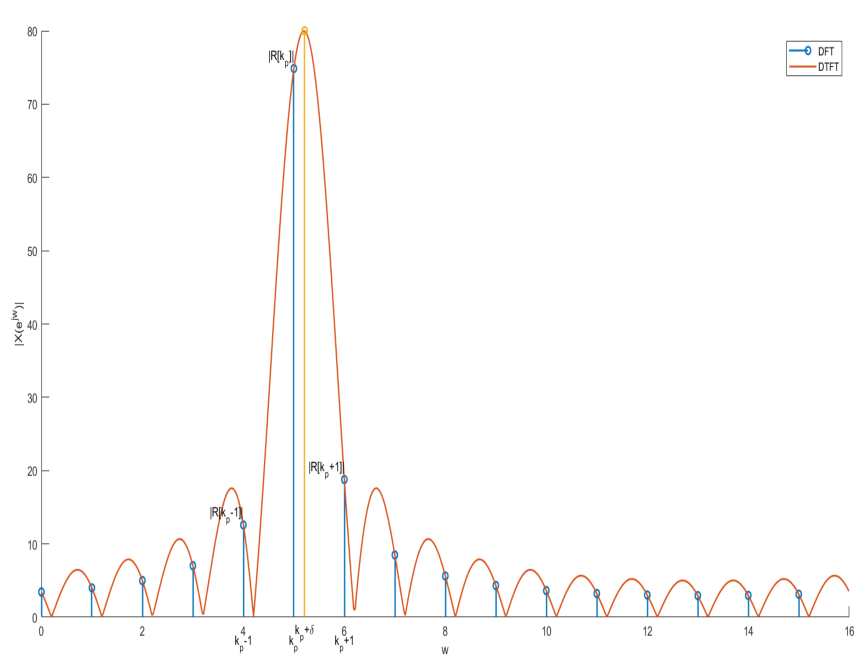
A Method of Fine Resolution Frequency Estimation from 3 DFT Samples

Cagatay Candan

Group 8 – Harish Umasankar(2020102067), Dosapati Sri Anvith(2020102015)

ABSTRACT

- Proposing a non-linear relation between 3 DFT samples to estimate the frequency of a signal
- Proposing Bias Correction for Jacobsen Estimator



MOTIVATION

1. Improve accuracy of Jacobsen Estimator by providing a Bias Correction Factor
2. Achieving a more unbiased estimator for Frequency Estimation
3. Reduce complexity of operations for Frequency Estimation
4. Justifying the expression for δ obtained from Jacobsen Estimator

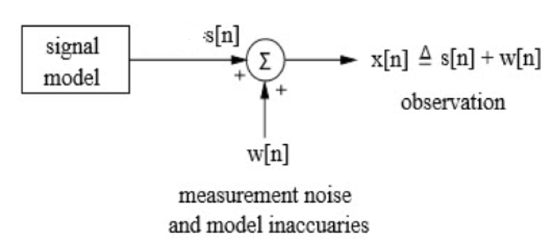
APPLICATIONS

1. Radar Signal Processing
2. Speech Processing
3. Communication Systems

THEORY

1. What is Signal Estimation?

   Process of extracting useful information from noisy signals is called Signal Estimation

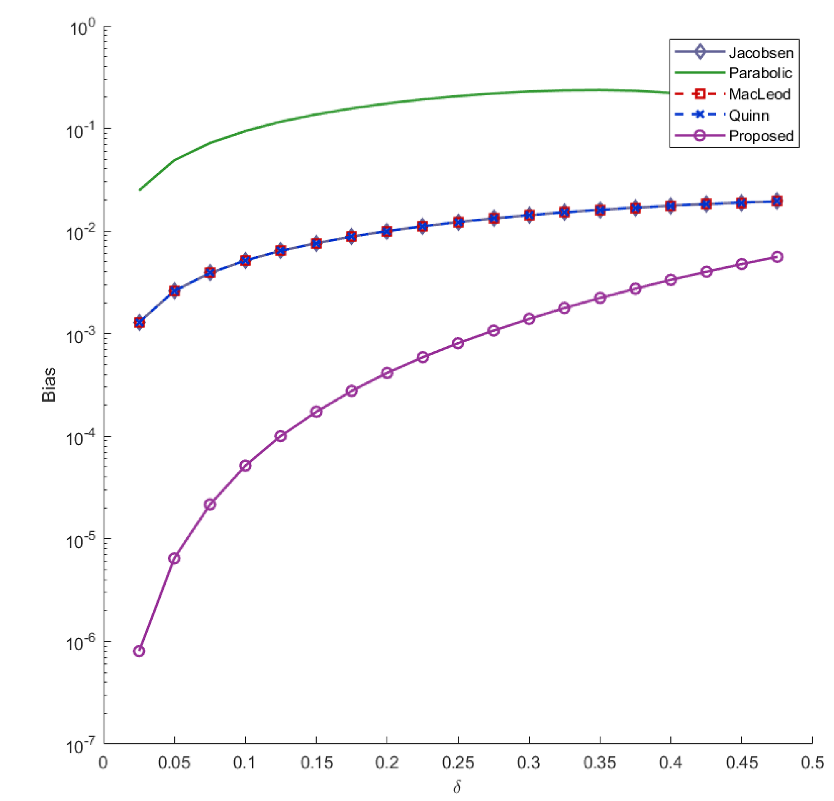


2. Estimator
   Set of rules/algorithm to calculate the value about a quantity based on observed data
3. Bias
   Expected value of difference in estimate and actual value of the parameter
4. Characteristics of a good estimator
   - Unbiased
   - Minimum Variance
   - Consistent

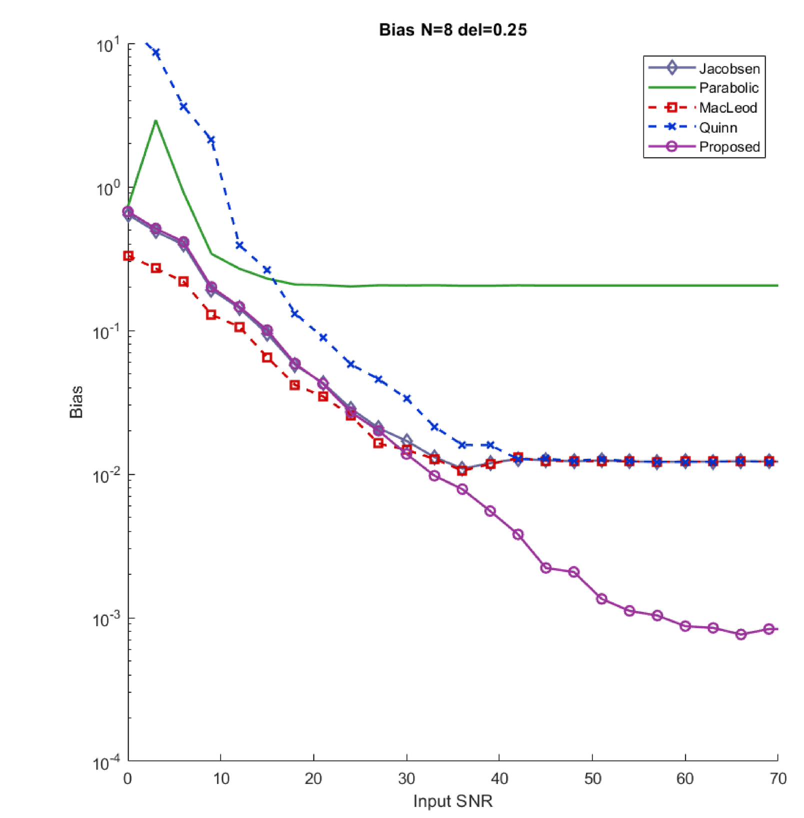
METHOD

1. Standard Method of Frequency Estimation
   1. Find a Coarse Frequency Estimate to get Peak Frequency
   2. Fine Search around the Peak Frequency
2. Candan's Estimator Steps
   - Calculate FFT of signal
   - Calculate index for maximum magnitude of R[k], called kpeak
     Frequency of the signal $\omega = \frac{2\pi}{N}(k_p + \delta)$
   - Compute value of bias using value of FFT at index: kpeak, kpeak-1, kpeak+1
3. Method for Numerical Comparison for the signal in the Prescence of noise
   - Calculate the power of signal
   - For every SNR ratio for chosen range
   - Calculate power of noise from SNR and power of signal
   - Generate Gaussian Noise for the calculated power using randn()
   - Calculate the bias for each SNR over T trials

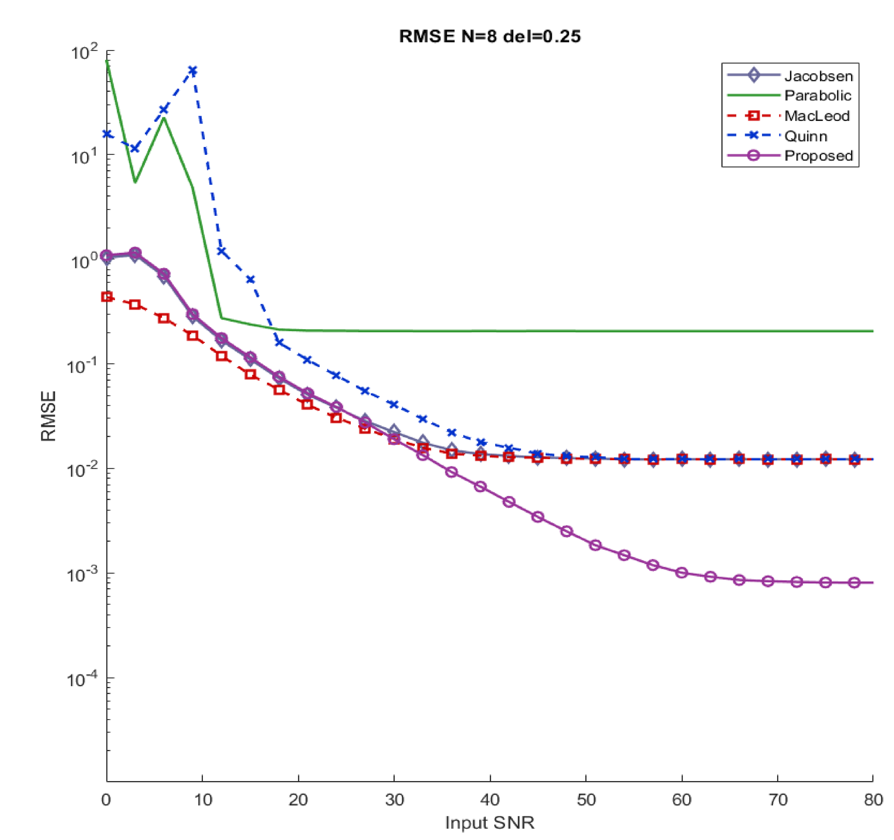
RESULT



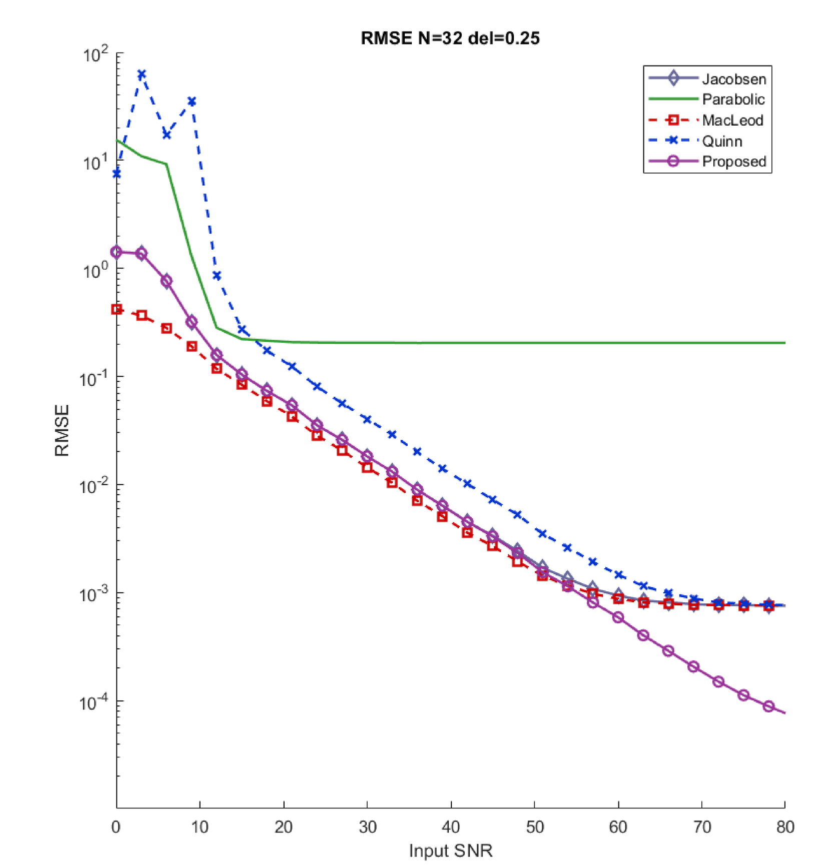
Bias of δ estimate for a Noiseless Signal
The estimators have behave similarly in the absence of noise.



Bias of δ estimate for a Noisy Signal
The bias of the estimators approach 10^-3, which coincides with the value for bias for noiseless case when δ = 0.25



RMSE of δ estimate for N = 8 and δ = 0.25 for varying levels of Input SNR
Proposed estimator follows Cramer Rao Bound Closely in high SNR Region



RMSE of δ estimate for N = 32 and δ = 0.25 for varying levels of Input SNR
The floor of the RMSE value occurs at a lower SNR value for higher N (N=32)

CONCLUSION

1. From the observations, we can conclude that the proposed estimator and bias correction values have improved the estimator, by decreasing the bias and RMSE.
2. The proposed estimator is more efficient in computing the frequency of signals.

REFERENCES

1. M.A.Richards, Fundamentals of Radar Signal Processing.New York: McGraw-Hill, 2005.
2. E. Jacobsen and P. Kootsookos, "Fast, accurate frequency estimators," IEEE Signal Process. Mag., vol. 24, pp. 123–125, May 2007.
3. NPTEL Course: Signal Detection & Estimation Theory(Figures used)