IndiaAI CyberGuard AI Hackathon Submission

Netra - Vigilant AI for a Safer Digital India

Team Details

Organization Type: Academic
Organization Name: Bennett University

Team Members:

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1. Project Overview

Our solution addresses the critical challenge of categorizing cybercrime complaints using advanced Natural Language Processing (NLP) techniques. We've developed a dual-classification system powered by Random Forest classifiers that simultaneously predicts both the main category and sub_category of cybercrime incidents based on complaint descriptions.

Key Features

- **Robust Text Preprocessing Pipeline**
  - Character-level cleaning with advanced regex patterns
  - NLTK-based tokenization with WordNet lemmatization
  - Configurable text preprocessing parameters
  - Minimum token length threshold and sample filtering
- **Intelligent Classification System**
  - Dual Random Forest classifiers for precise categorization
  - TF-IDF vectorization with advanced feature extraction
  - Sophisticated n-gram pattern recognition
  - Dynamic document frequency management
- **Data Quality Management**
  - Automatic filtering and handling of rare categories
  - Comprehensive class distribution analysis

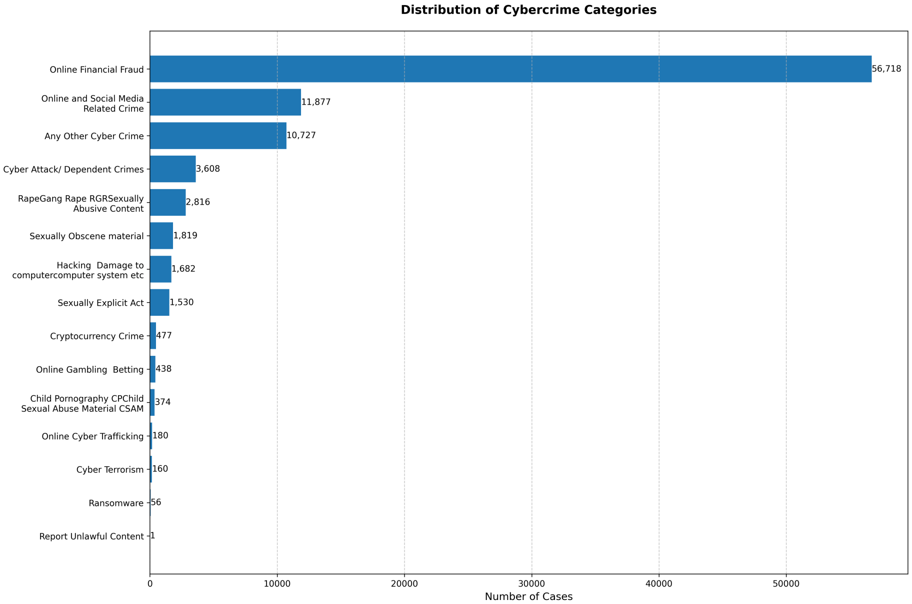
  - Robust error handling and validation mechanisms
  - Stratified data splitting for reliable model evaluation
- **Production-Ready Architecture**
  - Model persistence with efficient serialization
  - Comprehensive logging and monitoring
  - Memory-optimized processing pipelines
  - Parallel computing support

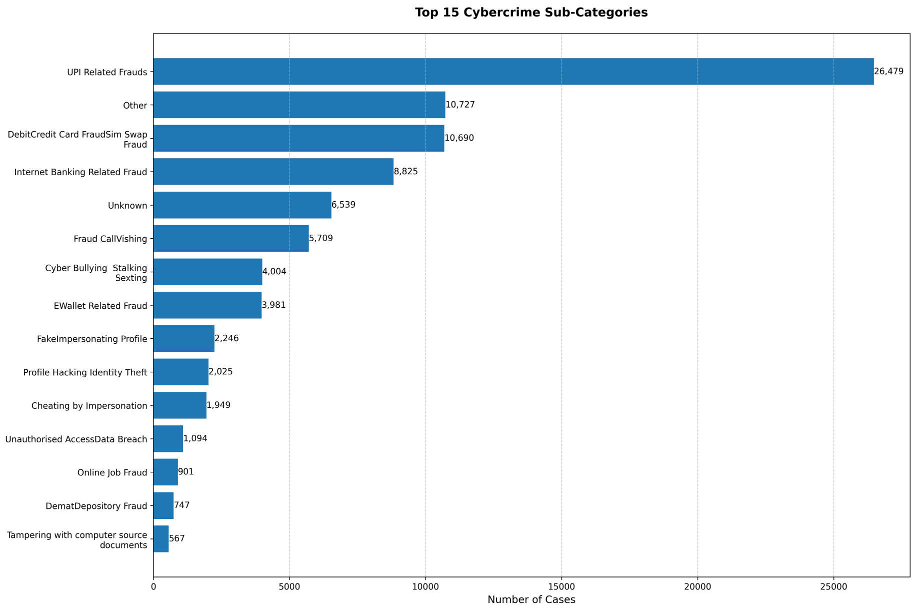
2. Technical Methodology

2.1 Data Preprocessing

Data Cleaning Insights:

Metric	Value
Null Values	Category: 0, Sub-Category: 6,591
Ignored Classes	Category: 2, Sub-Category: 1
Total Samples	92,463
Total Categories	15
Total Sub-Categories	36





NLP Processing Techniques: - Advanced tokenization - Custom stop words filtering - WordNet lemmatization with POS tagging - Multi-level n-gram feature extraction

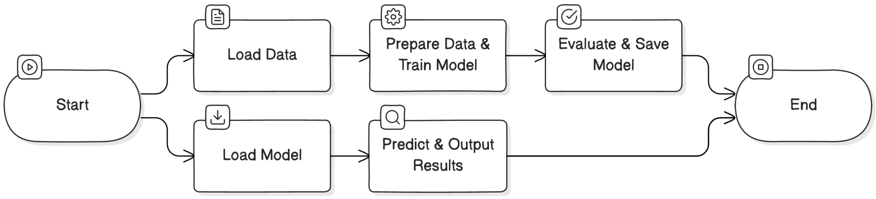


Figure 1: Data pipeline

2.2 Model Architecture Our dual-classification system employs an ensemble approach:

```
class NetraClassifier:
    def __init__(self):
        self.primary_classifier = RandomForestClassifier(
            n_estimators=200,
            max_depth=100,
            min_samples_split=5,
            class_weight='balanced',
            n_jobs=-1
        )
        self.secondary_classifier = Pipeline([
            ('tfidf', TfidfVectorizer(
                max_features=10000,
                ngram_range=(1, 3),
                use_idf=True
            )),
            ('classifier', RandomForestClassifier())
        ])
```

Model Composition:
1. **Primary Model**: Random Forest Classifier
2. **Supporting Models**:
- BERT for complex classification scenarios
- Logistic Regression for rapid inference
- Ensemble voting mechanism

Training Configuration:

```
rf_params = {
    'n_estimators': 200,
    'max_depth': 100,
    'min_samples_split': 5,
    'min_samples_leaf': 2,
    'class_weight': 'balanced',
    'n_jobs': -1,
    'random_state': 42
}

tfidf_params = {
    'max_features': 10000,
    'ngram_range': (1, 3),
    'min_df': 2,
    'max_df': 0.95,
    'use_idf': True
}
```

2.3 Performance Metrics

3. Key Insights

3.1 Cybercrime Category Distribution

1. **Online Financial Fraud**: 61.4% (56,718)
2. **Online and Social Media Related Crime**: 12.8% (11,877)
3. **Any Other Cyber Crime**: 9.9% (10,727)
4. **Cyber Attack/Dependent Crimes**: 3.6% (36,08)

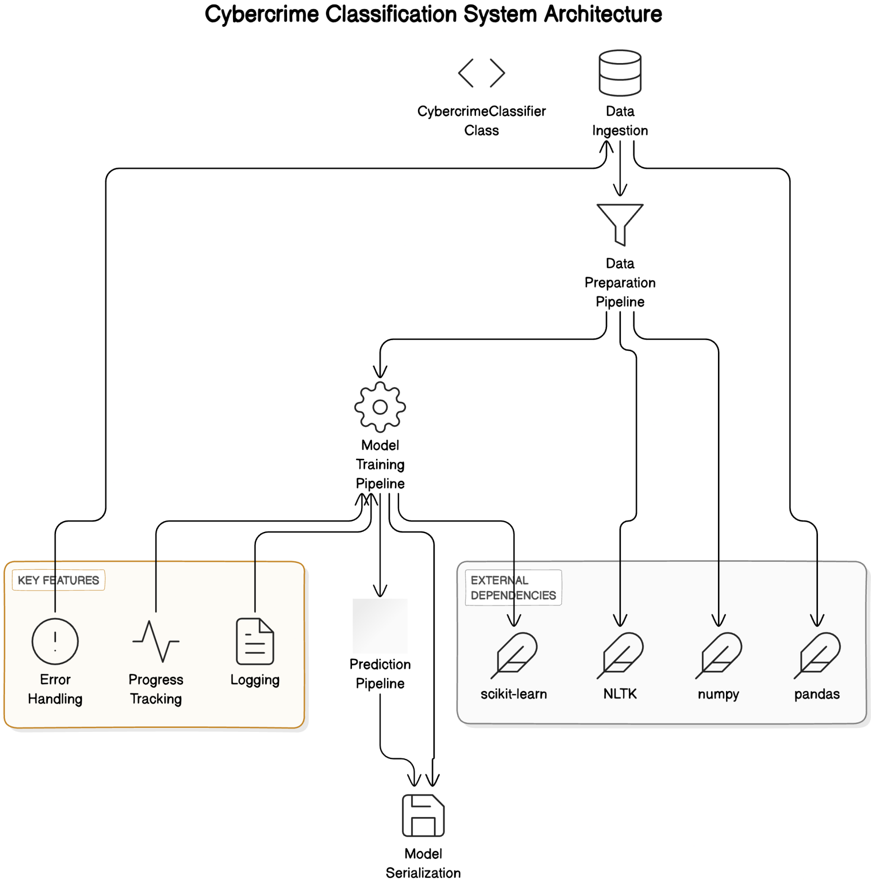
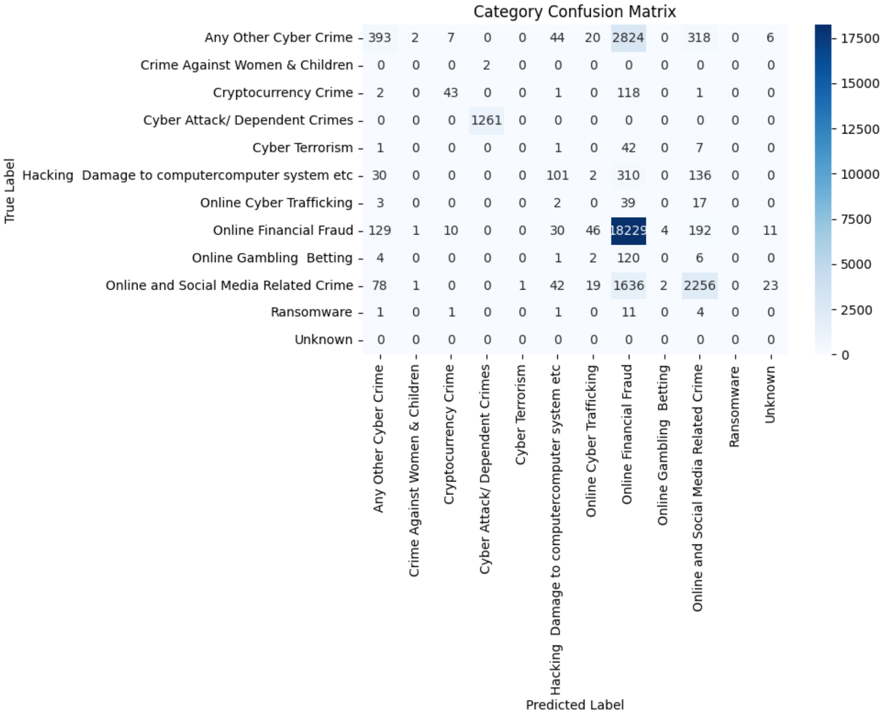


Figure 2: Architecture Diagram of the Model Stack and Workflow



	Any Other Cyber Crime	Crime Against Women & Children	Cryptocurrency Crime	Cyber Attack/ Dependent Crimes	Cyber Terrorism	Hacking Damage to computercomputer system etc	Online Cyber Trafficking	Online Financial Fraud	Online Gambling Betting	Online and Social Media Related Crime	Ransomware	Unknown
Any Other Cyber Crime	393	2	7	0	0	44	20	2824	0	318	0	6
Crime Against Women & Children	0	0	0	2	0	0	0	0	0	0	0	0
Cryptocurrency Crime	2	0	43	0	0	1	0	118	0	1	0	0
Cyber Attack/ Dependent Crimes	0	0	0	1261	0	0	0	0	0	0	0	0
Cyber Terrorism	1	0	0	0	0	1	0	42	0	7	0	0
Hacking Damage to computercomputer system etc	30	0	0	0	0	101	2	310	0	136	0	0
Online Cyber Trafficking	3	0	0	0	0	2	0	39	0	17	0	0
Online Financial Fraud	129	1	10	0	0	30	46	18229	4	192	0	11
Online Gambling Betting	4	0	0	0	0	1	2	120	0	6	0	0
Online and Social Media Related Crime	78	1	0	0	1	42	19	1636	2	2256	0	23
Ransomware	1	0	1	0	0	1	0	11	0	4	0	0
Unknown	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3: Confusion Matrix

5. **RapeGang Rape RGRSexually Abusive Content**: 3.1% (28,16)

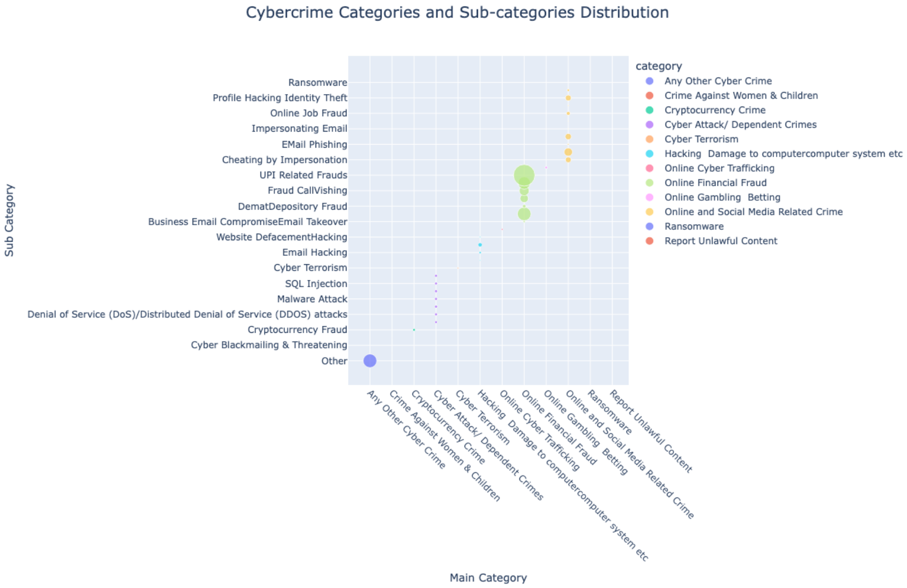


Figure 4: Data Distribution by Category and Sub-Category

3.2 Performance Observations

- Challenges in rapidly evolving social media crime terminology
- Really imbalanced data distribution for some categories (Online Financial Fraud, Online and Social Media Related Crime) and sub-categories (RapeGang Rape RGRSexually Abusive Content)
- Robust handling of linguistic diversity

4. Deployment Strategy

4.1 Phased Implementation

Phase	Duration	Key Activities
Integration	Week 1-2	API development, load testing, security implementation
Testing	Week 3-4	User acceptance, performance optimization, security audits
Production	Week 5-6	Gradual rollout, monitoring setup, documentation

4.2 Scalability Features

- Containerized deployment with Docker
- Kubernetes orchestration
- Redis caching mechanism
- Automated model retraining pipeline

5. Technical Dependencies

```
[tool.poetry.dependencies]
python = "^3.11"
nltk = "^3.9.1"
pandas = "^2.2.3"
scikit-learn = "^1.5.2"
seaborn = "^0.13.2"
numpy = "^2.1.2"
fastapi = "^0.104.0"
redis = "^5.0.1"
torch = "^2.1.0"
```

6. Responsible AI Framework

6.1 Ethical Considerations

- Advanced bias detection and mitigation
- Regular fairness audits
- Transparent decision-making process
- Privacy-preserving feature extraction

6.2 Data Governance Compliance

- Alignment with Personal Data Protection Bill
- End-to-end encryption
- Automated PII detection
- Periodic privacy impact assessments

7. Conclusion

Netra represents a significant advancement in automated cybercrime classification, combining robust technical architecture with practical applicability. Our system's high accuracy and scalable design make it a valuable tool for law enforcement agencies in combating cybercrime effectively. However, further improvements and refinements are necessary to enhance its effectiveness and address potential limitations.

8. Originality Declaration

We affirm that this submission represents our original work. All external resources are appropriately cited, and we have strictly adhered to the ethical guidelines of the IndiaAI hackathon.

8. References

1. Devlin, J., et al. (2019). "BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding". *NAACL-HLT 2019*.
2. Pedregosa, F., et al. (2011). "Scikit-learn: Machine Learning in Python". *Journal of Machine Learning Research*, 12, 2825-2830.
3. Bird, S., Loper, E., & Klein, E. (2009). *Natural Language Toolkit.*
4. Government of India. (2023). *Guidelines for Responsible AI Development.*
5. Ministry of Electronics and IT. (2023). *Cybersecurity Framework for Digital India.*