
CAPSTONE PROJECT

NETWORK INTRUSION DETECTION

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OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- Algorithm & Deployment
- Result (Output Image)
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PROBLEM STATEMENT

Create a robust network intrusion detection system (NIDS) using machine learning. The system should be capable of analyzing network traffic data to identify and classify various types of cyber-attacks (e.g., DoS, Probe, R2L, U2R) and distinguish them from normal network activity. The goal is to build a model that can effectively secure communication networks by providing an early warning of malicious activities.

PROPOSED SOLUTION

- The proposed system aims to detect malicious network activity by analyzing traffic data and classifying it as either normal or intrusive. The approach leverages machine learning via IBM Watsonx.ai and includes the following components:
- **Data Collection:**
 - Used Kaggle dataset: *Network Intrusion Detection*
 - Collected network traffic logs with 41 features and a target label (class).
- **Data Preprocessing:**
 - Uploaded CSV to IBM Watsonx.ai
 - No manual preprocessing required — AutoAI handled:
 1. Missing values
 2. Feature transformations
 3. Data normalization
- **Machine Learning Algorithm:**
 - Used **IBM Watsonx AutoAI** to automatically generate pipelines
 - Selected model: **Snap Decision Tree Classifier**
 - Enhancements applied:
 - Feature Engineering (FE)
 - Hyperparameter Optimization (HPO1, HPO2)

PROPOSED SOLUTION

Deployment:

- Promoted model to **IBM Cloud Deployment Space**
- Deployed as an **online REST API**
- Supports real-time predictions using JSON input

■ Evaluation:

- AutoAI evaluated models using **accuracy** as the main metric
- 8 pipelines compared; selected the best-performing one
- Deployment tested using sample network input

■ Result:

- Model accurately classified traffic as normal or intrusive
- Deployment is live and accessible via API
- System is scalable, reliable, and ready for further integration

SYSTEM APPROACH

The "System Approach" outlines the architecture and methodology used for building and deploying the Network Intrusion Detection System using IBM Cloud. Below is the structured breakdown:

- **System requirements:**
 - **Platform:** IBM Watsonx.ai on IBM Cloud Lite
 - **Access:** IBM Cloud account with AutoAI and Deployment Space enabled
 - **Input Format:** CSV file (42 columns including target label)
 - **Output:** Predicted class (normal or attack)
 - **Deployment Type:** REST API (Online deployment)

- **Library required to build the model:**
 - Since the model was developed using **IBM Watsonx AutoAI**, coding libraries were abstracted. However, under the hood, the following technologies were involved:
 - **AutoAI (automated ML pipeline generator)**
 - **Snap Decision Tree Classifier**
 - **Python Runtime (auto-managed by IBM)**
 - **Model Enhancements:**
 - Feature Engineering (FE)
 - Hyperparameter Optimization (HPO)

- **Note:** *Manual Python coding was not required as AutoAI handled all preprocessing and model building internally.*

ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
 - Chosen Algorithm: **Snap Decision Tree Classifier**
 - Type: **Supervised Classification**
 - Justification:
 - Fast training and prediction time
 - High accuracy and interpretability
 - Works well on structured datasets like intrusion detection logs
 - AutoAI tested multiple algorithms; this model outperformed others during evaluation
- **Data Input:**
 - The input dataset included **41 features**, such as:
 - duration, protocol_type, service, flag
 - src_bytes, dst_bytes, wrong_fragment, hot, etc.
 - Target column: class (normal or attack)
 - IBM Watsonx AutoAI handled:
 - Feature selection and encoding
 - Automatic data transformation

ALGORITHM & DEPLOYMENT

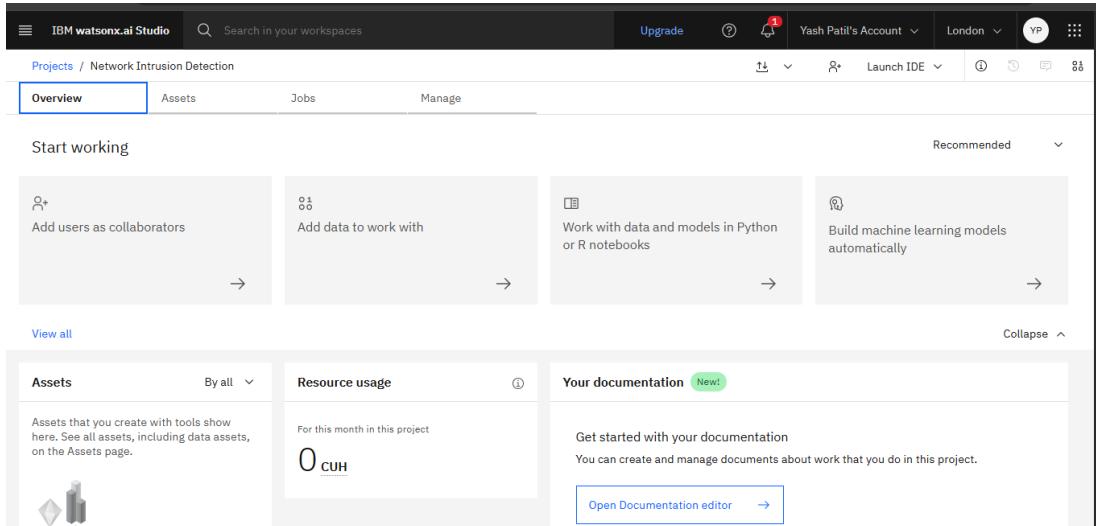
- **Training Process:**

- Dataset uploaded to IBM Watsonx.ai
- AutoAI split data into training and hold-out sets
- Multiple pipelines generated with:
 - Feature Engineering (FE)
 - Hyperparameter Optimization (HPO1, HPO2)
- Best pipeline selected using **cross-validation accuracy**

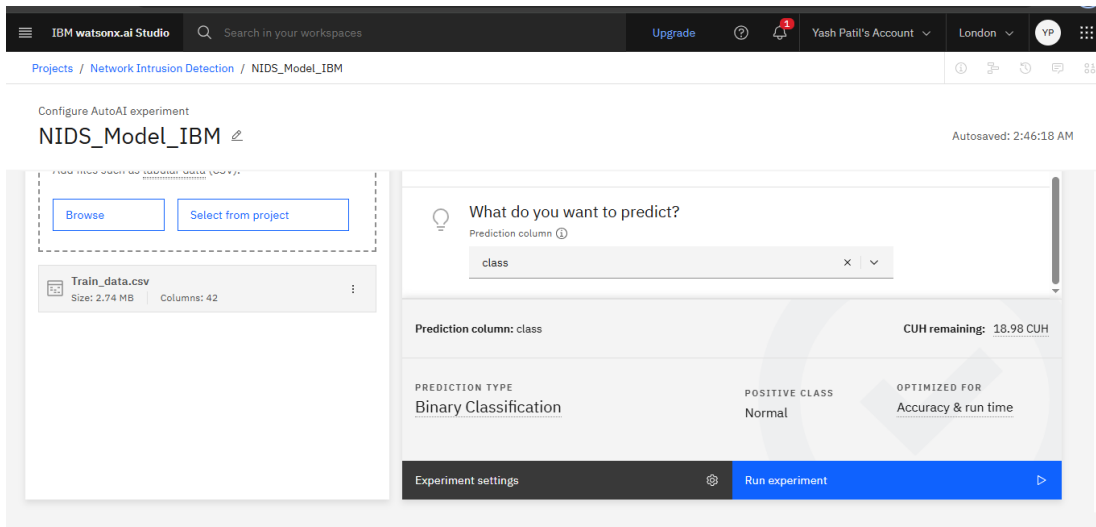
- **Prediction Process:**

- Model deployed as an **online REST API** via IBM Cloud
- Prediction made by sending **JSON-formatted inputs** with 41 features
- Output: Predicted network status (normal or attack)
- Real-time testing done via Watsonx.ai Test UI

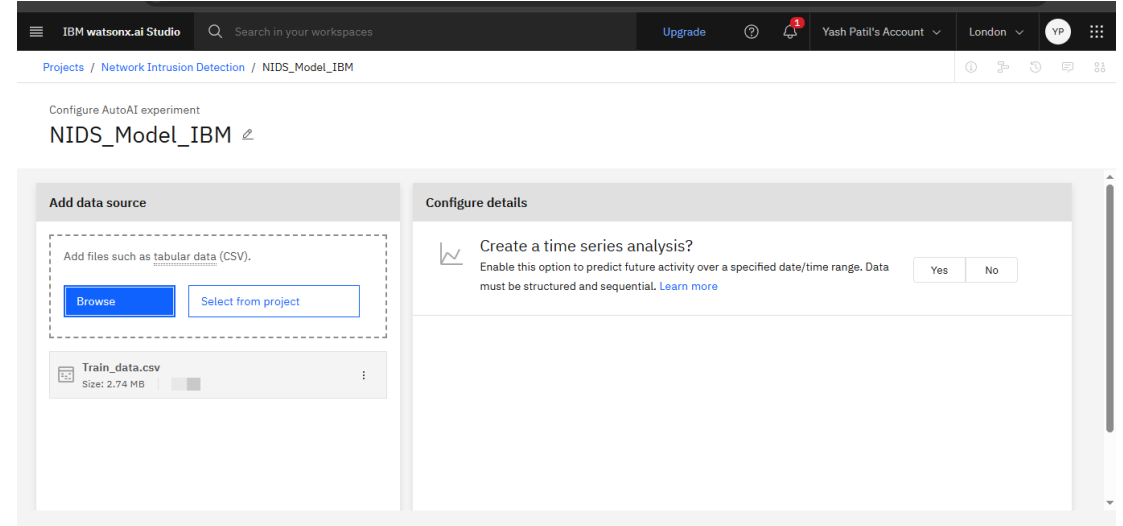
RESULT



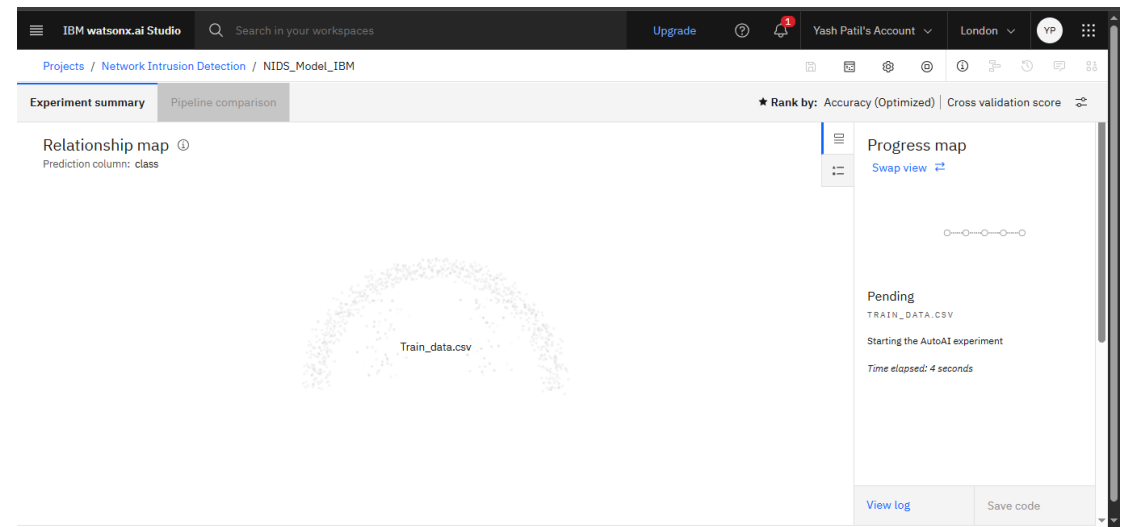
This screenshot shows the 'Overview' tab of a project named 'Network Intrusion Detection' in IBM watsonx.ai Studio. The interface includes a top navigation bar with the user's account 'Yash Patil's Account' and location 'London'. Below the navigation bar, there are tabs for 'Overview', 'Assets', 'Jobs', and 'Manage'. The main content area features a 'Start working' section with four recommended actions: 'Add users as collaborators', 'Add data to work with', 'Work with data and models in Python or R notebooks', and 'Build machine learning models automatically'. Below this, there are three panels: 'Assets' showing a list of assets, 'Resource usage' displaying '0 CUH' for the month, and 'Your documentation' with a link to 'Open Documentation editor'.



This screenshot shows the 'Configure AutoAI experiment' page for 'NIDS_Model_IBM'. The page is divided into two main sections. On the left, under 'Add data source', there is a 'Train_data.csv' file listed with a size of 2.74 MB and 42 columns. On the right, under 'Configure details', there is a 'What do you want to predict?' section with a dropdown menu set to 'class'. Below this, the 'Prediction column' is set to 'class', and the 'Prediction type' is 'Binary Classification'. The 'Positive class' is set to 'Normal', and the experiment is 'Optimized for Accuracy & run time'. At the bottom, there is a 'Run experiment' button. The top navigation bar shows the user's account 'Yash Patil's Account' and location 'London'.

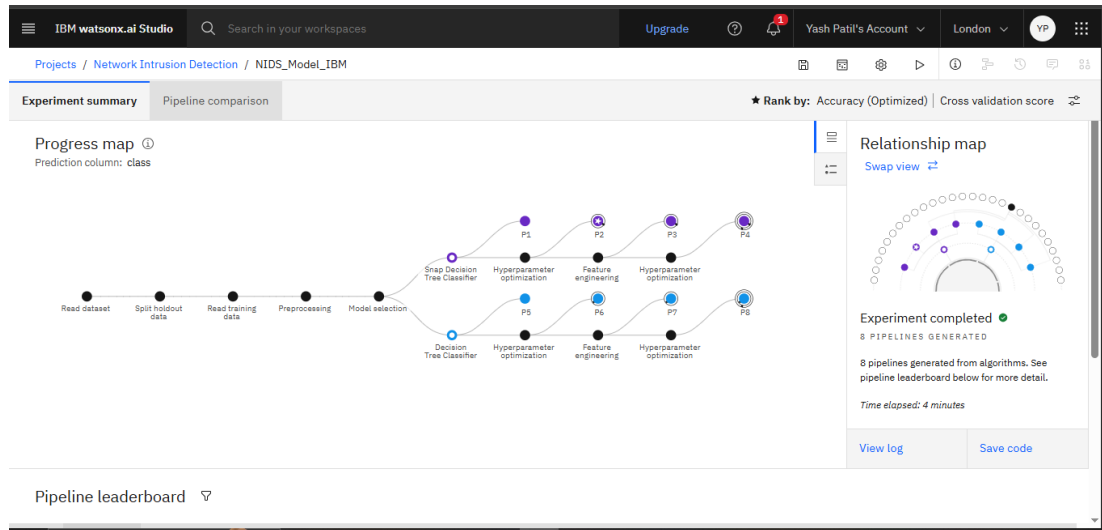


This screenshot shows the 'Configure AutoAI experiment' page for 'NIDS_Model_IBM', focusing on the 'Add data source' and 'Configure details' sections. The 'Add data source' section shows a 'Train_data.csv' file with a size of 2.74 MB. The 'Configure details' section has a 'Create a time series analysis?' checkbox, which is currently unchecked. The top navigation bar shows the user's account 'Yash Patil's Account' and location 'London'.



This screenshot shows the 'Experiment summary' page for 'NIDS_Model_IBM'. The page displays a 'Relationship map' showing the 'Train_data.csv' file as the input. On the right, there is a 'Progress map' section showing the status of the experiment. The status is 'Pending', and the message says 'Starting the AutoAI experiment'. The 'Time elapsed' is 4 seconds. The top navigation bar shows the user's account 'Yash Patil's Account' and location 'London'.

RESULT



Pipeline leaderboard

Rank	Name	Algorithm	Accuracy (Optimized) Cross Validation	Enhancements	Build time
1	Pipeline 2	Snap Decision Tree Classifier	0.995	HPO-1	00:00:09
2	Pipeline 1	Snap Decision Tree Classifier	0.995	None	00:00:04
3	Pipeline 6	Decision Tree Classifier	0.994	HPO-1	00:00:09
4	Pipeline 5	Decision Tree Classifier	0.994	None	00:00:04

Deployment spaces / NIDS_Deployment_Space1 / P4 - Snap Decision Tree Classifier: NIDS_Model_IBM

Deployments

Name	Type	Status	Tags	Last modified
NIDS_SnapTree_Deployment	Online	Deployed		24 seconds ago Yash Patil (You)

About this asset

Name
P4 - Snap Decision Tree Classifier: NIDS_Model_IBM

Description
No description provided.

Asset Details
Type: wml-hybrid_0.1
Model ID: 793f7cc7-6db9-48...
Software specification: hybrid_0.1
Hybrid pipeline software specifications: autoai-kb_rt24.1-py3.11

Tags
Add tags to make assets easier to find.

Source asset details

Deployment spaces / NIDS_Deployment_Space1 / P4 - Snap Decision Tree Classifier: NIDS_Model_IBM

NIDS_SnapTree_Deployment

API reference

Endpoints for scoring

Private endpoint
https://private.eu-gb.ml.cloud.ibm.com/v4/deployments/32e08b96-d0c9-4a86-b554-cdc931271e4...
Public endpoint
https://eu-gb.ml.cloud.ibm.com/v4/deployments/32e08b96-d0c9-4a86-b554-cdc931271e4...
Learn more about the 2021-05-01 version query parameter

Code snippets
cURL
Java
JavaScript
Python
Scala

About this deployment

Name
NIDS_SnapTree_Deployment

Description
No description provided.

Deployment Details
Deployment ID: 32e08b96-d0c9-4a86-b554-cdc931271e4...
Serving name: No serving name.
Software specification: hybrid_0.1
Hybrid pipeline software specifications: autoai-kb_rt24.1-py3.11
Copies: 1
Tags
Add tags to make assets easier to find.

Associated asset

RESULT

IBM watsonx.ai Studio

Deployment spaces / NIDS_Deployment_Space1 / P4 - Snap Decision Tree Classifier: NIDS_Model_IBM /

NIDS_SnapTree_Deployment Deployed Online

API reference **Test**

Enter input data

Text **JSON**

Enter data manually or use a CSV file to populate the spreadsheet. Max file size is 50 MB.

Clear all

	duration (double)	protocol_type (other)	service (other)	flag (other)	src_bytes (double)	dst_bytes (double)	land (double)	wrong_fragment (double)
4	0	tcp	http	Rej	12	44		
5								

2 rows, 41 columns

Predict

IBM watsonx.ai Studio

Deployment spaces / NIDS_Deployment_Space1 / P4 - Snap Decision Tree Classifier: NIDS_Model_IBM /

NIDS_SnapTree_Deployment Deployed Online

API reference **Test**

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Clear all

	duration (double)	protocol_type (other)	service (other)	flag (other)	src_bytes (double)	dst_bytes (double)	land (double)	wrong_fragment (double)
4	0	tcp	http	Rej	12	44		
5								

2 rows, 41 columns

Predict

NI Prediction results

Prediction type
Binary classification

Prediction percentage

Display format for prediction results
☒ Table view ☐ JSON view Show input data

	Prediction	Confidence
1	anomaly	100%
2	normal	100%
3		
4		
5		
6		
7		
8		

Download JSON file

IBM watsonx.ai Studio

Deployment spaces / NIDS_Deployment_Space1 / P4 - Snap Decision Tree Classifier: NIDS_Model_IBM /

NIDS_SnapTree_Deployment Deployed Online

API reference **Test**

Enter input data

Text **JSON**

Enter data manually or use a CSV file to populate the spreadsheet. Max file size is 50 MB.

Clear all

	duration (double)	protocol_type (other)	service (other)	flag (other)	src_bytes (double)	dst_bytes (double)	land (double)	wrong_fragment (double)
8	0	tcp	telnet	SF	129	174	0	0
9	0	tcp	http	SF	327	467	0	0

22,544 rows, 41 columns

Predict

NI Prediction results

Prediction type
Binary classification

Prediction percentage

Display format for prediction results
☒ Table view ☐ JSON view Show input data

	Prediction	Confidence
1	anomaly	100%
2	anomaly	100%
3	normal	100%
4	anomaly	100%
5	normal	100%
6	normal	100%
7	normal	100%
8	normal	100%

Download JSON file

CONCLUSION

- The Network Intrusion Detection System developed using IBM Watsonx.ai successfully demonstrates the use of machine learning to classify network traffic as normal or intrusive. By leveraging AutoAI, the Snap Decision Tree Classifier was trained with automatic feature engineering and hyperparameter optimization, resulting in a high-performing model deployed as a REST API. The system enables real-time predictions and provides a scalable solution for network security. Challenges included understanding complex network traffic patterns and configuring deployment inputs. Future improvements could involve multiclass classification, real-time data integration, and a user interface for monitoring. Overall, the solution proves effective in enhancing cybersecurity through intelligent threat detection.

FUTURE SCOPE

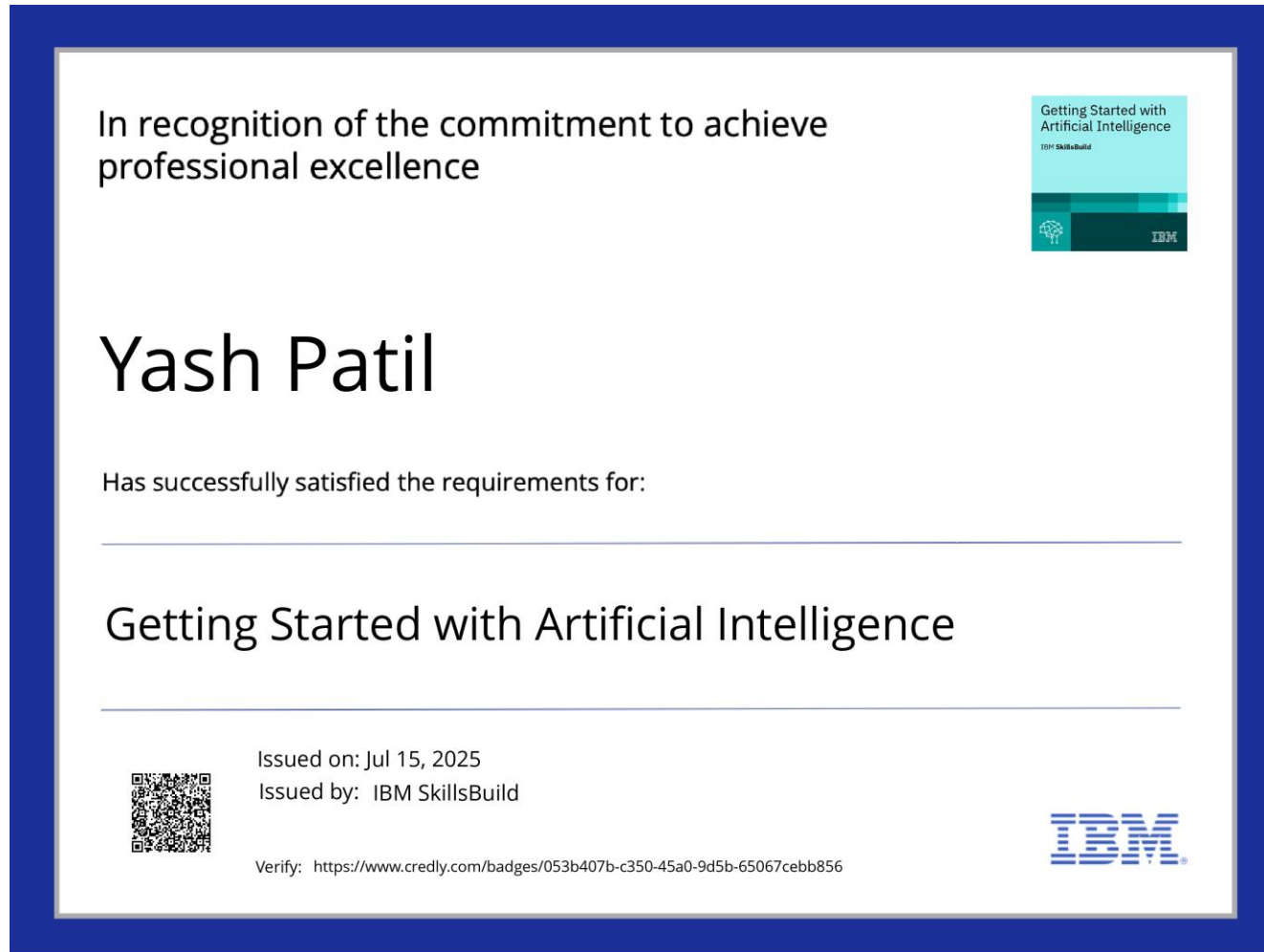
- **Incorporate real-time data:**
Integrate live network traffic and external threat intelligence feeds for dynamic and up-to-date intrusion detection.
- **Advanced machine learning models:**
Explore ensemble models, deep learning (e.g., LSTM, CNN), or anomaly detection techniques to improve classification accuracy.
- **Scalability across regions:**
Expand the system to monitor multiple networks across cities or enterprise branches for broader security coverage.
- **Edge computing integration:**
Deploy NIDS on edge devices to enable faster, decentralized threat detection with reduced response time.
- **Continuous learning:**
Implement online learning techniques for the model to adapt to new and evolving cyber-attack patterns.
- **User interface enhancement:**
Add dashboards or real-time alerting systems to support security teams with actionable insights.

REFERENCES

1. Kaggle Dataset – Network Intrusion Detection
<https://www.kaggle.com/datasets/sampadab17/network-intrusion-detection>
2. IBM Watsonx.ai – AutoAI
<https://www.ibm.com/cloud/watsonx/autoai>
3. IBM Cloud Deployment Space Documentation
<https://www.ibm.com/docs/en/cloud-paks/cp-data/4.7.x?topic=models-deploying>

IBM CERTIFICATIONS

- Screenshot/ credly certificate(getting started with AI)



IBM CERTIFICATIONS

- Screenshot/ credly certificate(Journey to Cloud)




IBM CERTIFICATIONS

- Screenshot/ certificate(RAG Lab)

IBM SkillsBuild

Completion Certificate



This certificate is presented to

YASH PATIL

for the completion of

Lab: Retrieval Augmented Generation with LangChain

(ALM-COURSE_3824998)

According to the Adobe Learning Manager system of record

Completion date: 15 Jul 2025 (GMT)

Learning hours: 20 mins



THANK YOU