Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Gokul Thillainathan
Assignment title:	Turnitin FINAL Dissertation Submission
Submission title:	C00313519_Gokul_Thillainathan.docx
File name:	C00313519_Gokul_Thillainathan.docx
File size:	1.69M
Page count:	28
Word count:	10,058
Character count:	59,768
Submission date:	19-Aug-2025 01:36AM (UTC+0100)
Submission ID:	2731645212

REACTIVE TO PREDICTIVE: ANOMALY DETECTION IN ROBOTIC ARM USING DEEP LEARNING

Gokul Thillainathan
MSc. Data Science
South East Technological University
Carlow, Ireland
gokulthillai2001@gmail.com

ABSTRACT

The rapid adoption of collaborative robots in manufacturing, logistics, and inspection sectors serves as a cornerstone of Industry 4.0, enabling intelligent and safe human-machine collaboration that enhances efficiency and productivity. As these robots become integral to mission-critical processes, their reliability and ease of maintenance assume central significance. Conventional maintenance paradigms—varying from reactive repairs to periodic overhauls—are proving insufficient in environments characterized by high throughput and tight precision tolerances. Such reactive regimes typically overlook gradual deterioration at the level of individual joints, permitting degradation to advance until catastrophic failure manifests. The consequences—unscheduled outages, diminished product quality, and inflated operational costs—underscore the urgency for more proactive interventions.

This research proposes a real-time, data-centric predictive maintenance framework tailored for collaborative robotic platforms. The architecture leverages state-of-the-art deep learning algorithms—specifically Long Short-Term Memory Autoencoders (LSTM-AEs) and Gated Recurrent Unit Autoencoders (GRU-AEs)—to discern anomalies in joint performance by reconstructing and analyzing multivariate time-series signals recorded during normal operation. The feature subset comprises actual and set-point measurements of joint position, velocity, and motor current, selected for their mechanical relevance and cross-validated using Principal Component Analysis (PCA) to balance physical interpretability with statistical robustness.

To ascertain the robustness of the detection mechanism, a head-to-head analysis of LSTM- and GRU-based autoencoder configurations is performed, with performance gauged by anomaly detection precision, mean and peak reconstruction errors, and wall-clock training and inference times.

While explicitly developed for collaborative robots, the framework outlined herein does not constrain itself to any particular platform or vendor. Its generality permits deployment on any robotic architecture that returns joint-level telemetry streams. By integrating deep-learning-powered anomaly characterization with thresholds rooted in domain expertise, the approach yields a proactive, interpretable, and scalable maintenance mechanism. Such a mechanism fortifies the robustness and productivity of smart robotic fleets, thereby