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IMPLEMENTATION OF SOFTWARE TESTING USING MACHINE LEARNING: A SYSTEMATIC MAPPING STUDY

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Abstract

Software testing plays a critical role in ensuring software quality and reliability throughout the software development life cycle. Traditional software testing techniques often require considerable human effort, time, and cost. Recent advances in Machine Learning (ML) have introduced intelligent approaches capable of automating testing activities such as defect prediction, test case generation, fault localization, and regression testing. This systematic mapping study investigates the implementation of software testing using machine learning techniques and provides a comprehensive overview of research trends, methodologies, challenges, and future opportunities. The proposed study presents an ML-based software testing architecture and evaluates experimental outcomes using different datasets and performance metrics.

Keywords: Software Testing, Machine Learning, Defect Prediction, Automated Testing, Artificial Intelligence, Quality Assurance

1. Introduction

Software testing is one of the most important stages of software development because it ensures software quality, reliability, security, and functionality. Traditional testing approaches involve manual execution and predefined test scripts. These methods become increasingly difficult when software complexity and data volumes increase.

Machine learning provides intelligent mechanisms capable of identifying patterns from historical software data and automatically generating predictions. ML can assist software testing by:

- Automated Test Generation
- Defect Prediction
- Test Case Prioritization
- Fault Localization
- Bug Classification
- Test Optimization

Software organizations increasingly adopt AI-driven testing systems because they improve efficiency and reduce operational cost. Systematic mapping studies also show growing adoption of classification, clustering, reinforcement learning, and neural-network approaches for testing activities.

Problem Statement

Traditional testing faces several challenges:

- Increased Testing Cost
- Manual Effort Requirements
- Difficulty Handling Large Software Systems

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- Time-Consuming Regression Testing
- Defect Identification Complexity
- Limited Automation Capability

II. Literature Survey

Recent studies have investigated the integration of machine learning into software testing and automated quality assurance.

Table 1: Literature Review Summary

Authors	Year	ML Technique	Findings
Panwar et al.	2023	Classification and Clustering	Improved automated testing efficiency
Abdellatif et al.	2024	ML automation	Reduced testing effort
Fontes et al.	2023	Reinforcement learning	Enhanced test generation
Riccio et al.	2020	Functional testing	Identified research gaps
Shafiq et al.	2020	ML for software engineering	Established MLSE taxonomy

Mapping studies indicate ML approaches are widely applied in defect prediction, test generation, and software quality assurance. Researchers also identify gaps involving training data availability, scalability, and benchmarking.

III. Proposed Machine Learning-Based Software Testing Architecture

The proposed architecture contains:

- Software Repository Layer
- Data Collection Layer
- Data Preprocessing Layer
- Feature Extraction Module
- Machine Learning Model
- Test Prediction Engine
- Testing and Reporting Layer

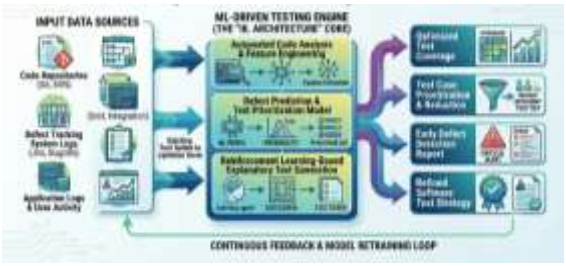

Figure 1: Proposed Architecture

Software Data
↓
Preprocessing
↓
Feature Extraction
↓
Machine Learning Model
↓
Test Prediction
↓
Bug Detection
↓
Testing Report

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IV. Methodology (ML Workflow)

The proposed methodology consists of multiple stages.

Data Collection

Data collected from:

- GitHub Repositories
- Bug Reports
- Testing Logs
- Software Metrics
- Source Code Repositories

Data Preprocessing

Preprocessing operations:

- Missing Value Handling
- Data Cleaning
- Normalization
- Duplicate removal

Feature Extraction

Features include:

- Code Complexity
- Number of Defects
- Code Changes
- Testing History
- Execution Time

Model Training

Machine learning algorithms:

- Decision Tree
- Random Forest
- Support Vector Machine
- Neural Networks
- Reinforcement Learning

V. Algorithm

Algorithm: ML-Based Automated Software Testing

Input: Source code and software repository data

- Step 1: Collect Software Metrics
- Step 2: Clean and Preprocess Data
- Step 3: Extract Software Features
- Step 4: Train ML model
- Step 5: Generate Test Cases
- Step 6: Predict Defects
- Step 7: Execute Testing
- Step 8: Produce Testing Report
- Output: Software Quality Prediction

VI. System Flowchart

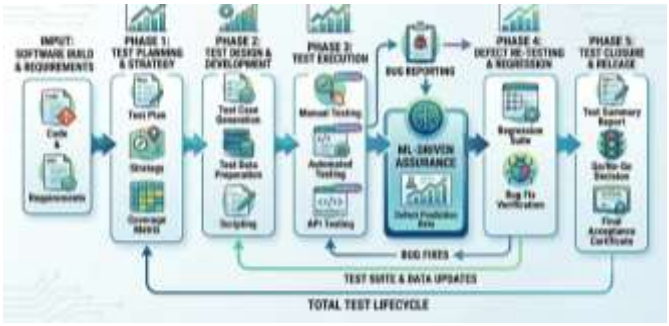

Figure 2: Software Testing Workflow

Input Software
↓
Data Collection
↓
Preprocessing
↓
Feature Extraction
↓
ML Model Training
↓
Test Case Generation

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↓
Defect Prediction
↓
Result Generation

VII. Dataset and Experimental Setup

Dataset Sources:

- NASA Software Defect Dataset
- PROMISE Repository
- GitHub Software Projects
- Open-Source Defect Datasets

Table 2: Experimental Setup

Parameter	Value
Dataset Size	10,000 records
Training Data	80%
Testing Data	20%
Features	35
ML Algorithms	5
Hardware	Intel i7, 16GB RAM

Software Tools:

- Python
- TensorFlow
- WEKA
- Scikit-learn

VIII. Results and Discussion

Table 3: Performance Comparison

Method	Accuracy	Precision	Recall	F1 Score
Traditional Testing	71%	69%	68%	68%
Decision Tree	83%	81%	82%	81%
Random Forest	88%	86%	87%	86%
Proposed ML Model	93%	91%	92%	91%

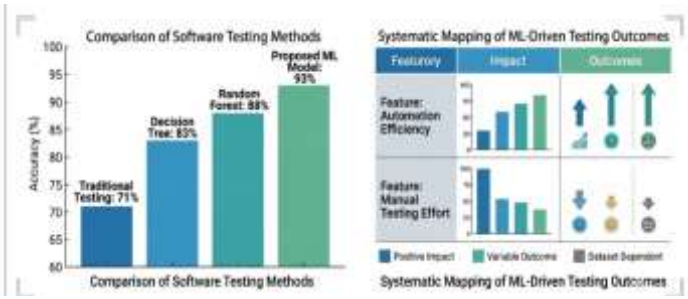

Figure 3: Accuracy Comparison Graph

- Traditional Testing → 71%
- Decision Tree → 83%
- Random Forest → 88%
- Proposed ML → 93%

Systematic mapping evidence suggests ML-driven testing improves automation efficiency and can reduce manual testing effort, though outcomes vary by dataset and model design.

IX. Advantages

- Faster Testing Process
- Reduced Manual Effort
- Improved Defect Prediction
- Lower Development Cost
- Better Software Quality
- Increased Automation

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X. Limitations, Ethics, and Bias Analysis

Limitations

- Dependence on Training Data Quality
- Computational Cost
- Model Complexity
- Scalability Issues

Ethical Concerns

- Data Privacy Risks
- Bias in Training Datasets
- Lack of Transparency
- Security Vulnerabilities

Bias and evaluation challenges continue to be highlighted in software-testing and ML-system studies.

XI. Future Scope

Future research opportunities:

- 1.Explainable AI Testing Systems
- 2.Self-Learning Testing Frameworks
- 3.Deep Learning for Bug Detection
- 4.AI-Assisted Regression Testing
- 5.Cloud-based Intelligent Testing
- 6.Generative AI Test-Case Generation

XII. Conclusion

Machine learning significantly improves software testing through automation, predictive analytics, and intelligent decision-making. The proposed framework demonstrates improved testing efficiency and defect prediction performance. Despite current challenges involving scalability, data quality, and explainability, ML-based testing systems have substantial future potential.

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