

Machine Learning in Applied Math Curriculum using MATLAB



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□ BACKGROUND AND INTRODUCTION

New applications of mathematics are constantly being discovered, and established techniques are being applied in new ways and in emerging fields. The value of global big data market is fast growing more than ever. Data science and applied statistics rooted in applied mathematics are essential in exploring big data from a wide range of science, businesses and industries.

MS program in Applied Math with Data Science Track at Northeastern has grown fast in the last decade. New applied math courses with applications to machine learning and deep learning are in high demand.

Several new applied math courses with application to data analysis, machine learning and deep learning were developed in the last few years. The courses includes computer labs and industry projects.

MATLAB provides powerful Toolboxes in math, optimization, statistics, data science, machine learning, deep learning, etc. The new courses provides students the opportunity to study and practice programming skills in MATLAB along their homework, computer labs and projects.

□ UNDERGRADUATE CURRICULUM

○ Several traditional undergraduate math courses:

- MATH 2321- Calculus 3
- MATH 2331- Linear Algebra
- MATH 3081- Probability and Statistics

○ A new advanced undergraduate applied math course for math, science, CS, engineering:

• MATH 4570-Matrix Methods in Data Analysis and Machine Learning

Topics include theory of linear spaces over any fields, basis and dimension, inner product spaces, matrix decompositions, general least squares and applications to dynamical system, page-rank algorithm, linear regressions, Ridge/Lasso regressions, logistics regressions, Artificial Neural Network (ANN), Convolutional Neural Network (CNN), SVM, and PCA methods.

□ GRADUATE CURRICULUM IN APPLIED MATH

• MATH 5110-Applied Linear Algebra and Matrix Analysis

Start with theory in general linear spaces over fields, basis and coordinate system, Jordan canonical form, inner product spaces, orthogonal basis, several matrix decompositions and Hilbert spaces. Applications include forces on bridges model, general least squares, function approximation, satellite position in coordinate system, dynamical systems, page-rank algorithm, FFT, SVD for image compression, PCA, etc.

• MATH 7243-Machine Learning and Statistical Learning Theory 1

Topics include linear regressions, logistics regressions, Gaussian discriminant analysis (LDA/QDA), Naive Bayes, SVM and Kernel methods, Decision Trees, k-Nearest Neighborhoods, Clustering methods, PCA, Mixture of Gaussians, deep learning topics: ANN, CNN, Recurrent Neural Network (RNN), U-Net, GoogLeNet etc.

• MATH 7339-Machine Learning and Statistical Learning Theory 2

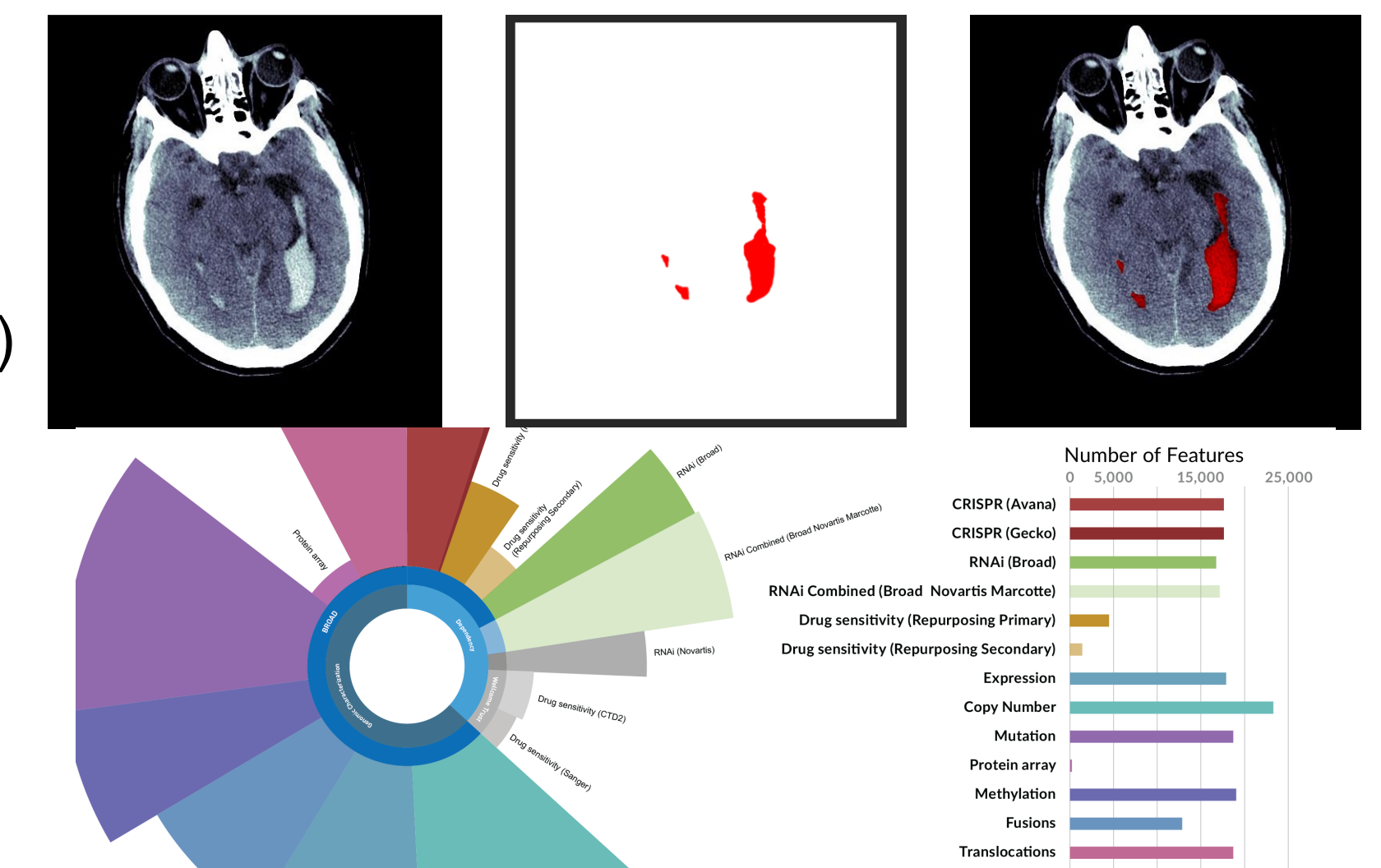
Theory of Bias-variance trade-off, Model Complexity, VC dimension, Degree of Freedom, Bayesian methods in statistics and machine learning, latent variable models, Splines, General Additive Models, classical Time Series methods, ARIMA, spectral analysis, regressions and forecasting and deep learning methods in time series data. Further topics includes forecasting at scale (Prophet), Topological Data Analysis, natural language processing.

□ INDUSTRY PROJECTS

1. Brain CT image hemorrhage classification and segmentation (Zeta Surgical company)
2. Machine Learning - Find Novel Intrinsic Oncology Targets and Biology (Merck Research Lab)

□ CONCLUSION AND FUTURE WORK

- New math courses with applications in data analysis, machine learning and deep learning achieve a big success with large number of students, including MS and PhD students in math, network science, and engineering.
- Develop more related undergraduate and graduate applied math courses with MATLAB.



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