Isometric Contraction ankle joint in Cerebral Palsy using Naive Bayes

Muhaimin Hasanudin, Yudo Devianto, Wawan Gunawan, Saruni Dwiasnati and Ifan Prihandi

***Abstract*—Cerebral palsy is an abnormal brain development or brain damage that affects the sufferer's ability to move and maintain their balance and posture. Spastic Cerebral Palsy is a type of Cerebral Palsy that has brain damage and muscle stiffness. These muscles become stiff because the message to the muscles is delivered incorrectly by the damaged part of the brain. The purpose of this study is to classify isometric contractions in Spastic Cerebral Palsy (SCP) children aged 5-15 years with GMFCS levels at levels 1 and 2 using the Naive Bayes Algorithm while the dataset used is open public, namely Mendeley Data Repository, there are 24 attributes used to classify isometric contractions of the ankle joint in SCP children. Existing data is divided into training data and test data based on hold out validation. Based on the classification results, Naive Bayes with a training and test data ratio of 1:1 produced the highest accuracy of 84%.**

***Keywords*—Cerebral Palsy, isometric contraction, ankle joint, Naive Bayes**

I. Introduction

Children with cerebral palsy are children who experience motor impairments caused by damage to the brain and impact other abilities such as mobilisation, coordination, balance and so on [1,2]. Cerebral palsy is a group of disorders that affect the normal movement of different parts of the body. These conditions can cause problems with posture, gait, muscle tone, and coordination of movement. The word "cerebral" refers to the cerebrum, the part of the brain that regulates motor functions. "Palsy" refers to the paralysis of voluntary movement in a specific part of the body. Cerebral palsy is caused by brain damage in the fetus or infant. Although it is difficult to determine the exact cause of brain damage, there are several factors that can cause children to experience this condition, namely Bacterial and viral infections such as meningitis, bleeding in the brain, Head injuries that occur at birth or the first few years of infancy Lack of oxygen to the brain, and others[3,4].

Cerebral palsy is classified according to the Gross Motor Function Classification System (GMFCS). The World Health Organisation (WHO) and the European. The GMFCS is an age-based tool that assesses gross motor function in various areas, including mobility, posture and balance, and categorizes the severity of each area into one of five levels. Level I indicates mild limitations e.g. can walk without restrictions and Level V indicates severe limitations e.g. requires a wheelchair. Cerebral Palsy Surveillance have developed GMFCS as a universal standard for determining the physical abilities of people with cerebral palsy [5,6]. This system focuses on the ability to sit, the ability to move and mobility, and the extent to which the sufferer is affected by cerebral palsy [6,7].

There are five levels classified by GMFCS, in this study, we focus on gross motor classification between the ages of 5-15 years at GMFCS level 1 and 2 At level one (1), the child can walk at home, school, outdoors and in social life. The child can walk up and down the street without physical assistance and up and down stairs without using a bar [6,8]. The child shows gross motor skills such as running and jumping but has limitations in speed, balance, and coordination.

The child can participate in physical activities and participate in sports depending on personal choice and environmental factors. Whereas at level 2, the child can walk in most situations [8,9]. The child may have difficulty walking long distances and balancing on uphill and uneven surfaces, in crowded areas, in limited space or when carrying an object. The child can go up and down stairs holding on to the bar or with physical assistance if there is no bar. Outdoors and in community life, the child can walk with physical assistance, hand-held mobility aids, or use wheeled mobility devices when walking long distances. Children are at their best with minimal ability to demonstrate gross motor skills such as running and jumping. Performance limitations in gross motor may encourage adjustments until the child is able to participate in physical activities and sports.

The purpose of this study is to classify isometric contractions in Spastic Cerebral Palsy (SCP) children aged 5-15 years with GMFCS levels at levels 1 and 2 while the method used in this study is the Naive Bayes algorithm using an open public dataset containing 29 respondents with static contractions of the ankle joint in CPS children while the dataset is obtained from Mendeley Data Repository [10]. There are 24 attributes used to classify isometric contractions of the ankle joint in CPS children. The existing data is divided into training data and test data based on hold out validation. This study is expected to provide information about the output of muscle strength and ratio in children with SCP [13]. Muscle size-strength relationships can be defined and combined with the influence of age and functional level and can also compare muscle activation at the level of locomotion before and after BoNT-A injection [11,12].

II. RESEARCH METHODOLOGY

A. Research Methods

This study aims to classify isometric contractions in Spastic Cerebral Palsy (CPS) children aged 5-15 years with GMFCS levels at level 1 and 2 using the Naive Bayes Algorithm while the dataset used is open public, namely Mendeley Data Repository, Existing data is divided into training data and test data based on hold out validation. In this study, the method used was machine learning with the Naïve Bayes Classifier algorithm. The research flow is presented in figure 1.

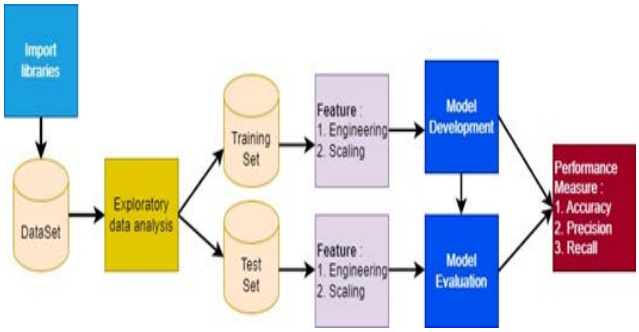

Figure 1. Research Data Modelling Stages

B. Naive Bayes

Naive Bayes is an algorithm that classifies data based on probability theory and Bayesian Theorem by assuming that variable X is an independent variable [14]. In classification using Naive Bayes, the frequencies and combinations of values in the dataset are summed together to produce probabilities. Naive Bayes is a supervised method, where in performing classification, this algorithm requires training data. According to research conducted by Syarifah and Muslim, there are many advantages in using the Naive Bayes algorithm for data classification (Syarifah and Muslim, 2015). This is because the Naive Bayes algorithm does not require a lot of training data to determine the mean and variance of the variables needed in the classification process. In addition, Naive Bayes has been proven to classify data easily, quickly, and has high accuracy [22].

C. Participants

Data were collected from children aged 5 to 15 years with spastic CP i.e. CP group with age 13 and typically developing children with TD group with over 29. Inclusion criteria for the CP group included spasticity affecting the lower limbs requiring BoNT-A treatment. Exclusion criteria for the CP group included severe cognitive or visual impairment that interfered with the ability to cooperate with the experimental protocol, concomitant neurological disease, BoNT-A injection within the previous 4 months, neurosurgical and orthopedic procedures of the lower limbs within the previous 12 months, previous selective dorsal rhizotomy, and intrathecal baclofen treatment. Children in the TD group were required to be healthy with no lower limb neurosurgical or orthopedic procedures within the 12 months prior to participation.

D. Datasets

The dataset used in this study is from high-density electromyography (HDEMG) data collected during isometric contractions of the ankle joint from children with and without spastic Celebral Palsy, approximately 2-6 weeks after BoNT-A treatment. In addition, concurrent torque data provides information on muscle force output. This will allow comparison of muscle activation at the locomotion level before and after BoNT-A injection. Furthermore, data on participants performing the Timed Up and Go (TUG) test was provided. This popular test can be linked to the Gross Motor Function Classification System (GMFCS), Disability and Health activity domain and provides important information on the participant's dynamic balance. Furthermore, TUG assessment can be used to evaluate the relationship between neuromuscular - characteristics and mobility function in CP. In addition, the data collected can be developed in children by comparing between groups [10, 11]. Botulinum toxin type A (BoNT-A) is one of seven botulinum toxin serotypes (A to G) produced by the anaerobic bacterium Clostridium botulinum. BoNT-A is now used as a first-line therapy for focal spasticity. BoNT-A releases acetylcholine into the neuromuscular junction (NMJ). This injection causes temporary muscle weakness[23]. The onset of muscle weakness occurs within 14 days, although it is usually apparent a few days after injection with an average duration in children of 3-6 months. Once classified by GMFCS, patients can be monitored as they age to see if treatment improves their GMFCS levels. Additional scoring systems, such as the Wong-Baker FACES pain rating scale, can also be used to assess response to treatment.

In this study, the dataset was obtained from an open public containing 29 children's respondents with static contraction of the ankle joint in SCP children while the dataset was obtained from Mendeley Data Repository [11]. There are 24 attributes used to classify isometric contractions of the ankle joint in SCP children. Existing data is divided into training data and test data based on hold out validation. The data obtained is then processed using google colab, a snapshot of the data that will be processed further is shown in Figure 2 below.

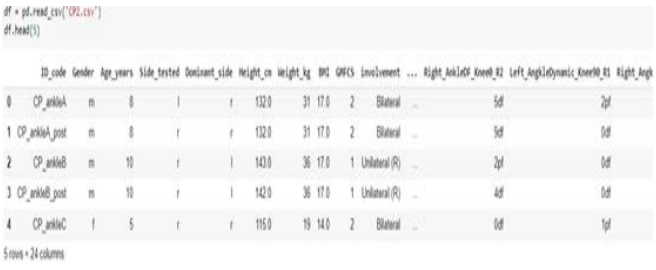

Figure 2. Data Snapshot after Selection

Outliers are data that do not follow the general pattern in the resulting regression model, or do not follow the overall data pattern. The presence of outliers in the data can interfere with the data analysis process, resulting in larger residuals and variance in the data. We checked the data attributes for Age_years, Height_cm, Weight_kg, BMI,

GMFCS, day_injection and TUG, resulting in no residual data as shown in Figure 3.

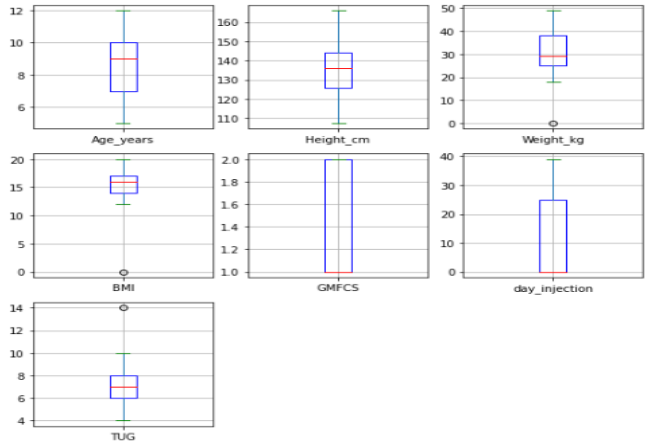

Figure 3: Outlier data

E. Visualisasi

Visualisation with the correaltion matrix heatmap aims to make it easier for users to see the correlation or relationship between variables that are quantitative in nature accompanied by colouring.

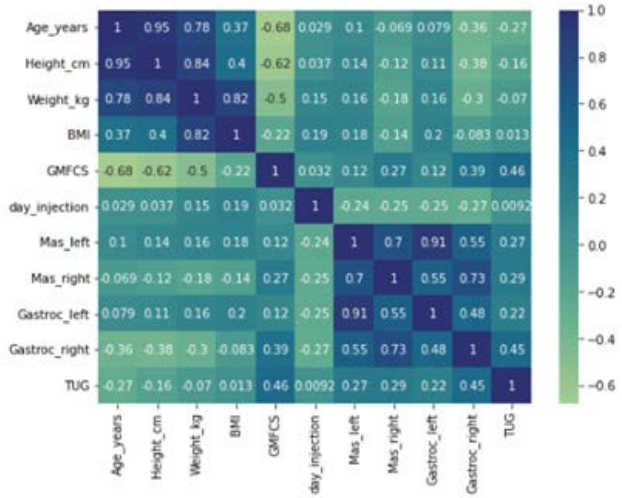

Figure 4. HeatMap Display

From the visualisation in Figure 4, there is a very strong positive correlation between the age variable (age_years) and TUG (Timed Up and Go), which is 0.27. This means that the smaller the age of a person, the faster the time for recovery. So, it is not surprising that the age_years variable also has a very strong correlation with the TUG variable.

The following shows a confusion matrix to evaluate the classification results that have been carried out with the Naïve Bayes Gaussian Classifier algorithm, as in Figure 5.

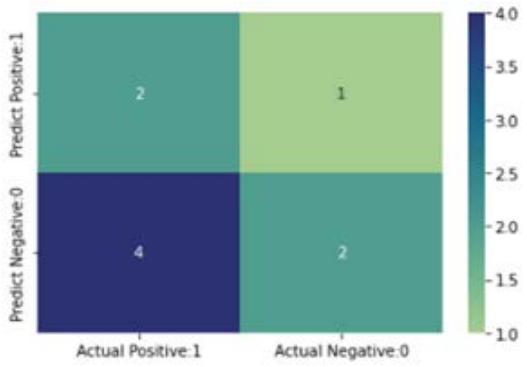

Figure 5. Confusion Matrix

Based on the 2x2 confusion matrix in Figure 4, predictions are made to determine the classification of Isometric Contractions of the ankle joint in Spastic Cerebral Palsy children on 29 records. The prediction results for the simple Gross Motor Function Classification System (GMFCS) classification labeled 1 as many as 17 and labeled 2 as many as 12.

III. RESULTS AND DISCUSSION

Furthermore, to determine the performance of the Naïve Bayes Classifier algorithm in classifying Isometric contractions of the ankle joint in Spastic Cerebral Palsy children, an evaluation is carried out by calculating the accuracy, precision, recall, and f1-score values. The resulting accuracy is 84%, with average scores for precision, recall, and f1-score being 84%, 84%, and 84% respectively. These results indicate that the Naïve Bayes Classifier algorithm performs adequately in classifying Isometric Contractions of the ankle joint based on the Gross Motor Function Classification System (GMFCS). involving 10 (ten) attribute conditions. The results obtained are shown in Figure 6 below.

	precision	recall	f1-score	support
1	0.93	0.97	0.84	3
2	0.97	0.93	0.84	6
accuracy			0.84	9
macro avg	0.80	0.80	0.84	9
weighted avg	0.86	0.80	0.84	9

Figure 6 score for Each Label/Class

This study investigates how to improve the accuracy of error estimation based on variance analysis. By describing the quantitative relationship between the CV variance and its accuracy, which can provide guidance for improving accuracy by reducing variance. In Figure 7 the average value of the resulting K-Fold Cross Validation is 80%.

```
print('Average cross-validation score: {:.4f}'.format(scores.mean()))
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Average cross-validation score: 0.8000
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Figure 7. Resulting K-Fold Cross Validation

IV. CONCLUSION

In this project, I built a Gaussian Naïve Bayes Classifier model to predict whether the Classification of Isometric Contractions of the ankle joint in Spastic Cerebral Palsy children with Gross Motor Function Classification System (GMFCS) at level 1 and 2 Model produces sufficient performance as shown by the model accuracy found to be 0.84. The Nave Bayes Classifier algorithm has shown sufficient performance by producing a high accuracy value of 84%. In addition, the average precision, recall, and f1-score obtained were 84%, 84%, and 84%, respectively. The training-set accuracy value is 1.0000 while the test-set accuracy is 0.84. These two values are not comparable.

This research can be developed and improved by applying other classification algorithms to compare the best performance in classifying Isometric Contractions of the ankle joint in Celebral Palsy children.

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