

## **Attention-based BiLSTM-XGBoost model for reliability assessment and lifetime prediction of digital microfluidic systems**

In this manuscript the authors proposed an Attention-based BiLSTM-XGBoost model for reliability and lifetime detection for DMF systems. The detailed reviews of the manuscript are as follows:

Specific Comments:

Abstract:

1. The abstract contains too lengthy sentences; try to simplify and shorten them.
2. In the last sentence of the abstract, there is a misplaced stop (.) in between “accuracy. which”, correct it.

### **Section 1: Introductory:**

3. First paragraph: write “With these devices” instead of “With EWOD devices”.
4. “EWOD-based DMF systems”: You have already mentioned that DMF systems are based on EWOD, hence no need to repeat this.
5. Write “In recent years, Tong Zhaoduo et al. proposed a DMF device” instead of “In recent years, Tong Zhaoduo et al. proposed a DMF system device”.
6. Last sentence second paragraph: replace “EWOD” by “DMF”.
7. First sentence third paragraph: replace “in China and abroad” by “worldwide”, also the statement is missing references.
8. First sentence in fourth paragraph: “Li et al. 2022” this paper is missing in the reference list. The claim of the authors is also vague; though the “methods already exist in other fields” does not assure that, these methods will be fruitful for DMF; as lots of constraints are there, like tiny size, different working principle, application of DMF in safety critical application & point of care, implying precision and robustness important attribute for DMF devices. Hence without thorough experiment and observation it cannot be concluded that methods useful for others areas could be easily incorporated for DMF devices.
9. Last sentence in fourth paragraph: “These reliability assessments and remaining life prediction methods provide valuable references and theoretical values for the reliability and life detection methods of DMF systems.” None of these papers discussed in this paragraph are related to microfluidic technology. Most funny is that the last one is on aircraft engine (Guo, J., Lei, S., & Du, B. (2024). MHT: A multiscale hourglass-transformer for remaining useful life prediction of aircraft engine.)

### **Section 2: Driving and detection mechanism of DMF system based on EWOD**

10. Reference is required for 3<sup>rd</sup> sentence in first paragraph.
11. What is “DWOD”?
12. Throughout the first paragraph sentences require references. A figure of the device could better describe the structure.
13. As mentioned by the authors “Here we define: when the equivalent capacitance value of the drive electrode of the EWOD device is 80-100% of the original value as the normal loss period. When the equivalent capacitance value of the drive electrode is 50-80% of the original value, it is the recession period. When the equivalent capacitance value of the drive electrode is less than 50% of the original value, it is the damage period.” What is basis these?

### **Section 3: Reliability Assessment and Failure Time Prediction Model Based on BiLSTM-XGBoost Model**

14. Last sentence, Second Para “(Nguyen H.D et al. 2020; School of Communication and Information Engineering et al. 2020; Jaemin Yang and Jonghyun Kim. 2018).” :the reference “of Communication and Information Engineering et al. 2020” is wrongly inserted or not found.

15. The authors mentioned: “the next level or final output. These weights correspond to the weights of the forgetting gate, the input gate and the output gate, respectively.” It is not clear which weights the authors talking about? They did not mention anything about parameter settings and weights yet.

#### Section 4: Experiments and analyses

16. In the first sentence of the second paragraph the authors mention that “In this study, the capacitance values of the EWOD device were collected as experimental data using the equivalent capacitance acquisition system previously proposed by the research team.” Proper reference of this existing work and dataset description with data link are required. Otherwise the proposed worked cannot be verified.
17. The figure 8 is confusing as the test droplet stays at the same position in the 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> sub-figure similarly 1<sup>st</sup>, 5<sup>th</sup> and 6<sup>th</sup>. Also it would be better if you numbered the figure as “figure 8.a, figure 8.b and so on.
18. Repeated statements under section 4.3 “ It can be seen that among the three optimization algorithms, the RMSE of Adam and RMSprop is significantly smaller than that of SGDM. although Adam and RMSprop have their advantages and disadvantages in many experiments, in general, Adam has the smallest RMSE when it is used as an adaptive optimization algorithm. Therefore, in this experiment, we use the Adam optimizer for gradient optimization to obtain the optimal model parameters.”
19. The authors mentioned that “the fitting results of the three experiments are shown in Fig. 6, where the red curve represents the target value of the model, and the blue curve represents the predicted value of the model.” But there is no such result in Fig. 6.
20. Repeated statements in last paragraph under section 4.3 “we do not need to take corresponding measures, we only need to continue to monitor the device Therefore, we do not need to take corresponding measures, just need to continuously monitor the device”.
21. As mentioned by the authors in last paragraph under section 4.3: “such as lowering the voltage, lowering the temperature of the device, and so on.” How did you lower the temperature of the DMF devices?
22. Repeated statements in last sentence of first paragraph under section 4.4 “To investigate whether the BiLSTM model has better performance than the BiGRU model in this experiment, in this experiment, we use the same idea to construct the BiGRU model and use the same Attention-based architecture for fair comparison.”
23. Last sentence of the fourth paragraph under section 4.4: “In the prediction task at 45V driving voltage, the performance is even degraded compared to the BiGRU model, and its prediction metrics are overall lower than the BiLSTM-XGBoost model.” The sentencing is confusing, meaning not clear.
24. As mentioned by the authors: “To verify the effectiveness of each part of the BiLSTM pre-trained model, a series of ablation experiments were conducted, and the specific results are shown in Tables 7, 8, and 9.” Is BiLSTM a pre-trained model? Or the authors trained it with the EWOD capacitance dataset? If first one is true then, will it perform accordingly to predict the lifetime of a digital microfluidic systems?
25. As mentioned by the authors: “The experiments show that the prediction model using both the two-layer BiLSTM model and the Attention layer achieves the best results in the prediction tasks for all three driving voltages.” Which one is better model “two-layer BiLSTM model with Attention or BiLSTM-XGBoost?

General Comments:

Abbreviations are used without defining full form (SS, MEC, etc).

Throughout the manuscript author-year citation is used, but reference list does not follow the same, hence difficult to track.

Too many long sentences throughout the manuscript; shorten them.