Durable Tie Bar: Detection and Prediction using Artificial Intelligence

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ABSTRACT

Durable devices are very important for factories that fully use the devices. All devices have their own expiration date. But some devices are broken earlier than the expiration date. So, in this project we use Artificial Intelligence approach for prediction and detection on the device which is tie bar. This prediction and detection are including the strain, durability, rusting, density, expiration date, and other else. With this AI system, Alcon will be more alert on doing the maintenance.

Keywords: maintenance,tie bar,prediction,WEKA,MQTT protocol

1. Introduction

A tie bar construction for an injection molding machine, comprising of a stationary platen; a movable platen which is movable with respect to the stationary platen from a closed position in clamping engagement with the stationary platen to an open position spaced from the stationary platen; at least two hollow tie bars connecting the stationary platen to the movable platen; a stroke cylinder including a stroke cylinder rod within at least two of said tie bars operative to move the platens from an open to closed position and from a closed to an open position; wherein said at least two tie bars are fixed at one end only to one platen and said stroke cylinder rods are fixed at one end to the other platen; releasable clamping means to clamp the platens together in the closed position; and engagement means carried by at least two of said tie bars to engage said clamping means. It is used to support and align the platens, which then support the mold. The tie bars seldom break if it is properly maintained. However, if there are any issues regarding this part, it is usually because of fatigue damage, overload and break, failure caused by instantaneous impact stress and et cetera.

With the help of machine learning, data injected during the operation can be found and classify according to the training set we get from the most accurate and efficient algorithm we tested using data supplied by Alcon. Then, we get to predict which machine's tie bar is more likely to be prioritized for maintenance according to the pattern of data so technician can prepare beforehand.

2. Related Work

2.1 Artificial Intelligence

Artificial intelligence is one of the powerful technologies nowadays. It is also stated that the Artificial Intelligence itself will be focused more on the Industrial Revolution 5.0 which shows that AI is a very powerful technology to be implemented in any system or industry. As in [1], artificial intelligence means "is the ability of a computer program or a machine to think and learn. It is also a field of study which tries to make computers smart". Basically, artificial intelligence itself actually works as it trains the computer brain to works and learns how to make a decision for a human on any specific task. The training requires an exercise for many situations for the computer in order to understand the probability in all the situations so that it can totally predict the right outcome to their users. Once the computer understands the algorithm, it will be totally useful for humans as it can help the human brain to do many works as it can make the decision for the human.

2.2 WEKA

WEKA is one of the tools that provide machine learning to the user so that it can make use of it to learn the algorithm of a situation to perform as artificial intelligence. WEKA itself actually stands for "Waikato Environment for Knowledge Analysis" which was developed at the University of Waikato in New Zealand [2]. The learning algorithm made by the WEKA itself is all written in Java and almost all platforms can be used this application. These tools are actually aimed to provide a comprehensive collection of machine learning algorithms and data preprocessing tools to researchers and practitioners alike [3]. As it provides the machine learning tool, all the training data set can be the input for it so that it can train itself to understand the algorithm of the situation. After that, the WEKA tools also can test and apply to the real situation data to predict the next outcome for the data. Overall, WEKA tools are very powerful tools that are using the artificial intelligence concept which can help any problem and provide a solution by predicting the right outcome to the problem so that it can help humans to identify the outcome earlier before it happens.

2.3 MQTT Protocol

Nowadays the Internet of things has been very popular technology used since Industrial Revolution 4.0 which can help the connectivity to all devices in a system. Therefore, in IoT itself must have its own communication system in order to make all the devices connected to each other. MQTT is one of the connection systems which is a bit simpler and easier to manage the setup to be compared with any other communication system. MQTT itself actually stands for MQ Telemetry Transport. The MQTT is an extremely simple and lightweight messaging protocol, designed for constrained devices and low-bandwidth, high-latency or unreliable networks. MQTT protocol is used in the system for the communication part as it functions only on top of the Transport Control Protocol (TCP). [4] Furthermore, the MQTT protocol functions on a server-client system where the server, called a broker which pushes updates to MQTT clients. Thus, this communication system is really suitable for a simple IoT application such as this project which needs a simple connection and also lightweight message just to update the data regularly to the user.

3. Proposed Scheme

3.1 Real-time Data Collection

The strain sensor will be connected to NodeMCU or another Microcontroller. The microcontroller will be pushed the data to the Adafruit server via the MQTT protocol. Data is visualized using a built-in, customizable dashboard. To push the data, the microcontroller must be connected to the internet. The application that running on NodeMCU is written usingthe c-programming language, which is quite simple and easy to understand.

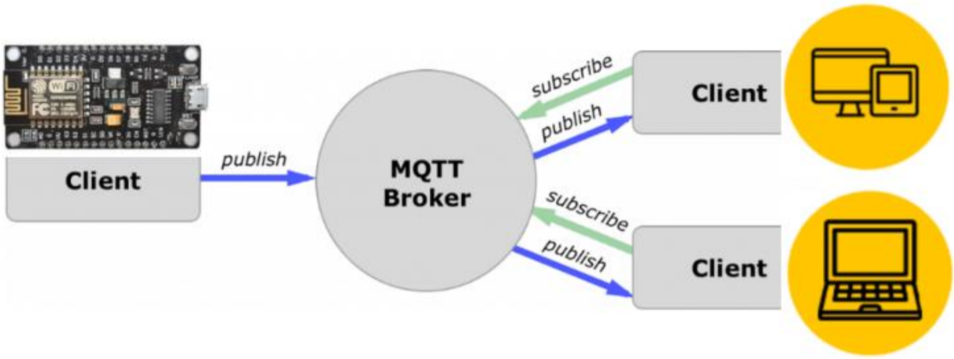

Figure 1. Client and Server Connection

From Figure 1 shows that microcontroller as the client. The microcontroller will be attached to every machine that have tie-bar and every tie-bar in the machine will be attached with the strain sensor as in Figure 2. The strain sensor will collect the strain value and the microcontroller will send the data to the MQTT broker which is the Adafruit server. The microcontroller must have internet connection for send the data. The data will be logging every 5s in the MQTT Broker. The client will see the data logging if the client subscribes to the MQTT broker.

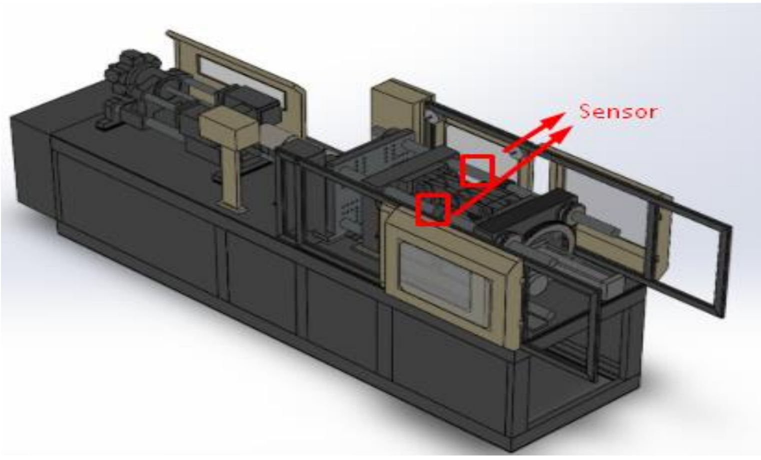

Figure 2. Placement of Sensor

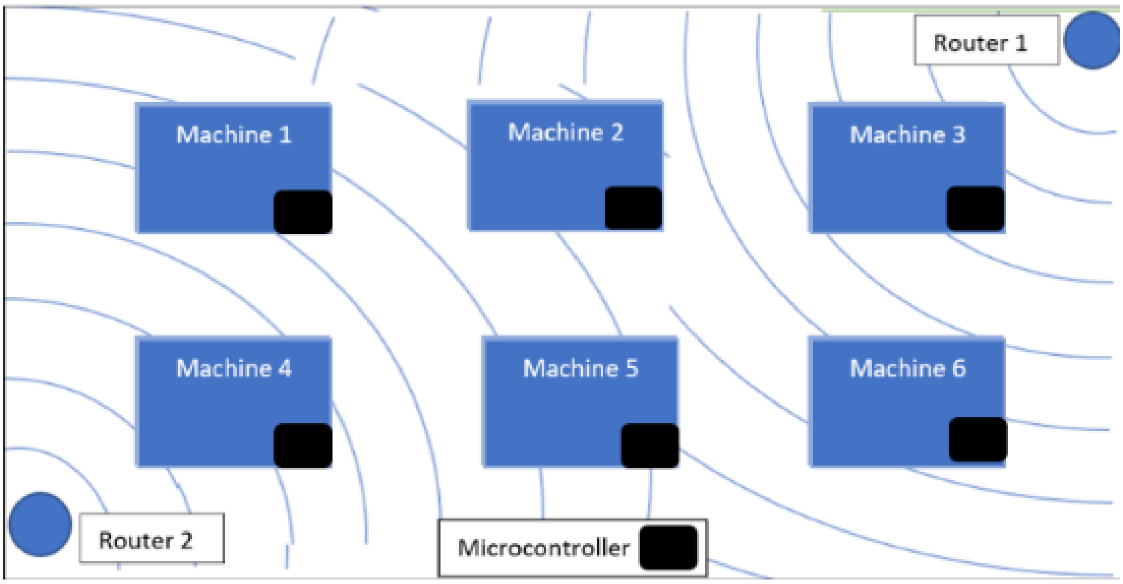

Figure 3. The Assembly Line in the Factory with Router Connection

In Figure 3 shows that how the microcontroller will be connected to the internet. The router will connect the internet and spread the internet wirelessly. A wireless network allows devices or microcontroller to stay connected to the network, but roam untethered to any wires. Access points amplify Wi-Fi signals, so a microcontroller can be far from a router but still be connected to the network. The problem of no connection of internet will be solved as Figure 3.

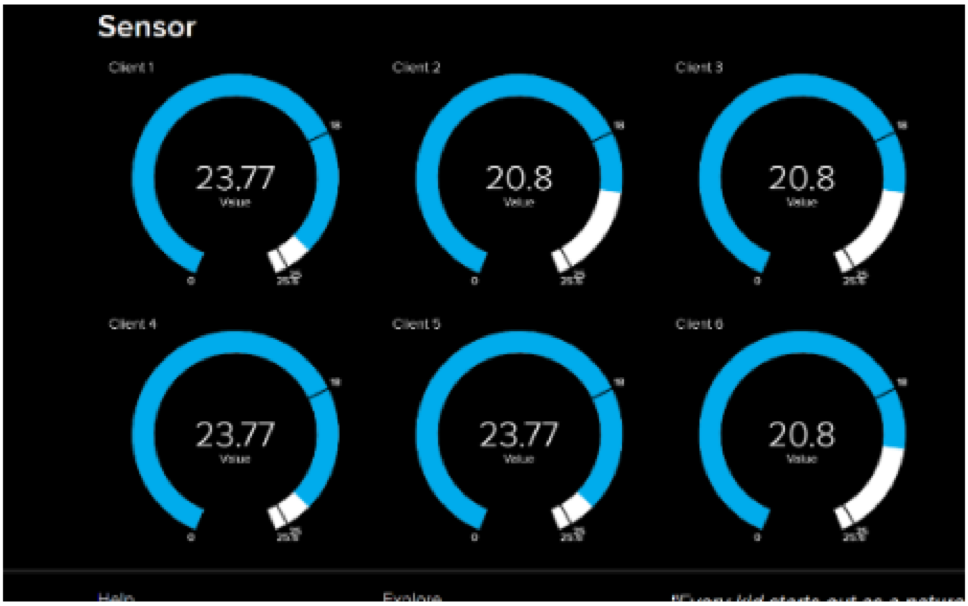

Figure 4. Data Show in Adafruit Server

When all the data were collected and log into Adafruit server as Figure 4. The data can be downloaded in csv file for further step which is using the WEKA tool for doing the prediction.

3.2 Classification

WEKA will be used to classify between pass and fail of machine rods. By using decision tree J48, first injecting the training dataset of 42 instances as shown in Figure 5, choose cross validation of 10 folds, important parameters such as accuracy, efficiency, ROC area and etc. of the classifier chosen will be analyzed shortly. By having the training dataset, the classifier finds that the average mean value is 24.66 as shown in Figure 6, the range of 24.5 to 25.5 will be considered passed while out of range will be failure.

STRAINVALU	STATUS(ROD)
24.77	Pass
27.5	Failed
24.41	Failed
24.77	Pass
24.68	Pass
24.5	Pass
24.23	Failed
24.5	Pass
24.05	Failed
23.69	Failed
24.14	Failed
23.78	Pass
24.32	Failed

Figure 5. Training Dataset

Selected attribute

Name: STRAINVALUE Type: Numeric
Missing: 0 (0%) Distinct: 29 Unique: 22 (55%)

Statistic	Value
Minimum	23.06
Maximum	27.5
Mean	24.66
StdDev	0.886

Figure 6. Range of Data Inserted

3.3 Prediction

A C program will be created in order to predict the real time data. If more than 2 rods are out of range, the machine will be called as failure and needs maintenance urgently. In order to prevent malware to enter our system, a question is prepared for the user to answer to prove that he is a real user.

4. Verification

4.1 Data Collection

For verifying that our proposed scheme is useful. We do a little bit of experiment on collecting data and do the prediction. For collecting data, we use the hardware as shown below:

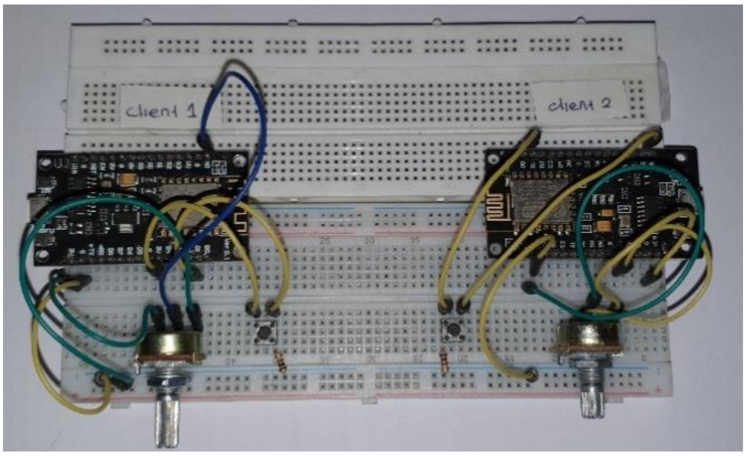

Figure 7. Connection of the Client

In this experiment, we use NodeMCU as the microcontroller that will be used in the factory. Potentiometer as the strain sensor for collecting analog value. The connection is shown in Figure 7. As mention in the proposed scheme, the microcontroller must be connected to the internet. So, for the experiment we use the hotspot from phone for connecting the microcontroller to the internet.

After connected to the Internet, we open the Adafruit server in the laptop and subscribe to the MQTT broker. The data that were collected from the sensor or potentiometer will be sent to the MQTT broker. The MQTT broker will publish all the result that will be sent to the Adafruit server. This will show as the result in the Figure 8. So, the data also can be downloaded in csv file format for prediction using the WEKA tool.

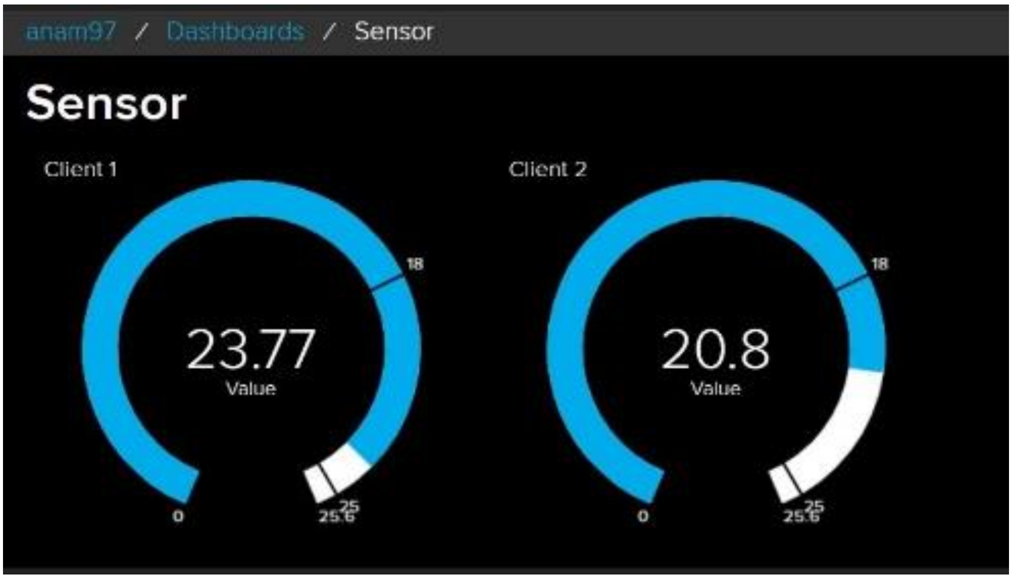

Figure 8. Adafruit Dashboard

4.2 Range Predicted

The range expected is 24.5 to 25.5. By looking at the tree generated by the classifier as shown in Figure 9 and Figure 10, if less than or equal to 24.45, it is failed. While more than 24.45 and less than or equal to 25.5, it is passed. Other the range stated, it will be failed.

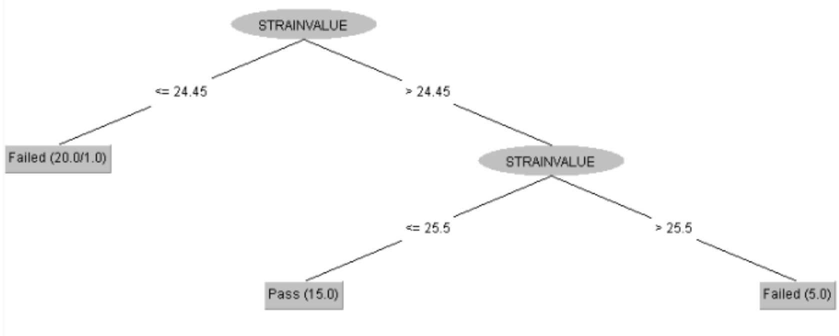

Figure 9. Decision Tree

```
J48 pruned tree
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STRAINVALUE <= 24.45: Failed (20.0/1.0)
STRAINVALUE > 24.45
|   STRAINVALUE <= 25.5: Pass (15.0)
|   STRAINVALUE > 25.5: Failed (5.0)
```

Figure 10. Range generated by the classifier

As shown in Figure 11 and 12, there are many parameters that can be used to measure the performance of classifier. For example, the efficiency is 0.02 with the 42 instances created while the accuracy is 92.5%. ROC area as long as it is with 0.9 to 1.0 it is considered excellent performance. For time taken to train the classifier might increase when the number of instances increases. Confusion matrix in Figure 13 also summarizes the performance of the classification algorithm.

```
Time taken to build model: 0.02 seconds

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances          37               92.5    %
Incorrectly Classified Instances         3                7.5    %
Kappa statistic                          0.8421
Mean absolute error                      0.0988
Root mean squared error                  0.2763
Relative absolute error                 20.4009 %
Root relative squared error             56.0061 %
Total Number of Instances               40
```

Figure 11. Summary of Cross-Validation

```
=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.875    0.042    0.933      0.875    0.903      0.843    0.872     0.867     Pass
                 0.958    0.125    0.920      0.958    0.939      0.843    0.872     0.852     Failed
Weighted Avg.    0.925    0.092    0.925      0.925    0.925      0.843    0.872     0.858
```

Figure 12. Detailed Accuracy of Classifier

```
=== Confusion Matrix ===

  a  b   <-- classified as
 14  2 |  a = Pass
  1 23 |  b = Failed
```

Figure 13. Confusion Matrix

Later, the new real time data is injected. To make it easier, only 4 data at one time which symbolizes the machine with 4 rods. As shown in Figure 14, the time taken to predict four data is only 0.01s. While the result is accurately predicted. To verify, the injected real time csv file is shown in Figure 15.

```
Time taken to build model: 0.01 seconds

=== Predictions on test set ===

inst#,actual,predicted,error,prediction
1,1:?,1:Pass,,1
2,1:?,2:Failed,,1
3,1:?,1:Pass,,1
4,1:?,1:Pass,,1
```

Figure 14. Prediction on Test Set

STRAINVALUE	STATUS(ROD)
24.57	Pass
25.75	Fail
24.51	Pass
24.77	Pass

Figure 15. Input Dataset

The result will be sent to C program that was created earlier, if 1 of the rods is failed, the system will declare that machine does not need any maintenance in a short period of time until 2 or more than 2 rods are failed as shown in Figure 16.

```
C:\Users\YingYenn\Desktop\AI\Demo\MaintenanceDetection.exe
Location of File: C:\Users\YingYenn\Desktop\AI\Demo\40output.arff
Type Fail to prove that you are human: Fail
1 rods are out of range
This machine is working well.
--------------------------------
Process exited after 34.47 seconds with return value 0
Press any key to continue . . .
```

Figure 16. Input Dataset

5. Conclusion

It is clear that artificial intelligence (AI) plays key role in current industrial revolution 4.0. Artificial intelligence (AI) is wide-ranging branch of computer science concerned with building smart machines capable of performing tasks the typically require human intelligence. AI is an interdisciplinary science with multiple approaches, but advancements in machine learning and deep learning are creating a paradigm shift in virtually every sector of the tech industry. Analytics Technology of AI converts the sensory data from critical components into useful information. In this study we utilize the one of the main algorithms of machine learning that classification. The algorithm was used to classify sensor data into pass or fail category. Apart from that, there would be no fourth industrial revolution, no Industry 4.0 and no Smart Factory without the Internet of Things. In this study, internet of things was used to send obtained sensor data from sensors to server via MQTT protocol. Data is then will be visualized using a built-in, customizable dashboard. Thus, IOT platform enables many machines to interact simultaneously through simple networking protocol. The expectations from Industrial AI and Internet of Things are versatile and enormous and even a partial fulfilment of these expectations would give better and improved productivity to the company.

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