Background

The increasing interest in e-mobility vehicles fosters a strong demand for corresponding batteries. To satisfy the market, Edison Cars AG operates production facilities for manufacturing e-mobility vehicle batteries at four sites worldwide (i.e., Germany, China, South Africa, and the USA). However, in these production facilities, unscheduled machine breakdowns repeatedly lead to production stops that inhibit permanent and saturated production. Despite the company having already made great efforts in the past to improve maintenance activities, the current maintenance strategy is still cost- and time-intensive. Hence, the Board of Edison Cars AG strategically moved from reactive to predictive maintenance.

To do so, Edison Cars AG has already equipped its assembly robots with various sensors, including temperature and pressure sensors, which continuously monitor machine performance. Edison Cars AG aims to detect unscheduled machine breakdowns at an early stage, especially by monitoring the temperature and pressure of the assembly robots during the manufacturing of e-mobility vehicle batteries.

The temperature sensors play a crucial role in detecting potential issues with the robot's soldering temperature. The predictive maintenance system compares the temperature data with the pre-set values. If the system detects that the soldering temperature exceeds the acceptable range for an extended period, it immediately issues a warning. This early detection allows a technician to be notified promptly. Upon inspecting the robot, the technician discovers the welding nozzle is damaged. By addressing this issue promptly, the technician avoids more significant damage that could have occurred if the problem had gone unnoticed.

Similarly, vibration sensors are employed to monitor the robot's housing. The predictive maintenance system continuously analyzes the vibration levels and compares them to the pre-set values. If the system detects excessive vibrations persisting over an extended period, it alerts a technician. Upon investigation, the technician finds that a screw is loose and requires replacement. Identifying and resolving this issue promptly prevents potential malfunctions or breakdowns, ensuring uninterrupted production.

Task

Determine from the given sensor values of 20 robots with the help of an algorithm whether a robot currently works well, requires maintenance, or is at risk of breaking down. In this context, label the sensor data into three machine intervals: "long" = no maintenance is necessary, "short" = robot should be maintained, and "urgent" = robot is in danger of breaking down (tip: have a look at the data before your labeling).

Describe your labeling strategy for the test data and mention the aspects that influenced your choice (e.g., late maintenance may cause costs for production). Please also justify why the three machine intervals have the length you choose.

Finally, implement a predictive maintenance algorithm, which can detect based on the sensor data of a robot when no maintenance is necessary ("long"), a robot should be maintained ("short"), and the robot is in danger of breaking down ("urgent"). Also, calculate the confusion matrix for your trained algorithm.

Input

For this task, you will be provided with the following input:
- Sensor data from 20 robots (approx. 6000 data points per sensor), each with 4 temperature and 4 vibration sensors.
- Code example to perform a simple classification. You can also create a solution yourself in a common programming language if you prefer.
- Further information for predictive maintenance and machine learning. These are possible approaches that have different advantages and disadvantages. Of course, you can also use other approaches and resources:
  - Code quality: browserstack.com
  - Confusion Matrix:
    - https://towardsdatascience.com/understanding-confusion-matrix-a9ad42dcfd62
    - https://scikit-learn.org/stable/modules/generated/sklearn.metrics.confusion_matrix.html

  - Machine learning for Predictive Maintenance:
    - https://rjunaidraza.medium.com/predictive-maintenance-using-machine-learning-lstm-python-373396c6bb82
    - Part 1: https://datatonic.com/insights/machine-learning-predictive-maintenance/
    - Part 2: https://datatonic.com/insights/machine-learning-predictive-maintenance-hard-drive-failure/

Submission

The following documents must be emailed to s3g@fim-rc.de as one zip folder by 02:00 pm on 27.05.2024:
- Code file(s) to reproduce the results. This includes particularly the machine learning model for maintenance interval determination.
- Complete confusion matrix of the trained algorithm.
- A PowerPoint presentation explaining your approach to maintenance and how you labeled the data.

Keep in mind

The content provided here serves only as a starting point. Feel free to use your own approaches and algorithms to get the best possible maintenance intervals.

Use only the data provided.

The following aspects are important for the assessment of your submission:
- Code quality: The code must be executable, readable, commented, and adhere to the output format
- Your model will be tested on a hidden dataset of 5 more robots
- Predictive Maintenance Prediction: The prediction of the machine intervals should be as accurate as possible. The team with the best estimate receives a bonus
- Explanation of the approach should be understandable