

Final Project

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6/23/2021

Predicting Violent Crime Rates

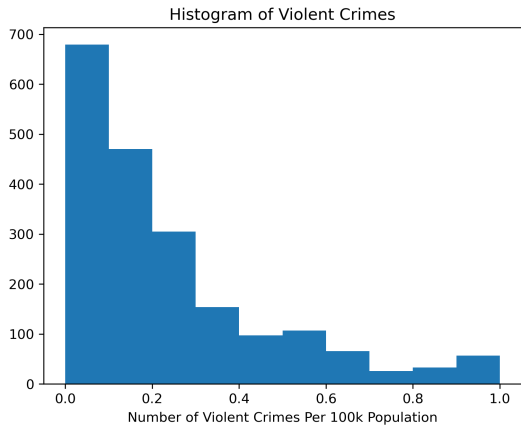
Dataset

- ▶ Data hosted on the University of California Irvine machine learning repository (Redmond 2009)
- ▶ Combines data from three datasets, the 1990 Census, 1995 FBI Uniform Crime Report (UCR), and the 1990 US Law Enforcement Management and Administrative Statistics Survey (LEMAS)
- ▶ Contain information about socio-economic indicators (e.g., median family income) and crime/law enforcement (e.g., per capita number of police officers)
- ▶ 1994 observations and 122 predictive features.

Problem Statement

- ▶ In this project, we want to predict violent crime rates from a variety of features using the “Communities and Crime” dataset
- ▶ Main challenges are processing the dataset, choosing predictors, and models

Target



Plan

- ▶ Choose a method for dealing with missing data
- ▶ Filter features to choose the most relevant
- ▶ Pick the best model
 - ▶ Compare MLP with classical machine learning methods

Contribution

- ▶ This data set does not have any published papers relevant to it (Redmond 2009)
 - ▶ So any analysis with this particular data set is new
- ▶ There is a large literature on the use of machine learning in so-called “predictive policing” (Hardyns and Rummens 2018)
- ▶ Many predictive policing systems use a single method ML method, like gradient boosting
- ▶ We have tried many different methods and compared them

Missing Data

- ▶ Data are “missing not at random” (Rubin 1976)
- ▶ Impute data using *MICE* algorithm (Van Buuren 2018)
 - ▶ Implemented as part of `MultipleImputer`
- ▶ Check analysis as part of robustness check

Preprocessing

- ▶ Filter features based on correlation, drop variables with correlation greater than a cutoff value
- ▶ Algorithm for removing highly correlated features is taken from (Kuhn, Johnson, and others 2013, 26:47)
 1. Calculate correlation matrix (`.corr()`)
 2. Find two predictors with largest absolute pairwise correlation (A and B)
 3. Find average correlation for all features with A and all features with B
 4. If A greater than B, remove A. Else, B
 5. Repeat until no correlations above threshold

Solver

- ▶ Rather than stochastic gradient descent, use L-BFGS solver (limited memory Broyden–Fletcher–Goldfarb–Shanno) (Aggarwal and others 2018, 148)
- ▶ Approximates Newton method:

$$\mathbf{W}(t+1) = \mathbf{W}(t) - \mathbf{H}^{-1} \nabla F(t)$$

- ▶ Replace \mathbf{H}^{-1} with an approximation $\mathbf{G}(t)$

$$\mathbf{W}(t+1) = \mathbf{W}(t) - \alpha(t) \mathbf{G}(t) \nabla F(t)$$

Hyperparameter Tuning

- ▶ For every model type, there are many parameters to choose
 - ▶ For MLP, can choose number of hidden layers, activation function, learning rate, etc.
- ▶ We use 5-fold cross validation to choose hyperparameters for each model type
- ▶ Implemented with `GridSearchCV`, scored by `neg_mean_squared_error`

Results

Model Architecture

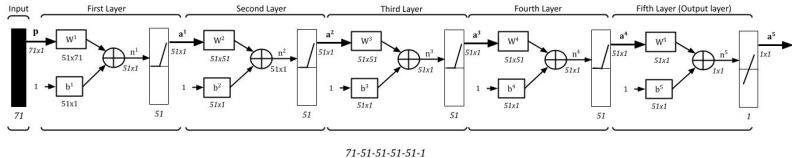


Figure 1: Chosen MLP

Results

Table 1: Model Performance for Non-Imputed Data

Model Type	Best 5-Fold MSE	Test MSE
SVR	0.0186	0.0203
DTR	0.0356	0.0453
RFR	0.0181	0.0187
MLP	0.0180	0.0130

Table 2: Model Performance for Imputed Data

Model Type	Best 5-Fold MSE	Test MSE
SVR	0.0185	0.0199
DTR	0.0352	0.0389
RFR	0.0178	0.0187
MLP	0.0181	0.0167

Predicted Values

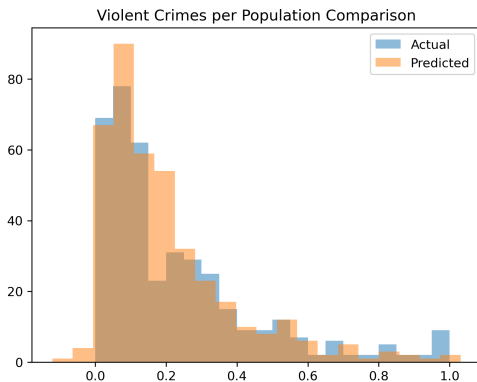
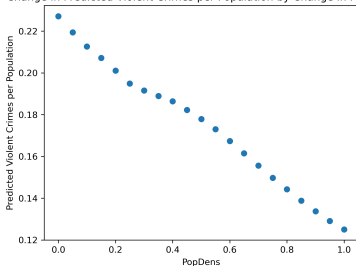


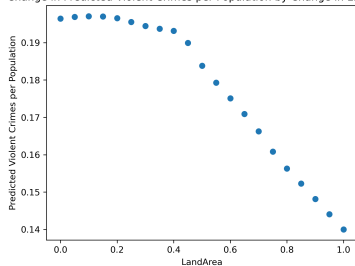
Figure 2: Violent Crime Per Population Comparison (Test Data)

Predicted Crime Rate Changes

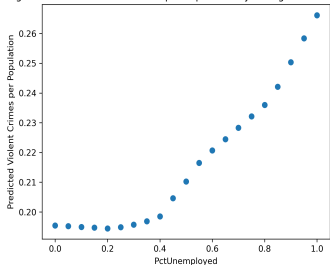
Change in Predicted Violent Crimes per Population by Change in PopDens



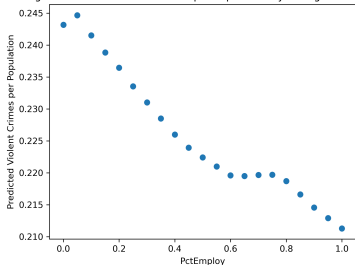
Change in Predicted Violent Crimes per Population by Change in LandArea



Change in Predicted Violent Crimes per Population by Change in PctUnemployed



Change in Predicted Violent Crimes per Population by Change in PctEmploy



Further Work

- ▶ Better data imputation algorithm
 - ▶ IterativeImputer has multiple estimations methods or KNNImputer
- ▶ More up to date data
 - ▶ Potentially incorporate time series data
- ▶ More comprehensive hyperparameter grid to search

References I

Aggarwal, Charu C, and others. 2018. "Neural Networks and Deep Learning." *Springer* 10. Springer: 978–3.

Hardyns, Wim, and Anneleen Rummens. 2018. "Predictive Policing as a New Tool for Law Enforcement? Recent Developments and Challenges." *European Journal on Criminal Policy and Research* 24 (3). Springer: 201–18.

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Redmond, Michael. 2009. "Communities and Crime." <https://archive.ics.uci.edu/ml/datasets/Communities+and+Crime>.

Rubin, Donald B. 1976. "Inference and Missing Data." *Biometrika* 63 (3). Oxford University Press: 581–92.

Van Buuren, Stef. 2018. *Flexible Imputation of Missing Data*. CRC press.