Automating Robotic Construction and Extrusion System Through Control System Applications

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Introduction

Motivation and Objectives

- *Current 3DCP applications are dominated by heuristic, trial-and-error methods, relying heavily on human decision making. Manual process control increases material consumption costs and prolongs production times.*
- *Anomaly detection can be used to predict failures, and provide a step towards real-time automatic control for 3DCP applications.*

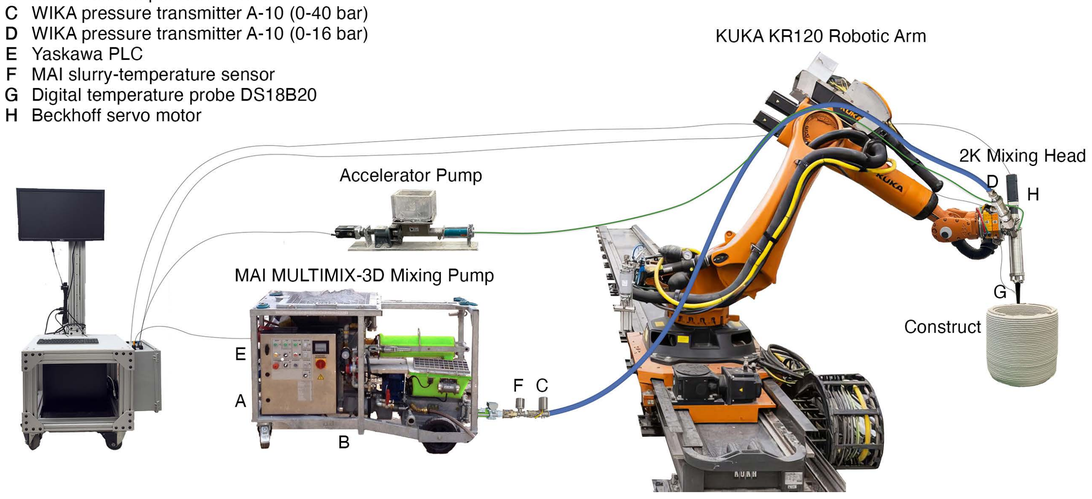
Contributions

- We present a method for indentifying key indicators that can detect when an anomaly has occured in a 3DCP system.
- Experimental results have bee shown to predict failures up to 40 minutes in advance of manual detection.

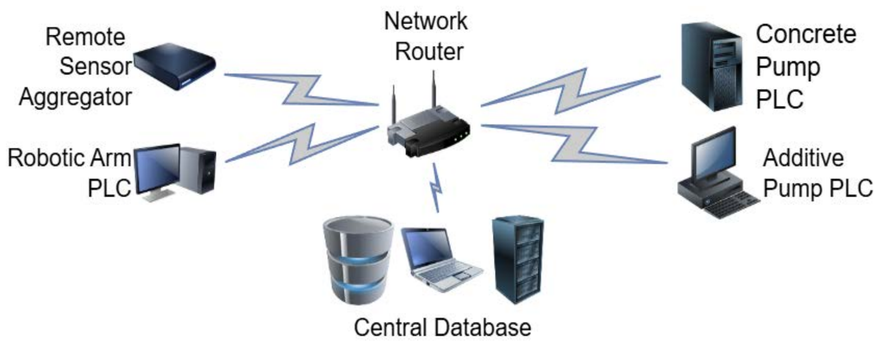
Research Set Up

1 Part 01 - System Creation

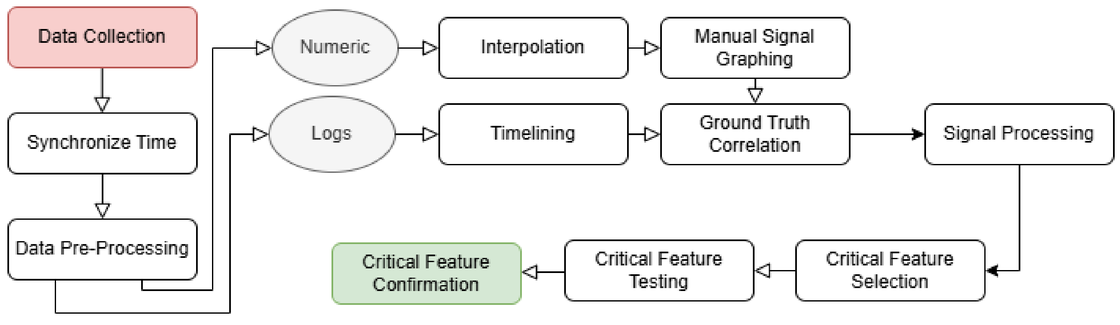
A OMET temperature / humidity transmitter P3110E
B MAI water-temperature sensor
C WIKA pressure transmitter A-10 (0-40 bar)
D WIKA pressure transmitter A-10 (0-16 bar)
E Yaskawa PLC
F MAI slurry-temperature sensor
G Digital temperature probe DS18B20
H Beckhoff servo motor



2 Part 02 - Data Collection

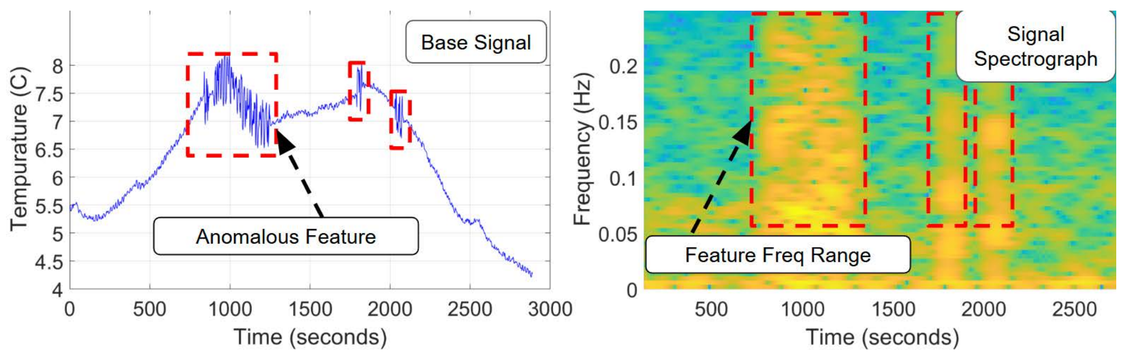


3 Part 03 - Workflow design

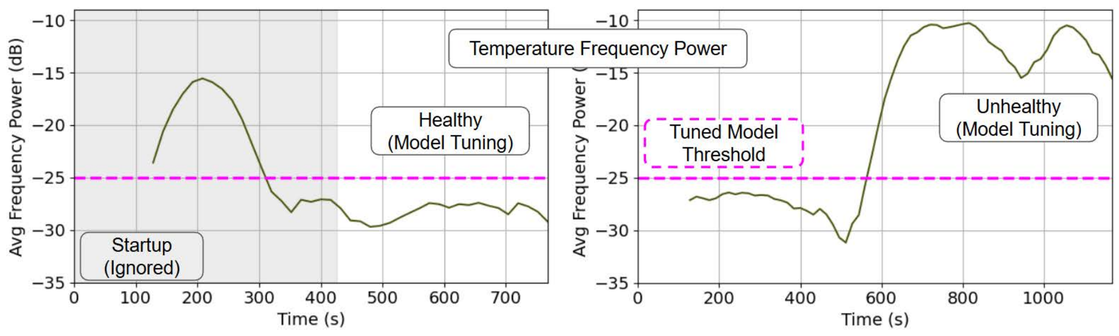


Results

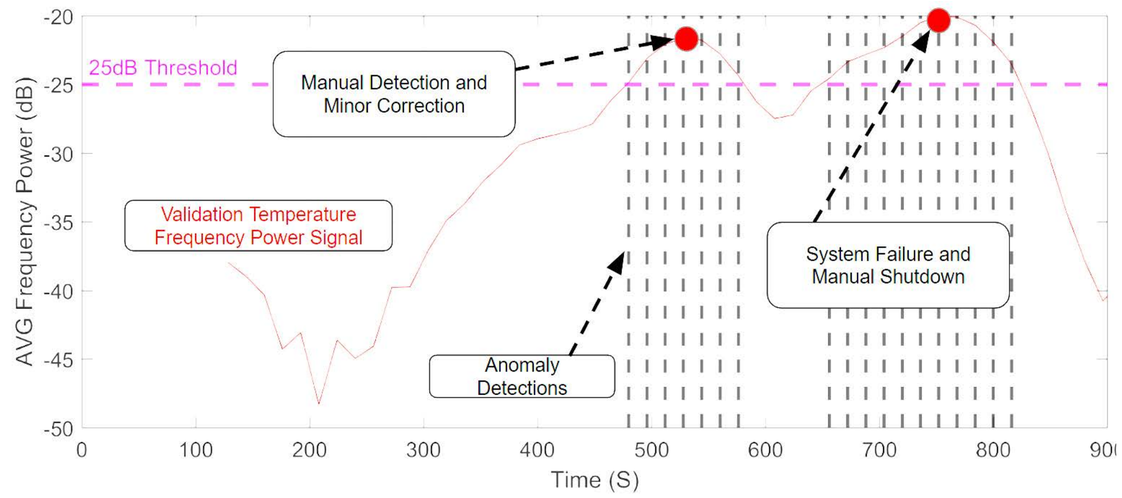
1 Step 01- Feature Identification



2 Step 02 - Constant Threshold Tuning



3 Result03 - Feature Verification



Real Time Simulation

Conclusion and Future work

Conclusions

- *Our proposed framework can detect anomalies using signal indicators from temperature, pressure, and torque data..*
- *Testing our framework using experimental data shows anomaly detections up to 40 minutes prior to manually identified anomalies within the system.*

Future Work

- Future research will explore anomaly classification across a wide range of failure modes.
- Predictive control strategies will be investigated to ensure robust 3DCP under uncertain conditions.

Reference:
[1]Bos, F., Wolfs, R., Ahmed, Z., Salet, T., 2019. Large scale testing of digitally fabricated concrete (dfc) elements, in: First RILEM International Conference on Concrete and Digital Fabrication–Digital Concrete 2018, Springer. pp. 129–147
[2]Wolfs, R., Bos, D., Caron, J.F., Gerke, M., Mesnil, R., Buswell, R., Ducoulombier, N., Hack, N., Keita, E., Kinnell, P., et al., 2024. On-line and in-line quality assessment across all scale levels of 3d concrete printing. Cement and Concrete Research 185, 107646.
[3]Kamhawi, A., Lin, Y., Watson, C., Barton, K., & Meibodi, M. A. (2025). A framework for process anomaly detection in 3D concrete printing (Preprint). University of Michigan.