



向过去致敬
为未来向前

AHG12: Regularized EIP

QIN Hongdong, Jacek KONIECZNY, DING Keqin, XU Zhuowei

Date: 2024-04-19



- ECM uses ordinary least squares methods for several coding modes, including CCCM, EIP, etc.
- The model coefficients are computed as solving a system of linear equations

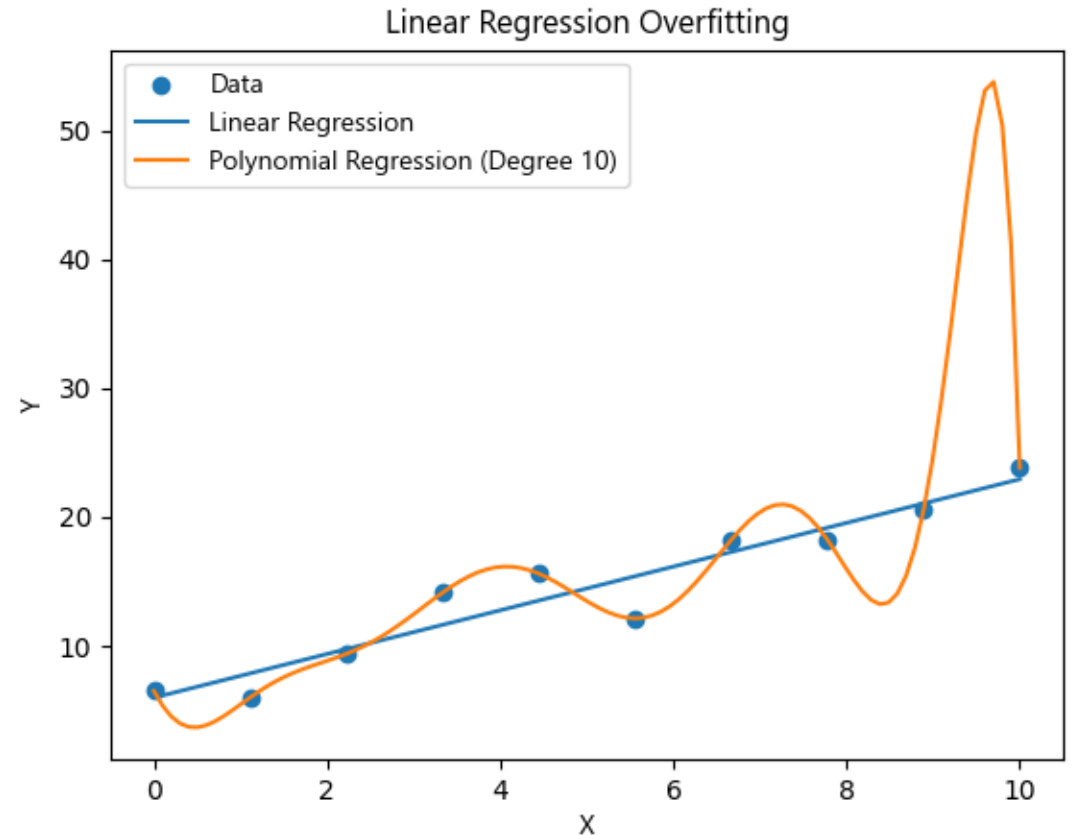
$$\mathbf{A}^T \mathbf{y} = (\mathbf{A}^T \mathbf{A}) \hat{\boldsymbol{\beta}}$$

- The solution to the model coefficients is

$$\hat{\boldsymbol{\beta}} = (\mathbf{A}^T \mathbf{A})^{-1} \mathbf{A}^T \mathbf{y}$$

Overfitting in linear regression

- The coefficients in CCCM, EIP and other related modes are solved with ordinary least squares.
- OLS is known to be suffering from noise and/or overfitting.
 - Especially when the template (sampling set) is small and the model tap number is relatively large.
- Regularization is a popular approach to address this issue.



- It is proposed to introduce L2-regularization to EIP (ReEIP).

$$\mathbf{A}^T \mathbf{y} = (\mathbf{A}^T \mathbf{A} + \lambda \mathbf{I}) \hat{\boldsymbol{\beta}}$$

- The model coefficients are computed as

$$\hat{\boldsymbol{\beta}} = (\mathbf{A}^T \mathbf{A} + \lambda \mathbf{I})^{-1} \mathbf{A}^T \mathbf{y}$$

- λ is a regularization parameter.
- Prediction is kept as the convolution between model and input vector.
- There is no signalling change as parameters are fixed or derived.
- L2-regularization can also be applied to CCCM (ReCCCM).
 - The first (co-located luma) and last (Bias) terms are unregularized: the top-left and bottom-right entries of the identity matrix is set to zero.

- Test 1: ReEIP with $\lambda = p_{EIP} \times 128$
 - $p_{EIP} = 15$ is the number of filter taps in EIP.
 - Enabled whenever `CccmCovariance::solveEip()` is called.

	AI						
	Y	U	V	EncT	DecT	EncVmPeak	DecVmPeak
Class A1	-0.06%	-0.03%	-0.01%	100.4%	100.3%	102.0%	100.1%
Class A2	-0.03%	0.06%	-0.01%	100.1%	100.2%	98.9%	99.8%
Class B	-0.05%	0.01%	0.03%	99.8%	100.3%	98.7%	100.0%
Class C	0.00%	-0.06%	0.02%	100.1%	100.9%	99.5%	100.0%
Class E	-0.04%	-0.06%	-0.20%	100.1%	100.4%	103.0%	99.9%
Overall	-0.04%	-0.01%	-0.02%	100.1%	100.5%	100.2%	99.9%
Class D	-0.02%	0.18%	0.01%	99.3%	100.0%	100.0%	100.0%
Class F	0.03%	-0.07%	0.13%	99.2%	99.9%	100.0%	100.0%
Class TGM	-0.01%	0.06%	-0.02%	100.4%	99.9%	101.3%	100.1%

Class A2 is missing DaylightRoad2 QP 22. The line is filled with Anchor.

- Test 2: ReEIP $\lambda_{EIP} = p_{EIP} \times 128$, ReCCCM $\lambda_{CCCM} = p_{CCCM} \times 32$
 - p_{CCCM} is the number of parameters in the relevant CCCM model.
 - Whenever CccmCovariance::solveEip() is called.
 - Whenever CccmCovariance::solve2() is called with interCccmMode == false.

	AI						
	Y	U	V	EncT	DecT	EncVmPeak	DecVmPeak
Class A1							
Class A2							
Class B							
Class C	0.01%	-0.09%	0.06%				
Class E	-0.04%	-0.20%	-0.08%				
Overall							
Class D	-0.04%	-0.03%	-0.11%				
Class F							
Class TGM							

- In this contribution, regularized least squares is proposed as a replacement of ordinary least squares for computing EIP/CCCM coefficients.
- The proposed methods offer coding gains with good tradeoff against encoding time.
- It is recommended that the proposed methods be studied in the next round of EE2.
- Thank OPPO for crosschecking!
- Thank you for your attention.