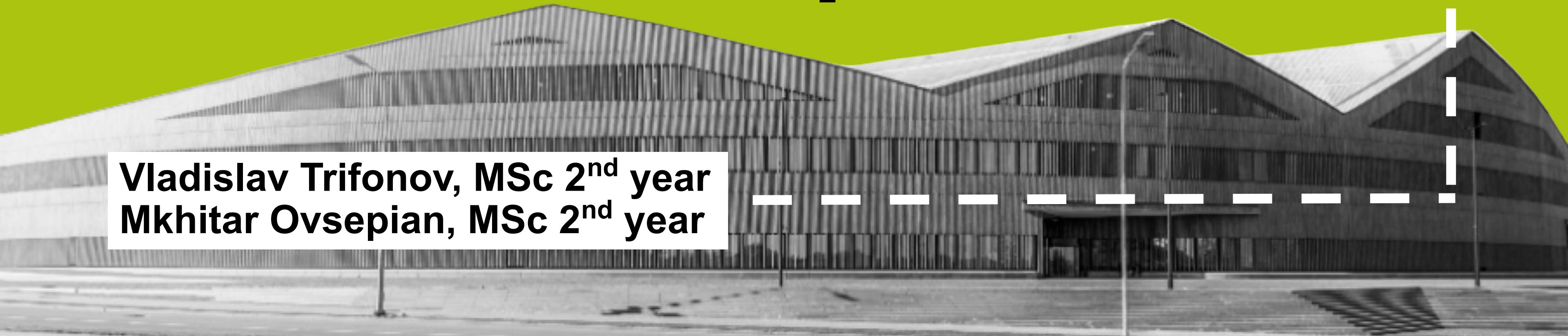
Cross Validation wrt Hydrolyzed Polyacrylamide Research Paper



Vladislav Trifonov, MSc 2nd year
Mkhitar Ovsepian, MSc 2nd year

Polymer Flooding *(HPAM)* for EOR

- Mobility control: *the displacing fluid mobility should be equal to or less than the (minimum) total mobility of displaced multiphase fluids.*

$$M = \frac{\lambda_{water}}{\lambda_{oil}} = \frac{\frac{k_{water}}{\mu_{water}}}{\frac{k_{oil}}{\mu_{oil}}}$$

How it can be done:
increasing the viscosity of aqueous phase

HPAM flooding efficiency depends on:

a) polymer type
b) concentration
c) salinity
d) pH
e) hydrolysis degree
f) rock type
g) crude oil compositions

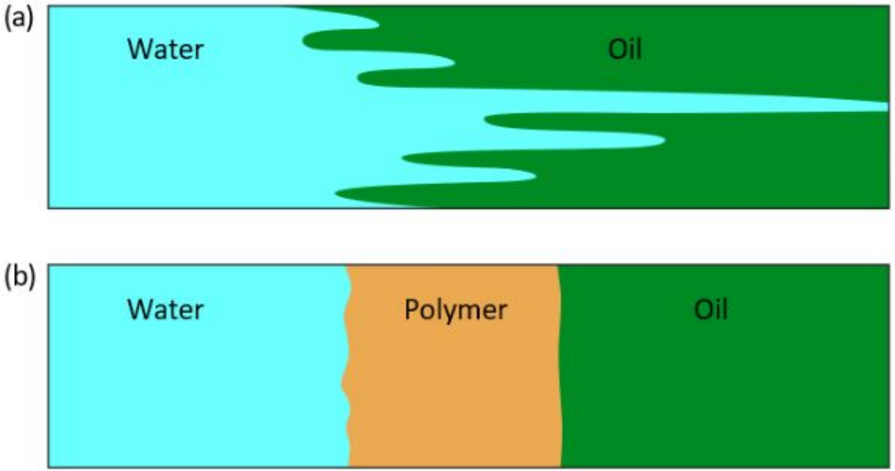


Fig 1. A simplified presentation of the difference between water (a) and polymer (b) flooding.

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HPAM

Models describing rheology:

$\tau = K\gamma^{n}$ - Ostwald-de Waele law

$\tau = \gamma\left(\eta_{\infty} + \frac{\eta_0 - \eta_{\infty}}{\left(1+(\lambda\gamma)^{a}\right)^{\frac{1-n}{a}}}\right)$ - Carreau - Yasuda model

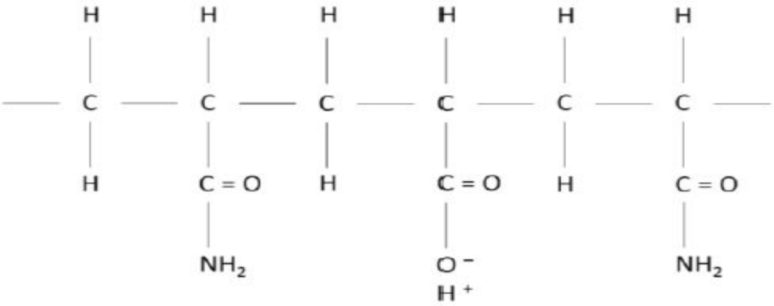

Fig 2. Molecular structure of a partially hydrolyzed polyacrylamide

- Hydrolysis degree: 15-35% (in EOR *25%*)
- If >40% - viscosity reduction resulted from sever compression and distortion of the flexible chains of the polymer

Salt influence

$$I = \frac{1}{2}\sum m_i z_i^2$$ *- Ionic strength*

m is the molar concentration of ion *i*,
z is the charge number of that ion.

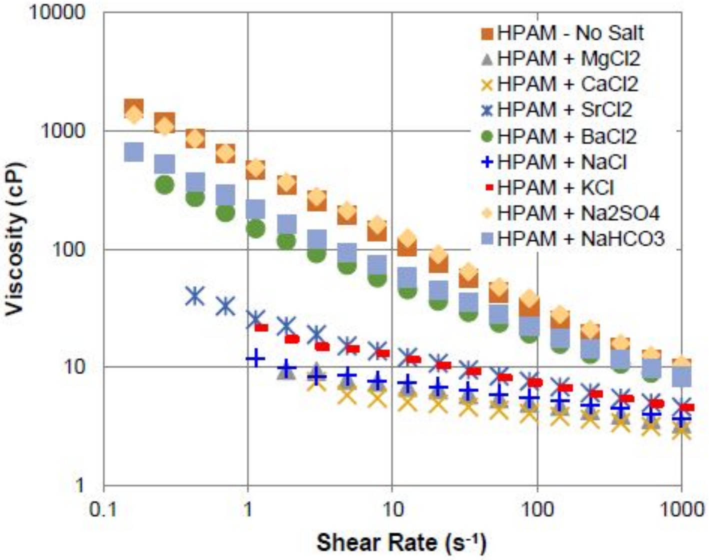

Fig 3. Influence of each salt addition on the original viscosity of the fluid (1250 ppm HPAM).

Alkalinity influence

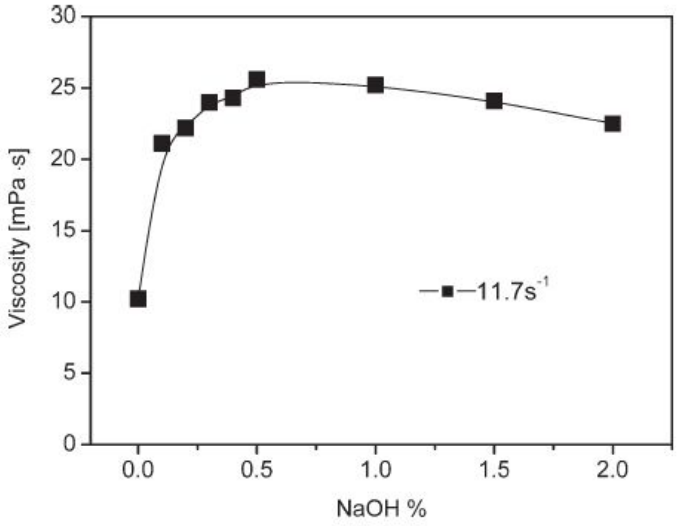

Fig 4. Influence of adding alkalines

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Machine Learning Outline

- Problem setting
- Cross validation wrt to paper
- General ML approach
- Dimensionality reduction

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Problem Setting. Dataset

Effects of salts and temperature on rheological and viscoelastic behavior of low molecular weight HPAM solutions

Fabián Andrés Tapias Hernandez*; Juan Carlos Lizcano Niño; Rosângela Barros Zanoni Lopes Moreno.

School of Mechanical Engineering, University of Campinas. Campinas, São Paulo, Brazil

*E-mail: fabian.tapias@hotmail.com

Features: 11
Samples: 1010

Rheology and Polymer Flooding Characteristics of Partially Hydrolyze Polyacrylamide for Enhanced Heavy Oil Recovery

Jae Chul Jung,[1] Ke Zhang,[2] Bo Hyun Chon,[1] Hyoung Jin Choi[2]

[1]Department of Energy Resources Engineering, Inha University, Incheon 402-751, Korea

[2]Department of Polymer Science and Engineering, Inha University, Incheon 402-751, Korea

Correspondence to: B. H. Chon (E-mail: bochon@inha.ac.kr) or H. J. Choi (E-mail: hjchoi@inha.ac.kr)

Features: 6
Samples: 147

Rheological Evaluation of HPAM fluids for EOR Applications

L. F. Lopes, B. M.O. Silveira, R. B. Z. L. Moreno - State University of Campinas

Features: 6
Samples: 350

Rheology of diluted and semi-diluted partially hydrolyzed polyacrylamide solutions under shear: Experimental studies

Rui Zhang [b], Xianru He [a,*], Shuwei Cai [a], Kun Liu [c]

[a] *State Key Laboratory of Oil and Gas Reservoir Geology & Exploitation, College of Materials Science and Engineering, Southwest Petroleum University, Chengdu 610500, PR China*

[b] *Institut für Physik, Universität Rostock, Albert-Einstein-Str. 23-24, 18051 Rostock, Germany*

[c] *Geological Research Institute of Shengli Oil Field, Sinopec. Ltd Corp., Dongying 257015, PR China*

Features: 5
Samples: 406

Problem Setting. Data Exploration

Target: Viscosity

Mutual features: Shear_Rate, Molecular_Weight,

Polymer_Concentration, Temperature, Salinity

New features: NaCl_only, paper

Use only **general** Ionic_Strength/Salt_Concentration

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Problem Setting. Models

Linear model: Ridge, Ridge with polynomial features

Tree models: Tree regression, XGBoost regression

KNN Regression

Metric: r^2 score

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Cross Validation wrt to Paper

Target: Viscosity **Mutual features:** Shear_Rate, Molecular_Weight, Polymer_Concentration, Temperature, Salinity

	r2_train	r2_test
hernandes	0.999366	-2512.544995
jung	0.999557	-3.872665
lopes	0.930532	0.003470
zhang	0.859104	-0.482914

XGB. All features

	r2_train	r2_test
hernandes	0.409036	-329.343886
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zhang	0.167513	-0.327928

KNN. Shear rate only

	r2_train	r2_test
hernandes	0.999975	-747.689690
jung	0.999994	0.603260
lopes	0.992848	-0.704386
zhang	0.996622	-0.628992

Tree. All features + poly

	r2_train	r2_test
hernandes	0.153243	-51.532936
jung	0.073928	0.175766
lopes	0.423256	-0.038115
zhang	0.423280	-24915.173580

Ridge. All features + poly

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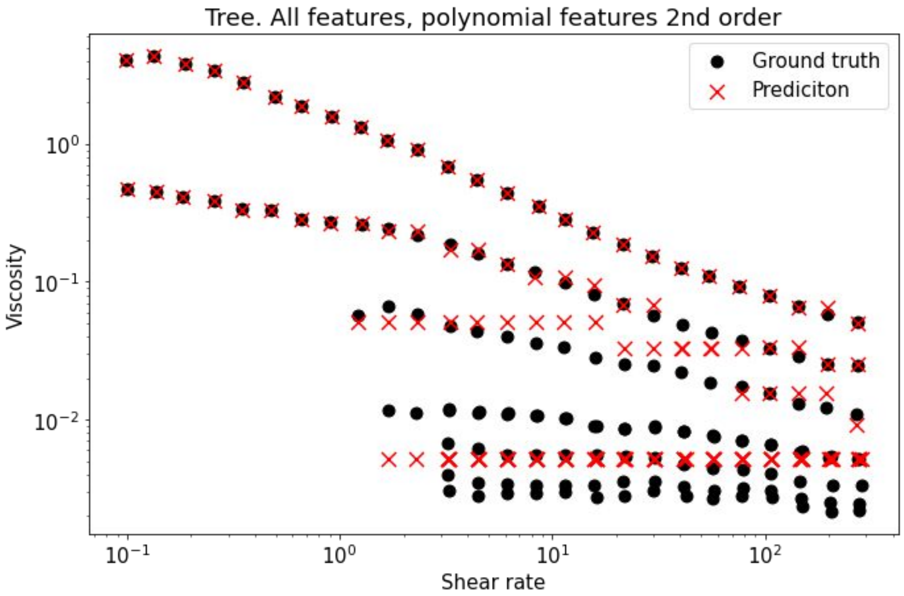

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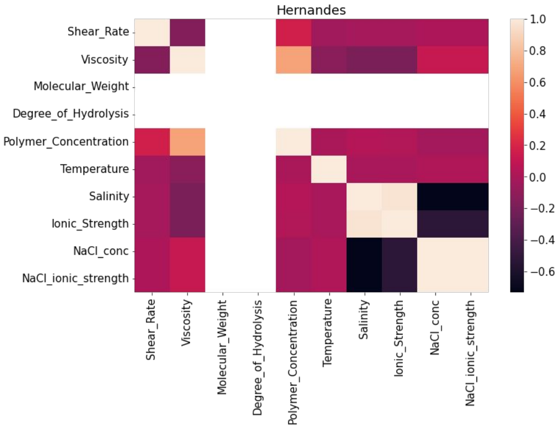

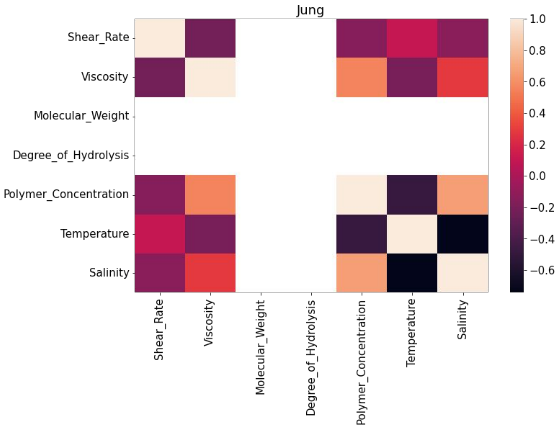

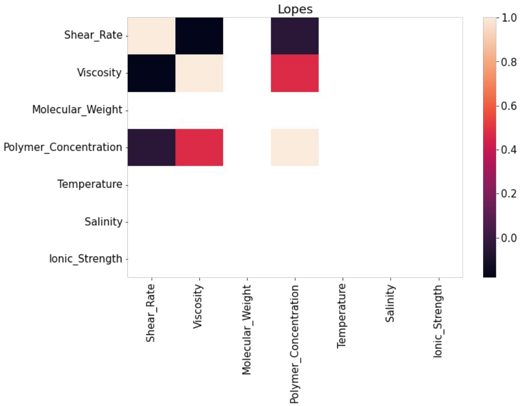

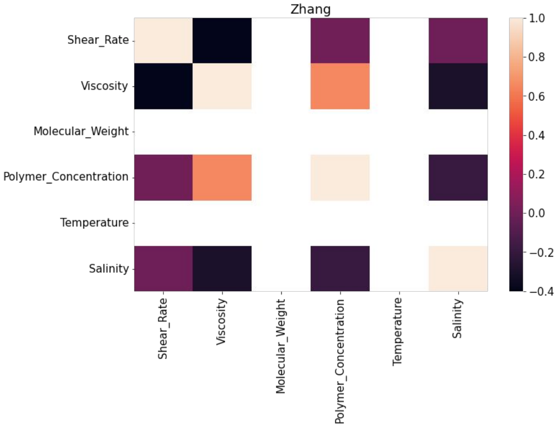

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General ML approach

Target: Viscosity

Mutual features: Shear_Rate,

Molecular_Weight,

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Temperature, Salinity

General ML approach

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General ML approach

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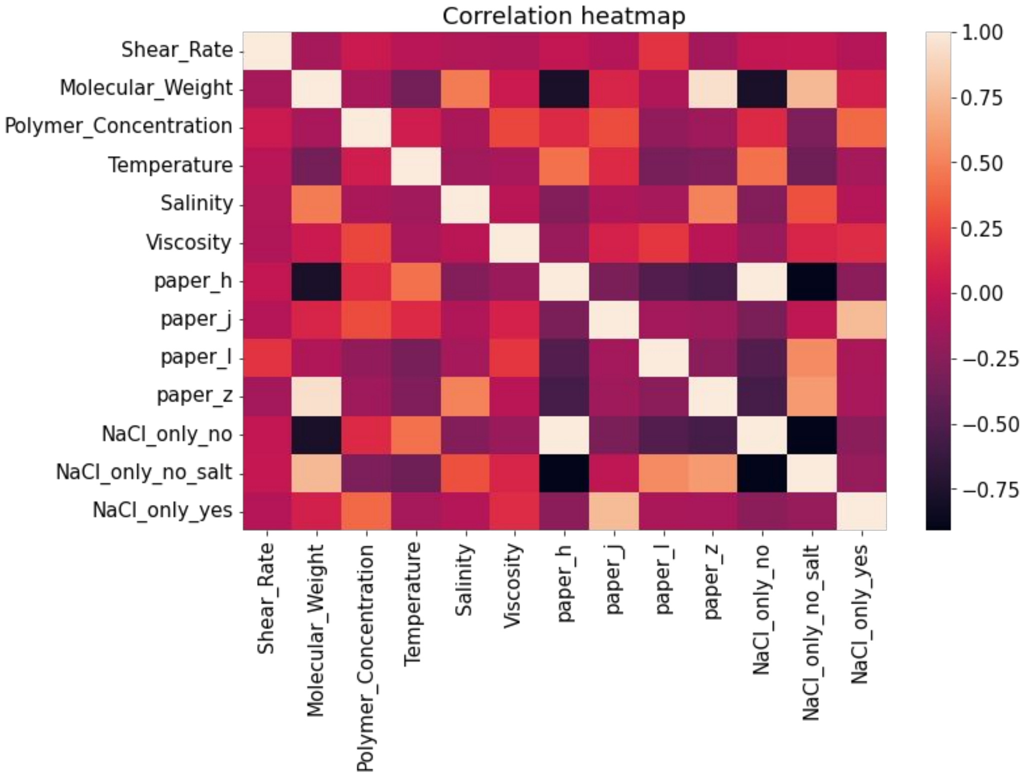
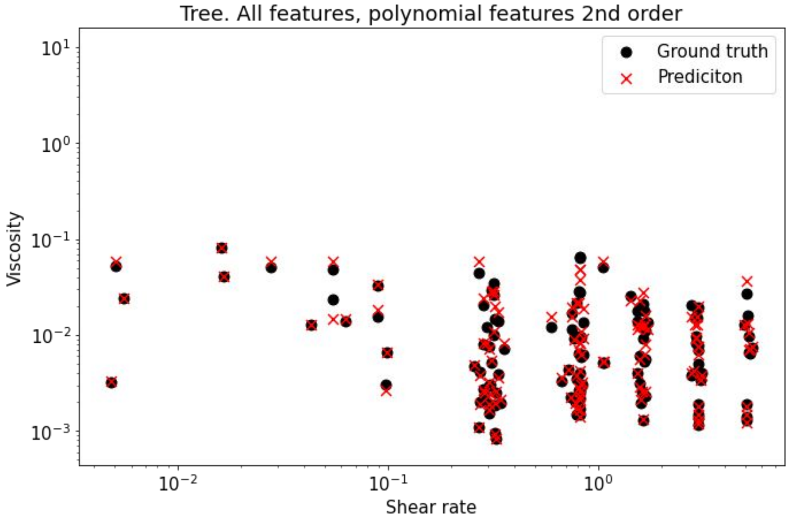


General ML approach



Train r^2 score: ~1.0

Test r^2 score: 0.85-0.88

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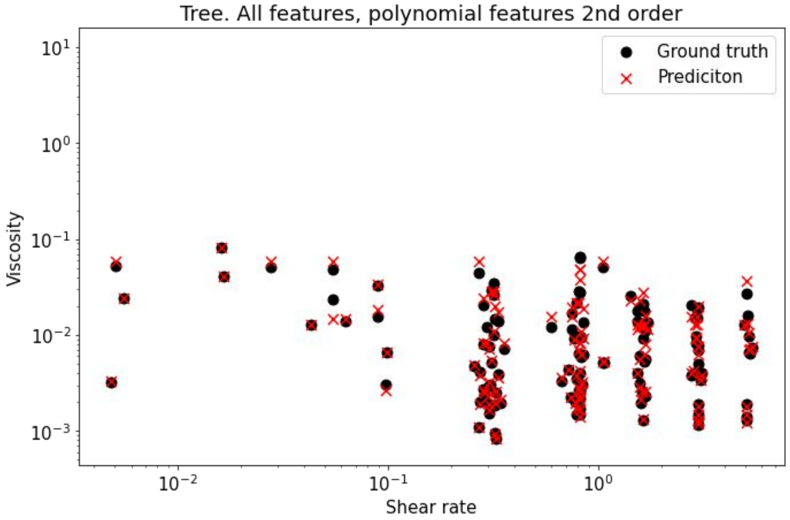
General ML approach



Train r^2 score: ~1.0

Test r^2 score: 0.85-0.88

<u>KNN Regression:</u>

Train r^2 score: 1.0

Test r^2 score: 0.8733

n_neighbor: 1

p: 1

weights: uniform

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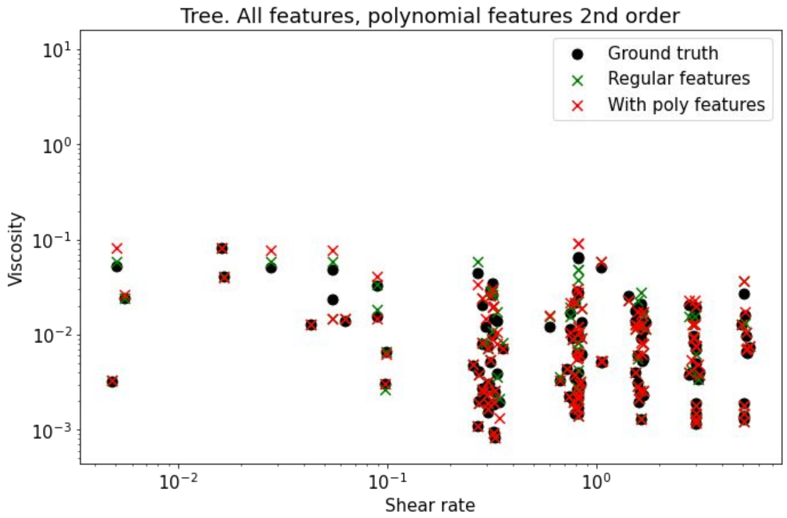
General ML approach. Polynomial Features



<u>Tree Regression:</u>

Train r^2 score: ~1.0

Test r^2 score: 0.9402

max_depth: 18

criterion: mae

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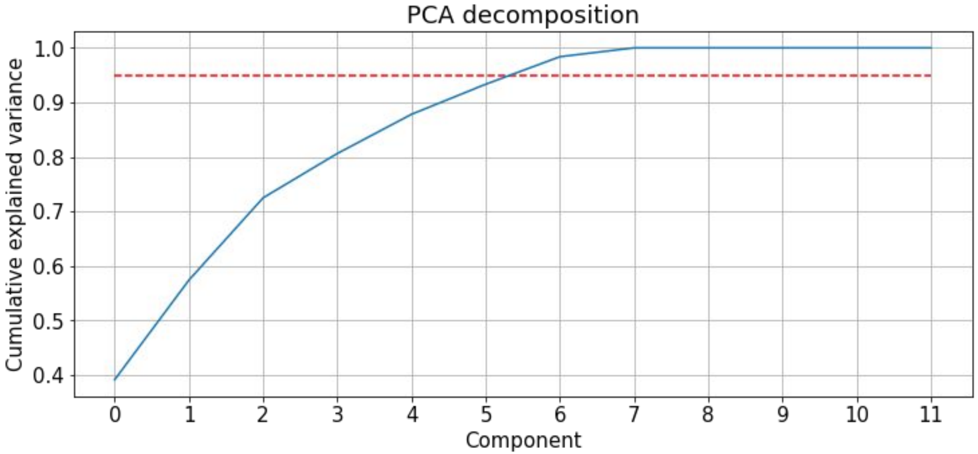
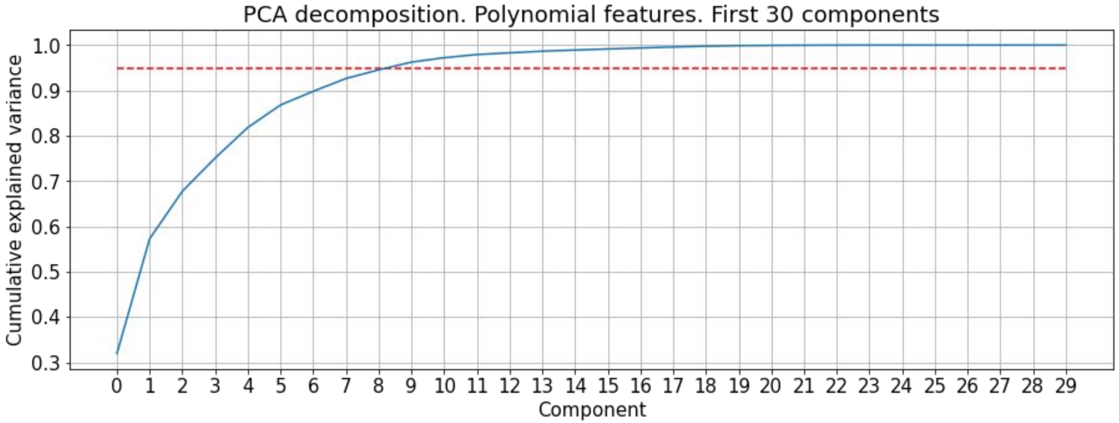
Dimensionality Reduction





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thx.

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