Partus referral classification using backpropagation neural network

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Abstract. The number of maternal mortalities in Indonesia keeps increasing significantly. The same thing occurs to the number of fetal mortalities which is not less than maternal ones. It is a given knowledge that the condition of expectants is mostly vulnerable to various disorders. Therefore, there is a high possibility of the occurrence of any maternal and fetal mortality. Things most likely to go wrong when the partus occurs and if the disorders are not treated as fast as possible, it will be very dangerous for the expectants. To minimize such occurrences, medical officers have been using a certain method named screening to detect which partus case which potentially has high risk before it is too late. Nevertheless, the results of screening are not always accurate. In this paper, we are going to come up with any other way, which is data mining computation. Data mining has known to be able to help human solving problems as well as a promising region for data classification. Most medical problems have been classified using data mining. Backpropagation Neural Network method will be used in this paper to classify partus referral cases. Thus, Backpropagation Neural Network method will be compared to other algorithms to know if it is a better algorithm for this case based on real data of cohort register. The result of the researches confirms that Backpropagation Neural Network is the best of all three methods (Backpropagation Neural Network, C4.5 and Naive Bayes Classifier) used to classify partus referral.

1. Introduction
Partus is the outgoing process of conception result from woman’s uterus through the way it should’ve been or not, with help or not [1]. All of the expectants would want a normal process of childbirth after expecting for averagely nine months long. Based on World’s Health Organization (WHO), preterm birth complications, birth asphyxia and birth trauma are the 8th and 10th top causes of death consecutively [2]. But the fact is the maternal mortalities have been increased if compared with 20th century, from 228 to 359 in 10 thousands births [3]. There are about 10-15% of outcomes are having troubles [4] so that the expectants needs to be hurried to the medical place that has higher medical facility.

One of effort that has been made to reduce the risk of partus is improving system of referral. Referral system is one of medical facility that enable responsibilities exchanges of patients both horizontally and vertically to increase the quality, scope and efficiency of medical service [5]. The referral system that currently exists is rather complicated and must go through few steps of administrations before the patient getting the medical service they deserve. Patients that are about to be submitted must meet several predetermined criteria and have a medical examination by medical personnel. While filling the administration, the patient who need the treatments will have to wait. The time spent to wait themselves
got treated is considered very dangerous, especially if they need to be taken care of quickly. To prevent such things, medical personals usually predict the risks before.

The problems regarding partus and its referrals have been appointed as a topic on few papers before. It is said that there is a tardiness on recognizing risks, as well as decision making, so that the referral process might as well be too late for the expectants [6]. The parameter of maternal delivery referral has also been evaluated by Zubaidah on her research as the referral processes often face some problems [7]. A good education to expectants is a good way to decrease maternal mortalities [8].

Medical personals use a method which is called screening method. The screening method is a method to predict if expectant has great risk while delivering his baby. To do this method, they are scoring based on the possible risk of deliveries and giving them a score if they meet the criteria. The higher the score, the higher the risk of the delivery so that the process must be conducted on medical place with higher facility, such as hospitals. But sometimes the result of screening method is not always accurate. There are some inexperienced personals giving score of screening so the result is not 100% accurate.

Researches that are related to pregnancy and deliveries have been conducted. One of the topics that has been explored and predicted is preterm birth. C4.5 Algorithm has been used to predict the premature delivery [9] which is optimized using Particle Swarm Optimization to increase its accuracy [10]. There have been conducted some other researches using Neural Network with Particle Swarm Optimization as its optimization to selecting features of premature deliveries prediction [11]. Naïve Bayes also has been used to predict if the delivery will be normal or not [12]. The comparison of few methods of classification has been conducted by several researchers. On a research conducted by Delen, it is said that decision tree (C.5) beat the accuracy of artificial neural networks and logistic regression models on predicting breast cancer survivability [13]. Meanwhile, Bayesian classifiers is said to have an advantage against other algorithms because in medical data sets, attributes are typically independent [14]. While on another research, another famous algorithms, Artificial Neural Network, is proven to outstand other regression models in 28 studies included [15].

Based on the description, we found out that computation methods in data mining are able to be used to predict some cases on medical datasets such as cancers, tumors, pregnancies and deliveries field. But there are barely research conducted regarding partus referral on deliveries cases, which is why on this paper we are going to conduct the research. Back propagation Neural Network will be used to classify paper referral and we will compare other methods which are C4.5 Algorithm and Naive Bayes Classifier as we know that these algorithms are commonly used in previous researches.

## 2. Methods

### 2.1. Dataset

The collecting process of the dataset that is going to be used is by studying documents. The document used is a secondary documents which is confidential. The collected document from “Register Kohort Ibu” book’s validity is trustworthy. “Register Kohort Ibu” is the data source of expectants services as well as their risks written by medical personals. The source itself has been written and reported by midwifes from 2014 to 2016. The amount of record data that has been collected are 321 record data. There are two classes that will be classified based on the label of partus attribute, which is Referred and Not Referred. K-fold cross validation is used to divide data training and data test. The information summary of dataset that we used is shown on Table 1.

Because the dataset is not in good shape, was not one for data mining purpose, there is a need to preprocess so that the data is easier to process. The preprocessing consists of changing some records that has missing values with average value of its attribute’s values. In Backpropagation Neural Network (BNN) case, we change nominal data (from attribute education) into numerical type of data so it could be processed since BNN can only process numerical data. Right after data is pre-processed, the data will be split using k-cross validation method. The $k$ is determined as 10 for the process as the research conducted by Kohavi recommend us to use stratified ten-fold cross-validation [16]. Finally, the data will be tested using various methods which is described as follows.
### Table 1. Partus Dataset’s Descriptions

| Attribute       | Descriptions                                      | Data type   | Values Range |
|-----------------|---------------------------------------------------|-------------|--------------|
| education       | Level of last education                           | String      | SD, SMP, SMA, PT |
| age             | The age of expectant                              | Numeric     | 15 - 50      |
| gravida         | Shows number of pregnancies                       | Numeric     | 1 - 4        |
| weight          | Pregnant women’s weight                           | Numeric     | 32 - 95      |
| height          | Pregnant women’s height                           | Numeric     | 138-170      |
| upper arm       | Mid-upper arm circumference in pregnant women     | Numeric     | 19-38        |
| hemoglobin      | Pregnant women’s hemoglobin                       | Numeric     | 4 - 14       |
| systolic        | The systolic of blood pressure showing higher one | Numeric     | 90 - 160     |
| diastolic       | The diastolic of blood pressure showing lower one | Numeric     | 60 - 130     |
| interval        | The interval between pregnancies in year          | Numeric     | 0 - 19       |
| partus          | The note if the expectants needs a referral or not| String      | Reffered, Not Reffered |

#### 2.2. Backpropagation Neural Network

Artificial neural network is one of methods in artificial intelligence which is popular and frequently used on medical field [17]. It is said because it’s predictive work, although there are some disadvantages like its high sensitivity on parameter from the method. Artificial Neural Network can be used to classify and recognize pattern. Artificial neural network’s architecture consists of the amount of neurons in input layer, hidden layers and output layer.

For this case, we will use technique of error back propagation to train. Back propagation algorithm is a supervised learning method which can be divided into two phases: propagation and weight update. The two phases are repeated until the performance of the network is good enough. The steps to model Backpropagation Neural Network are described as follows [18]:

- **Input partus data.**
- **Initialize initial weight** \((V_i)\), **bias weight** \((X_0)\), **weight** \((W_i)\) to \(y\), and **bias weight** \((W_0)\) to \(y\), randomly with range values between -0.5 to 0.5. Determine value of learning rate, hidden layers, maximum epoch and threshold.
- Do normalization on inputs using Equation 1; where \(x'\) is the new value of \(x_i\), \(x_i\) is the value of \(x\) on \(i\)-throw, \(\text{min}(x)\) is the minimum value of \(x\) in dataset and \(\text{max}(x)\) is the maximum value of \(x\).

\[
x' = \frac{x_i - \text{min}(x)}{\text{max}(x) - \text{min}(x)}
\]  

(1)

- Count the output in hidden layer \((Z_{in,i})\) using Equation 2; where \(v_{0i}\) is initial weight and \(v_{ij}\).

\[
z_{in,i} = v_{0i} + \sum_{j=1}^{n} v_{ij} \times x_i
\]  

(2)

- Calculates the \(Y_{in}\) from the sum the \(Z_i\) multiply by the weights \((W_i\) and \(W_0)\) using Equation 3.

\[
y_{in} = w_0 + w_1 \times z_1 + w_2 \times z_2 + w_3 \times z_3
\]  

(3)

where \(Z_i\) is activated with binary sigmoid rules:

\[
z_i = \frac{1}{1 + e^{-z_{in,i}}}
\]  

- Generate \(Y\) using Equation 4 after activating \(Y_{in}\) wit a binary sigmoid rule like \(Z_i\).
\[ y = \frac{1}{1 + e^{-\gamma_{ln}}} \]  \hspace{1cm} (4)

- Calculation error and quadrant error using Equation 5.
  \[ \text{error} = \text{actual data} - y_{ln} \]
  \[ \text{quadrant error} = (\text{error})^2 \]  \hspace{1cm} (5)

- If error \( \leq 10^{-6} \), directly to testing phase, if not then directly to the stage of weighting.
- Initialize target which is the testing data which will be compared with predicted results.
- Calculate the value of \( \delta \) by using Equation 6.
  \[ \delta = (T - y) \ast \left( \frac{e^{-\gamma_{ln}}}{(1 + e^{-\gamma_{ln}})^2} \right) \ast \left( 1 - \frac{e^{-\gamma_{ln}}}{(1 + e^{-\gamma_{ln}})^2} \right) \]  \hspace{1cm} (6)

- Calculate the weight calculation (\( \Delta W_i \)) and the bias weight (\( \Delta W_0 \)) using Equation 7.
  \[ \Delta W_i = \alpha \ast \delta \ast z_i \]
  \[ \Delta W_0 = \alpha \ast \delta \]  \hspace{1cm} (7)

- Calculate the value of \( \delta_i \) using Equation 8.
  \[ \delta_i = \delta_{in,i} \ast \left( \frac{e^{-\gamma_{ini}}}{(1 + e^{-\gamma_{ini}})^2} \right) \ast \left( 1 - \frac{e^{-\gamma_{ini}}}{(1 + e^{-\gamma_{ini}})^2} \right) \]  \hspace{1cm} (8)

  where
  \[ \delta_{in,i} = \delta \ast w_i \]

- Calculate the weight calculation (\( \Delta V_i \)) and the bias weight (\( \Delta V_0 \)) using Equation 9.
  \[ \Delta V_{oi} = \alpha \ast \delta_i \]
  \[ \Delta V_{ji} = \alpha \ast \delta_i \ast x_{ji} \]  \hspace{1cm} (9)

- Update new weight (\( V_{ji(n ew)} \)) and new bias weight (\( V_{0i(old)} \)) using Equation 10.
  \[ V_{ji(n ew)} = V_{ji(old)} + \Delta V_{ji} \]
  \[ V_{0i(n ew)} = V_{0i(old)} + \Delta V_{0i} \]
  \[ W_{i(n ew)} = W_{i(old)} + \Delta W_i \]
  \[ W_{0(n ew)} = W_{0(old)} + \Delta W_0 \]  \hspace{1cm} (10)

3. Result and discussion
We have performed the methods discussed above on partus dataset to classify which data will be recommended to have a referral or not. To measure the result, we will depend on accuracy, recall, precision and also Root Mean Squared Error (RMSE). Accuracy, recall and precision are commonly used evaluation measures that can be measured by using confusion matrix methods. While RMSE are evaluation measurement that represents differences between real values and predicted values. The summary of the experiments done is shown on Table 2.

| Table 2. Methods’ performance |
|-------------------------------|
| Method                                      | Accuracy | Recall | Precision | RMSE  | Execution time |
|-------------------------------------------|----------|--------|-----------|-------|----------------|
| C4.5 Algorithm                            | 69.17%   | 65.34% | 68.98%    | 0.458 | 9s             |
| Backpropagation Neural Network             | 80.91%   | 78.54% | 82.03%    | 0.361 | 25s            |
| Naive Bayes Classifier                     | 65.94%   | 61.69% | 64.94%    | 0.472 | 5s             |
Based on the Table 2, although Backpropagation Neural Network needed a longer time to process, Backpropagation Neural Network have the best accuracy, recall, precision and the least RMSE (which means best RMSE since the least error is produced). On the second place is C4.5 Algorithm which is better than Naive Bayes Classifier. And the last place is Naive Bayes Classifier.

4. Conclusion
It is concluded that the three methods have their own advantages, for example Naïve Bayes Classifier is better for use while data is independent to each other. While for C4.5 Algorithm, the result will be transparent so that humans will be able to use it easily. Although, Backpropagation Neural Network got the highest result of all. In this case, we can conclude the best method to use is Backpropagation Neural Network because it got the best accuracy, recall, precision, and RMSE. Backpropagation Neural Network needs a longer time to train, longer than Decision Tree and Naive Bayes classifier is probably one of the reason that makes the said method got better result. Backpropagation Neural Network is said to have better results on data with large number of features or high dimensionality, like the dataset used. For the further experiment, the use of bigger dataset, different value of \( k \) in \( k \)-cross validation and more vary methods are recommended to see if Backpropagation Neural Network would still lead the best accuracy. As the result’s accuracy is high, it is safe to say that we can use Backpropagation Neural Network to train dataset and as a reference in partus referral classification. For future researches, deep learning of Backpropagation Neural Network is recommended to be conducted for a better result.

References

[1] Reviews C T I 2016 *Step-by-Step Medical Coding 2009 Edition* Cram101.
[2] WHO2017 The top 10 causes of death *WHO*.
[3] AmirahA N2016 BKKBN: Angka kematian ibu melahirkan meningkat | republika online *Antara News*.
[4] Triana A, Damayanti I P, Afni Rand Yanti J S2015 *Buku Ajar Kebidanan Kegawatdaruratan Maternaldan Neonatal: Penuntun Belajar* (Jakarta: Deepublish).
[5] Syafrudin and Hamidah 2009 *Kebidanan Komunitas* (Jakarta: Penerbit Buku Kedokteran EGC).
[6] Palimbo A, Sriti Aand Kuntjoro T 2015 Implementation on the Referral System of High Risk Pregnant Women from Villages Midwives to Primary Healthcare Center with Basic Obstetric and Neonatal Emergency Care in Banjar District, South Kalimantan (a Case Study in Sungkai Primary Healthcare Center) vol 03 no 01.
[7] ZubaidahAW and Hakimi M2005 Paramater on maternal delivery referral process *J. Keperawatan* vol 1270.
[8] Handriani I and Melaniani S 2015 The effect of referral process and complications to maternal mortality *J. Berk. Epidemiol*. vol 3 pp 400–11.
[9] Puspita A 2016 Prediksi kelahiran bayi secara prematur dengan menggunakan algoritma C4.5 berbasis particle swarm optimization *J. Tek. Informatika STMIK Antar Bangsa* vol 11 no 1 pp. 11–16.
[10] Puspita A and Wahyudi M 2015 Algoritma C4.5 berbasis decision tree untuk prediksi kelahiran bayi prematur.
[11] Ramanda K 2015 Penerapan particle swarm optimization sebagai seleksi fitur prediksi kelahiran *vol 1* pp 178–83.
[12] Nugroho A and Subanar 2013 Klasifikasi naïve bayes untuk prediksi kelahiran pada data ibu hamil vol 23 pp 297–308.
[13] Delen D, Walker G and Kadam A 2005 Predicting breast cancer survivability: a comparison of three data mining methods *Artif. Intell. Med.* vol 34 no 2 pp 113–27.
[14] Kononenko I 2001 Machine learning for medical diagnosis: history, state of the art and perspective *Artif. Intell. Med.* vol 23 no 1 pp. 89–109.
[15] Sargent D J 2005 Comparison of artificial neural networks with other statistical approaches *Cancer*
[16] Kohavi R 2016 A study of cross-validation and bootstrap for accuracy estimation and model selection Learning no March 2001 pp 1137–43.

[17] Bellazzi R and Zupan B 2008 Predictive data mining in clinical medicine: current issues and guidelines Int. J. Med. Inform. vol 77 no 2 pp 81–97.

[18] Wahyuni I, Adam N R, Mahmudy W F and Iriany A 2017 Modeling backpropagation neural network for rainfall prediction in tengger east java 2nd Int. Conf. Sustain. Inf. Eng. Technol (SIET 2017) pp 1–5.