CHANNEL IMPULSIVE NOISE MITIGATION FOR LINEAR VIDEO CODING SCHEMES

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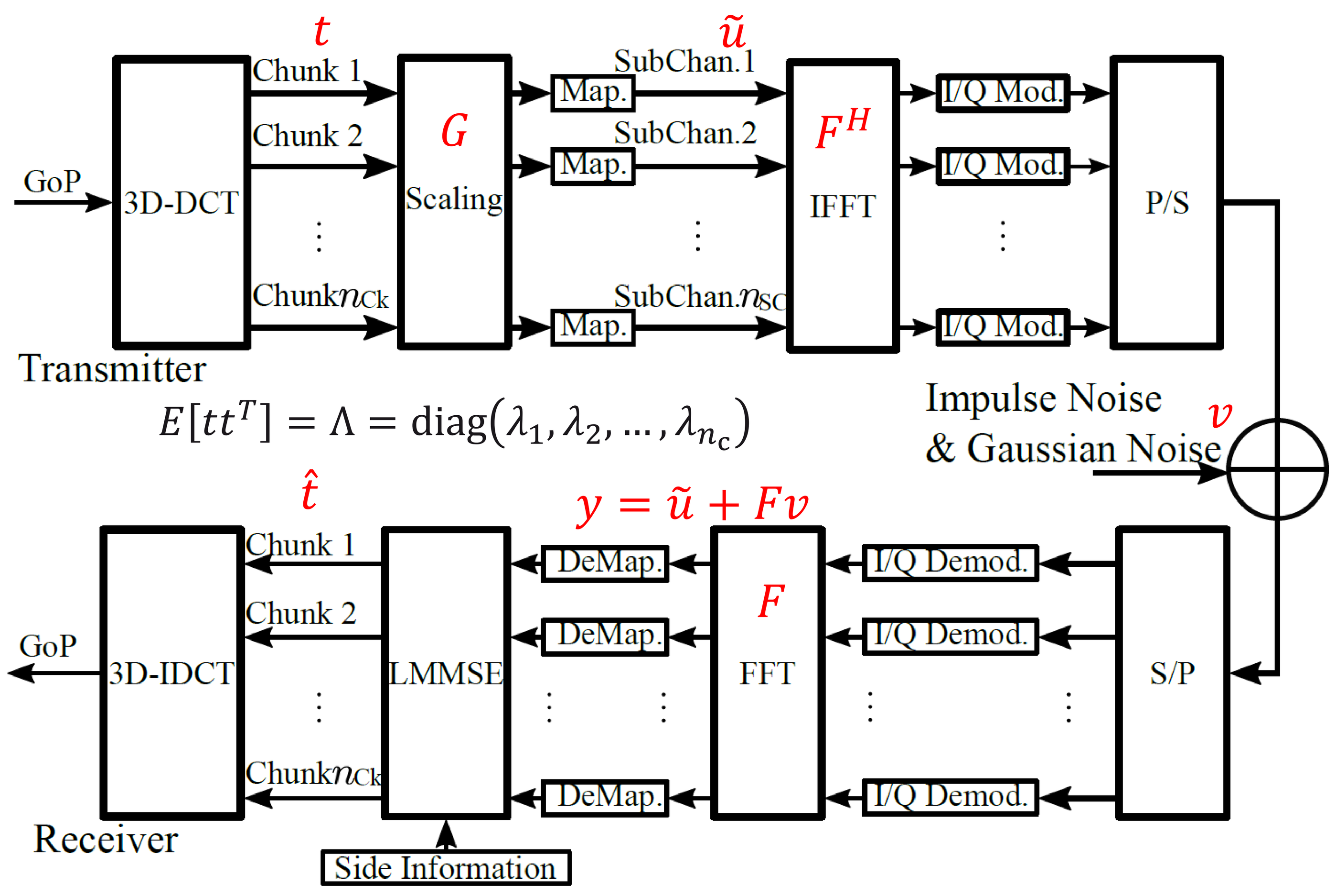
ABSTRACT: The problem of impulse noise mitigation is considered when videos encoded using a SoftCast-based Linear Video Coding (LVC) scheme are transmitted using an OFDM scheme over a wideband channel prone to impulse noise. A Fast Bayesian Matching Pursuit algorithm is employed for impulse noise mitigation. This approach requires the provisioning of some OFDM subchannels to estimate the impulse noise locations and amplitudes. Provisioned subchannels cannot be used to transmit data and lead to a decrease of the nominal decoded video quality at receivers in absence of impulse noise. Using a phenomenological model (PM) of the residual noise variance after impulse correction, an algorithm is proposed to evaluate the optimal number of subchannels to provision for impulse noise mitigation. Simulation results show that the PM can accurately predict the number of subchannels to provision and that impulse noise mitigation can significantly improve the decoded video quality compared to a situation where all subchannels are used for data transmission.

SoftCast-based Linear video coding (LVC)

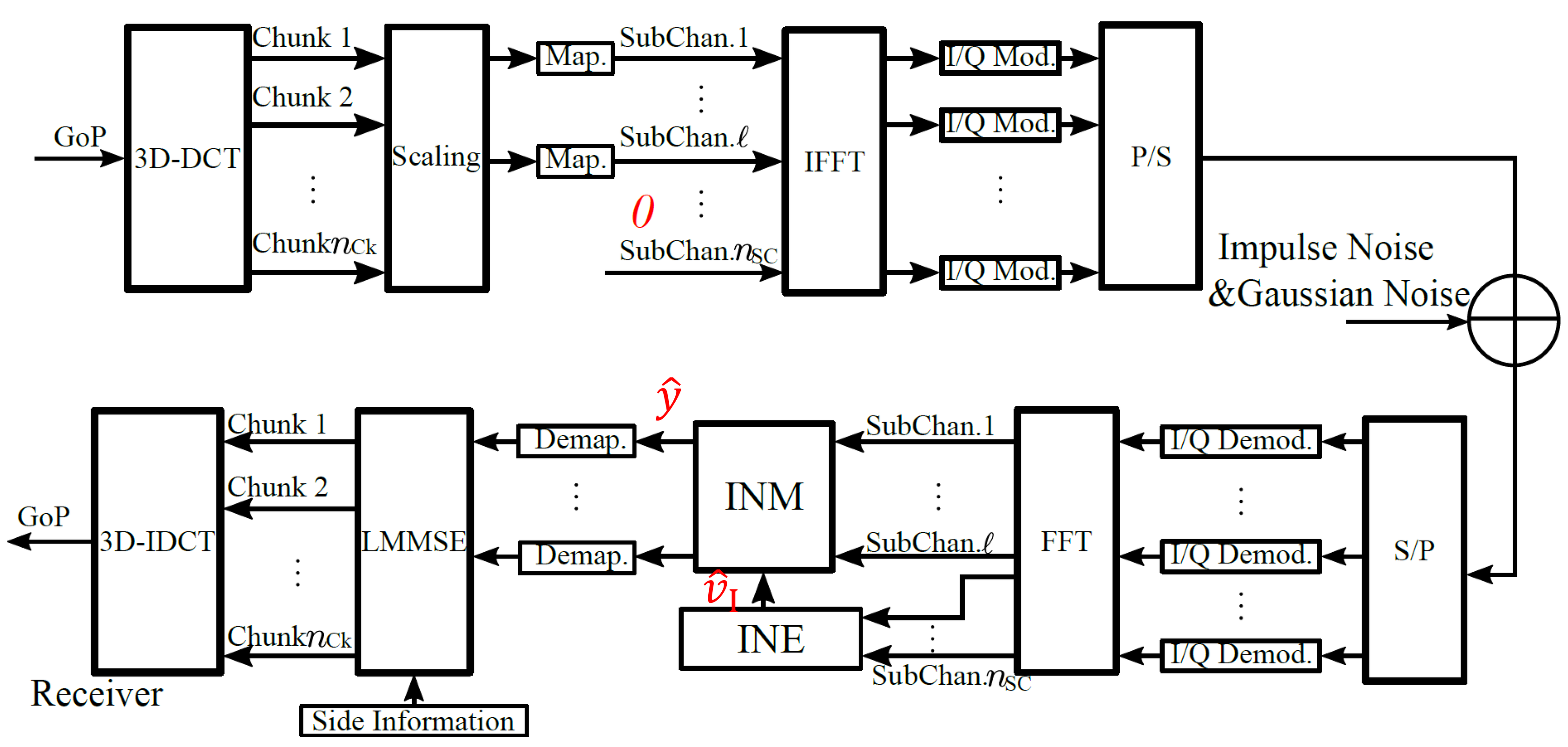
SoftCast [1]: Linear joint source-channel video coder

- 3D-DCT, power allocation, analog modulation, LMMSE estimation
- Received quality improves gracefully with channel quality.



$v = v_{\mathrm{I}} + v_{\mathrm{g}}$, v_{I} is a *sparse impulse noise vector* [2] and v_{g} is a Gaussian noise vector and $Fv_{\mathrm{g}} \sim \mathcal{CN}(0, 2N)$, where $N = \mathrm{diag}(\sigma_1^2, \sigma_2^2, \ldots, \sigma_{n_{\mathrm{SC}}}^2)$.

LVC with Subchannel Provisioning and Impulse Noise Correction



$q = n_{\mathrm{SC}} - l$ subchannels are *provisioned for impulse noise correction*

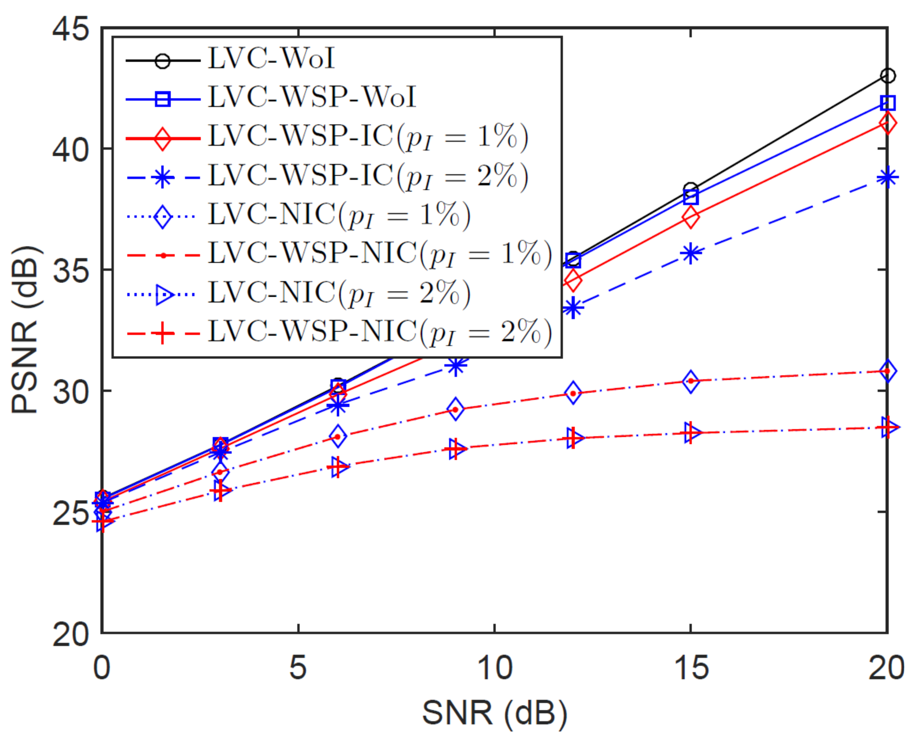
INE: estimate impulse noise $\hat{v}_{\mathrm{I}}$ using Fast Bayesian Matching Pursuit (FBMP) [3].

INM: remove estimated impulse noise $\hat{v}_{\mathrm{I}}$ from received vector

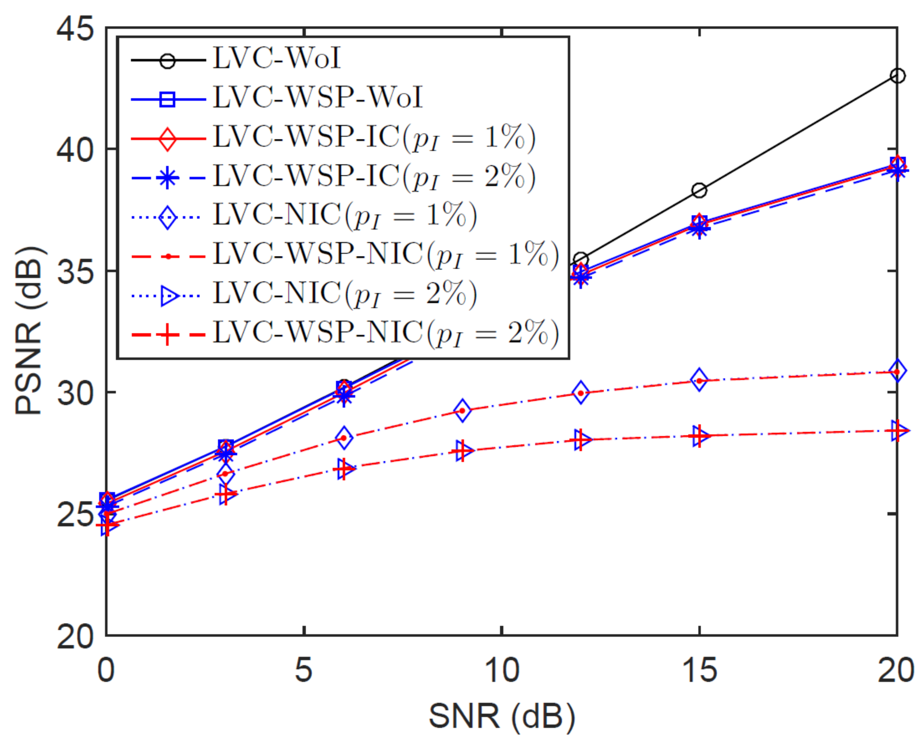
$$\hat{y} = \tilde{u} + F(v_{\mathrm{I}} - \hat{v}_I) + Fv_{\mathrm{g}}$$
$$= \tilde{u} + Fv_{\mathrm{r}} + Fv_{\mathrm{g}}$$

Impact of proportion of provisioned subchannels $r_{\mathrm{d}} = q/n_{\mathrm{SC}}$

First 5 GoPs of BQSquare, with different impulse noise probability p_I and r_{d}.



$r_{\mathrm{d}} = 0{,}25$



$r_{\mathrm{d}} = 0{,}5$

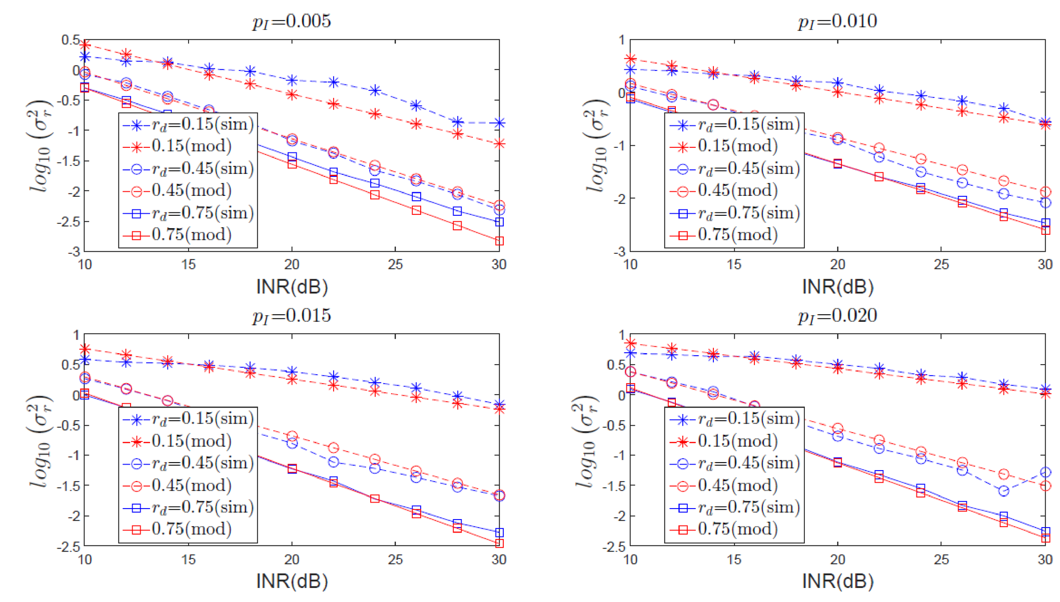
r_{d} has to be optimized. Optimal value depends on p_I and σ_I^2.

Optimal subchannel provisioning (OSP)

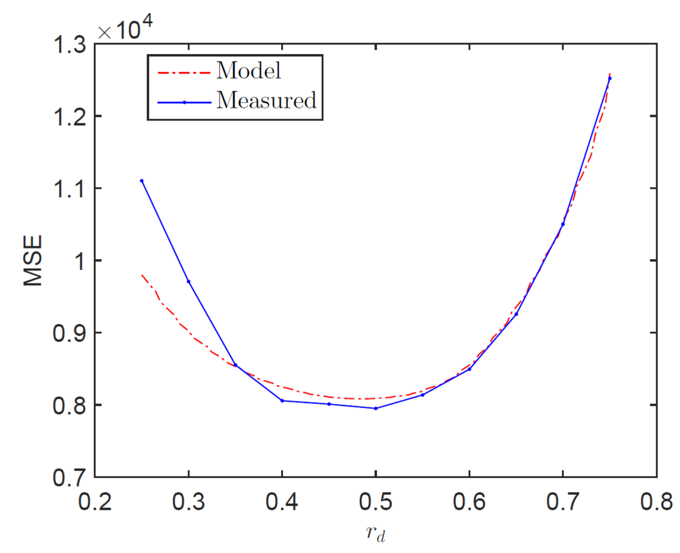
Assuming $Fv_{\mathrm{r}} \sim \mathcal{CN}(0, \sigma_r^2 I)$, a phenomenological model for

$$\log_{10}(\sigma_r^2) = \mu_0(r_{\mathrm{d}}, \mathrm{INR_{dB}}) + \mu_1(r_{\mathrm{d}}, \mathrm{INR_{dB}})\log_{10}(p_I),$$

where $\mu_i = \mu_{i,0} + \mu_{i,1}\mathrm{INR_{dB}} + \mu_{i,2}(1 - r_{\mathrm{d}})^2 + \mu_{i,3}(1 - r_{\mathrm{d}})^2\mathrm{INR_{dB}},\ i = 0,1$ and $\mathrm{INR_{dB}}$ is impulse-to-noise ratio. Example when $n_{\mathrm{SC}} = 256$.



PM for σ_r^2 used in optimal precoding matrix design and LMMSE [1].
Finally we can get MSE model of $E(\|t - \hat{t}\|_2^2)$ [4].



Example for a group of chunks of BQSquare when SNR is 12dB, p_I=0.02.

PM based MSE model to find an optimal r_{d} is accurate

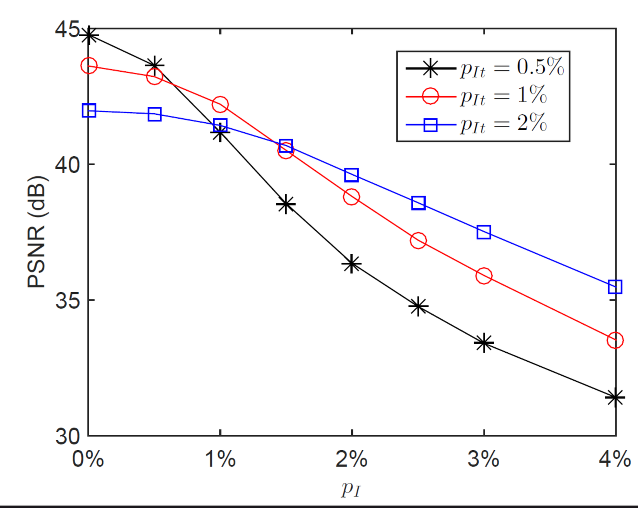
Results

First frame of RaceHorses when $\mathrm{SNR_{dB}}$ = 15 dB, $\mathrm{INR_{dB}}$ = 10 dB and p_I = 0.01.

LVC-NIC: PSNR 30.83dB

LVC-OSP-IC: PSNR 38.64dB

Impact of mismatched p_{It}s



Conclusions

SoftCast-based LVC with impulse noise mitigation scheme is proposed. Phenomenological model proposed to estimate variance of impulse noise residual after impulse mitigation. Used to optimize subchannel provisioning. Approach robust to mismatched impulse noise characteristics.

Bibliography

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