INSTITUTE FOR SOCIAL RESEARCH
UNIVERSITY OF MICHIGAN

CJARS Criminal Justice Administrative Records System

Hierarchical Approaches to Text-based Offense Classification

Jay Choi[1] David Kilmer[2] Michael Mueller-Smith[1] Sema Taheri[2]

[1]University of Michigan [2]Measures for Justice

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Motivation

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Offense classification plays critical roles for society, research, and public administration:

1. Criminal background checks (employment, public benefit eligibility, security credentialing, firearm purchases)
2. Evaluating sentencing disparities, testing behavioral theories, etc
3. Public funding, resource allocation, election outcomes

Yet, no comprehensive standard currently exists to cover the universe of illicit activity nor a mechanism to map free-entry descriptions into systematic codes, leading to:

- More discretion with little oversight
- Inconsistent definitions and mappings
- Irreproducible research

Project summary

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In this paper, we do the following:

1. Introduce the Uniform Crime Classification Standard (UCCS)
   - Schema satisfying 4 design principles laid out by the National Academy of Sciences
2. Develop the Text-based Offense Classification (TOC) tool
   - Hierarchical machine learning model trained on over 300k hand coded training records
3. Experiment with model variation in TOC to assess determinant of prediction success
   - Help identify potential lessons for other classification applications

Four design principles for offense classification

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National Academy of Sciences (2016) laid out four goals of offense schema:

1. Encompass new and emerging crime types
2. Fully realized classification for statistical purposes
3. Attribute-based classification
4. Enable comparisons between jurisdictions across time

	Summary Reporting System (SRS)	**National Incident-Based Reporting System (NIBRS)**	**National Corrections Reporting Program (NCRP)**	**Uniform Crime Classification Standard (UCCS)**
Principle 1:	×	✓	×	✓
Principle 2:	×	×	×	✓
Principle 3:	✓	✓	✓	✓
Principle 4:	×	×	×	✓

Uniform Crime Classification Standard

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Each UCCS code has four digits:

- First digit → Broad code
- Digits 2 and 3 → Offense code
- Fourth digit → Offense modifier

Example UCCS codes:

UCCS Code/Description		Broad Code/Description		Offense Code/Description		Offense Modifier Code/Description	
1010	Murder	1	Violent	01	Murder	0	
1011	Attempted Murder	1	Violent	01	Murder	1	Attempt
1012	Conspiracy to Commit Murder	1	Violent	01	Murder	2	Conspiracy
1020	Unspecified Homicide	1	Violent	02	Unspecified homicide	0	
1021	Unspecified Homicide, Attempted	1	Violent	02	Unspecified homicide	1	Attempt
1022	Unspecified Homicide, Conspiracy	1	Violent	02	Unspecified homicide	2	Conspiracy
1030	Voluntary Manslaughter	1	Violent	03	Voluntary/nonnegligent manslaughter	0	
1031	Voluntary Manslaughter, Attempted	1	Violent	03	Voluntary/nonnegligent manslaughter	1	Attempt
1032	Voluntary Manslaughter,Conspiracy	1	Violent	03	Voluntary/nonnegligent manslaughter	2	Conspiracy
1040	Vehicular Manslaughter	1	Violent	04	Voluntary/nonnegligent manslaughter	0	
1041	Vehicular Manslaughter, Attempted	1	Violent	04	Voluntary/nonnegligent manslaughter	1	Attempt
1042	Vehicular Manslaughter, Conspiracy	1	Violent	04	Voluntary/nonnegligent manslaughter	2	Conspiracy

Text-based Offense Classification tool

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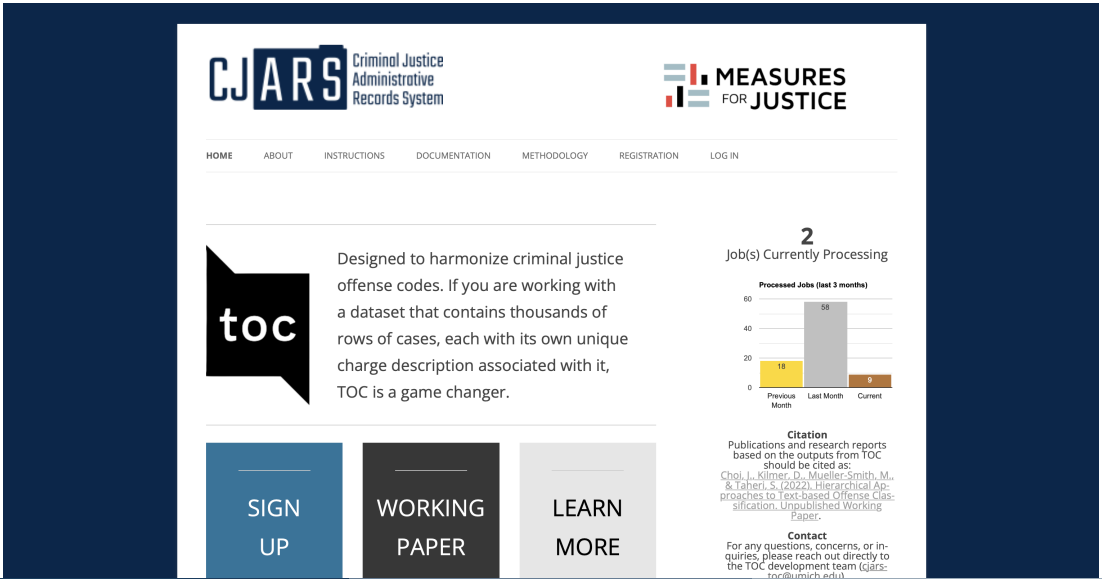
TOC tool maps free-entry offense description fields to UCCS codes

Built through a partnership between Measures for Justice (MFJ) and CJARS

- MFJ hand coded significant volume of offense descriptions, creating training data to develop TOC
- 313,209 hand-coded offense descriptions from 24 states

Freely available to general public online: `https://cjars-toc.isr.umich.edu`

Text-based Offense Classification tool



Prediction models

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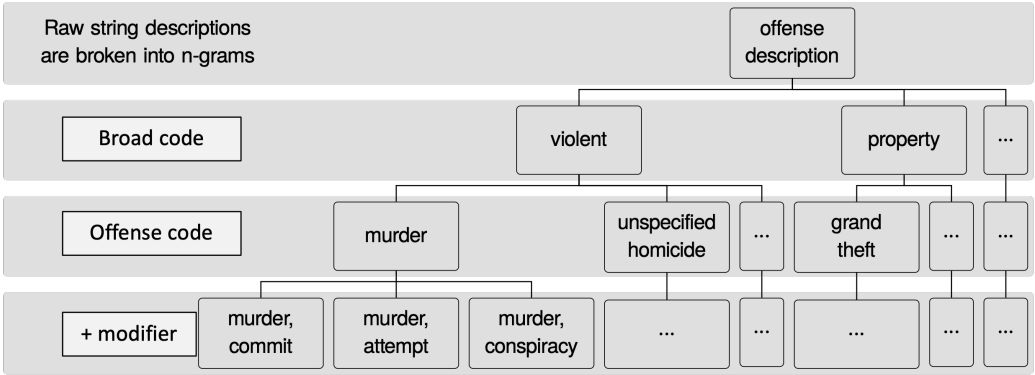

Prediction models: flat

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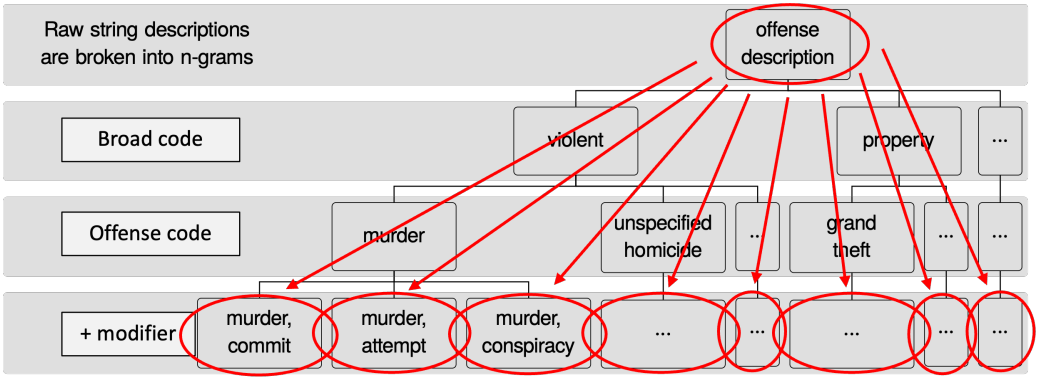

Prediction models: flat

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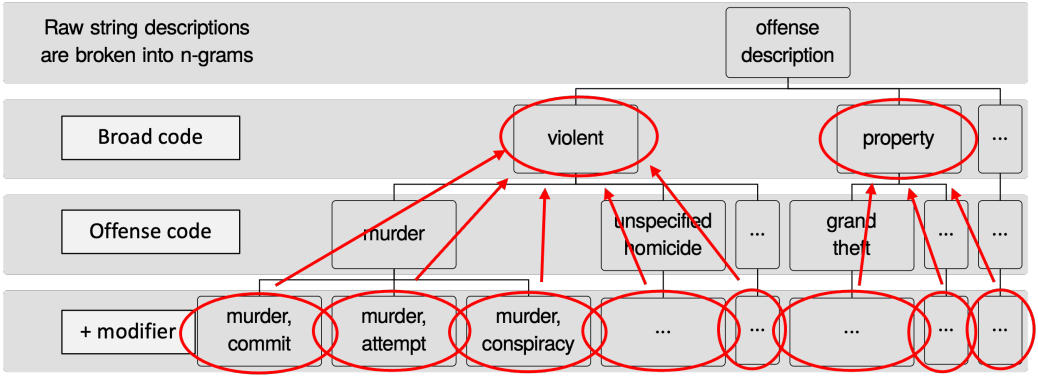

Prediction models: hierarchical

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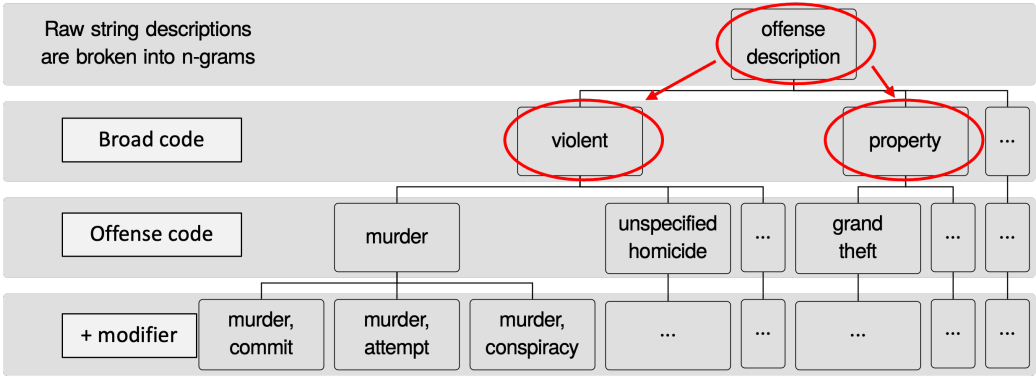
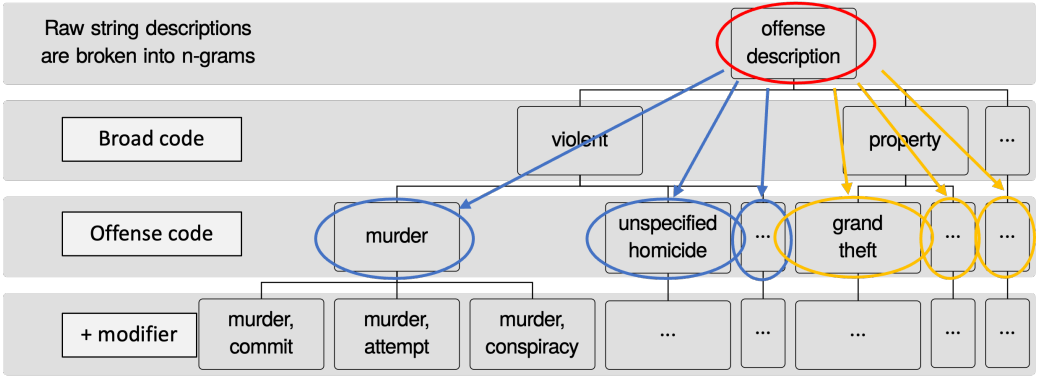


Prediction models: hierarchical



Model details

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- 75% - 25% random split of hand-coded data for training vs testing purposes
  - Avoids known problems arising from data leakage
- Modest preprocessing: remove articles, punctuation, capitalization, word normalization
- Tokenization: 4-grams
- Feature selection: Term Frequency-Inverse Document Frequency
- Optimization algorithm: neural network
  - Multi-layer perceptron model with 1 hidden layer and 100 neurons

Feature extraction via n-grams

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(a) Contiguous sequence of 4 characters

theft from person > 65 value >300k<10k

t**heft** from person > 65 value >300k<10k

th**eft** from person > 65 value >300k<10k

...

theft from person > 65 value >30**0k<1**0k

theft from person > 65 value >3**00k<10**k

theft from person > 65 value >30**0k<10k**

(b) Extracted features

'thef', 'heft', 'eft ', 'ft f', 't fr', ' fro', 'from', 'rom ', 'om p', 'm pe', ' per', 'pers', 'erso', 'rson', 'son>', 'on>6', 'n>65', '>65 ', '65 v', '5 va', ' val', 'valu', 'alue', 'lue>', 'ue>3', 'e>30', '>300', '300<', '00<1', '0<10', '<10k', ...

Defining success

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We evaluate three related standard performance statistics:

- Precision: % of positive predictions that are correctly labelled
- Recall: % of labels that are correctly made
- F1 Score: harmonic mean of precision and recall

Model performance is assessed at both the broad crime type and full UCCS code levels

Performance Statistics

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	Broad Crime Type			Full UCCS Code		
	Precision	Recall	F1 Score	Precision	Recall	F1 Score
All Crime Types	0.983	0.983	0.983	0.963	0.963	0.963
Broad Crime Type Code:						
Violent	0.997	0.994	0.995	0.993	0.989	0.991
Property	0.927	0.990	0.957	0.884	0.944	0.913
Drug	0.999	0.960	0.979	0.862	0.828	0.845
DUI	0.987	0.986	0.986	0.942	0.941	0.941
Public Order	0.993	0.938	0.965	0.977	0.923	0.949
Criminal Traffic	0.987	0.991	0.989	0.986	0.991	0.988

Out-of-state performance

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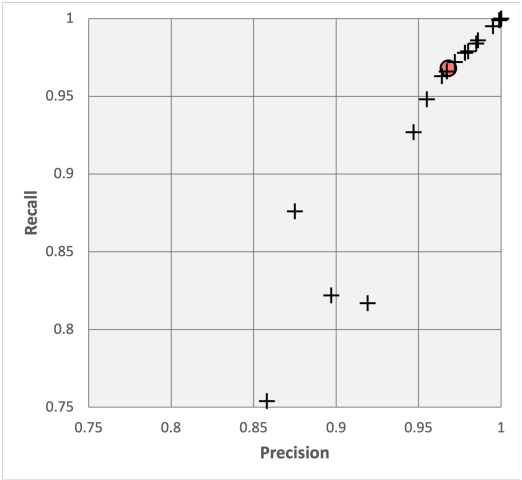
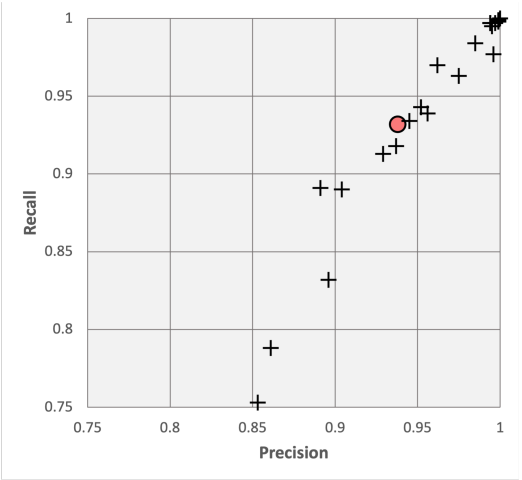
Broad crime type



Full crime type



Comparison with existing resources

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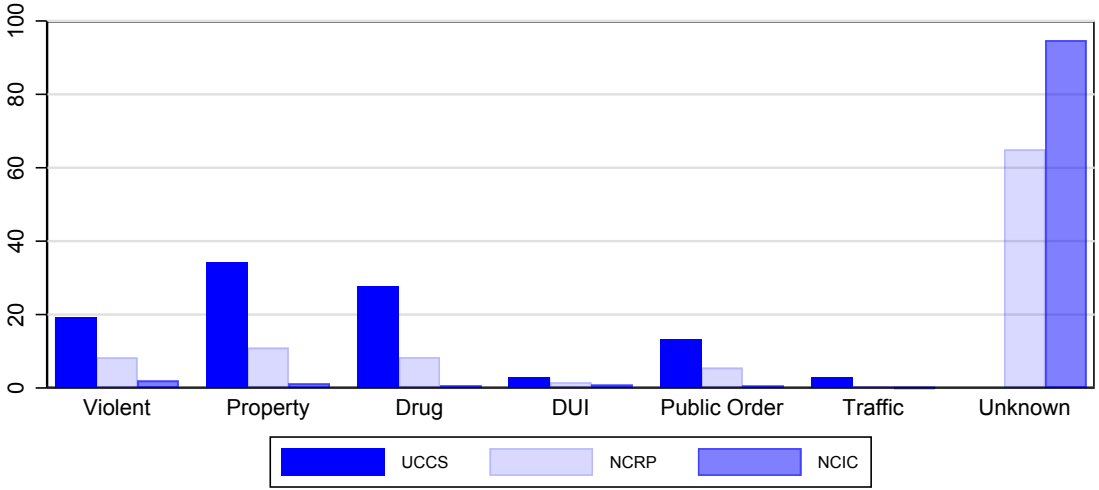
Distribution of offense types for felony charges in CJARS



Comparison with existing resources

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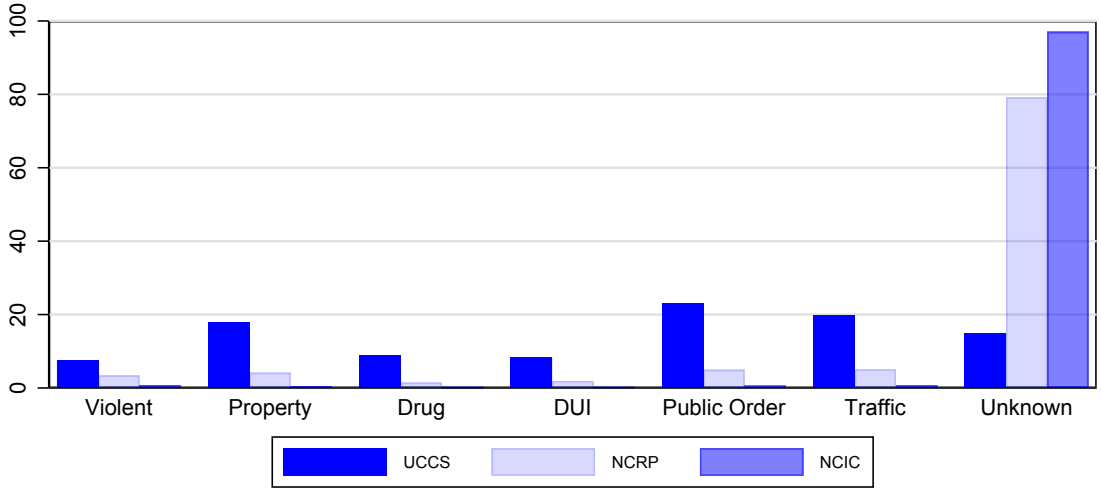
Distribution of offense types for misdemeanor charges in CJARS



Evaluating optimal model parameterization

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- Variation in size of training data: 5,000 – 200,000 training observations link
- Feature unit (n-grams, bag-of-words) and selection mechanism (Count Vectorizer vs. TF-IDF) link
- Total number of features: 100 – 10,000 selected features link
- Machine learning algorithm: Random Forest vs. Neural Network link

Next steps:

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1. Expand geographic coverage of training data to non-covered jurisdictions
2. Crowdsource prediction errors to improve corpus of training records via TOC portal
3. Incorporate feasibility to process cited statute numbers
   - Requires comprehensive database mapping statutes to offense descriptions
4. Develop mechanism to evaluate updates to schema

Summary and conclusion

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This project introduces the UCCS schema and the TOC tool to map free entry offense descriptions to standardized codes

Goal is to raise the bar for research and statistical reporting:

- Reduce researcher discretion as well as data wrangling burden
- Improve common definitions and comparability across jurisdictions
- Expand coverage of historically understudied (but large!) portion of the justice system: misdemeanor caseload
- Lower research barriers to increase diverse perspectives on justice system

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Appendix Slides

Variation in size of training data

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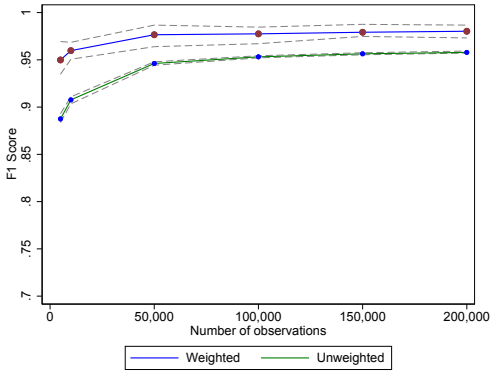
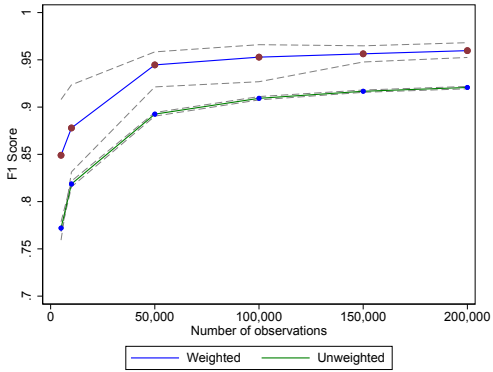
(a) Broad Crime Type



(b) Full UCCS Code



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Feature unit selection mechanism

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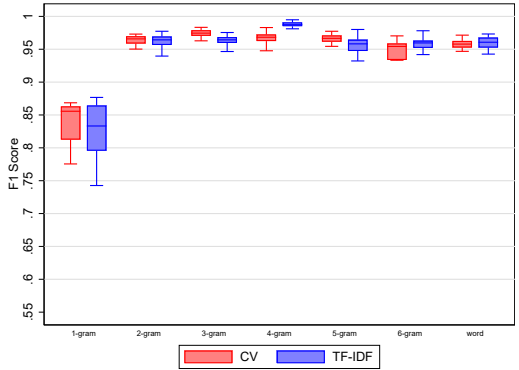
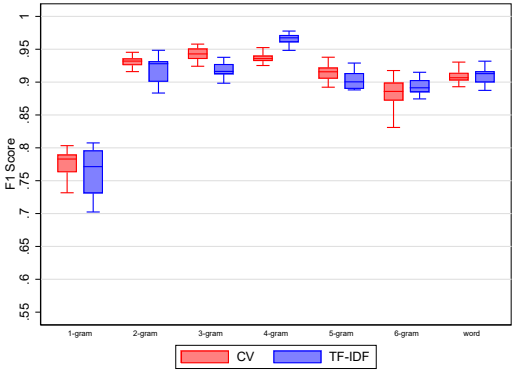
(a) Broad Crime Type



(b) Full UCCS Code



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Total number of features

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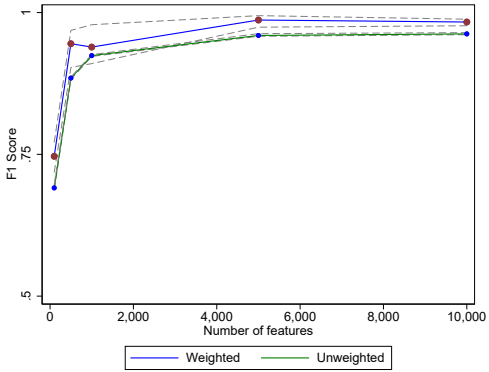
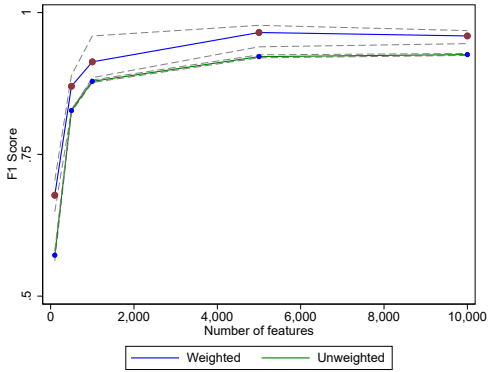
(a) Broad Crime Type



(b) Full UCCS Code



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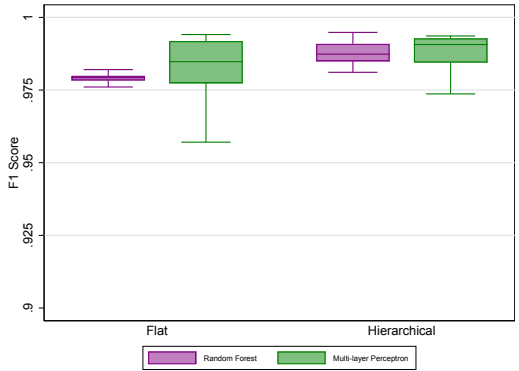
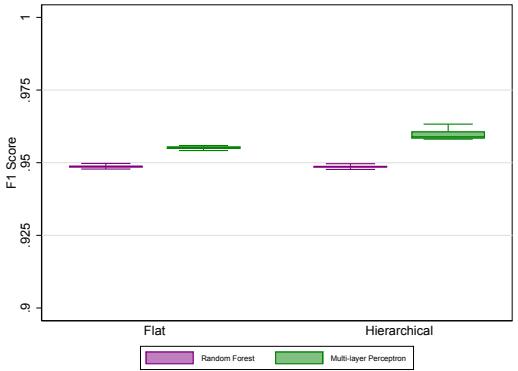
Machine learning algorithm

(a) Broad Crime Type



(b) Full UCCS Code



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