Predictive maintenance magnetic sensor using random forest method

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Abstract. BMKG has observations of earth's magnets which are scattered in Indonesia. The BMKG earth magnetic sensor produces real-time data output. This research focuses on predictive maintenance models on earth magnetic sensors based on data output. The resulting data output is in the form of a delimited format in the form of spaces so that it is easy to process. The magnetic component used is the total component data (F) from the earth's magnetic sensor. Data processing using python scripts with the algorithm used is the random forest method by comparing the resulting value difference to find out whether the data generated is still in tolerance or not. The results of the prediction model with the number of estimators 10 produce RF Score = 0.98 and MAE = 0.83.

1. Introduction

Earth's magnetism is a natural phenomenon that continuously occurs and can be observed at any time. Earth is likened to a giant magnet that has two magnetic poles in the south and north. The position of the earth's magnetic poles is reversed and close to the geographic poles of the earth so that there is a deviation of a few degrees from the earth's geographical poles which is then called declination (D) while the deviation from the horizontal plane is called inclination (I). Earth's magnetic field has five components which include three directional components namely north (X), east (Y), vertical (Z) and two other components namely the magnitude of the magnetic field in the horizontal plane (H) and the total geomagnetic field (F) [1]. Relationship of each component as follows.

\[ X = H \cos D \]
\[ Y = H \sin D \]
\[ Z = F \sin I \]
\[ H = F \cos I \]
\[ F^2 = H^2 + Z^2 = X^2 + Y^2 + Z^2 \] (1)

Observation of the earth's magnetic field produces different and varied values due to the inclination value of each place. In Indonesia there are BMKGs that observe the earth's magnetic field in real-time in six locations, namely Tuntungan, Tangerang, Pelabuhan Ratu, Tondano, Kupang, and Jayapura [2]. The quality of the earth's magnetic data is influenced by the location and capability of the sensors used. For this reason, sensor maintenance is needed so that data quality is maintained. Because observations are carried out in real-time and continuous, predictive maintenance is needed, that is if
there is damage to the equipment, do not wait for preventive maintenance so that the observation continues.

![Earth's Magnetic Field Component](image)

**Figure 1.** Component of earth’s magnetic field

Predictive maintenance (PdM) is one of the maintenance methods which based on the prediction of equipment failure by processing the output data of the equipment [3]. Equipment failure indicator is used as a limitation for maintenance. Maintenance can be done before the actual failure occurs so that the equipment does not stop suddenly. This method can extend equipment life, reduce maintenance or repair costs if equipment is damaged, and prevent data loss. Predictive maintenance has been done by Butte in the process of making microelectronics using a deep neural network [8].

One method used to perform predictive maintenance is the random forest method. Random forest is a combination of tree predictors such that each tree depends on the values of a random vector sampled independently and with the same distribution for all trees in the forest. The generalization error for forests converges as to a limit as the number of trees in the forest becomes large. The generalization error of a forest of tree classifiers depends on the strength of the individual trees in the forest and the correlation between them [4]. The random forest method was used by Scheibelhofer to predict machine maintenance in the semiconductor manufacturing industry [7]. He implements time-based which is associated with conditioned-based maintenance.

2. **Experiment**

Predictive maintenance has been carried out by Canizo on wind turbines which are divided into 2 (two) main parts: predictive generator models based on historical wind turbine data and monitoring wind turbines every 10 minutes to make predictions [6]. Canizo carries out predictive maintenance by studying historical data from wind turbines. records from historical data are processed using the random forest method to produce a predictive model that is used to predict generator maintenance. The results of these predictions by Canizo serve as a warning to operators in the form of notifications.

In this work, make a prediction model for when the earth's magnetic observation equipment is maintained. This study uses sensor output data in the form of total geomagnetic field (F) as input from the model. The algorithm used is the random forest method, which is a method that has several predictions from a decision tree and then the predictions from each decision tree are aggregated into one prediction decision.
The sensor output data used is total geomagnetic field (F) data from Pelabuhan Ratu date October 01-12, 2019 with the amount of data reaching 314,835 data. Before we do data processing, we pre-process the data by taking two fields from the sensor output data in the form of a time column and total geomagnetic field (F) column into a dataset. Then we predict the value of F using the random forest algorithm from the dataset. The results of the model, we compare with the table of values from Indonesian Geomagnetic Maps for Epoch 2015.0 at table 1 to produce ΔF. Then we predict the value of ΔF using a random forest algorithm. The indicator that we use in this study to determine that the earth's magnetic sensor needs to be maintained is when the value generated is 200nT.

Table 1. Total geomagnetic field (F) from Indonesian Geomagnetic Maps for Epoch 2015.0

| Date          | Total Geomagnetic Field (nT) |
|---------------|------------------------------|
| Oktober 1, 2019 | 44832.10                     |
| Oktober 2, 2019 | 44832.02                     |
| Oktober 3, 2019 | 44831.93                     |
| Oktober 4, 2019 | 44831.85                     |
| Oktober 5, 2019 | 44831.77                     |
| Oktober 6, 2019 | 44831.69                     |
| Oktober 7, 2019 | 44831.60                     |
| Oktober 8, 2019 | 44831.52                     |
| Oktober 9, 2019 | 44831.44                     |
| Oktober 10, 2019| 44831.36                     |
| Oktober 11, 2019| 44831.27                     |
| Oktober 12, 2019| 44831.19                     |

3. Result and discussion
Evaluation of predictive models created using Ramdom Forest (RF) scores and Mean Absolute Error (MAE) [5]. RF-Score, the first scoring function using RF as the regression model, was found to outperform a range of widely-used classical scoring functions by a large margin. MAE shows how many predictions from the actual deviation. Figure 3 show the regression results for the training. Results of the experiment have an RF score = 0.74 and MAE value = 1.44. Seen in the picture, there are many values outside the line. Figure 4 shows the results of the comparison of ΔF values between the testing data and the regression results against the testing data using the random forest method. The results of the training on delta F have an RF score = 0.81 and MAE = 1.08.
Based on the characteristics of the movement of $\Delta F$ value when it passes the 200nT value, we try to predict the movement of that value as a reference for maintenance. Prediction models have an RF score = 0.98 and MAE = 0.83. When $t = 7000$, $\Delta F$ value reaches 799 nT.
4. Summary
The results of this study conclude that the output data from the mounted magnetic sensor can be used to predict the time to carry out maintenance with certain borders. The prediction model uses the random forest method with estimator = 10, RF score = 0.98, and MAE = 0.83. In the future, further research needs to be done on other components related to the total magnetic field.

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