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Naïve Bayes Method to Determine Learning Specialization for New Students

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Abstract. In life, a person is often confronted with several choices and is required to be able to choose from those choices. One example is the selection of Major's specialization. There are several campuses or universities in Indonesia that require students to choose the type of specialization or concentration before starting their first lecture, such as the Postgraduate Program at Universitas Atma Jaya Yogyakarta. Naive Bayes method is one of the probability methods used to predict the likelihood that will occur in the future by using previous data. The purpose of this study is to use the Naive Bayes method to make a recommendation based on the attributes that have been determined. The method used in this research is: data collection using qualitative methods and distributing questionnaires to parties related to this research. As for the points of the questions in the questionnaire are (1) the previous department, (2) the final score of the cumulative achievement index, (3) interest in the field, (4) individual ability, (5) certain subject values, (6) concentration chosen, and (7) the level of suitability of concentration selection. This study uses a sample data of 25 Postgraduate students of Magister Teknik Informatika at Universitas Atma Jaya Yogyakarta. The results of this study are a recommendation for the selection of majors at the Postgraduate Department of Universitas Atma Jaya Yogyakarta.

1. Introduction

Today, in the current higher education system, universities offer elective courses to postgraduate students as part of their study curriculum. E.g., when students finish their entrance examination, they must choose specialization courses for their masters' program. Students like this system as it gives them a chance to make their own major choices. Usually, the decision made by considering many factors such as student interests, career paths, fields of study, student talents, and many others. Students get to know about their choices through reading the graduate manual books and by accessing their campus websites. However, the students are not able to know whether their majors are easy or difficult since they lack guidance at the registration phase. This problem may lead some of the students to wrong choices as some of them make decisions according to their friends' interests and not their abilities or talents [1].

The students need to make the right choices for which fields they want to specialize in, as this is beneficial to students both in the short and long run of their studies. [2]. Firstly, the performance of the student each semester will always be determined by which course he or she chooses. This, as time

goes on, will finally impact the whole GPA of the student at the end of his/her studies. If the student chose the course that is beyond his capacity, then it is with less doubt that the student will end up with a poor grade (GPA) at the end his studies, and if he or she made a right choice, then he/she will reap good results. Therefore, a choice made by students is critical as it determines their success in their future careers.

In addition to that, the university needs to keep track of its students that have completed their studies successfully at their universities and use this information to motivate the new students and also guide them in making the right choices. Using these records about the fields of the former students that have finished their studies successfully and attained good grades can assist some of the new students to discover to determine their talents and potentials [3]. Therefore, rules can be mined and extracted by carrying out a critical analysis of the choices made by the students and their performance.

Rule mining and extraction can be done by asking students to select several courses they would like to major in right from semester one till the last semester before the final examination. One of the factors that influence the selection of student courses is their value in lectures [4]. The value a student will get from lecturing on the entrance exam depends on many factors such as 'uncertainty.' This uncertainty, however, can be reduced by obtaining related student parameters like gender, GPA, and student-related subject values [5]. Unfortunately, some of the parameters, such as the students' psychological state, are not easily obtained, which will undoubtedly have a significant effect on their grades on the entrance examination [6] [7]. Many factors need to be considered before estimating implementation. In addition to that, it is crucial to understand the level to which these factors influence the estimation.

As proposed by British scientist Thomas Bayes, the Naive Bayes algorithm is defined as a classification method that uses probability and statistical methods. This method bases on the past data to predict the future. This is called Bayes Theorem [8]. Using this algorithm has one main advantage over using other methods, in that, the method determines the estimated parameters needed in the classification process by using minimal training data. This algorithm is therefore considered to be an independent variable since it only uses the variance of a variable in a class for its classification, and it does not use the whole covariance matrix compared to other algorithms do. In order to solve the above-described problem, this study used the Naïve Bayes model to determine students' interests in the choices of specialization courses at the Universitas Atma Jaya Yogyakarta.

2. Literature Review

2.1. Specialization

Specialization means focusing on one specific aspect from a particular topic/field. Frequently, specialization is used to represent a concentration of a specific field. It also shows expertise or competence in the field [9]. For example, when someone (male) is studying biology, his advisor will ask him to choose your specialization area. And after graduate, he has much knowledge about biology in general and also a specific area that he intensely studied [10].

2.2. Decision Support System (DSS)

Decision Support System is a computer-based information system that helps an organization to make a decision. DSS is specially developed to improve and support the decision-making process because DSS is a computer-based information system that is interactive, adaptive, and flexible [11]. In an organization, DSS helps the management, planning, and operations levels to make decisions. To provide an appropriate decision, DSS uses artificial intelligence-based algorithms. These algorithms make the system learning and considering all the problematic aspects before giving the decision. Therefore, DSS can provide high-value decisions [12].

2.3. Naïve Bayes Method

Naïve Bayes is a type of statistical classifier commonly used for predicting membership probabilities. The Naïve Bayes method has advantages over other methods, which can carry out the classification

process using only small data [13], easy to implement, and can work well in solving complex problems [14]. In previous studies mentioned that the Naïve Bayes method has a good level of accuracy in making decisions based on uncertain data [15].

3. Methodology

Naive Bayes (NB) is a simple classification algorithm that calculates the probabilities from a dataset by adding up the combination and the frequency of the values [16]. This following formula can be used to calculate the probabilities:

$$P(X) = \frac{P(C) x P(C)}{P(X)} \quad (1)$$

where:
P(C|X) = The probability of C (class or target), given the attribute or input data X.
P(X|C) = The posterior probability of the input data X, given C.
P(C) = is the prior probability of C or class.
P(X) = is the prior probability of input data X.
When P(X) is identical in all classes, it can be ignored [17]. Therefore, the algorithm of Naive Bayes can be defined as follows [18]:

1) N-dimensional vector can be used to represent each input data: X = (x1,x2,.....,xn).
2) When there are more than one or m classes (C1, C2, C3, ..., Cm) and the class label of data X is unknown, the NB classifier is going to predict data X belongs to which class depends on the highest probability from each class, conditioned on data X. Thus, the NB classifier assigns the data X to Ci class if and only if P(Ci|X)>P(Cj|X) for 1≤j≤m, and j≠i.
3) P(X|Ci) and P(Ci) must be maximized because P(X) in each class is constant. It is common to maximize P(X|Ci) when the probabilities of class prior are unknown with an assumption that all classes are likely to equal (P(C1)=P(C2)=P(C3)=...=P(Cm).
4) NB assumes all of the attributes are independent of each other to reduce the computation to compute P(X|Ci).

Therefore, $P(Ci) = \prod_{k=1}^{n} P(Xi|Ci)$

In developing this system, Rapid Application Development is used as a method to develop this system and using Ms. Excel as a system to do the calculation. This method is used to develop the system efficiently and to save time [14]. This system is used to determine the specialization or concentration of the Master of Informatics Engineering. The classes (specialization) for this NB system are intelligent informatics and innovation of computational science. The attributes to determine which class the input data belongs to are the bachelor's degree, interest, skill, calculus score, and GPA.

4. Implementation and Result

In this section, we will conduct the training phase, the testing phase of the NB method, and the results of the testing phase.

4.1. Training

In this training phase, we use 25 data obtained from the results of previous surveys. The data that we used was from the students who feel their specialization was suitable for them. The attributes of this system are the bachelor's degree, interest, skill, calculus score, and GPA. These attributes obtained from the results of the literature studies that we have done and will be used to determine which class the input data belong to. There are two different classes of the specialization of the Master of Informatics Engineering, namely, intelligent informatics and innovation of computational science. The following is the training data and calculations:

Bachelor's Degree	Interest	Skill	Calculus Score	GPA	Specialization
Electrical Engineering	Data Analysis	Multimedia	Good	Low	Intelligent Informatics
Informatics Engineering	Data Analysis	Robotic	Average	Average	Innovation of Computational Science
Computer Science	App Innovation	Others	Average	High	Innovation of Computational Science
Information System	Data Analysis	Programming	Good	High	Intelligent Informatics
Informatics Engineering	Data Analysis	Multimedia	Good	Low	Innovation of Computational Science
Informatics Engineering	Data Analysis	Programming	Average	High	Innovation of Computational Science
Informatics Engineering	App Innovation	Multimedia	Average	Average	Innovation of Computational Science
Informatics Engineering	Data Analysis	Programming	Good	High	Intelligent Informatics
Informatics Engineering	App Innovation	Multimedia	Average	Average	Intelligent Informatics
Informatics Engineering	Data Analysis	Programming	Good	Average	Intelligent Informatics
Informatics Engineering	App Innovation	Multimedia	Good	Average	Innovation of Computational Science
Informatics Engineering	App Innovation	Multimedia	Average	Average	Innovation of Computational Science
Information System	Data Analysis	Programming	Average	High	Intelligent Informatics
Informatics Engineering	App Innovation	Programming	Good	Average	Innovation of Computational Science
Information System	App Innovation	Programming	Average	Average	Innovation of Computational Science
Informatics Engineering	App Innovation	Programming	Low	Average	Intelligent Informatics
Computer Science	Data Analysis	Multimedia	Average	High	Innovation of Computational Science
Informatics Engineering	Data Analysis	Multimedia	Good	High	Innovation of Computational Science
Informatics Engineering	App Innovation	Programming	Good	High	Intelligent Informatics
Information System	App Innovation	Multimedia	Average	High	Innovation of Computational Science
Informatics Engineering	Data Analysis	Multimedia	Average	Average	Innovation of Computational Science
Information System	Data Analysis	Programming	Good	High	Intelligent Informatics
Informatics Engineering	Data Analysis	Programming	Good	Average	Innovation of Computational Science
Informatics Engineering	Data Analysis	Programming	Good	High	Innovation of Computational Science
Informatics Engineering	App Innovation	Multimedia	Good	Average	Innovation of Computational Science

Fig. 1 Naïve Bayes Training Data

Atrribute	Data	Specialization	Total Atrribute Data	Total Specialization Data	Results
Skill	Programming	Intelligent Informatics	7	9	0,777777778
		Innovation of Computational Science	5	16	0,3125
	Multimedia	Intelligent Informatics	2	9	0,222222222
		Innovation of Computational Science	9	16	0,5625
	Robotic	Intelligent Informatics	0	9	0
		Innovation of Computational Science	1	16	0,0625
Calculus Score	Good	Intelligent Informatics	6	9	0,666666667
		Innovation of Computational Science	7	16	0,4375
	Average	Intelligent Informatics	2	9	0,222222222
		Innovation of Computational Science	9	16	0,5625
	Bad	Intelligent Informatics	0	9	0
		Innovation of Computational Science	0	16	0
Bachelor's Degree	Informatics Engineering	Intelligent Informatics	5	9	0,555555556
		Innovation of Computational Science	12	16	0,75
	Information System	Intelligent Informatics	3	9	0,333333333
		Innovation of Computational Science	2	16	0,125
	Electrical Engineering	Intelligent Informatics	1	9	0,111111111
		Innovation of Computational Science	0	16	0
Interest	App Innovation	Intelligent Informatics	3	9	0,333333333
		Innovation of Computational Science	8	16	0,5
	Data Analysis	Intelligent Informatics	6	9	0,666666667
		Innovation of Computational Science	8	16	0,5
GPA	High	Intelligent Informatics	5	9	0,555555556
		Innovation of Computational Science	6	16	0,375
	Average	Intelligent Informatics	3	9	0,333333333
		Innovation of Computational Science	9	16	0,5625
	Low	Intelligent Informatics	1	9	0,111111111
		Innovation of Computational Science	1	16	0,0625

Fig. 2 Naïve Bayes Attributes Calculation

4.2. Testing

In this testing phase, we use 9 data obtained by selecting random master's degree students that feel their specialization was suitable for them to fill the surveys and then comparing the results from the system output and the specialization of those students. To calculating the results, the data attributes will be inputted into the system (fig. 3). The scores will be automatically calculated, and the specialization or with the highest results in the fig. 3 will become the output of the system. The following is the testing results:

Students with ->	Bachelor's Degree:	Interest:	Skill:	Calculus Score:	GPA:
	Informatics Engineering	Data Analysis	Programming	Average	High
Intelligent Inf. Score	0,555555556	0,666666667	0,777777778	0,222222222	0,555555556
Innoation of C. S. Score	0,75	0,5	0,3125	0,5625	0,375

		Attribute Score	Total Specialization Data	Total Data	Results
Results	Intelligent Informatics	0,035563684	9	25	0,012802926
	Innovation of Computational Science	0,024719238	16	25	0,015820313
Specialization =	Innovation of Computational Science				

Fig. 3 Naïve Bayes Results Calculation

Nama	System Output	Specialization
A	Intelligent Informatics	Intelligent Informatics
B	Innovation of Computational Science	Intelligent Informatics
C	Innovation of Computational Science	Innovation of Computational Science
D	Intelligent Informatics	Intelligent Informatics
E	Intelligent Informatics	Intelligent Informatics
F	Innovation of Computational Science	Innovation of Computational Science
G	Intelligent Informatics	Innovation of Computational Science
H	Intelligent Informatics	Intelligent Informatics
I	Innovation of Computational Science	Innovation of Computational Science

Fig. 4 Naïve Bayes Testing Results

4.3. Result

This proposed system can quickly make the specialization recommendations after the attributes have been inputted. This system will generate the output based on the combination of inputted data. In this study, this system was run nine times for each different set of data attributes. After the data is inputted into the system, the system will generate the score for each attribute and calculate the result of each class or specialization in this case. The example of the calculation and result of student I can be seen in figure 3.

Based on the test result from 9 sets of data that inputted into the system, there were two errors in determining the specialization or concentration of students in the Master of Informatics Engineering. The accuracy of this decision support system that adopts the Naive Bayes method for testing 9 data was 77.78%, and the error was 22.22%.

5. Conclusion

In this paper, we implemented a decision support system for determining the specialization of students in the Master of Informatics Engineering using the Naive Bayes method. The system was trained and tested by using student data sets with attributes consisting of the bachelor's degree, interest, skill, calculus score, and GPA. In the testing phase, the accuracy of this system from testing nine students is 77.78%. Therefore, we can conclude that this decision support system that adopts the Naive Bayes method can be used to determine the specialization of students in the Master of Informatics Engineering quite well.

Even though the result of this system is quite good, this study has limitations, and this system can still be developed further. Here are some suggestions for further research:

1) Using the Hidden Naive Bayes method as the classification method.
2) Use UML to design the system.

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