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REPORT

ON

APPLICATION OF ARTIFICIAL INTELLIGENCE TECHNIQUES IN SOFTWARE TEST AUTOMATION

BY

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APPLICATION OF AI TECHNIQUES IN SOFTWARE TEST AUTOMATION

Pattern Recognition in production defects to identify similar patterns in new data, aiding in the recognition of common root causes

BITS SEZG628T: Dissertation

By

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Title of the Project: Application of AI Techniques in Software Test Automation - Pattern Recognition in production defects to identify similar patterns in new data, aiding in the recognition of common root causes

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Name & Designation of Supervisor: Phani Kumar Daddanala, Software Engineering Lead

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Key Words: *Artificial Intelligence, Test Automation, Production Defect Root Cause Analysis, Machine Learning, XGBoost*

Project Area: AI in Software Test Automation

ABSTRACT:

In the field of software development, software testing is a critical step in the process. Test automation is carried out in a controlled manner in which an application is monitored under specified situations, allowing testers to gauge the threshold and potential dangers associated with the software's deployment. In software testing, artificial intelligence (AI) aids in the prevention of application failovers that might be costly to both the program and the company in the long run [1].

Present study aims at bringing out an innovative approach to software test automation by implementing artificial intelligence (AI) models for Production Defect Root Cause Analysis (RCA). Traditional defect RCA methods often rely on manual inspection or rule-based systems, which can be time-consuming and subjective. In contrast, generative AI models offer the ability to automatically identify patterns in large volumes of production data and generate plausible root causes for defects.

Planned framework implements AI model in the defect RCA process, encompassing Data Collection, Data Pre-Processing, Feature Selection, Model Selection, Training, Evaluation, Deployment, and Maintenance Stages. By leveraging existing machine learning algorithm, the approach enables automated root cause analysis, leading to more efficient quality control processes and product improvements.

Aim is to demonstrate the effectiveness of this approach through experimental validation on real-world production defect datasets. Results are expected to indicate that AI models can achieve high accuracy in identifying defect root causes, outperforming traditional methods. Furthermore, it will discuss the implications of integrating generative AI into defect detection workflows and highlight opportunities for future research and application in software quality assurance domain.

Overall, this dissertation contributes to advancing the field of Defect RCA by leveraging the capabilities of generative AI models to streamline and enhance the defect analysis process, ultimately leading to improved product quality and customer satisfaction.

Signature of the Student
Name: Malliswari Rama Raju
Date: 29th April, 2024
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1. INTRODUCTION:

1.1 Background:

Current application under study “Cirrus” is an Optum proprietary customer installation and member enrolment web application. The application is live in production since 2017, and, it is continuously evolving with new products and different migrations being launched and merged into the system.

Any defects identified in production are logged in CA Rally tool, assigned to appropriate team for analysis and fix, tested, accepted and deployed to production through the established CI/CD pipeline. The accepted defects are then analysed by Quality team to identify the root cause and take appropriate actions during development and testing to prevent similar failures in future.

Root Cause Analysis (RCA) of software defects in production is a systematic process for identifying the underlying causes of the defects. The manual RCA process includes analysing the production defect description, analysing the customer data in database, analysing the codebase and configuration, then identifying the root cause as a Design/Database/Code issue or missed requirement or not a defect. Based on the root cause and finalized defect fix, “Resolution” field in Rally is filled with appropriate resolution of “Design/Code Change”, “Database Change”, “Converted to a User Story”, “Not a Defect” or “Duplicate Defect”.

1.2 Research Objective:

This dissertation aims to provide a comprehensive exploration of pattern recognition techniques in the context of software production defects, offering insights into their effectiveness, practical applications and potential challenges. Through empirical studies and analysis, it seeks to contribute to the advancement of defect analysis methodologies and support the development of more robust and reliable software systems.

1.3 Scope and Limitations:

1.3.1. Scope:

Production defect RCA has been identified as a Classification problem. The primary focus to address the problem is on how AI-based pattern recognition can aid in root cause analysis of software defects and predict their Resolution, based on existing defects, using supervised learning-based classification model.

Current scope of dissertation includes defect data collection, data pre-processing, splitting data into training and test data, implementing supervised learning model for predicting “Resolution” for test data, and measuring accuracy of prediction on test data.

The dissertation has been implemented as a POC (Proof of Concept) in Optum due to database and code integration limitations described below.

1.3.2 Limitations:

a) Dataset size – Production defects data could be gathered for 2023 and 2024 only, as Rally became the source of truth for prod defects from 2023. This limited the dataset size to less than 1200 records, which posed challenges for training complex predictive AI models.

b) Data Quality – Prod defects description is not in consistent format and, lacks enough details, as the prod support team is not trained to log defects consistently.

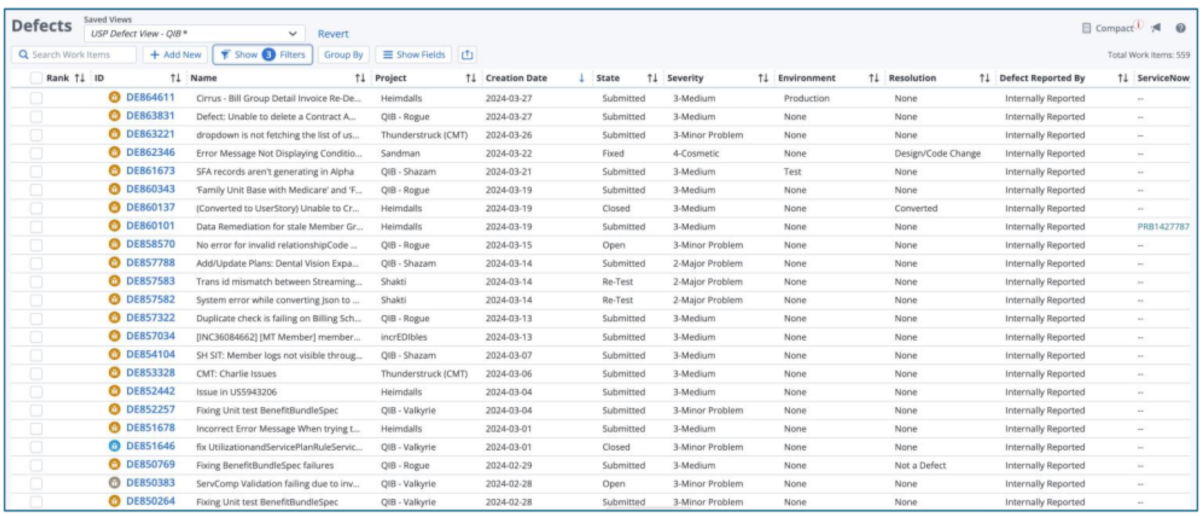
c) Data and Code Confidentiality – Optum is a US based healthcare insurance organization. Since Cirrus is a member enrolment application, its database consists of member PII (Personal Identifiable Information) and PHI (Protected Health Information), which is confidential and restricted from sharing outside the organization. Cirrus codebase is strictly confidential and cannot be accessed outside, as per company security policies. These limitations do not allow database and code integration with the AI model, reducing the scope and accuracy of the model.

2. MAIN TEXT:

2.1 Data Collection & Pre-Processing:

2.1.1 Data Collection:

a. Gathered historical data on production and non-production defects (starting 1/1/2023), including information such as Defect Name, Description, Severity, Schedule State, Timestamps, Related code changes, and any contextual information.
b. The dataset is from Cirrus test & prod environments and covers a diverse range of scenarios (*Figure 1*)



Defects
Saved Views
USP Defect View - QIB *
Revert
Search Work Items
Add New
Show 3 Filters
Group By
Show Fields
Compact
Total Work Items: 559

Rank	ID	Name	Project	Creation Date	State	Severity	Environment	Resolution	Defect Reported By	ServiceNow
	DE864611	Cirrus - Bill Group Detail Invoice Re-De...	Heimdalls	2024-03-27	Submitted	3-Medium	Production	None	Internally Reported	--
	DE863831	Defect: Unable to delete a Contract A...	QIB - Rogue	2024-03-27	Submitted	3-Medium	None	None	Internally Reported	--
	DE863221	dropdown is not fetching the list of us...	Thunderstruck (CMT)	2024-03-26	Submitted	3-Minor Problem	None	None	Internally Reported	--
	DE862346	Error Message Not Displaying Conditio...	Sandman	2024-03-22	Fixed	4-Cosmetic	None	Design/Code Change	Internally Reported	--
	DE861673	SFA records aren't generating in Alpha	QIB - Shazam	2024-03-21	Submitted	3-Medium	Test	None	Internally Reported	--
	DE860343	'Family Unit Base with Medicare' and 'F...	QIB - Rogue	2024-03-19	Submitted	3-Medium	None	None	Internally Reported	--
	DE860137	(Converted to UserStory) Unable to Cr...	Heimdalls	2024-03-19	Closed	3-Medium	None	Converted	Internally Reported	--
	DE860101	Data Remediation for stale Member Gr...	Heimdalls	2024-03-19	Submitted	3-Medium	None	None	Internally Reported	PRB1427787
	DE858570	No error for invalid relationshipCode ...	QIB - Rogue	2024-03-15	Open	3-Minor Problem	None	None	Internally Reported	--
	DE857788	Add/Update Plans: Dental Vision Expa...	QIB - Shazam	2024-03-14	Submitted	2-Major Problem	None	None	Internally Reported	--
	DE857583	Trans id mismatch between Streaming...	Shakti	2024-03-14	Re-Test	2-Major Problem	None	None	Internally Reported	--
	DE857582	System error while converting Json to ...	Shakti	2024-03-14	Re-Test	2-Major Problem	None	None	Internally Reported	--
	DE857322	Duplicate check is failing on Billing Sch...	QIB - Rogue	2024-03-13	Submitted	3-Medium	None	None	Internally Reported	--
	DE857034	[INC36084662] [MT Member] member...	incrEDIbles	2024-03-13	Submitted	3-Medium	None	None	Internally Reported	--
	DE854104	SH SIT: Member logs not visible throug...	QIB - Shazam	2024-03-07	Submitted	3-Medium	None	None	Internally Reported	--
	DE853328	CMT: Charlie Issues	Thunderstruck (CMT)	2024-03-06	Submitted	3-Medium	None	None	Internally Reported	--
	DE852442	Issue in US5943206	Heimdalls	2024-03-04	Submitted	3-Medium	None	None	Internally Reported	--
	DE852257	Fixing Unit test BenefitBundleSpec	QIB - Valkyrie	2024-03-04	Submitted	3-Minor Problem	None	None	Internally Reported	--
	DE851678	Incorrect Error Message When trying t...	Heimdalls	2024-03-01	Submitted	3-Medium	None	None	Internally Reported	--
	DE851646	fix UtilizationandServicePlanRuleServic...	QIB - Valkyrie	2024-03-01	Closed	3-Minor Problem	None	None	Internally Reported	--
	DE850769	Fixing BenefitBundleSpec failures	QIB - Rogue	2024-02-29	Submitted	3-Medium	None	Not a Defect	Internally Reported	--
	DE850383	ServComp Validation failing due to inv...	QIB - Valkyrie	2024-02-28	Open	3-Minor Problem	None	None	Internally Reported	--
	DE850264	Fixing Unit test BenefitBundleSpec	QIB - Valkyrie	2024-02-28	Submitted	3-Minor Problem	None	None	Internally Reported	--

Figure 1 - Cirrus defects logged in Rally tool

c. Defect details exported from Rally and saved in .csv format (*Figure 2*):

Formatted ID	Name	Project	Creation Date	State	Severity	Environment	Resolution	Defect Reported By	iceNow_Prol	iceNow_Inci	Now_Probler	Owner	A Root Cause	Iteration	chedule Stat	ccepted Date
DE864611	Cirrus - Bill Group Detail Invoice Re-Deriation Utility popup	Heimdalls	27/03/24	Submitted	3-Medium	Production		Internally Reported							Refining	
DE863831	Defect: Unable to delete a Contract Affiliation after it has been validated	QIB - Rogue	27/03/24	Submitted	3-Medium			Internally Reported				Russell Hammond		2024.PI49.2	Defined	
DE863221	dropdown is not fetching the list of userids through ldapAutofill API	Thunderstruc	26/03/24	Submitted	3-Minor Problem			Internally Reported				Monika Verma		2024.PI49.1	In-Progress	
DE862346	Error Message Not Displaying Conditional Value	Sandman	22/03/24	Fixed	4-Cosmetic		Design/Code Change	Internally Reported				Simon Yawin		2024.PI49.1	Accepted	25/03/24
DE861673	SFA records aren't generating in Alpha	QIB - Shazam	21/03/24	Submitted	3-Medium	Test		Internally Reported							Defined	
DE860343	'Family Unit Base with Medicare' and 'Family Unit based with Age Gender' Search List paginatio	QIB - Rogue	19/03/24	Submitted	3-Medium			Internally Reported				Samakshi Ma	US6700266	2024.PI49.2	In-Progress	
DE860137	(Converted to UserStory) Unable to Create Members in Member Entry in Cirrus Alpha for GF/TR	Heimdalls	19/03/24	Closed	3-Medium		Converted	Internally Reported							Refining	
DE860101	Data Remediation for stale Member Group Action Event	Heimdalls	19/03/24	Submitted	3-Medium			Internally Reported	599cd60993c9c618984fb		Proactive				Refining	
DE858570	No error for invalid relationshipCode when submitted via API (HW and CCV3)	QIB - Rogue	15/03/24	Open	3-Minor Problem			Internally Reported				David Powell		2024.PI49.1	In-Progress	
DE857788	Add/Update Plans: Dental Vision Expand Collapse Navigation Functionality	QIB - Shazam	14/03/24	Submitted	2-Major Problem			Internally Reported				Mujib Adem	US3945989	2024.PI48.5	Accepted	20/03/24
DE857583	Trans id mismatch between Streaming & HCP XML for dependents (sourceSystemTransID)	Shakti	14/03/24	Re-Test	2-Major Problem			Internally Reported				Madhavi Mahanthi		2024.PI49.1	In-Progress	
DE857582	System error while converting Json to XML message (Member Logical delete scenario)	Shakti	14/03/24	Re-Test	2-Major Problem			Internally Reported				Madhavi Mahanthi		2024.PI49.1	In-Progress	
DE857322	Duplicate check is failing on Billing Schedule Age Gender Screen	QIB - Rogue	13/03/24	Submitted	3-Medium			Internally Reported				Visweswar Gaddam		2024.PI49.1	In-Progress	
DE857034	[INC36084662] [MT Member] memberDemographics API is taking time around 1min for few payl	incrEDIbles	13/03/24	Submitted	3-Medium			Internally Reported				JAMES BESSE		2024.PI49.2	In-Progress	
DE854104	SH SIT: Member logs not visible through CIDM JSON	QIB - Shazam	07/03/24	Submitted	3-Medium			Internally Reported						2024.PI49.2	Defined	
DE853328	CMT: Charlie Issues	Thunderstruc	06/03/24	Submitted	3-Medium			Internally Reported				Himanshu Yadav			Refining	
DE852442	Issue in US5943206	Heimdalls	04/03/24	Submitted	3-Medium			Internally Reported				Jay Jordan Ma			Accepted	12/03/24
DE852257	Fixing Unit test BenefitBundleSpec	QIB - Valkyrie	04/03/24	Submitted	3-Minor Problem			Internally Reported				Pranav Kumar		2024.PI48.5	Accepted	07/03/24
DE851678	Incorrect Error Message When trying to logically delete group affiliation	Heimdalls	01/03/24	Submitted	3-Medium			Internally Reported							Refining	
DE851646	fix UtilizationandServicePlanRuleServiceCompositeHolder	QIB - Valkyrie	01/03/24	Closed	3-Minor Problem			Internally Reported				Dudi Vinay		2024.PI48.5	Accepted	15/03/24
DE850769	Fixing BenefitBundleSpec failures	QIB - Rogue	29/02/24	Submitted	3-Medium		Not a Defect	Internally Reported				Logan Fabyanske		2024.PI48.4	Accepted	01/03/24
DE850383	ServComp Validation failing due to invalid jobSeqNum	QIB - Valkyrie	28/02/24	Open	3-Minor Problem			Internally Reported				Dudi Vinay		2024.PI48.5	Accepted	14/03/24
DE850264	Fixing Unit test BenefitBundleSpec	QIB - Valkyrie	28/02/24	Submitted	3-Minor Problem			Internally Reported				Pranav Kumar		2024.PI48.4	Accepted	28/02/24
DE850027	Getting Exception when trying to add a Member Group Event with Closed status	QIB - Rogue	28/02/24	Open	3-Medium	Production	Design/Code Change	Internally Reported						2024.PI49.2	Refining	
DE848974	Update systematic persistence of subsAffiliationExternalID / subsAffilExtIDContOptType	QIB - Shazam	26/02/24	Submitted	2-Major Problem		Design/Code Change	Internally Reported				Keith Rieck	US6547071	2024.PI48.4	Accepted	14/03/24
DE848483	Update error / warning processing logic	QIB - Shazam	23/02/24	Submitted	2-Major Problem			Internally Reported						2024.PI49.3	Defined	
DE848473	Update ""Upload Edit Code and Attributes File"" member utility	QIB - Shazam	23/02/24	Submitted	2-Major Problem			Internally Reported				Maddipaty Anusha		2024.PI49.1	In-Progress	
DE848238	Migration Script Issue - Less than or Equal to Date Update	QIB - Shazam	23/02/24	Submitted	2-Major Problem		Design/Code Change	Internally Reported				Mahesh Gurala		2024.PI48.5	Accepted	08/03/24
DE847527	problem with data persisted to a subsAffiliationExternalID child table	QIB - Shazam	22/02/24	Submitted	2-Major Problem		Design/Code Change	Internally Reported				Keith Rieck	US6547071	2024.PI48.4	Accepted	26/02/24
DE847126	Regarding ERR2215 Med PCP sent for Dental	incrEDIbles	21/02/24	Submitted	3-Medium			Internally Reported						2024.PI49.2	Defined	
DE846883	Contract Option UI - Search Options - Clear button does not set ""Show Deleted Records"" to de	Heimdalls	21/02/24	Submitted	3-Minor Problem			Internally Reported							Defined	
DE846645	Handle multiple requests for the same transaction id	Thunderstruc	21/02/24	Submitted	3-Minor Problem			Internally Reported				Khushi Pawar		2024.PI49.1	In-Progress	
DE846643	(Converted to UserStory) Unable to commit against JDBC Connection issue	Thunderstruc	21/02/24	Closed	3-Minor Problem		Converted	Internally Reported				Himanshu Yadav			In-Progress	
DE846452	Member Group Action Event | Group Contract Event Not Creating	QIB - Rogue	20/02/24	Open	2-Major Problem	Production	Design/Code Change	Internally Reported						2024.PI48.4	Accepted	28/02/24
DE846385	Update Date and User ID no longer displaying on UI	QIB - Shazam	20/02/24	Submitted	2-Major Problem			Internally Reported				Alex Ertl		2024.PI48.4	Accepted	22/02/24
DE844308	NullPointerException on Contract Option Ins Rule / Contract Opt Pop Ins Rule when user press	QIB - Rogue	15/02/24	Open	3-Minor Problem			Internally Reported						2024.PI48.4	Accepted	05/03/24
DE844300	Bill group affiliation to member validation move to UI validation	Sandman	15/02/24	Submitted	3-Minor Problem			Internally Reported				Karma Gurung		2024.PI48.4	Accepted	01/03/24
DE843578	Auto-Close Logic for FPP Benefit Refresh Event	QIB - Rogue	14/02/24	Open	3-Medium	Production	Design/Code Change	Internally Reported					US6582277	2024.PI48.3	Accepted	22/02/24
DE843415	Not able to fetch Member Record : Cirrus UI ALpha	QIB - Shazam	14/02/24	Submitted	3-Medium			Internally Reported						2024.PI49.2	Defined	
DE843256	CMT>> Upload Source names >> Getting Internal Server Error.	Thunderstruc	14/02/24	Submitted	3-Medium			Internally Reported				Hritwika Sarkar		2024.PI48.5	Accepted	19/03/24
DE842924	Fix BeneCodeNetwork versioning issue	QIB - Valkyrie	13/02/24	Submitted	3-Minor Problem			Internally Reported				Tyler Amunds	DE704417 - c	2024.PI48.4	Accepted	28/02/24
DE842074	Handling SubsJob page w/o selecting member/subsAffiliation	incrEDIbles	12/02/24	Submitted	3-Medium			Internally Reported						2024.PI48.3	Accepted	15/02/24
DE840257	Child Contract Affil Cancellation - No Admin Cancel, No Warning, No Reinstatement	Heimdalls	07/02/24	Submitted	3-Medium			Internally Reported						2024.PI48.4	Refining	
DE840245	Child Contract Affiliation - No Termination Action Available	Heimdalls	07/02/24	Submitted	3-Medium			Internally Reported						2024.PI48.4	Refining	
DE838673	Split Platform Migration : Member Group Contract Option table missing records in Cirrus alpha	Heimdalls	06/02/24	Submitted	3-Medium			Internally Reported				Sathish Chandrakani		2027.PI67.5	Accepted	27/02/24

Figure 2 - Rally defects exported to .csv

d. Identified relevant features or variables in the data that can contribute to identifying root causes.

e. Raw data from Rally contains the below features:

   i. Formatted ID (Defect ID)
   ii. Name (Defect Description)
   iii. Project
   iv. Creation Date
   v. State
   vi. Severity
   vii. Environment
   viii. Resolution
   ix. Build Number
   x. Defect Reported By
   xi. ServiceNow_Problem
   xii. ServiceNow_Incident
   xiii. ServiceNow_Problem Type
   xiv. Owner
   xv. RCA Root Cause US
   xvi. Iteration
   xvii. Schedule State • Accepted Date

f. Features relevant for RCA would be:

   i. Formatted ID (Defect ID)
   ii. Name
   iii. Description
   iv. Schedule State
   v. Severity
   vi. Resolution

“Resolution” is the target field whose value needs to be predicted with high accuracy.

2.1.2 Data Pre-processing:

Data Augmentation – Since overall dataset size is limited (~ 1200 records), data augmentation is done to artificially increase the size of dataset by creating modified versions of existing data samples, increasing the record count to > 1600.

Cirrus production defect details are in text format. These are processed and transformed to numeric and binary matrix formats using Label Encoding and One-Hot Encoding techniques. These are the two most used encoding techniques for converting categorical feature to numerical feature [3].

The LabelEncoder class from sklearn.preprocessing module is used to encode the target variable "Resolution" into numerical labels (*Figure 3*).

```
# Specify columns to drop from features (X)
columns_to_drop = ['Resolution', 'Formatted ID', 'Name', 'Description', 'Severity', 'Schedule State']

# Separate features (X) and target variable (y)
X = data.drop(columns_to_drop, axis=1)
y = data['Resolution']  # Target variable

# Initialize LabelEncoder for target variable
label_encoder = LabelEncoder()

# Encode target variable (y) into numeric labels
y_encoded = label_encoder.fit_transform(y)
```

Figure 3 - Utilising LabelEncoder() as a pre-processing technique

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The get_dummies function is used to perform one-hot encoding on input variables of the dataset. OneHotEncoder class from sklearn.preprocessing module is used to convert input array of categorical variables (input features identified above - 'Resolution', 'Formatted ID', 'Name', 'Description', 'Severity', 'Schedule State') into a binary matrix representation, where each category is represented by a binary column (*Figure 4*).

```
# Specify columns to drop from features (X)
columns_to_drop = ['Resolution', 'Formatted ID', 'Name', 'Description', 'Severity', 'Schedule State']

# Separate features (X) and target variable (y)
X = data.drop(columns_to_drop, axis=1)
y = data['Resolution']  # Target variable

# Initialize LabelEncoder for target variable
label_encoder = LabelEncoder()

# Encode target variable (y) into numeric labels
y_encoded = label_encoder.fit_transform(y)

# One-hot encode categorical features in X
X_encoded = pd.get_dummies(X)  # This will one-hot encode all categorical columns
```

Figure 4 - Utilising get_dummies() function for one-hot encoding

2.2 **Resolution Prediction Algorithm:** Github Link - https://github.com/msarraj27/Dissertation.git

a) First step is to split the dataset into Training and Testing datasets using train_test_split function. The train and test sets model is one of the simplest models available where we split the entire dataset into training set and testing set [4].
b) Using a test_size of 0.2, the proportion of dataset to include in test split is defined as 20%, while 80% is used for training. Random_state of 42 is used to ensure efficiency of the model as the training and test datasets will remain the same whenever code is run.
c) Second step is to use machine learning Classification Model XGBoost (Extreme Gradient Boost) to classify and predict the "Resolution" in test dataset (*Figure 5*).

```
import numpy as np
from sklearn.metrics import accuracy_score, classification_report
from sklearn.preprocessing import StandardScaler
import xgboost as xgb

class SimpleClassifier:
    def __init__(self, n_estimators=100, max_depth=5, learning_rate=0.1):
        self.n_estimators = n_estimators
        self.max_depth = max_depth
        self.learning_rate = learning_rate
        self.scaler = StandardScaler()
        self.model = xgb.XGBClassifier()

    def fit(self, X, y):
        # Scale input features
        X_scaled = self.scaler.fit_transform(X)

        # Fit the XGBoost classifier
        self.model.fit(X_scaled, y)

    def predict(self, X):
        # Scale input features
        X_scaled = self.scaler.transform(X)

        # Make predictions using the XGBoost classifier
        return self.model.predict(X_scaled)

# Example usage:

# Assuming X_train, X_test, y_train, and y_test are defined
# Instantiate the custom XGBoost classifier
model = SimpleClassifier(n_estimators=100, max_depth=5, learning_rate=0.1)

# Train the model
model.fit(X_train, y_train)

# Make predictions on test data
y_pred = model.predict(X_test)

# Evaluate accuracy
accuracy = accuracy_score(y_test, y_pred)
```

Figure 5 - ML algorithm XGBoost for classification and prediction

d) XGBoost is an implementation of gradient boosting, a machine learning technique that builds an ensemble of decision trees sequentially, with each tree correcting the errors of its predecessors.
e) Self.model variable is to store the initialized XGBClassifier model instance. Storing the model as self.model attribute allows easy access to the model within the class methods and facilitates training and prediction tasks.
f) Once the model is initialized, training on training data, evaluating its performance and making predictions on new data is achieved.

2.3 Evaluation and Metrics:

a) Evaluation of the AI model is done to assess the performance of the algorithm to predict value of target variable "Resolution" in terms of essential metrics such as Accuracy, Precision, Recall, f1-score, Support, Macro Average and Weighted Average (*Figure 6*).

Accuracy: 0.78

	precision	recall	f1-score	support
0	0.90	0.56	0.69	16
1	0.50	1.00	0.67	1
2	0.89	0.87	0.88	62
3	0.62	0.44	0.52	18
4	0.68	0.85	0.76	46
6	1.00	1.00	1.00	1
accuracy			0.78	144
macro avg	0.76	0.79	0.75	144
weighted avg	0.79	0.78	0.77	144

Figure 6 - Metrics

b) Accuracy of **78%** for predicting Resolution of production defects in test dataset is achieved with the implemented AI model.
c) Precision – It is a measure of the correctness of positive predictions. The precision values range from 0.50 to 1.00, with an **average weighted precision of 0.79**.
d) Recall – Also known as Sensitivity or True Positive Rate, it is a measure of the model's ability to correctly identify all positive instances. Recall values range from 0.44 to 1.00, with an **average weighted recall of 0.78**.
e) F1-Score – It is the harmonic mean of precision and recall, providing a balance between the two metrics. F1-score values range from 0.52 to 1.00, with an **average weighted f1-score of 0.77.**
f) Support – It indicates the number of actual occurrences of each class in the test set.

2.4 **Conclusions and Recommendations**:

a) With the current limitations on dataset and company policy restrictions, accuracy, precision, recall and f1-score values are reasonable. The POC is done to showcase that artificial intelligence is a promising solution to predict RCA of production defects.

b) With consistent and extensive dataset, and proper database and codebase integration, Generative AI models can be implemented for higher accuracy and prediction of defects based on the customer data.

Future Scope:

Deployment:

a. Train prod-support team to maintain Rally defects consistently. The business requirement is to create a simple automated RCA approach that will be used for problem avoidance in future [2].
b. Once extensive dataset is available, enhance the current model to implement Gen AI to predict RCA.
c. Demo the model to team & MLRB (Machine Learning Review Board) and get their approval.
d. Upon getting the approval, deploy the model to Rally production defects.

Feedback Loop:

a. Incorporate feedback from users and domain experts to continuously improve the model's accuracy and effectiveness.

3. WORK PLAN:

Phases	Start Date – End Date	Work to be Done	Status
Submission of Dissertation Outline	13th Jan – 20th Jan 2024	a. Dissertation topic analysis and preparation of Outline report b. Review and comments by Supervisor	COMPLETED
Design & Development	21st Jan – 9th Mar 2024	a. Identify and design components of AI model b. Development activity	COMPLETED
Testing	10th Mar – 31st Mar 2024	a. AI model testing, user evaluation, conclusion	COMPLETED
Mid-Term Report Submission	22nd Mar – 29th Mar 2024	a. Prepare & submit mid-term progress report	COMPLETED
Dissertation Review	1st Apr – 22nd Apr 2024	a. Review of Dissertation report and feedback by Supervisor and Examiner, update the report based on feedback	COMPLETED
Final Dissertation Report & Presentation submission	23rd April – 30th April 2024	a. Consolidate the final report and submit in viva portal	COMPLETED

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5. GLOSSARY:

1. RCA [4] – Root Cause Analysis
2. CA Rally [6] – CA Agile Central (Rally) is an Agile Project Management Tool that allow users to gain visibility into the status of features, quality and risks.
3. CI/CD Pipeline [6] – Dev Ops automated process for Continuous Integration/Continuous Deployment
4. POC [6] – Proof of Concept – demonstration that illustrates the feasibility of an idea
5. PII [7] – Personal Identifiable Information – Member information such as First Name, Last Name, SSN, Date of Birth, Address
6. PHI [7] – Protected Health Information – Member health information such as member plan and claims details
7. Defect Resolution [8] – This field indicates the action taken to fix the defect. Valid values in Optum include – Design/Code change, Database Change, Converted, Not a Defect, Duplicate
8. Severity [8] – Shows the impact of defect, classified as Critical, Major, Medium, Low
9. MLRB [12] – Machine Learning Review Board – Board internal to Optum responsible for review and release of AI based software in production. Ensures company standards are met.
10. AI [4] - Artificial Intelligence
11. XGBoost [10] – Extreme Gradient Boosting is a powerful and efficient machine learning algorithm that is used for supervised learning tasks.

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