



CERTIFICATE

TO:

Yuni Yamasari

as Presenter

Combining the Unsupervised Discretization Method and the Statistical Machine Learning on the Students' Performance

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With the theme "Strengthening the Framework of Society 5.0 through Innovations
in Education, Electrical Engineering, and Informatics Engineering".

Surabaya, October 3-4, 2020

Chairman of ICVEE



Prof. Dr. Bambang Suprianto, M.T.



Vice Rector I of UNESA

Prof. Dr. Bambang Yulianto, M.Pd.



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Message from the General Chair



It gives me great pleasure to all of the keynote/invite speakers, distinguished guests, and ICVEE participants, welcome to 2020 the third International Conference on Vocational Education and Electrical Engineering (ICVEE). Due to the COVID-19 ICVEE conference which is organized by the Department of Electrical Engineering and Departement of Informatics, Universitas Negeri Surabaya and technical sponsorship IEEE Indonesia section hold the conference in the virtual event. The theme of our conference is “ Strengthening the framework of Society 5.0 through Innovations in Education, Electrical Engineering, and Informatics Engineering”.

This year we receive 134 articles and resulted in 71 articles that have been presented at this conference and will be submitted to the IEEE explorer. The article comes from some domestics and international universities. The International author and co-author come from Brazil, Jerman, Philippines, Japan, Taiwan, Singapore, Malaysia, Thailand, Saudi Arabia, and Australia. We would like to appreciate all of the keynotes and invite speakers, reviewers, committees, and participants for all the support and participation. We would like to give gratitude to the Universitas Negeri Surabaya as the organizer and IEEE Indonesian Section as a technical Co-sponsorship.

Finally, I wish all participants always successful and enjoy this conference. I hope this program will be interesting and useful for all the ICVEE participants.

Prof. Dr. Bambang Suprianto., MT

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Table of Contents

Title	i
Copyright – Proceeding ICVEE 2020	ii
Message from the General Chair ICVEE 2020	iii
Organizing Committee ICVEE 2020	iv
General and Paralel Schedule ICVEE 2020	vii
Table of Content (TOC) Proceeding ICVEE 2020	xviii

(TOC based on the sequence of the paper ID)

Mobile Augmented Reality Application with Multi-Interaction for Learning Solutions on the Topic of Computer Network Devices (Effectiveness, Interface, and Experience Design)

Subandi Subandi, Aulia Akhran Syahidi, Joniriadi, Amran Mohamed

The Concept of Using Interactive Educational Media with problem-posing Interaction Flow in Basic Programming Learning

Aulia Akhran Syahidi, Herman Tolle, Ahmad Afif Supianto, Ahmad Afif Supianto, Tsukasa Hirashima

E-Voting on Blockchain using Solidity Language

Yamuna Rosasooria , Abd Kadir Mahamad, Sharifah Saon, Mohd Anuar Mat Isa, Shingo Yamaguchi, Mohd Anuaruddin Ahmadon

Difference Between Students from Senior High School and Vocational School in the learning Outcomes of Electrical Engineering Students

Yuli Sutoto Nugroho, Alexandra K Paleologoudias

Tuning of Power System Stabilizer Using Cascade Forward Backpropagation

Widi Aribowo, Supari Muslim, Unit Three Kartini, I Gusti Putu Asto Buditjahjanto, Bambang Suprianto, Munoto munoto

Optimization of Water Level Control Systems Using ANFIS and Fuzzy-PID Model

Muhlasin, Budiman, Machrus Ali, Asnun Parwanti, Aji Aknbar Firdaus, Iswinarti

Combining the Unsupervised Discretization Method and the Statistical Machine Learning on the Students' Performance

Yuni Yamasari, Anita Qoiriah, Naim Rochmawati, Wiyli Yustanti, Hapsari P. A. Tjahyaningtjas, Puput W. Rusimamto

Motion Sensing for Wireless Body Area Networks Based on Android Using Wi-Fi Direct Transmission

Eppy Yundra, Lingga Arianto, Unit Three Kartini

Setting Coordination Relay Protection On Multiloop Model Distribution Electrical Power System Using Firefly Algorithm

Daeng Rahmatullah, Belly Yan Dewantara , Iradiratu Diah P K, Fendi Achmad

The effect of changing the type of lamp, lighting power and adding light points to the strength of the lighting in the Classroom and Reading Room of the Postgraduate Program at the Bung Hatta Building, Jakarta State University

Massus Subekti, Imam Arif Rahardjo, Eka Mardiana Mardiana

Validation of Voice Recognition in Various Google Voice Languages using Voice Recognition Module V3 Based on Microcontroller

Khusnul Khotimah , Alfiantin Noor Azhiimah, Meini Sondang Sumbawati, Agus Budi Santoso, Bambang Suprianto, Tri Rijanto, Miftahul Ma'arif

Hybrid Model For The Next Hourly Electricity Load Demand Forecasting Based on Clustering and Weather Data

Unit Three Kartini, Deddy Putra Ardyansyah, Eppy Yundra

Risk Analysis of Cloud Computing in the Logistics Process

Maniah, Shiyami Milwandhari

Impact of Nonlinear Distortion with the Rapp Model on the GFDM System.

Ari endang jayati, Muhammad Sipan

The New Intelligent Wireless Sensor Network using Artificial Intelligence for Building Fire Disasters

Irawan Dwi Wahyono, Khoirudin Asfani, Mohd Murtadha Mohamad, HA Rosyid , AN Afandi, Aripriharta

Texture Analysis of Knee Osteoarthritis Using Contrast Limited Adaptive Histogram Based Gray Level Co-occurent Matrix

Mohammad Meizaki Fatihin , Farid Baskoro, Lilik Anifah

A Vivaldi Antenna Palm Tree Class with Koch Square Fractal Slot Edge for Near-Field Microwave Biomedical Imaging Applications

Raimundo Eider Figueredo Sobrinho, Alexandre Maniçoba De Oliveira, Nurhayati Nurhayati, Antonio Mendes De Oliveira Neto, Ingrid Correia Nogueira, João Francisco Justo Filho, Arnaldo de Carvalho Junior, Marcelo Bender Perotoni

Factor Analysis that Influences CPL/Pilot License Commercial Phase Technical Knowledge of Cadets of Official Aviation School Vocational Education

Ahmad Hariri, Bambang Suprianto, I Gusti Putu Asto B, Arie Wardhono

Design of Model Predictive Control for Stability of Two Stage Inverted Pendulum

Rifqi Firmansyah, 1,2, Pressa P. Surya Saputra

Decision Support System Cattle Weight Prediction using Artificial Selected Weighting Method

Lilik Anifah , Haryanto

Measurement Model of Employability Skills of Vocational High School Student in East Java Using Structural Equation Model (SEM)

Tri Wrahatnolo, Ekohariadi Ekohariadi, Munoto Munoto

Design of X-Band Microstrip Antenna for Circularly Polarized Synthetic Aperture Radar (CP-SAR) System

Falah Khairullah, Tommi Hariyadi

What's in a Caption?: Leveraging Caption Pattern for Predicting the Popularity of Social Media Posts
Shintami Chusnul Hidayati, Raden Bimo Rizki Prayogo, Mhd. Fadly Hasan, Satria Ade Veda Karuniawan, Yeni Anistyasari

Hydrothermal Growth Temperature Dependence of Nanostructured Nickel Oxide Transparency
Teuku Muhammad Roffi, Fathur Rozi Yansyah, Arya Widya Ramadhan, Romi Naufal Karim, Nita Indriani Pertiwi

Designing Automatic Dispensers for the Blind People based on Arduino Mega using DS18B20 Temperature Sensor

Ali Nur Fathoni, Noor Hudallah, Riana Defi Mahadji Putri, Khusnul Khotimah, Tri Rijanto, Miftahul Ma'arif

Research on the Influencing Factors of Industrial Designers' Potential Traits on Career Planning

Ming-Chang Wu, Chun-Hsien

The Effectiveness and Efficiency of Google Classroom as an Alternative Online Learning Media to Overcome Physical Distancing in Lectures Due to the Covid-19 pandemic: Student perspectives

Miftahur Rohman, Farid Baskoro, L Endah Cahya Ningrum

Effects of Precursor Concentration on the Transparency of Hydrothermally Grown Zinc Oxide
Zayyan Rafi Kesuma, Kamelia Agustina, Antonius Daud Bastian Wibowo, Teguh Aryo Nugroho, Teuku Muhammad Roffi

Effectiveness of Mobile Learning Implementation in Increasing Student Competence and Preventing the Spread and Impact of COVID-19

Joko Joko, Supari Muslim, Agus Budi Santoso, Rina Harimurti

The Effect of Participation in Scientific Research and Conference on Vocational Teachers' Competence

Ismet Basuki, Joko Joko, Arif Widodo

Performance Evaluation of ESP8266 for Wireless Nurse Call System

Arif Widodo, Muhammad Adharul Imron, Nurhayati Nurhayati

Design and Implementation of IoT System for Aeroponic Chamber Temperature Monitoring

Charisma Aulia Jamhari, Wahyu Kunto Wibowo, Aulia Rahma Annisa, Teuku Muhammad Roffi

Design of Horizontal Polarization Microstrip Patch Antenna with Bandwidth Enhancement at C-band Frequency

Nedya Ulfah, Tommi Hariyadi

Fractional Gradient Descent Optimizer for Linear Classifier Support Vector Machine

Dian Puspita Hapsari, Imam Utoyo, Santi Wulan Purnami

A current mode ACG base on Sub-threshold MOS Translinear Principle

Natthapanya Pichetpiriya, Pawich Choykhuntod, Phamorn Silapan, Rapeepan Kaewon

Comparison Study of Hilbert Sierpinski and Koch Fractal on Coplanar Vivaldi Antenna for L/S band application

Nurhayati Nurhayati, Alexandre M De Oliveira, Antonio M de Oliveira, Raimundo Eider Figueredo, Marco Antonio Bernardino Pinto, João F. Justo, Fitri Adi Iskandarianto, Takeshi Fukusako

Design And Development Of Attendance System Application Using Android-Based Flutter

Giri Wahyu., Ramadan Wibi Surya Aji, Djul Fikry

Autonomous Robotics in Agriculture: A Review

Reza Rahmadian, Mahendra Widyartono

Design of Fire Detection Equipment Due to the Arc-Fault Series on Low Voltage Networks Based on Internet of Things (IoT)

Abdillah Fashiha Ilman, Mohammad Jauhari , Mohammad Nur, Dzulkiflih Dzulkiflih

Partial Shading Effect on I-V Characteristic and Maximum Power of a Photovoltaic Array

Mahendra Widyartono, Reza Rahmadian

A New Adaptive Online Learning using Computational Intelligence

Irawan Dwi Wahyono, Khoirudin Asfani, Mohd Murtadha Mohamad, Djoko Saryono, M Ashar, S. Sunarti

Design of a Microstrip Line Quad-band Bandpass Filter based on Fibonacci geometric sequence

Marco Antonio Bernardino, Raimundo Eider Figueiredo, João Francisco Justo, Marcelo Bender Perotoni, N. Nurhayati, Alexandre Maniçoba de Oliveira

The Identification of the Apples (*Malus Sylvestris*) Skin Wax Coating Using the Edge Detection Method

Robby Kurniawan Budhi, Alan Budi Rianto, Agus Prayitno

Evaluation of Indonesian Technical and Vocational Education in Addressing the Gap in Job Skills Required by Industry

Muhammad Ali, Bruri Triyono, Thomas Koehler

Semantic Web Ontology for Vocational Education Self-Evaluation System

Muhammad Ali, Faiq Miftakhul Falakh

The impact of The COVID-19 Pandemic in Indonesia (Face to face versus Online Learning)

Dina Fitria Murad, Rosilah Hassan, Yaya Heryadi, Bambang Dwi Wijanarko, Titan

Combination of Fuzzy C-Means and Simple Additive Weighting Using Partition Coefficient Index

Faizal widya nugraha, Silmi Fauziati, Adhistya Erna Permanasari

High Availability in Software-Defined Networking using Cluster Controller: A Simulation Approach

I Made Suartana, Mokhamad Aguk Nur Anggraini, Abhimata Zuhra Pramudita

Effect of Combination Fractional Slot Number and Slotting Technique on the Cogging Torque in Permanent Magnet Machines

Marsul Siregar, Tajuddin Nur, Liza Evelyn Joe, Karel O. Bachri, Catherine Olivia Sereati, Sandra O.B.W

Covid Symptom Severity Using Decision Tree

Naim Rochmawati, Hanik Badriyah Hidayati, Wiyli Yustanti, Yuni Yamasari, Lusya Rakhmawati, Hapsari PA tjahyaningtijas, Yeni Anistyasari, Lusya Rakhmawati

Deep Learning Implementation of Facemask and Physical Distancing Detection with Alarm Systems
Sammy Victoriano Militante, Nanette Villavert Dionisio

Pneumonia and COVID-19 Detection using Convolutional Neural Networks
Sammy Victoriano Militante, Renante Apelado Diamante, Brandon G. Sibbaluca

Development of Mapping Area Software for Dismissal people affected by Covid 19
Aries Dwi Indriyanti, Dedy Rahman Prehanto, I Gusti lanang Putra Eka, I Kadek Dwi Nuryana, Agus Wiyana

Key Rate Enhancement by Using the Interval Approach in Symmetric Key Extraction Mechanism
Mike Yuliana, Suwadi, Wirawan

The Role of Information Technology Knowledge and Online Learning on Learning Environmental Changes in Vocational Education
Yuyun Suprpto, Mochammad Rifai, Fiqqih Faizah, Ariyono Setiawan

Design of Competency Test Model for Electrical Installation Automation Based Project Learning for Electrical Engineering Students
Subuh Isnur Haryudo, Ekohariadi, Munoto, Setya Chendra Wibawa, Fendi Achmad, Edy Sulistyo

Potentials of Metasurface Technology on Antennas and Propagation
Takeshi Fukusako, Ryuji Kuse

An Enhanced Cryptographic Algorithm in Securing Healthcare Medical Records
Jessie Retorca Paragas

A Hybrid Classification Based on Machine Learning Classifiers to Predict Smart Indonesia Program
Ichwanul Muslim Karo Karo, Ari Wilyan Ramadhelza, Ryan Ramdhani, Bilal Zahran Aufa

The Effectiveness of the Use of Learning Media of Interactive Multimedia in Facial Skin Care Courses
Murni Astuti

The Effect of Mobile-Learning Models on Students' Learning Outcomes of Research Methodology Courses at the Cosmetology and Beauty Department
Rahmiati Rahmiati, Yuliana, Muhamad Adri, Ika Parma Dewi

Simulation and Performance Evaluation of Fiber Optic Sensor for Detection of Salinity in Prawn Pond Application
Sapitri Hermawati, Budi Mulyanti, Roer Eka Pawinanto, Arjuni Budi Pantjawati, Lilik Hasanah, Wawan Purnama

EnORS: An Enhanced Object Relationship Schema
Ritchell Solitario Villafuerte, Deborah Go Brosas, Dindo C. Obediencia, Jessie R. Paragas

Adaptive Neuro-Fuzzy Approach for Cacao Bean Grading Classification Process
Deborah G. Brosas, Ritchell S. Villafuerte, Dindo C. Obediencia

Microcontroller and Wireless Communication Based Smart Laboratory Box System Implementation
Hadiwiyatno, M. Nanak Zakaria, Septriandi Wira Yoga

The Marketing of Teaching Factory Product Through Online E-Commerce at Fashion Design Vocational High Schools

Ratna Suhartini, Diyan Vitariyanti, Bima Yatna Anugerah Ramadhani, Eva Maria Yuli Astuti

Parking Management by Means of Computer Vision

Mochamad Mobed Bachtiar, Adnan Rachmat Anom Besari, Atikah Putri Lestari

A Dual UPQC to Mitigate Sag/Swell, Interruption, and Harmonics on Three Phase Low Voltage Distribution System

Amirullah, Adiananda, Ontoseno Penangsang, Adi Soeprijanto

Detecting SQL Injection On Web Application Using Deep Learning Techniques: A Systematic Literature Review

Muhammad Takdir Muslihi, Daniyal Alghazzawi

Integration of FAHP and COPRAS Method for New Student Admission Decision Making

Yeni Kustiyahningsih, Husni, Ismy Qorry Aini

Non-Proliferative Diabetic Retinopathy Classification Based on Hard Exudates Using Combination of FRCNN, Morphology, and ANFIS

Ricky Eka Putra, Handayani Tjandrasa, Nanik Suciati, Ardian Yusuf Wicaksono

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Abstract— the suitability of the data with the method in the process of data mining is very important to increase the process performance. However, In Educational Data Mining (EDM), not much research has focused on this field. Therefore, this study proposes to combine an unsupervised discretization method called "equal width interval" and logistic regression as statistical machine learning to improve the performance of the model relating to students' performance. The discretization method is performed on student data with several intervals, namely: 3-interval, 4-interval, and 5-interval. Then, these intervals are combined with logistic regression in two regularizations, namely: lasso and ridge. Evaluation is carried out on all combinations. The experimental results indicate that the highest performance, in terms of the accuracy level, is achieved by the model combining a 3-interval and logistic regression on all regularization. This combination can increase the model performance based on the average accuracy level of about 4.08-8.49 on the ridge regularization and about 4.28-8.6 on the lasso regularization.

Keywords—students' performance, data mining, machine learning, logistic regression, discretization

I. INTRODUCTION

Nowadays, almost all education institutions explore information and communication technology to enhance their process, for example learning process [1][2][3], evaluation process [4][5] despite its security [6]. This situation generates massive data pushing research about Educational Data Mining (EDM) [7]. The one of popular tasks in EDM is the classification of students' performance[8]. Here, student data is mined to get information about the students' performance. Before the mining process is done, methods sometimes are applied in the pre-processing stage [9]. They are the normalization, feature extraction, feature selection, the discretization method, etc. One of the objectives is to improve the performance of the system built [10].

Relating to the discretization method, it is used to transform the numerical method to a categorical method. Also, this method changes the non-standard probability distribution to the standard probability distribution. This method is applied with many reasons as follows: algorithms of machine learning requiring categorical or ordinal variables [11], the non-standard probability distributions causing the performance degradation of machine learning, the result of mapping smoothing out the relationships between observations because of providing a high-order ranking of values [12]. There are

two mainstreams of the discretization methods, namely: the supervised methods and the unsupervised methods. The methods included in the unsupervised discretization methods are equal width interval, equal frequency interval, etc. For the supervised method, they are adaptive quantizes, chi merge, predictive value max, etc. [13]

The logistic regression is one of the methods in machine learning requiring the categorical variables. This method is grouped in the statistical machine learning [14]. As we have known, statistics have a very important role in the development of other sciences to draw conclusions, test hypotheses or theories, understand phenomena, analyze experiments, determine decisions, and so forth. Meanwhile, Machine learning, which is one branch of artificial intelligence (artificial intelligence) is currently continuing to experience growth and increasingly popular. The development of statistics and machine learning is of course because it can not be separated from the main factor, namely data. Machine learning has at least two main objectives, namely: solving problems in predicting the future (unobserved event) and gaining knowledge (knowledge discovery). Statistical machine learning refers to techniques for predicting the future and getting knowledge from data rationally. To be able to get these goals, statistical machine learning can be the right tool or method. Statistics acts as a learning base that utilizes statistical theory to inference and interprets the models, while machine learning focuses on the use of models to predict new data. Statistics and machine learning form a concept called Statistical machine learning using logistic regression models. Logistic regression models are among the models that are often used by machine learning practitioners [15].

Our paper focuses on the exploration of one of the discretization method called "equal width interval" and the statistical machine learning, namely: logistic regression on the students' performance domain.

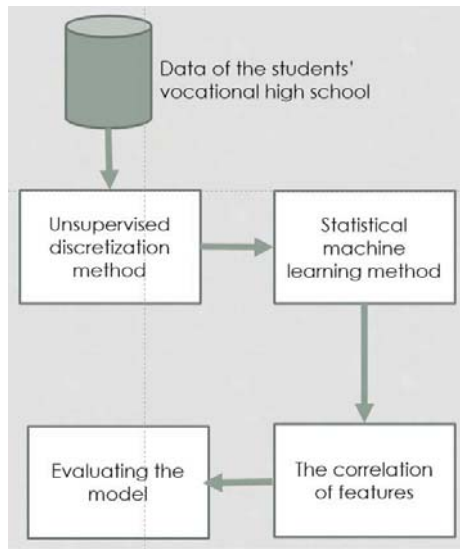


Fig. 1. The proposed architecture

II. METHOD

In this section, this proposed method is depicted in Fig.1. Here, this architecture consists of many stages. They are as follows:

Stage 1: data of students' vocational high school

This research mine the student data of the previous work [16]. The student data is collected when the students join the evaluation process in the e-learning system. The data consists of 5 features that are extracted from 101 features of the raw dataset. They are as follows: Done, PercentTrue, Time, Hint, and Score which having the numeric data type.

Stage 2: the exploration of the unsupervised discretization method

In this stage, we apply the unsupervised discretization method called “equal width interval” with formula as follows:

$$w = \frac{(value_{\max} - value_{\min})}{k} \quad (1)$$

Where, w = width of an interval, k = the number of intervals which can be determined manually. For the range threshold on $value_{\min} + iw$, where, $i = 1, \dots, k-1$, each range can be defined as follows:

$$value_{\min} + w, value_{\min} + 2w, \dots, value_{\min} + (k-1)w \quad (2)$$

We divide student data into some intervals, namely: 3, 4, and 5. Then we definite as 3-interval, 4-interval, and 5-interval. This stage is done to know how many of the best intervals are implemented on our student data. This information is very important to the labeling process relating to the students' performance evel.

Stage 3: logistic regression

We combine the result of the previous stage with logistic regression in this stage. Also, there are two regularizations in the logistic regression, namely: Lasso [17] and Ridge[18][19]. We explore all regularizations to be experimented in our research to reach the optimum result.

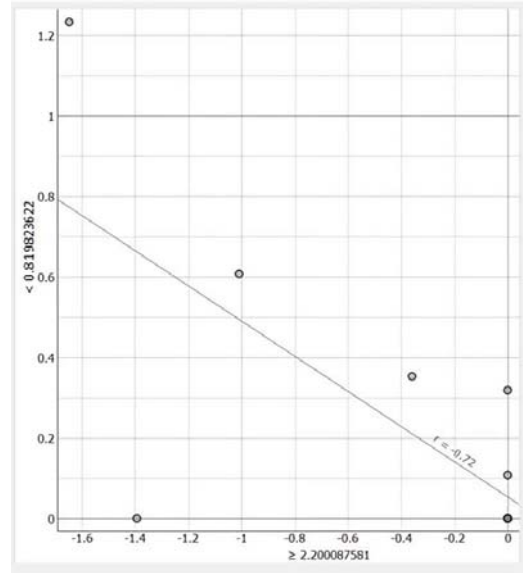


Fig. 2. Regression line with the highest correlation on discretization-3-interval-lasso

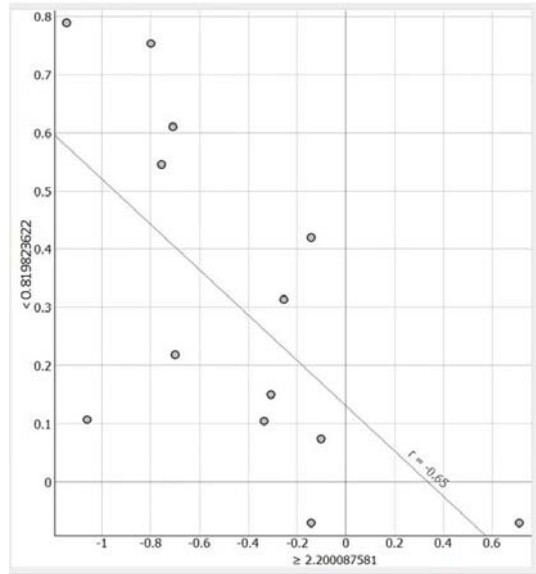


Fig. 3. Regression line with the highest correlation on discretization-3-interval-ridge

Stage 4: analyzing the correlation of features

In this stage, we analyze the correlation on all features. We do one by one of the features to observe the correlation between the one features with the others. This stage also can be used to evaluate the relevant features to determine the target. Further, we also do the visualization for this step.

Stage 5: evaluating the model

The last stage evaluates the model built by the combination of the discretization method and logistic regression using the accuracy level metric. The stage observes the highest performance of the model.

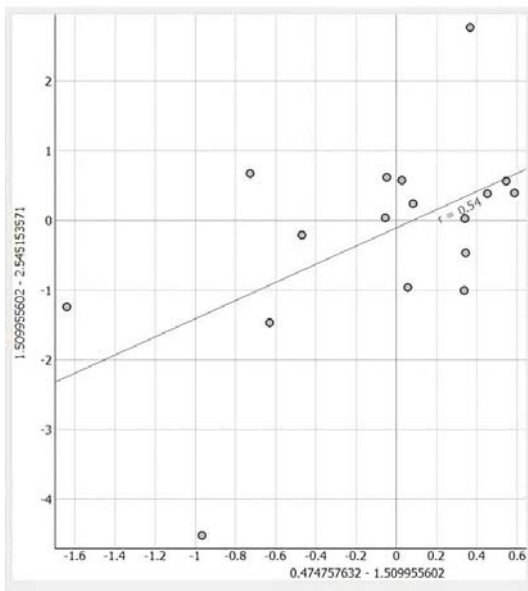


Fig. 4. Regression line with the highest correlation on discretization-4-interval-lasso

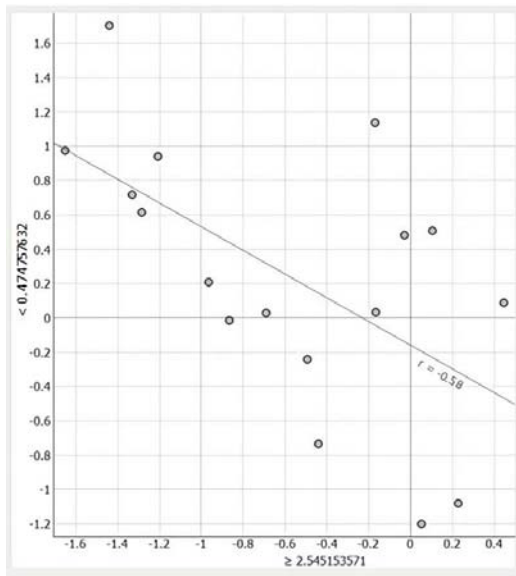


Fig. 5. Regression line with the highest correlation on discretization-4-interval-ridge

III. RESULT AND DISCUSSION

In this section, the proposed architecture is executed and then the result is analyzed. There are 2 sub-section explained, namely: the features correlation and the performance measurement. The performance of the model is evaluated using the accuracy level.

A. The correlation of features

The first session describes the correlation of features. After the discretization method is applied, we do combine the results of the discretization method using the logistic regression on all regulations.

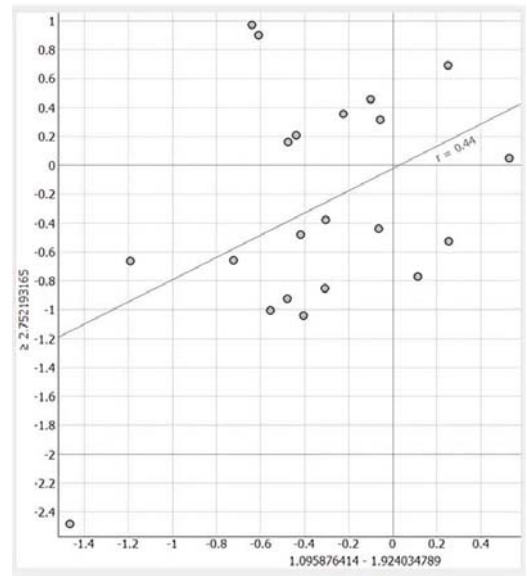


Fig. 6. Regression line with the highest correlation on discretization-5-interval-lasso

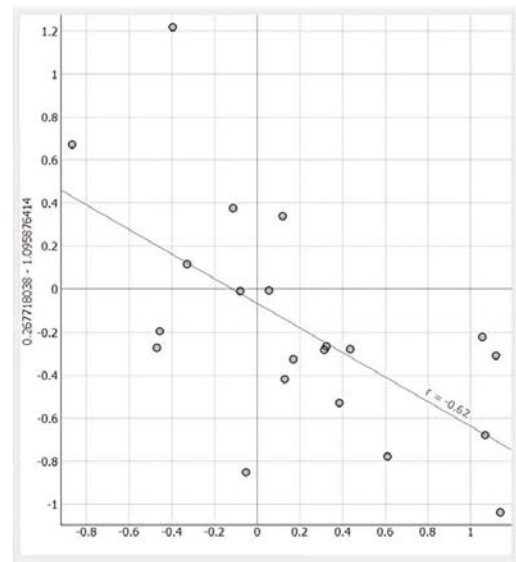


Fig. 7. Regression line with the highest correlation on discretization-5-interval-ridge

For that, there are 6 combinations, namely: 3-interval-lasso, 3-interval-ridge, 4-interval-lasso, 4-interval-ridge, 5-interval-lasso and 5-interval-ridge.

Then, we compute the correlation of features on each combination which is stated with the r symbol. In here, we only visualize the highest results on the all combinations depicted in the Fig.2-Fig.7. The general, the combinations of the discretization method, and the logistic regression on the ridge regulation correlate higher than others in all cases. In detail, the highest correlation is reached by 3-interval-lasso, namely: around $r = -0.72$. Contrarily, the lowest correlation of about $r = 0.44$ is achieved by 5-interval-lasso.

TABLE I. THE ACCURACY LEVEL OF THE COMBINATION OF LOGISTIC REGRESSION AND DISCRETIZATION METHOD WITH 3-INTERVAL

	3-interval-lasso					3-interval-ridge				
	Repeat train									
Training set size	2	3	5	10	20	2	3	5	10	20
10%	85.3	85.3	85.3	85.3	85.3	84.8	85	84.9	84.7	84.5
20%	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.6	84.4	84.4
30%	85	85	85	85	85	85	85	84.8	84.9	84.9
40%	85.3	85.3	85.3	85.3	85.3	85.3	85.3	85.3	85.1	85.2
50%	84.2	84.2	84.2	84.2	84.2	84.2	83	85.3	83.9	83.9
60%	84.8	84.8	84.8	84.8	84.8	84.8	84.8	84.8	84.8	84.8

TABLE II. THE ACCURACY LEVEL OF THE COMBINATION OF LOGISTIC REGRESSION AND DISCRETIZATION METHOD WITH 4-INTERVALS

	4-interval-lasso					4-interval-ridge				
	Repeat train									
Training set size	2	3	5	10	20	2	3	5	10	20
10%	79.4	80.1	80.6	81	81.2	79.9	80.4	80.8	80.5	80.3
20%	80.2	80.6	80.9	81.1	81.1	80.8	81	80.7	81	80.9
30%	78.7	79.6	80.2	80.7	80.9	80.6	80.4	80.5	80.9	80.7
40%	79.4	79.9	79.7	80	80.4	79.4	79.4	80	80.1	80.5
50%	78.9	79.5	80	80.4	80.3	80.7	80.7	80.7	80.5	80.4
60%	82.6	82.6	82.6	82.6	82.6	80.4	81.2	81.7	82	82

TABLE III. THE ACCURACY LEVEL OF THE COMBINATION OF LOGISTIC REGRESSION AND DISCRETIZATION METHOD WITH 5-INTERVALS

	5-interval-lasso					5-interval-ridge				
	Repeat train									
Training set size	2	3	5	10	20	2	3	5	10	20
10%	77.5	77.5	77.3	77.5	77.3	76	76.8	76.5	76.7	76.5
20%	75.3	73.6	74.9	75.9	76.3	75.8	75.1	75.8	76.3	76.5
30%	76.9	76.7	76	75.7	75.7	76.9	76.7	76.7	76.5	76.4
40%	76.5	76.5	75.6	76	76.2	76.5	76.5	75.6	75.9	75.9
50%	77.2	76	76.5	76.3	76.8	76.3	76	76.1	76.1	76.7
60%	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	75.9	75.9

Further, the 3-interval is illustrated in Fig.2-3. The correlation exploration of all features on the 3-interval is found that the highest correlation on logistic regression with lasso regulation. It is around $r = -0.72$. This condition occurs on the value of axis-x ≥ 2.200087581 and the value of axis-y < 0.819823672 . For logistic regression with ridge regulation, the highest correlation is about $r = -0.65$ with the value of axis-x ≥ 2.200087581 and on the value of axis-y < 0.8198234672 .

The 4-interval is illustrated in Fig.4-5. The correlation exploration of all features on the 4-interval is found that the highest correlation on logistic regression with lasso regulation. It is around $r = 0.54$. This condition occurs on the value of axis-x $0.474757632-1.509955602$ and the value of axis-y $= 1.509955602-2.545153571$. For logistic regression with ridge regulation, the highest correlation is about $r = -0.58$ with the value of axis-x ≥ 2.545153571 and axis-y < 0.474757632 .

The 5-interval is illustrated in Fig.6-7. The correlation exploration of all features on the 4-interval is found that the highest correlation on logistic regression with lasso regulation. It is around $r = 0.44$. This condition occurs on the value of axis-x $0.474757632-1.509955602$ and the value of axis-y $= 1.509955602-2.545153571$. For logistic regression with ridge regulation, the highest correlation is about $r = -0.62$ with the value of axis-x ≥ 2.545153571 and axis-y < 0.474757632 .

B. The performance measurement

The next discussion is about the model performance, in terms of level accuracy. Discretization methods at all intervals and all regulations are presented in TABLE I-III. This step is carried out to analyze which intervals and regulations have the best performance in logistic regression. Trials are conducted on a set of training sizes multiples of 10 from 10% -60% and repetition of train 2, 3, 5, 10, and 20.

The trial results of a combination of 3-interval discretization and logistic regression regulation of the lasso and ridge are presented in TABLE I. The table shows the highest accuracy level of 85.3% occurred in the trial scenario training size of 10% and 40% with all the repeat train settings for lasso regulation. Whereas in ridge regulation, the test scenario is the training set size of 40% with repeat train 2, 3, 5, and the training set size 50% with repeat train 5. Conversely, in discretization 3 intervals, logistic regression with lasso regulation experiences the lowest accuracy level of 84.2 % occurs in the trial scenario the training set size is 50% for all repeat trains. Whereas logistic regression with ridge regulation experienced the lowest accuracy level of 83% in the training set size of 60% and repeat train 3.

The experimental result of a combination of 4-interval and logistic regression with the regulation on the lasso and ridge is presented in TABLE II. The table shows the highest level of accuracy in both regulations that occurred in the training set= 60%. For lasso, the highest accuracy level is 82.6% on all repeat trains. The ridge reaches the highest accuracy level of

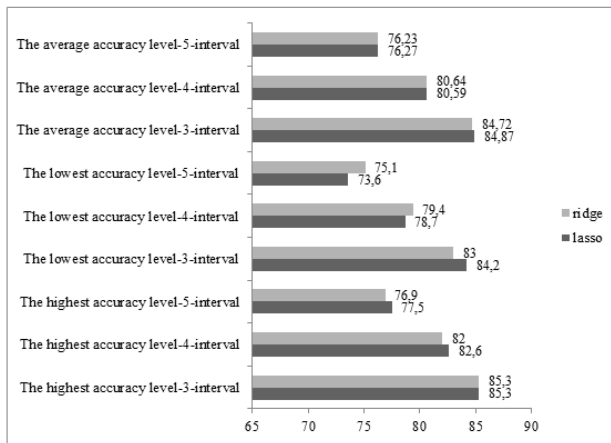


Fig. 8. The comparison of accuracy level on all intervals

82% on repeat trains 10 and 20. Meanwhile, the lowest accuracy level of 78.7% is experienced by Lasso regulations in the training set size of 30% with repeat train 2. For ridge, the lowest level of accuracy 79.4% is experienced on the training set size of 40% with repeat train 2 and 3.

The experiment result of a combination of 5-interval and logistic regression with the regulation on lasso and ridge is represented in TABLE III. The table shows the highest accuracy level of 77.5% occurring on the training set size of 10% in almost all repeat train settings for lasso regulation. Meanwhile, in ridge regulation, the highest accuracy level of 76.9% is achieved with a training set size of 30% and repeat train 2. Conversely, logistic regression with the Lasso regulation experience the lowest accuracy level of 73.6% occurred in the training set size of 20% and repeat train 3. While in logistic regression with ridge regulation, the lowest accuracy level is 75.1% in the training set size of 20% and repeat train 2.

The overall results of the experiment presented in TABLE I-III show special conditions, namely: achieving quite high accuracy with a small training set size (10%). This is possible because the data of students selected in the construction of the model are sufficiently representative. Moreover, the data selected for this training set is most likely to have the most influence on the target. Thus, this data is sufficient to represent the data as a whole although only slightly in size. To further clarify the results obtained, the average accuracy level, lowest accuracy level, and highest accuracy level are presented in Fig.8. The discretization method for 3-interval dominates the highest results among the others, and then followed by the discretization method for 4-interval and finally 5-interval in all regulations of logistic regression

IV. CONCLUSION

The Equal width interval can be combined with logistic regression with lasso and ridge regulation in the students' performance data. Among the intervals that have been carried out, the combination of discretization of 3 intervals in this realm and logistic regression of all regulations has been proven to achieve the best results, in terms of the highest level of accuracy.

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