Lifetime Prediction of 1550 nm DFB Laser using Machine Learning Techniques

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Motivation

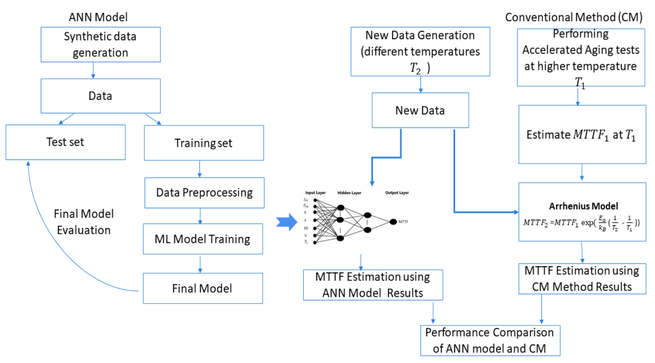
- The drawbacks of the conventional method:
  - Computationally complex and time consuming
  - Inaccurate and low level of confidence
  - Overestimation of actual MTTF
- Machine learning (ML) is a powerful tool to develop predictive maintenance approaches
- The ability of ML to glean insights from data within a complex and dynamic environment
- The ability of ML to adjust to new and unseen data

Objectives

- To develop a laser lifetime prediction model based on ML modelling the dependency between MTTF and the different laser parameters
- Accurate prediction of MTTF under different operating conditions

Methods

Methodology Flowchart



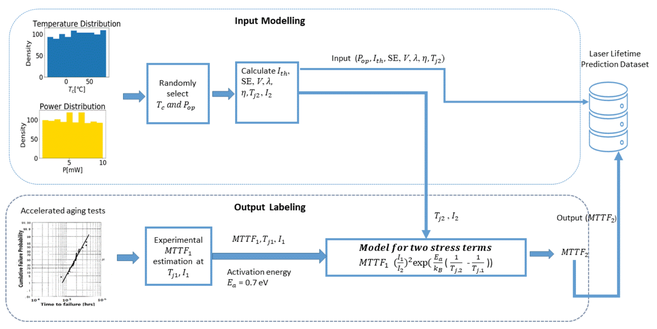
Case Study:

1550 nm InGaAsP MQW DFB laser

Electro-Optical Characteristics:

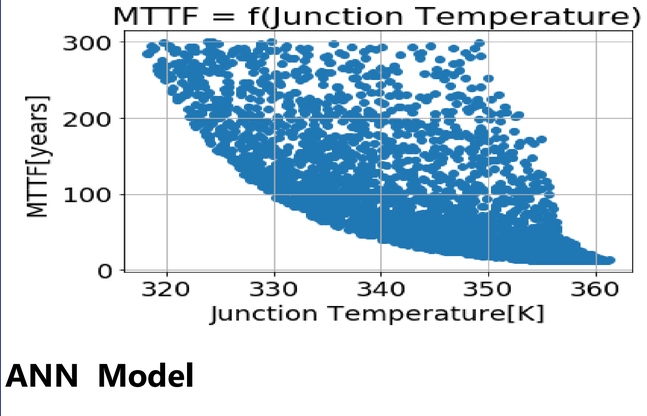
- -40 °C $\leq T_c \leq$ 85 °C
- 1530 nm $< \lambda <$ 1570 nm
- 0.9 V $< V <$ 1.3 V
- $P \leq$ 10 mW
- SMSR > 30 dB

Dataset Generation Process



Dataset Overview

2539 samples



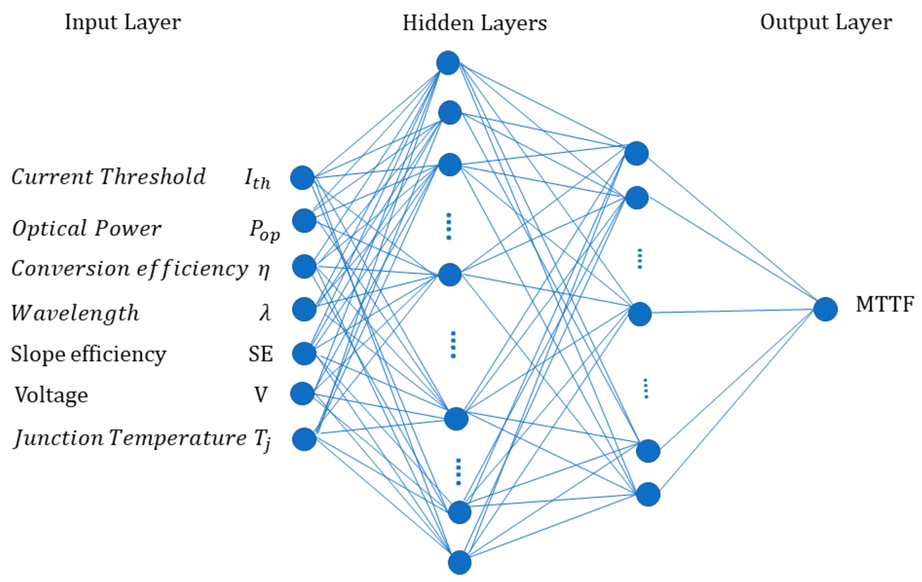
ANN Model

Two hidden layers:

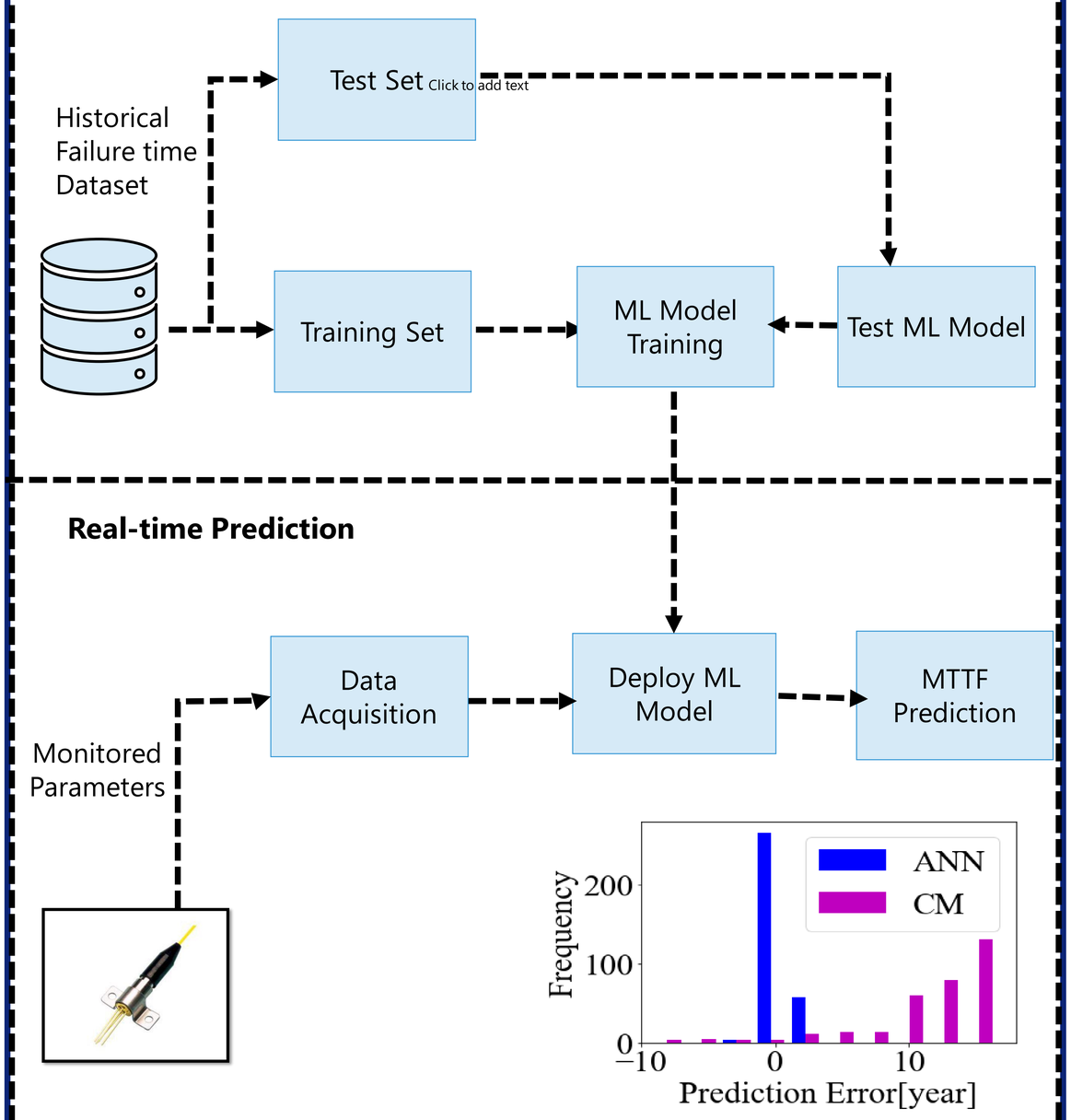
- 1st hidden layer: 200 neurons
- 2nd hidden layer: 100 neurons

An **artificial neural network** (ANN) based approach predicts the **mean-time-to failure** (MTTF) of **laser** under different operating conditions with **higher accuracy** compared to the accelerated aging tests.

ANN Model for Laser Lifetime Prediction



ML Model Flow Chart



Conclusions

- A novel approach for laser lifetime prediction using ANN has been presented
- The proposed ANN Model outperforms the conventional laser lifetime projection method
- Higher accuracy and applicability to unseen operating conditions

Next Steps

- Collection of experimental or in-field data for the performance evaluation of the developed model

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Results

Evaluation Metrics

- RMSE

$$RMSE = \sqrt{\frac{\sum (MTTF_{predicted} - MTTF_{GT})^2}{N}}$$

- Scoring Function

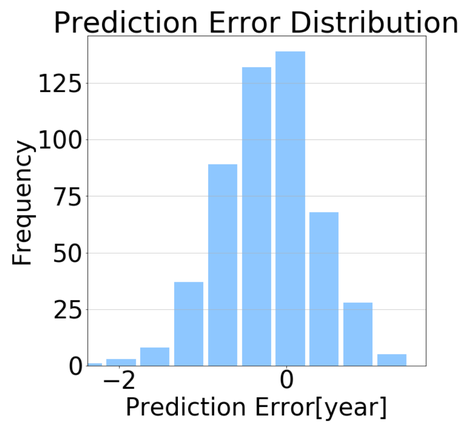
$$S = \begin{cases} \sum_{i=1}^{N} (e^{\frac{-h_i}{13}} - 1) & \text{for } h_i < 0 \\ \sum_{i=1}^{N} (e^{\frac{h_i}{10}} - 1). & \text{for } h_i \geqslant 0 \end{cases}$$

Where $h_i \triangleq MTTF_{predicted} - MTTF_{GT}$

ANN Model vs Conventional Method

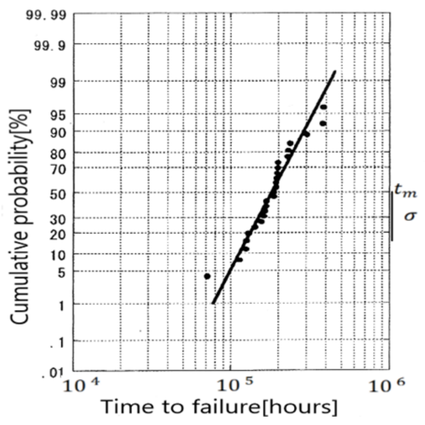
ANN Performance Evaluation

- RMSE = 0.54[year]
- Scoring function = 5.29×10^2



Conventional Method

- Accelerated aging tests for 25 devices under constant power 10 mW at 70 °C conducted for 5,000 hours
- **Failure criterium** defined as **50%** increase of the operating current
- Probability density function of life modelled by **log-normal distribution**



Comparison of Results

Test Dataset

- Similar optical power P = 10 mW
- Different (case) temperatures
- 334 samples

Evaluation Metric

- RMSE
- Scoring function

Evaluation Metric	ANN	Conventional Method
RMSE[year]	0.8	12.6
Scoring Function	3.46×10^2	11.51×10^2

References

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