



Cyprus
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Master's Thesis

**PREDICTIVE MAINTENANCE OF CONTAINER
HANDLING EQUIPMENT USING MACHINE LEARNING**

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Limassol, May 2025

CYPRUS UNIVERSITY OF TECHNOLOGY
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DEPARTMENT OF ELECTRICAL ENGINEERING, COMPUTER
ENGINEERING AND INFORMATICS

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Supervisor

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Approval Form

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ABSTRACT

This thesis explores the application of Machine Learning (ML) techniques for Predictive Maintenance (PdM) in container terminal operations, with a focus on predicting inverter overtemperature faults due to fan failures, clogged filters, and other related issues in Straddle Carriers, a type of Container Handling Equipment (CHE). The study uses operational data collected from the EUROGATE Container Terminal Limassol in Cyprus. Five ML models, namely Artificial Neural Networks (ANN), Random Forest (RF), Extreme Gradient Boosting (XGB), Decision Trees (DT), and Gaussian Naïve Bayes (GNB), were developed, trained, and optimized using Grid Search. Feature importance analysis identified inverter and motor data as the most influential predictors of failure. The models were evaluated on a test dataset using standard classification metrics, and an offline test was conducted using recorded failure events. Among the models, ANN, RF, and XGB demonstrated the highest effectiveness in detecting inverter overtemperature faults while minimizing false positives, achieving F1 scores of up to 0.82. These three models were further analyzed using SHapley Additive exPlanations (SHAP) and subjected to real-time testing through a Majority Voting approach. SHAP analysis revealed that RF and XGB predictions were primarily influenced by motor data, while ANN relied on both motor and inverter data. In two distinct real-time testing scenarios, the Majority Voting scheme achieved F1 scores of 0.68 and 1.00, respectively.