CAPSTONE PROJECT

NETWORK INTRUSION DETECTION USING MACHINE LEARNING

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OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- Algorithm & Deployment
- Result (Output Image)
- Conclusion
- Future Scope
- References

PROBLEM STATEMENT

Modern network infrastructures are increasingly exposed to a wide range of cyber-attacks such as Denial of Service (DoS), Probing, Remote-to-Local (R2L), and User-to-Root (U2R). These attacks can compromise data integrity, service availability, and system confidentiality. The key challenge is to accurately distinguish between normal and malicious network traffic using large volumes of connection records and behavioral patterns, without relying on manual monitoring. Failure to do so can result in undetected intrusions and potential breaches across critical systems.

PROPOSED SOLUTION

- The proposed system aims to address the critical challenge of automatically detecting and classifying malicious network traffic in order to strengthen cybersecurity defenses. Leveraging machine learning and data-driven techniques, the solution is designed to analyze historical connection data and predict whether a network activity is normal or an intrusion attempt.
- The system includes the following components:
- **Data Collection:**
  Utilized the NSL-KDD dataset, which is a refined version of the KDD Cup 1999 dataset, containing labeled records of network traffic across various attack types. The dataset includes 42 input features capturing characteristics such as protocol type, service, connection duration, byte counts, and error rates.
- **Data Preprocessing:**
  Cleaned and transformed the dataset to handle categorical variables using label encoding and normalized numerical values using feature scaling. Verified data integrity and ensured all records were consistently formatted for training.
- **Model Training & Algorithm Selection:**
  Employed **IBM Watson AutoAI**, which automatically tested multiple algorithms such as Random Forest, Snap Decision Tree Classifier. The best-performing model was selected based on accuracy and evaluation metrics. The system supports multiclass classification across 23 types of attacks and normal traffic.
- **Deployment:**
  The trained model was deployed via **IBM CLOUD**
- **Evaluation:**
  The model's performance was assessed using metrics like **accuracy**, **precision**, **recall**, and **confusion matrix**. Real input samples were tested through the deployment interface, and output responses were captured and documented.

SYSTEM APPROACH

- **Tools & Platforms:**
- IBM Cloud (Mandatory)
- IBM Watson Studio for model development and deployment.
- IBM Cloud Object Storage for dataset handling.
- **Dataset Used:**
- NSL-KDD Dataset (KDDTrain+) from Kaggle Dataset
  https://www.kaggle.com/datasets/hassan06/nslkdd?select=KDDTrain%2B.txt

ALGORITHM & DEPLOYMENT

- **Algorithm Used:** Snap Decision Tree Classifier
- **Input Features:** Protocol type, service, duration, bytes sent/received, error rates, etc.
- **Output:** Label representing intrusion type or normal
- **Training Process:**
- Categorical encoding + feature scaling
- Train-test split (80-20)
- **Deployment:**
- Trained model deployed on IBM Watson Studio with API endpoint for real time predictions.

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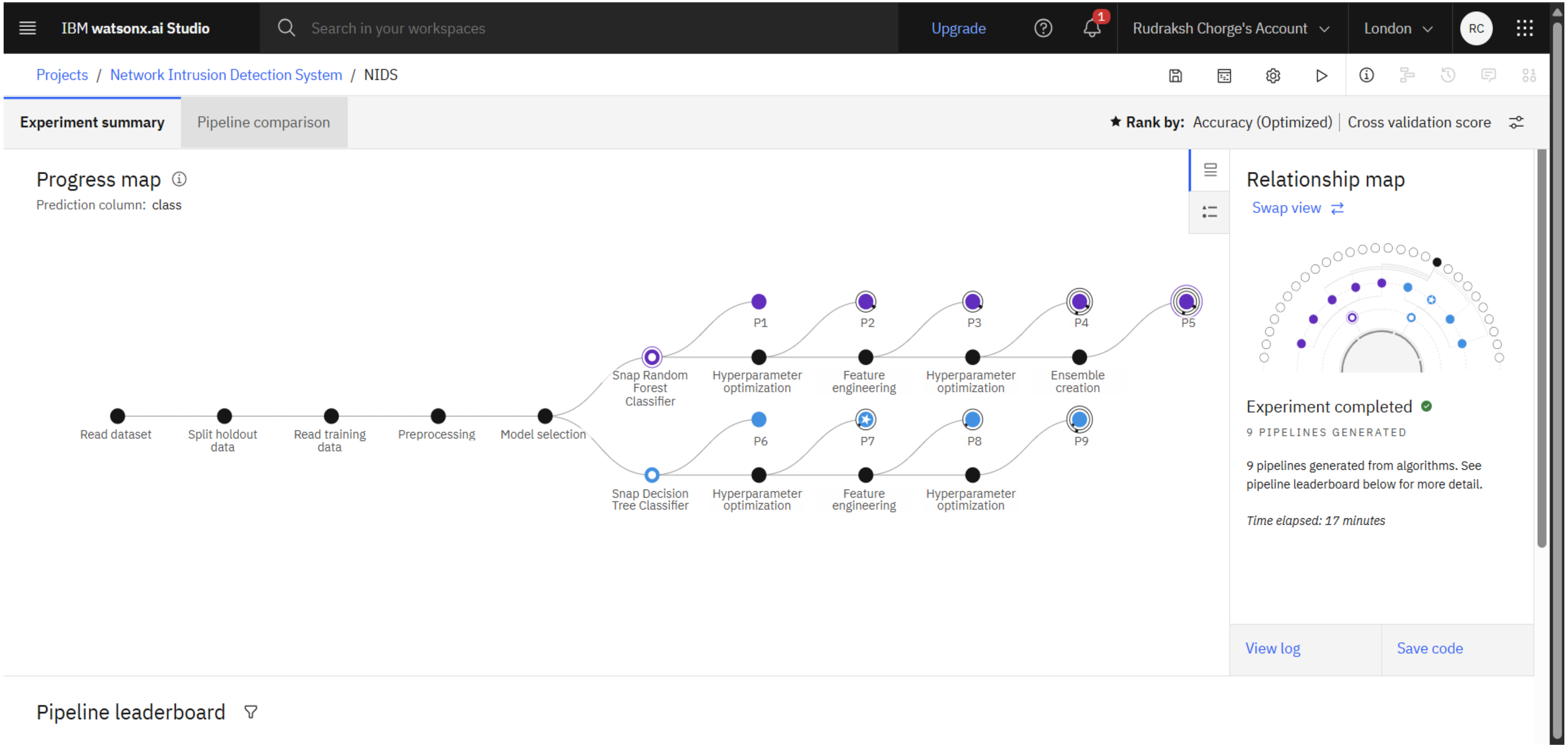
RESULT



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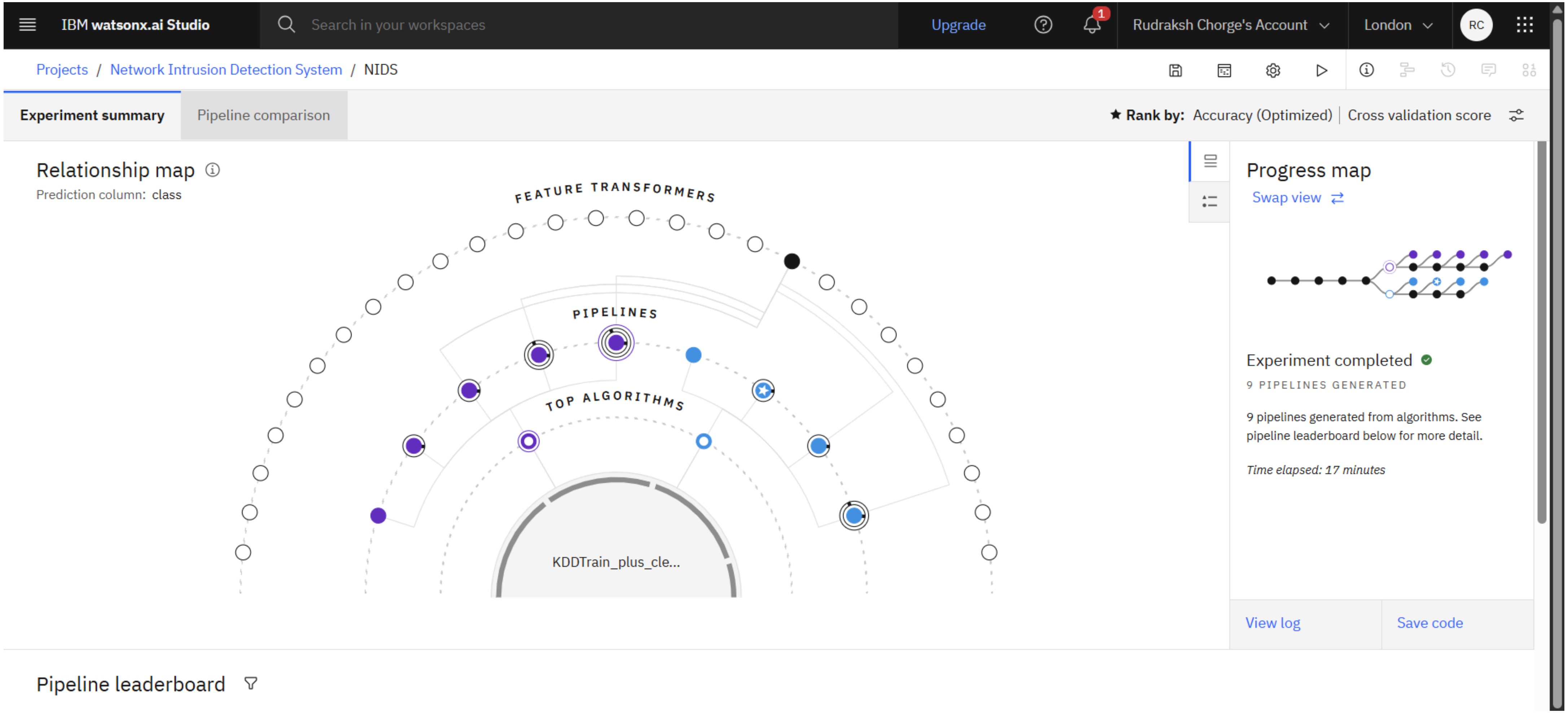
Projects / Network Intrusion Detection System / NIDS
Experiment summary
Pipeline comparison
Rank by: Accuracy (Optimized) | Cross validation score
Progress map
Prediction column: class
Read dataset
Split holdout data
Read training data
Preprocessing
Model selection
Snap Random Forest Classifier
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
Ensemble creation
P1
P2
P3
P4
P5
Snap Decision Tree Classifier
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
P6
P7
P8
P9
Relationship map
Swap view
Experiment completed
9 PIPELINES GENERATED
9 pipelines generated from algorithms. See pipeline leaderboard below for more detail.
Time elapsed: 17 minutes
View log
Save code
Pipeline leaderboard

RESULT



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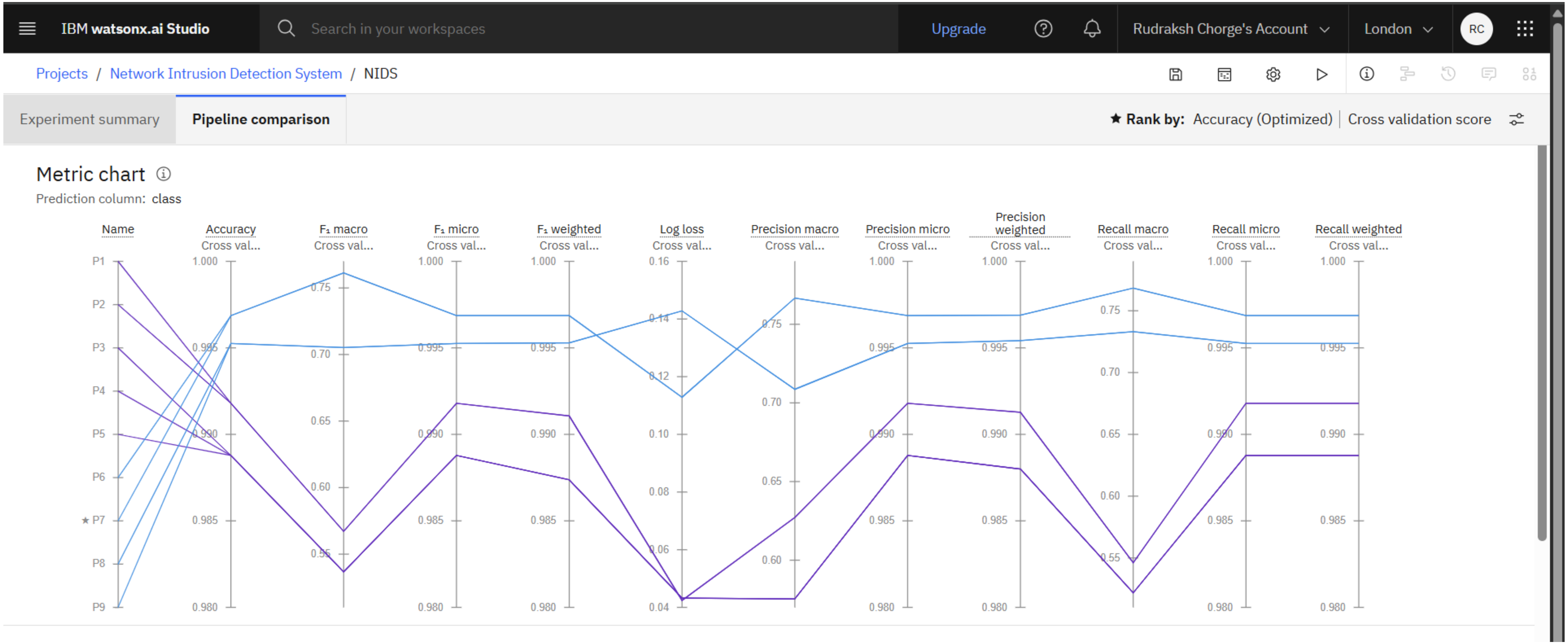
RESULT



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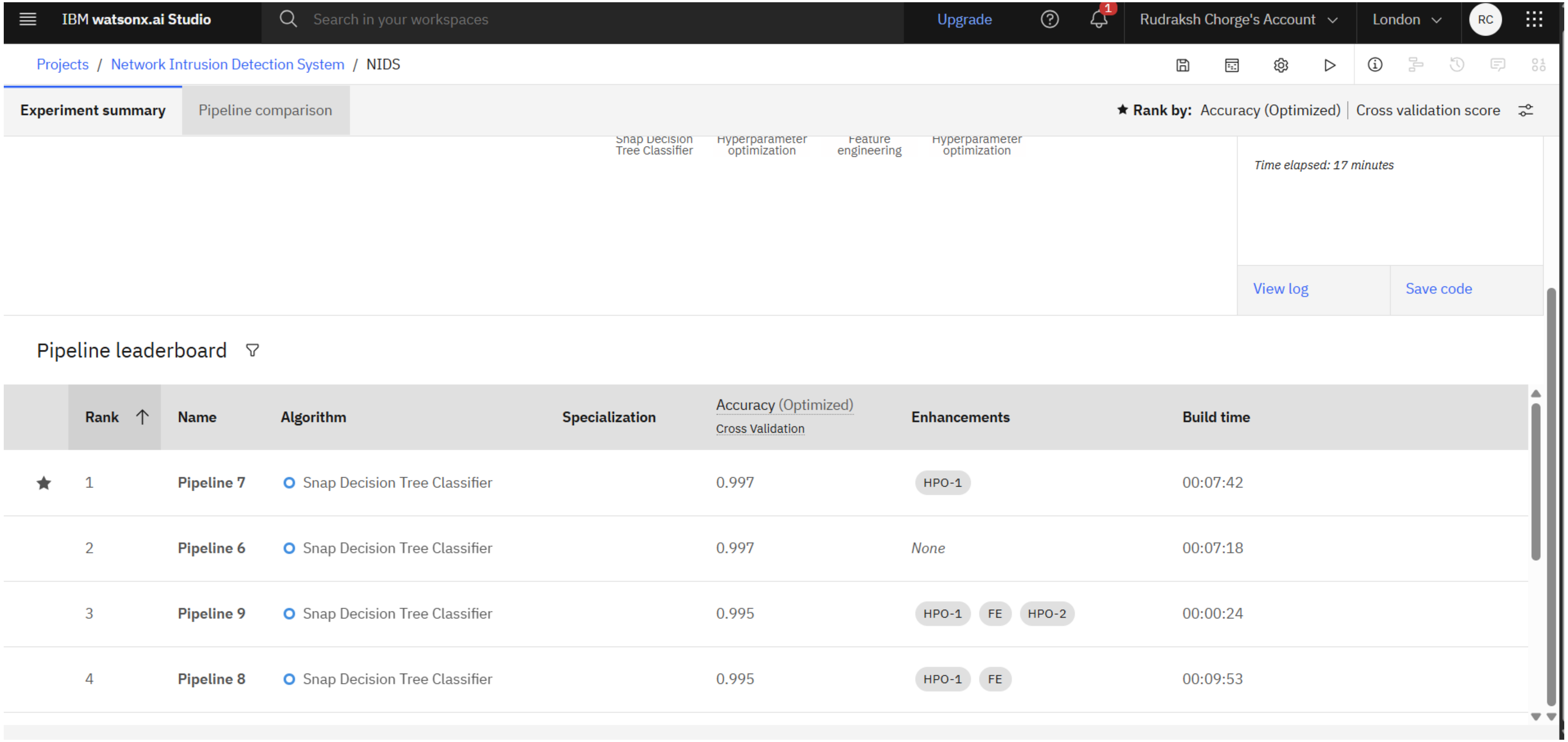
Experiment summary
Pipeline comparison
★ Rank by: Accuracy (Optimized) | Cross validation score
Metric chart
Prediction column: class
Name
Accuracy Cross val...
F1 macro Cross val...
F1 micro Cross val...
F1 weighted Cross val...
Log loss Cross val...
Precision macro Cross val...
Precision micro Cross val...
Precision weighted Cross val...
Recall macro Cross val...
Recall micro Cross val...
Recall weighted Cross val...
P1
P2
P3
P4
P5
P6
★ P7
P8
P9

RESULT



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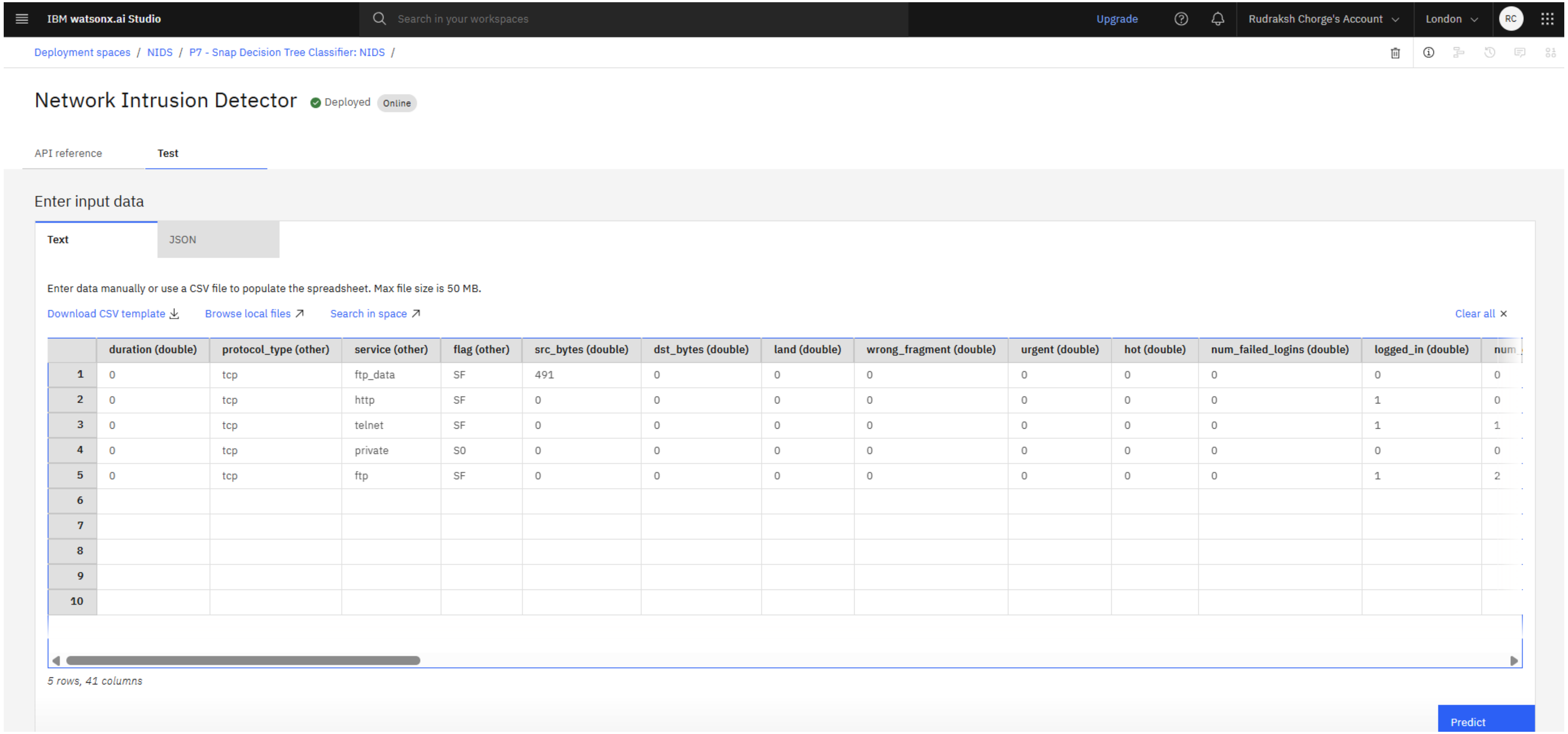
Snap Decision Tree Classifier
Hyperparameter optimization
Feature engineering
Hyperparameter optimization
Time elapsed: 17 minutes
View log
Save code
Pipeline leaderboard
Rank
Name
Algorithm
Specialization
Accuracy (Optimized)
Cross Validation
Enhancements
Build time
1 Pipeline 7 Snap Decision Tree Classifier 0.997 HPO-1 00:07:42
2 Pipeline 6 Snap Decision Tree Classifier 0.997 None 00:07:18
3 Pipeline 9 Snap Decision Tree Classifier 0.995 HPO-1 FE HPO-2 00:00:24
4 Pipeline 8 Snap Decision Tree Classifier 0.995 HPO-1 FE 00:09:53

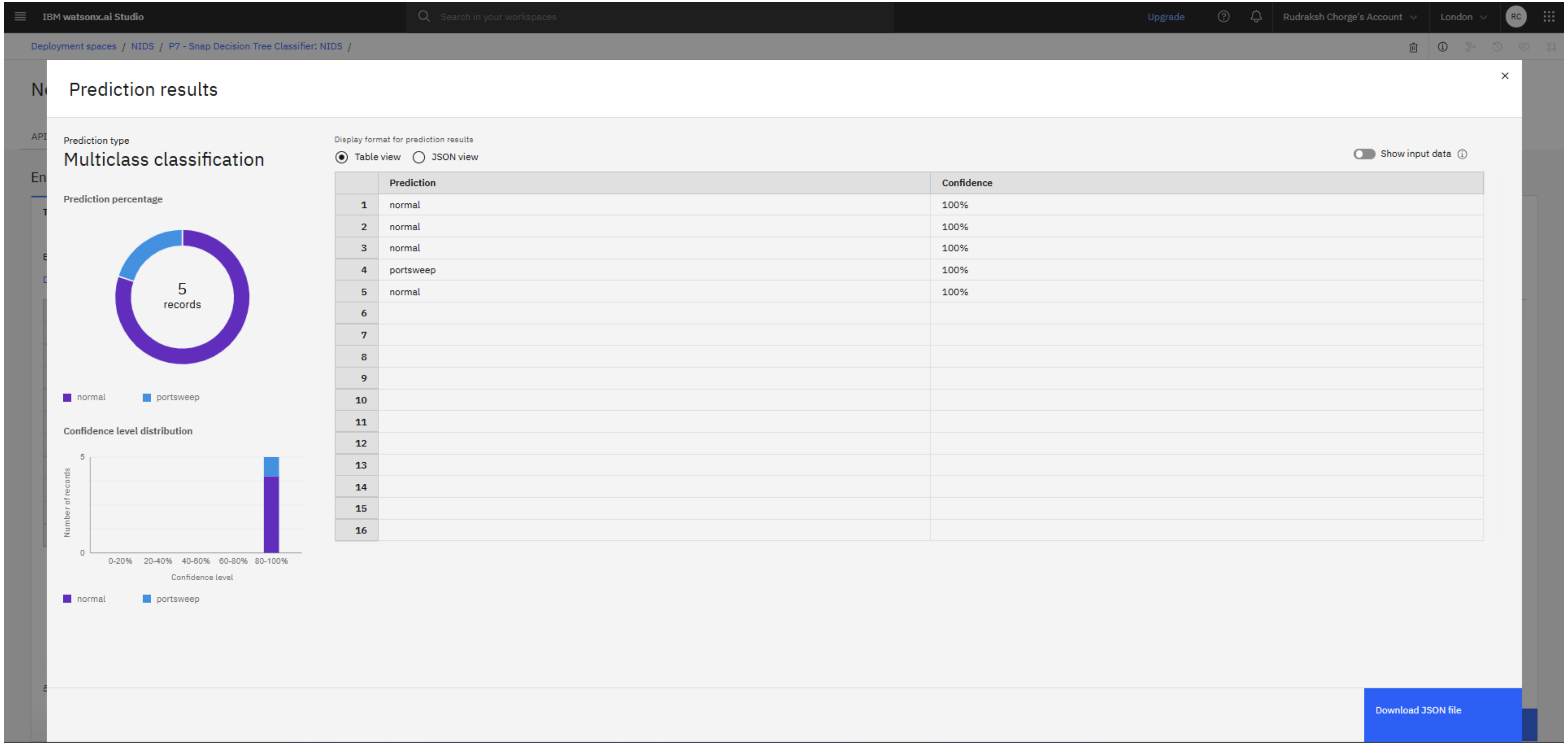
RESULT



	duration (double)	protocol_type (other)	service (other)	flag (other)	src_bytes (double)	dst_bytes (double)	land (double)	wrong_fragment (double)	urgent (double)	hot (double)	num_failed_logins (double)	logged_in (double)	num
1	0	tcp	ftp_data	SF	491	0	0	0	0	0	0	0	0
2	0	tcp	http	SF	0	0	0	0	0	0	0	1	0
3	0	tcp	telnet	SF	0	0	0	0	0	0	0	1	1
4	0	tcp	private	S0	0	0	0	0	0	0	0	0	0
5	0	tcp	ftp	SF	0	0	0	0	0	0	0	1	2
6													
7													
8													
9													
10													

Note: Only partial input shown here. Full input includes 42 features as per NSL-KDD dataset.

RESULT



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Deployment spaces / NIDS / P7 - Snap Decision Tree Classifier: NIDS /
Prediction results
Prediction type
Multiclass classification
Prediction percentage
5
records
normal
portsweep
Confidence level distribution
Number of records
5
0
0-20%
20-40%
40-60%
60-80%
80-100%
Confidence level
normal
portsweep
Display format for prediction results
Table view
JSON view
Show input data
Prediction
Confidence
1
normal
100%
2
normal
100%
3
normal
100%
4
portsweep
100%
5
normal
100%
6
7
8
9
10
11
12
13
14
15
16
Download JSON file

CONCLUSION

- The ML model effectively distinguishes between normal and malicious network traffic.
- IBM AutoAI streamlined model creation and deployment.
- NSL-KDD dataset helped train a robust, multiclass model.
- The system can help automate detection in real-time monitoring tools.

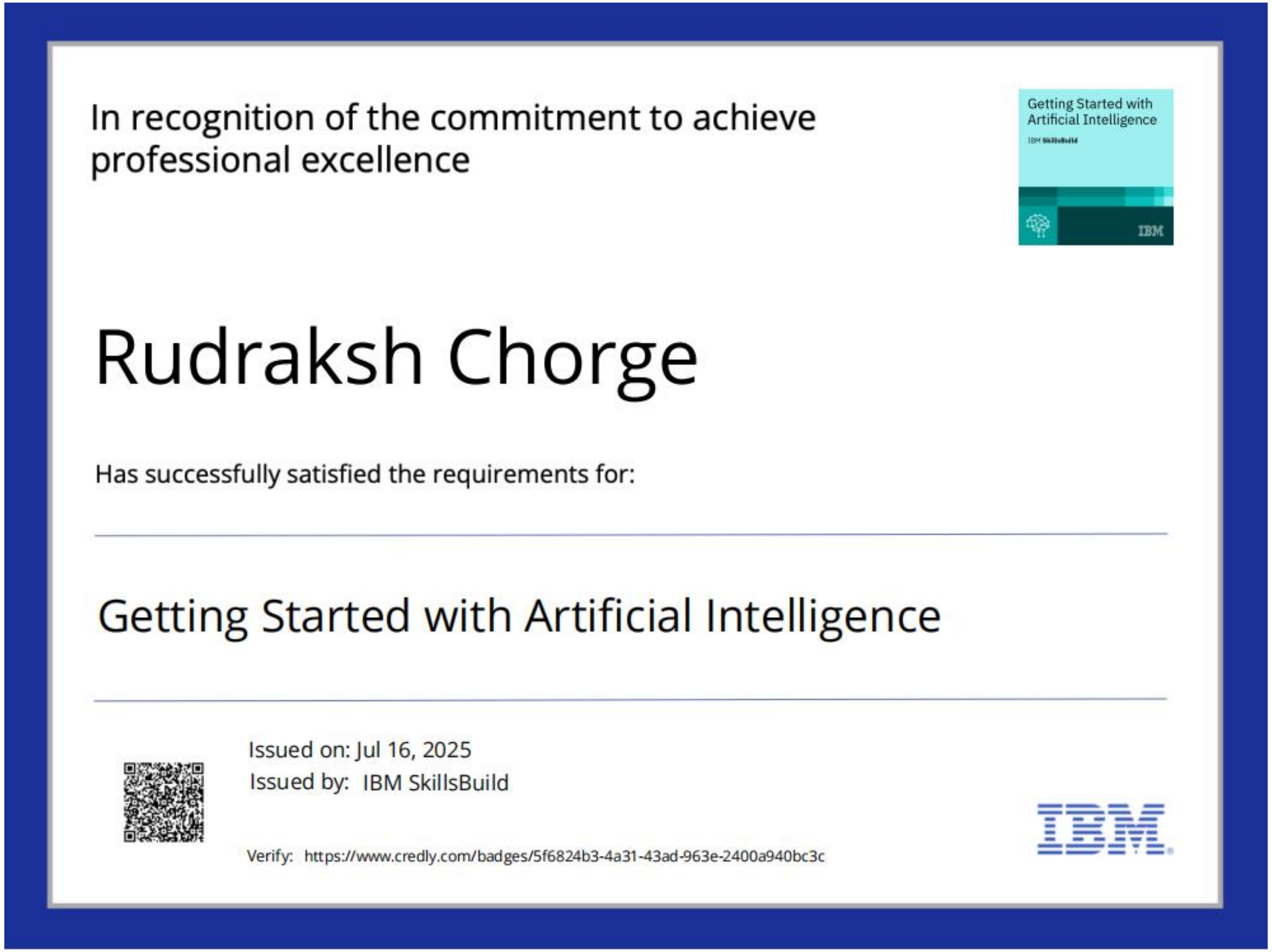
FUTURE SCOPE

- Real-time intrusion detection with streaming data
- Integration with SIEM tools (e.g., Splunk, QRadar)
- Use of deep learning models (e.g., LSTM, CNN) for sequential analysis
- Handle encrypted packet features using advanced methods
- Deployment in **edge environments** (e.g., routers, IoT gateways) for low-latency detection
- Combining IDS with **threat intelligence platforms** for proactive defense
- Expanding the system to detect insider threats and anomalies in user behavior

REFERENCES

- NSL-KDD Dataset: https://www.kaggle.com/datasets/hassan06/nslkdd?select=KDDTrain%2B.txt
- IBM Cloud and Watson Studio

IBM CERTIFICATIONS



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Rudraksh Chorge

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(ALM-COURSE_3824998)

According to the Adobe Learning Manager system of record

Completion date: 23 Jul 2025 (GMT)

Learning hours: 20 mins

THANK YOU