

# **MLSE Sequence Truncation Feature in COM Matlab Code**

## **COM Commit Request Number 4p6\_4**

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# Introduction

- Based on the resolution to comment #327 against Draft 1.1, MLSD implementation penalty will be now based on scaling noise
- This happens before MLSD and as such parameter  $Q$  in equation (178A-36) should be removed
- Consequently, parameters  $Q$  (param.Q) and  $Q\_budget\_adj$  (param.Q\_budget\_adj) should be removed from the code
- However, it is still useful to calculate COM, delta\_com, and DER\_MLSE with the MLSE sequence truncation effect
- COM code version 4.70beta1 has already implemented changes to include truncation
- These slides explain few further changes for clarification and to prevent possible confusion
- Truncation length is defaulted to a large number (set by parameter trunc, defaulted to 128) to ignore truncation by default

# Background

- After removing implementation penalty from the MLSE equation ( $Q$  in equation (178A-36), or  $IP$  in the supporting contributions), equation U1.c becomes (Contribution [Shakiba 3dj 01 2405.pdf](#)):

$$\text{U1.c without Truncation} \left\{ \begin{array}{l} \Delta COM \approx 20 \log_{10} \left( \frac{1}{A_s} CDF_{noise}^{-1} (1 - DER_{MLSE}) \right) \\ DER_{MLSE} \approx \sum_{j=1}^{\infty} \left( \frac{L-1}{L} \right)^{j-1} \left( CDF_{noise,jEE} \left( -A_s \frac{(\text{trace}(\rho_{noise,jEE}))^{\frac{3}{2}}}{\sqrt{\Sigma_{vertical} \Sigma_{horizontal}(\rho_{noise,jEE})}} \right) \right) \end{array} \right.$$

- With MLSE sequence truncated to a length of  $trunc$ , equation U1.c becomes (Contribution [Shakiba 3dj 01a 2407.pdf](#)):

$$\text{U1.c with Truncation} \left\{ \begin{array}{l} \Delta COM_{trunc} \approx 20 \log_{10} \left( \frac{1}{A_s} CDF_{noise}^{-1} (1 - DER_{MLSE,trunc}) \right) \\ DER_{MLSE,trunc} \approx \sum_{j=1}^{trunc-1} \left( \frac{L-1}{L} \right)^{j-1} \left( CDF_{noise,jEE} \left( -A_s \frac{(\text{trace}(\rho_{noise,jEE}))^{\frac{3}{2}}}{\sqrt{\Sigma_{vertical} \Sigma_{horizontal}(\rho_{noise,jEE})}} \right) \right) + L \left( \frac{L-1}{L} \right)^{trunc-1} \left( CDF_{noise,truncEE} \left( -A_s \frac{(\text{trace}(\rho_{noise,truncEE}))^{\frac{3}{2}}}{\sqrt{\Sigma_{vertical} \Sigma_{horizontal}(\rho_{noise,truncEE})}} \right) \right) \end{array} \right.$$

- Note that U1.c with truncation becomes same as U1.c without truncation as  $trunc \rightarrow \infty$

# Changes to the Code (1 of 8)

1) Comment out 6 lines:

```
2279 - j=j+1;
2280 - end
2281 - %% healey_3dj_01a_2407
2282 - if param.Q_budget_adj == 0
2283 -     Q_budget_adj=0;
2284 - else
2285 -     Q_budget_adj=param.Q_budget_adj(1) -param.Q_budget_adj(2)*COM_from_matlab;
2286 - end
2287 - %% shakiba_3dj_01_2407
2288 - % delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE      ,PDF,CDF ) )- param.Q ;% shakiba_3dj_01_2405
```

```
2279 - j=j+1;
2280 - end
2281 - % %% healey_3dj_01a_2407
2282 - % if param.Q_budget_adj == 0
2283 - %     Q_budget_adj=0;
2284 - % else
2285 - %     Q_budget_adj=param.Q_budget_adj(1) -param.Q_budget_adj(2)*COM_from_matlab;
2286 - % end
2287 - %% shakiba_3dj_01_2407
2288 - % delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE      ,PDF,CDF ) )- param.Q ;% shakiba_3dj_01_2405
```

# Changes to the Code (2 of 8)

## 2) Change 1 comment line:

```
2253 - j=1; DER_MLSE=0; DER_MLSE_j= inf;
2254 - P_j.y=cumsum(p_j.y);
2255 - smallest_relative_change=.0001;
2256 - %% 178A-37
2257 - rou=R_ni'/R_ni(1);
2258 - if DER_DFE <= param.DER_CDR
2259 - while j <= floor(num_ui/2) && DER_MLSE_j > DER_MLSE*smallest_relative_change
```

```
2253 - j=1; DER_MLSE=0; DER_MLSE_j= inf;
2254 - P_j.y=cumsum(p_j.y);
2255 - smallest_relative_change=.0001;
2256 - %% 178A-37 (Same as 178A-37 if N_tc is defaulted or large, otherwise also includes effect of truncation as per shakiba_3dj_01a_2407)
2257 - rou=R_ni'/R_ni(1);
2258 - if DER_DFE <= param.DER_CDR
2259 - while j <= floor(num_ui/2) && DER_MLSE_j > DER_MLSE*smallest_relative_change
```

# Changes to the Code (3 of 8)

## 3) Change 1 line:

```
2287 %% shakiba_3dj_01_2407
2288 % delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE      ,PDF,CDF ) )- param.Q ;% shakiba_3dj_01_2405
2289 - delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE_trunc,PDF,CDF ) )- Q_budget_adj ;% shakiba_3dj_01_2405
2290 %% shakiba_3dj_01_2407
2291 % delta_com=20*log10(1/A_s *-CDF_inv_ev ( 2/3*DER_MLSE,PDF,CDF ) )- Q ;% (178A-36)
```

```
2287 %% shakiba_3dj_01_2407
2288 % delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE      ,PDF,CDF ) )- param.Q ;% shakiba_3dj_01_2405
2289 % delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE_trunc,PDF,CDF ) )- Q_budget_adj ;% shakiba_3dj_01_2405
2290 - delta_com=20*log10(1/A_s *-CDF_inv_ev ( DER_MLSE_trunc,PDF,CDF ) ) ;% shakiba_3dj_01_2405
2291 %% shakiba_3dj_01_2407
2292 % delta_com=20*log10(1/A_s *-CDF_inv_ev ( 2/3*DER_MLSE,PDF,CDF ) )- Q ;% (178A-36)
```

# Changes to the Code (4 of 8)

## 4) Change 1 line

```
2290 %% shakiba_3dj_01_2407
2291 % delta_com=20*log10(1/A_s *-CDF_inv_ev ( 2/3*DER_MLSE,PDF,CDF ) )- Q ;% (178A-36)
2292 -
2293 - new_com=COM_from_matlab+delta_com;
2294 - if(delta_com<0)
2295 -     delta_com=0;
2296 -     warning('MLSE truncation failed. Try increasing trunc')
2297 -     try
2298 -         hx=msgbox('MLSE truncation failed. Try increasing N_tc','warning','warn');
2299 -         set(hx,'Color',[1 0 1]);
2300 -         movegui(hx,[randn randn]*100)
2301 -         set(hx,'Tag','COM') %
2302 -     catch
2303 -     end
2304 - end
```

```
2291 %% shakiba_3dj_01_2407
2292 % delta_com=20*log10(1/A_s *-CDF_inv_ev ( 2/3*DER_MLSE,PDF,CDF ) )- Q ;% (178A-36)
2293 - new_com=COM_from_matlab+delta_com;
2294 - if(delta_com<0)
2295 -     delta_com=0;
2296 -     % warning('MLSE truncation failed. Try increasing trunc')
2297 -     warning('MLSE truncation failed. Try increasing N_tc')
2298 -     try
2299 -         hx=msgbox('MLSE truncation failed. Try increasing N_tc','warning','warn');
2300 -         set(hx,'Color',[1 0 1]);
2301 -         movegui(hx,[randn randn]*100)
2302 -         set(hx,'Tag','COM') %
2303 -     catch
2304 -     end
2305 - end
```

# Changes to the Code (5 & 6 of 8)

5 & 6) Change 1 line and comment out 1 line

```
2304 - else
2305 -     warning('MLSE not applied because the DER is less than that required for the CDR to lock')
2306 -     DER_MLSE=NaN;
2307 -     new_com=COM_from_matlab;
2308 -     delta_com=0;
2309 -     Q=0;
2310 -     Q_budget_adj=0;
2311 -     %% shakiba_3dj_01_2407
2312 - end
```

```
2306 - else
2307 -     warning('MLSE not applied because the DER is less than that required for the CDR to lock')
2308 -     % DER_MLSE=NaN;
2309 -     DER_MLSE_trunc=NaN;
2310 -     new_com=COM_from_matlab;
2311 -     delta_com=0;
2312 -     Q=0;
2313 -     % Q_budget_adj=0;
2314 -     %% shakiba_3dj_01_2407
2315 - end
```



# Changes to the Code (7 & 8 of 8)

7 & 8) Comment out 2 lines and change 1 line

```
2314 %%  
2315 - MLSE_results.DER_MLSE_trunc = DER_MLSE_trunc;% shakiba_3dj_01_2407 (to add MLSE sequence truncation penalty)  
2316 - MLSE_results.Q_budget_adj=Q_budget_adj; % healey_3dj_01a_2407  
2317 - MLSE_results.COM_from_matlab=COM_from_matlab;  
2318 - MLSE_results.DER_MLSE=DER_MLSE;  
2319 - MLSE_results.DER_DFE=DER_DFE;  
2320 - MLSE_results.COM=new_com;  
2321 - MLSE_results.delta_com=delta_com;
```

```
2317 %%  
2318 % MLSE_results.DER_MLSE_trunc = DER_MLSE_trunc;% shakiba_3dj_01_2407 (to add MLSE sequence truncation penalty)  
2319 % MLSE_results.Q_budget_adj=Q_budget_adj; % healey_3dj_01a_2407  
2320 - MLSE_results.COM_from_matlab=COM_from_matlab;  
2321 % MLSE_results.DER_MLSE=DER_MLSE;  
2322 - MLSE_results.DER_MLSE=DER_MLSE_trunc;  
2323 - MLSE_results.DER_DFE=DER_DFE;  
2324 - MLSE_results.COM=new_com;  
2325 - MLSE_results.delta_com=delta_com;
```

# Example Outputs

	Before Change	After Change
Without Truncation (Default)	<p><b>Com_ieee8023_93a_470beta1</b> (N_tc = 128)</p> <p>DER_MLSE_trunc: 2.0764e-06            X → Q_budget_adj: 0            COM_from_matlab: -0.7246            X → DER_MLSE: 2.0764e-06            DER_DFE: 1.4827e-04            COM: 1.0876            delta_com: 1.8122</p>	<p><b>Com_ieee8023_93a_470beta1_trunc</b> (N_tc = 128)</p> <p>COM_from_matlab: -0.7246            DER_MLSE: 2.0764e-06            DER_DFE: 1.4827e-04            COM: 1.0876            delta_com: 1.8122</p>
With Truncation (truncated to 8)	<p><b>Com_ieee8023_93a_470beta1</b> (N_tc = 8)</p> <p>DER_MLSE_trunc: 3.5120e-05            X → Q_budget_adj: 0            COM_from_matlab: -0.7246            X → DER_MLSE: 2.0764e-06            DER_DFE: 1.4827e-04            COM: -0.1694            delta_com: 0.5551</p>	<p><b>Com_ieee8023_93a_470beta1_trunc</b> (N_tc = 8)</p> <p>COM_from_matlab: -0.7246            DER_MLSE: 3.5120e-05            DER_DFE: 1.4827e-04            COM: -0.1694            delta_com: 0.5551</p>

- Currently, it is confusing as DER\_MLSE is reported with and without truncation, whereas COM and delta\_com are reported only after truncation but without mentioning it (subscript \_trunc)

**Thank You 😊**

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