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Canon

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Data-Driven Solutions for Lifespan and Failure Prediction in Printing Systems

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Background

Precisely predicting the lifespan and failure mechanisms of critical components in production printing are essential for manufacturers to plan maintenance, optimize production output, and improve the functionality of their products.

This work, performed in collaboration with **Canon Production Printing (CPP),** proposes the use of **statistical** and **machine learning** methods to predict the **lifespan** and **failure mechanisms** of printheads.

Accurately performing failure patterns prediction is a **significant challenge** given their variability and complexity and lack of reliable data. Current approaches focus mainly on **rule-based classification**, which struggles with high variability and implicit patterns.

Printhead lifespan prediction

In this work, we investigated the use of **survival analysis** for predicting the **lifespan of production printheads** developed by **Canon Production Printing**. Specifically, we focused on the application of five (5) techniques to estimate **survival probabilities** and **failure rates**. Our work is organized in the following pipeline to obtain estimates.

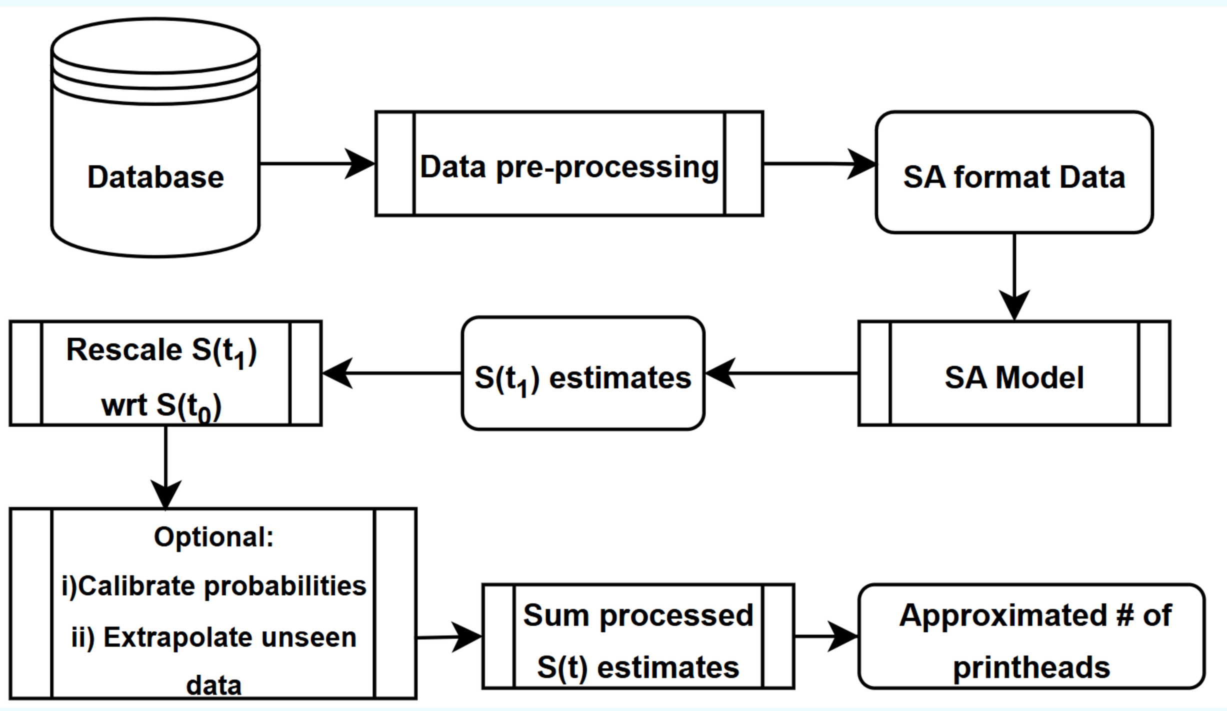
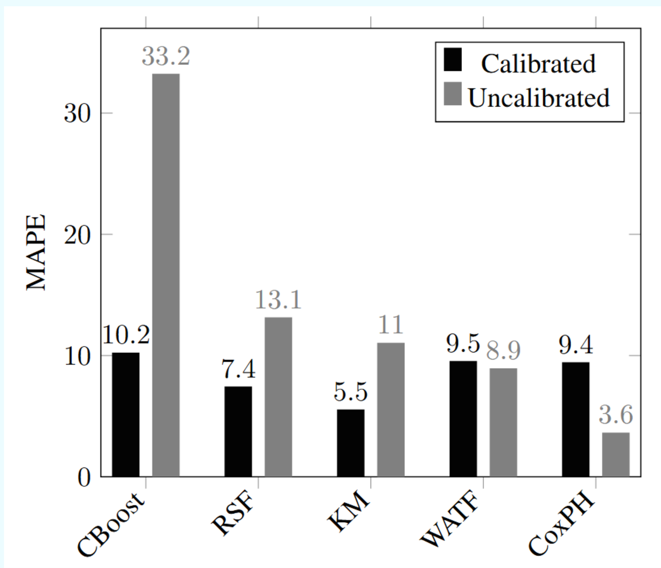


Figure 1: Outline of the prediction workflow

To generate the survival estimates we employed five different models: **Kaplan-Meier**, **Cox proportional hazard model**, **Random Survival Forest**, **Gradient Boosting** with **CoxPH loss function** and the **Weibull accelerated time-failure model.**

Our quantitative evaluation demonstrates that survival analysis **outperforms industry-standard baseline methods for printhead lifespan prediction**.



Model	CI	IBS
CBoost	**0.818**	**0.077**
RSF	0.807	0.096
WATF	0.79	0.091
CoxPH	0.774	0.094
KM	N/A	0.2
Random Estimator	0.5	0.25

Figure 2: Mean Absolute Percentage Error, Concordance Index and Integrated Brier score

Conclusion

This work provides the groundwork for further machine learning application at **CPP** and the development of **holistic intelligent monitoring and prediction systems**.

Failure mechanisms identification in printhead nozzles

A nozzle is a critical component of a printhead that jets ink on media. A printhead consists of hundreds of nozzles, the life status of which is constantly recorded. When printheads fail, it is often possible to establish the associated failure mechanism based on the patterns in nozzle logging.

The dataset of our study consisted of **411 printheads**, removed from printers in the field due to nozzle failures. There were five (5) failure mechanisms derived from nozzle log patterns, assigned by Canon Production Printing domain experts. The patterns can be observed in space from the top view of a nozzle log grid, and in time from the developments in the numbers of failed nozzles.

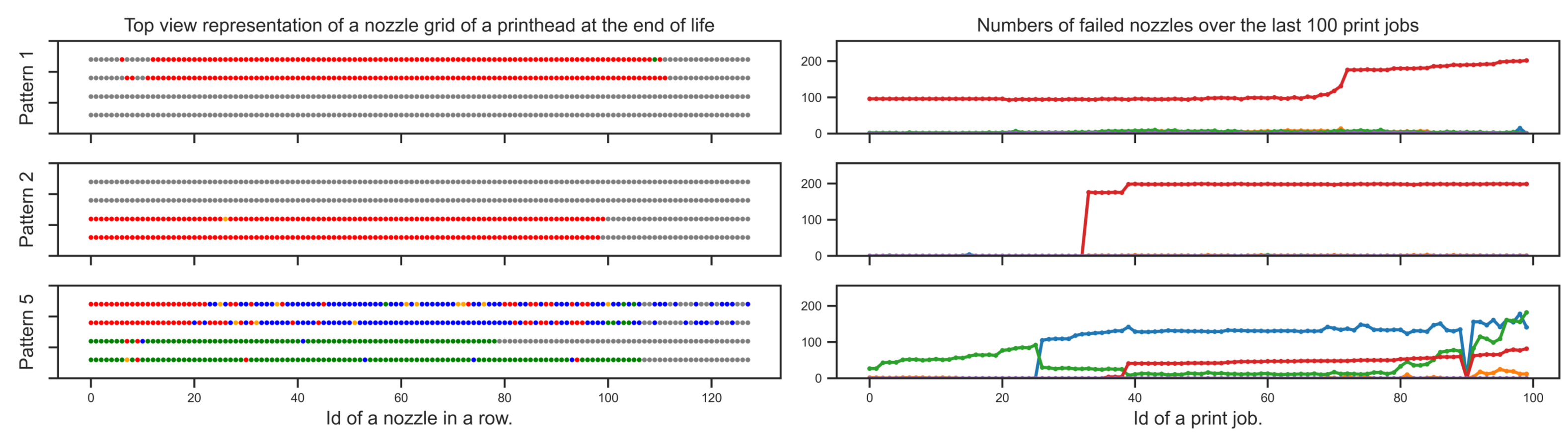


Figure 3: Example of failure patterns

	Model	P	R	F1	Support
Pattern 1	Rule-based	0.93	0.97	0.95	129
	OVR RF	0.91	0.96	0.93	
Pattern 2	Rule-based	0.80	0.99	0.89	75
	OVR RF	0.99	0.93	0.96	
Pattern 3	Rule-based	1.0	1.0	1.0	30
	OVR RF	0.90	0.90	0.90	
Pattern 4	Rule-based	0.76	0.73	0.75	26
	OVR RF	0.92	0.92	0.92	
Pattern 5	Rule-based	0.92	0.52	0.67	23
	OVR RF	0.91	0.87	0.89	
Weighted average	Rule-based	0.89	0.92	0.90	283
	OVR RF	0.93	0.94	0.93	

Figure 4: classification report of rule-based baseline and ML model for the five common output labels

A set of spatial and time-based features was extracted from nozzle log with the guidance of domain experts. An ML classifier based on **One-vs-Rest Random Forest** was developed, outperforming the rule-based baseline for most error classes, **improving F1 score from 0.90 to 0.93.**

References

Parii, D., Janssen, E., Tang, G., Kouzinopoulos, C., Pietrasik, M., 2025. “Predicting the Lifespan of Industrial Printheads with Survival Analysis”. To appear in the 2025 IEEE Conference on Industrial Cyber-Physical Systems. ICPS25

Prianikov, N., Janssen, E., Pietrasik, M., Kouzinopoulos, C., 2025. “Pattern Detection in Printhead Nozzle Logging”.

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