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Judul:
Estimation of Finger Joint Angle based on Surface Electromyography Signal using Long Short-Term Memory

disusun oleh:
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Message From The General Chairman

Welcome to virtual International Conference, International Conference on Computer Engineering, Network and Intelligent Multimedia (CENIM 2020) The theme of this conference is "Advancing Computer Engineering, Network and Intelligent Multimedia to Support Society in The New Normal Era". CENIM 2020 is an international conference that is organized by The Department of Computer Engineering - Institut Teknologi Sepuluh Nopember (DCE-ITS) and has been approved by IEEE for technical co-sponsorship. This conference is an excellent event where researchers and engineers from academia and industry, majority locally from Indonesia as well as from abroad, to meet and share their recent findings for the advancement of the field in Computer Engineering and its application.

In our records, CENIM 2020 has received 138 paper submission with authors coming from 12 different countries. This conference has accepted 78 papers for presentation from 9 countries on 4 continents such as USA, UK, Japan, Rwanda, Thailand, United Kingdom, Palestine, Germany, and Ethiopia. The topics of the papers are various including Computer network, soft computing and machine learning, Embedded System and robotics, biomedical signal and image processing, also game engineering and ICT in smart city. This conference has received tremendous help and support. Therefore, we would like to thank all the international advisory board, technical programme committee (TPC) for their contribution to reviews and selecting high-quality paper. Our gratitude also goes To Direktorat Riset dan Pengabdian Kepada Masyarakat (DRPM), Institut Teknologi Sepuluh Nopember, Surabaya, distinguished invited speakers who are experts in the topics related to the theme of the conference, and members of the local organizing committee, for their teamwork at preparing the virtual conference. Lastly, we hope that you can have a great time at the conference, and we wish you a pleasant virtual conference environment.

Dr. Supeno Mardi Susiki Nugroho
General Chairman

Message From The Dean Of The Faculty Of Intelligent Electrical And Informatics Technology (ELECTICS) - ITS Indonesia

Dear colleagues, researchers, honourable guests and keynote speakers, and all the attendees, On behalf of the staff and student of the Faculty of Intelligent Electrical and Informatics Technology ITS, I would like to welcome all of you in the 2020 International Conference on Computer Engineering, Network and Intelligent Multimedia, CENIM.

I am honoured to deliver the opening remarks in this first online CENIM conference, after it has been held annually since 2018. We all know that the ongoing Covid-19 pandemic is a big challenge to almost every aspect of life, including organizing CENIM. Therefore, I would like to express my appreciation to reviewers, speakers, and attendees of this conference, to take on this challenge.

Our faculty, ELECTICS, has a tagline. It is “Bring Humanized Intelligent Technology for Society”. It resonates with the theme of CENIM 2020 which is “Advancing Computer Engineering, Network and Intelligent ro Support Society in The New Normal Era”. Not only we aim to become a reference for education and research excellence, but also to contribute to the humanity and society.

During pandemic era, we able to create the RAISA Robot, a servant robot that is very helpful to reduce the risk of Covid-19 transmission to health workers without reducing the quality of service to patients. We have also made a remote system to be able to control the ventilator in the ICU room remotely. All of these products are the result of collaboration and perfect examples on how we can bring humanized intelligent technology for society.

The CENIM 2020 has a broad scope, ranging from control system engineering, electronics, power and energy, telecommunication and signal processing, also biomedical engineering and information technology. Therefore, I hope more new ideas and collaborations especially for the humanity, will be created and initiated through CENIM. I wish you a great and productive experience in the CENIM 2020.

Ladies and Gentlemen, the pandemic period taught us how to collaborate to solve humanitarian problems. Many collaborative research products have been produced during the pandemic. Therefore, I hope that this seminar will become a virtual space to meet and discuss and then collaborate. I congratulate and succeed for holding this seminar. Lastly, I would like to express my great thanks to the committee who have tried hard to hold this seminar.

Thank you.
Dr. I Ketut Eddy Purnama
Dean
Faculty of Intelligent Electrical and Informatics Technology (ELECTICS)
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia

Message From The Rector of ITS

Our respected guests and keynote speakers, colleagues, and all the participants, good morning, good afternoon, and good evening.

It is a pleasure to welcome all of you in this virtual event of 2020 International Conference on Computer Engineering, Network and Intelligent Multimedia, CENIM.

We will have Dr. I Ketut Eddy Purnama -my colleague from ITS who will present his latest research on biomedic engineering. Thank you Dr. I Ketut Eddy Purnama for representing ITS researcher and taking a part in CENIM.

We will also have a lecture from Prof. Dae-Ki Kang, which is now joining from Korea, which is two hours ahead of Indonesia. Thank you, Prof. Dae-Ki Kang, for accepting our invitation to share your valuable expertise with all of us. He will have a talk on Review on Standardization Activities of Artificial Intelligence and its Trustworthiness.
I would also like to thank Prof. Kai-Lung Hua, our keynote speaker from Taiwan, which is one hour ahead of Indonesia, he will have a talk on Deep Learning with Small Visual Data.

I would also like to thank Alfred Boediman, PhD, our keynote speaker from Samsung Research Indonesia, which is now in Jakarta. Mr Alfred already had a relationship with our researchers, had a research cooperation Evolution of Mobile and Embedded Smart Devices Technology.

I would also like to thank Winahyu H Utomo, our keynote speaker from US, which is twelve hours behind of Indonesia, which means it is still early morning there. He will give a guest lecture tomorrow and will deliver a lecture on Network Virtualization that makes sense.
Under the serious impact of Covid-19, the CENIM organizing committee has decided to switch the conference, which was initially to be held in Surabaya, to online platform. It might be disappointing that we might miss the opportunity to visit ITS and Surabaya, but through this online event I hope the networking and collaboration will be initiated and maintained even better.

Ladies and Gentlemen, ITS vision in 2020-2030 is to become a world-class university that contributes to the nation's independence and becomes a reference in education, research and community service and the development of innovation, especially in supporting industry and maritime. One of the real stage of the vision is the development of innovation and the creation of innovative products of science and technology. To achieve this, ITS has 10 research centers, 4 innovations centers, and 5 community research centers, and many innovated research labs in Departments.

With the Covid-19 pandemic, ITS has focused more on the development of medical products and strengthening collaboration with medical institutions. One highlighted innovation is our medical assistant robot named RAISA, a collaborative product between ITS and Airlangga University Hospital. RAISA is designed to replace medical personnel serving isolated patient, hence the number of direct contacts between patients and medical staff can be reduced, which reduces the infection risk as well as the needs of protective suit for the staff. As for now, RAISA has been serving in several hospitals and has been announced by the president of Indonesia as one of the 9 outstanding Indonesia Covid-19-related innovations. Beside RAISA robot , ITS also launch autonomous vehicle, ICar and IBoat, to boast AI research which can support for our transportation industry.

During this pandemic, even though we implemented Work From Home, we asked all units to execute the planned work program, make innovation including utilizing online system. Like the CENIM seminar, it is still run by The Computer Department of ITS. I see participants of this seminar not only from Indonesia but from many countries. This proves that we are all able to adapt quickly, still be productive, including attending this international seminar.

Ladies and Gentlemen, through this conference, I hope not only you will have the opportunity to see ideas and findings from other researchers, but also to get to know more about ITS. We have many collaborative programs for partners in Indonesia or abroad, we have initiated international undergraduate program last year and will launch master by research program this year. The pandemic has driven us to adapt, and few of the adaptions resulted in many documentedwebinars and courses from various departments in ITS which you can easily access. So I invite you to explore ITS and hopefully in the future you can also visit and interact with the students and staff here.
Finally, I wish that the 2020 CENIM conference will be a grand success. I wish you all the best.
Thank you.

Prof. Mochamad Ashari R
Rector Institut Teknologi Sepuluh Nopember
Surbaya, Indonesia

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CENIM 2020 GENERAL SCHEDULE

Tuesday 17 Nov 2020

Time	Schedule	Venue
07.00 - 09.00	**Registration.**	
09.00-09.30	**Opening Ceremony** Video National Anthem Indonesia Raya Welcome Speech: General Chairman of CENIM 2020 Welcome Speech: Dean of FTEIC-ITS, Dr. I Ketut Eddy Purnama Welcome Speech: Rector of ITS, Prof. Mochamad Ashari CENIM 2020 Opening, Prof. Mochamad Ashari Best Paper Award Announcement, Dr Supeno Mardi Susiki Best International Contribution Award, Dr. Ketut Edi Purnama **Keynote Speaker Session.** Moderator : Dr. Laili Yuhana	Webinar
09.30 - 10.30	1st Keynote Speaker Prof. Kai-Lung Hua, National Taiwan University of Science and Technology, Taiwan.	
10.30 - 11.30	2nd Keynote Speaker: Prof. Dae-ki Kang, Dongseo University, Korea	
11.30 – 12.30	**Break** **Keynote Speaker Session.** Moderator Dr. Reza Fuad .	
12.30 - 13.30	3rd Keynote Speaker: Alfred Boediman. PhD., Samsung Research and Development Institute Indonesia (SRIN), Indonesia	
13.30 – 13.45	**Break**	
13.45 - 17.00	Parallel Session 1(6 virtual meetings)	Break Out : Semeru, Kawi, Kelud, Agung, Rinjani,Bromo

Wednesday 18 Nov 2020

Time	Schedule	Venue
08.00-09.00	**Registration**	
	Keynote Speaker Session.	Webinar
	Moderator Dr. Reza Fuad .	
09.00 - 10.00	4th Keynote Speaker: Winahyu Hadi Utomo, Red Hat cloud consultant, California, USA	
10.00 - 11.00	5th Keynote Speaker: Dr. I Ketut Eddy Purnama Institut Teknologi Sepuluh Nopember, Indonesia	
11.00-11.30	Closing Ceremony Conference Dr. I Ketut Eddy Purnama	
11.30 – 12.30	Break	
12.30 - 15.30	Parallel Session 2 (6 virtual meetings)	Break Out : Semeru, Kawi, Kelud, Agung, Rinjani,Bromo
15.30 - 17.30	**Workshop** Deep Learning Latex	

SESSION I : TrackAssistive Technology
Date/Time : 17 November 2020/13.45 – 17.00
Room : Semeru
Moderator : Dr. Rika Rokhana

Code	Paper ID	Title	Author
AT-01	1570669847	*Fall Detection System for Elderly based on 2D LiDAR: A Preliminary Study of Fall Incident and Activities of Daily Living (ADL) Detection*	Herti Miawarni; Tri Sardjono; Eko Setijadi; Mauridhi Hery Purnomo; Agustinus Bimo Gumelar; Dwi Arraziqi; Wijayanti Wijayanti
AT-02	1570674074	*Design of Post-stroke Upper Limb Rehabilitation Game using Functional Electrical Stimulation for Hemiplegic Patient*	Steven Seaver Wiarta; Achmad Arifin; Siti Baki; Fauzan Arrofiqi; Muhammad Hilman Fatoni; Takashi Watanabe
AT-03	1570674356	*Subject Intention Speed Control of Electric Wheelchair for Person with Disabilities using Myoelectric Signals*	Elvina Ambarwati; Achmad Arifin; Muhammad Hilman Fatoni; Fauzan Arrofiqi; Tri Sardjono
AT-04	1570675240	*Design and Realization of Peristaltic Pump and Syringe Pump in Hemodialysis System*	Ilham Hadi Pramana; Tri Arief Sardjono; Siti Baki; Muhammad Hilman Fatoni; Rachmad Setiawan
AT-05	1570675295	*A Power Assist System for Elbow Movement Restoration of Post-Stroke Patients*	M. Putri; Atar Fuady Babgei; Achmad Arifin
AT-06	1570674326	*Design of Fuzzy Logic Control in Functional Electrical Stimulation (FES) Cycling Exercise for Stroke Patients*	Rizky Mayardiyah Syafitri Pandiangan; Achmad Arifin; Siti Baki; Rudy Dikairono

SESSION I : Biomedical Signal and Image Processing & Analysis

Date/Time : 17 November 2020/13.45 – 17.00
Room : Agung
Moderator : Dr. Tita Karlita

Code	Paper ID	Title	Author
BIO-01	1570675748	*Arrhythmia Classification on Electrocardiogram Signal Using Convolution Neural Network Based on Frequency Spectrum*	Arief Kurniawan; Ananda Ananda; Firdaus Pradanggapasti; Reza Fuad Rachmadi; Eko Setijadi; Eko Mulyanto Yuniarno; Mochammad Yusuf; I Ketut Pumama
BIO-02	1570675314	*The Utilization of Padding Scheme on Convolutional Neural Network for Cervical Cell Images Classification*	Imas Sukaesih Sitanggang; Toto Haryanto; Muhammad Agmalaro; Riries Rulaningtyas
BIO-03	1570670287	*Detection of Parkinson's Disease at The Level of Motor Experiences of Daily Living Using Spiral Handwriting*	Dwi Arraziqi; Herti Miawarni; Tri Sardjono; Mauridhi Hery Purnomo
BIO-04	1570670369	*U-Net Segmentation Achieve Clinically of HT29 Colon-Cancer Cell to Analyze Variations Morphology in Mitotic Defects and Micro Nuclei*	Adiratna Ciptaningrum; I Ketut Eddy Purnama; Reza Fuad Rachmadi
BIO-05	1570675094	*Time Series Analysis for Understanding Local Policy Impact of COVID-19 Cases in East Java*	Diana Purwitasari; Agus Budi Raharjo; Izzat Aulia Akbar; Faizal Johan Atletiko; Wiwik Anggraeni; Muhammad Ardian; Niko Azhari Hidayat; Hendro Suprayogi; Muhammad Amin
BIO-06	1570675376	*Comparison Of 10 QRS Detection Methods for Heart Beat Detection on Portable ECG Systems*	Yeni Wahyu Siswanti; Muhammad Yazid; Rachmad Setiawan
BIO-07	1570675156	*Automated Cerebral Lateral Ventricle Ratio Measurement From 2-Dimensional Fetal Ultrasound Image to Predict Ventriculomegaly*	Maratun Nabila; Muhammad Hilman Fatoni; Tri Sardjono

SESSION I : Biomedical Signal and Image Processing & Analysis
Room : Rinjani
Date/Time : 17 November 2020 / 13.45 – 17.00
Moderator : Dr Adhi Dharma

Code	Paper ID	Title	Author
BIO-08	1570670002	*An auto contrast custom convolutional neural network to identifying Gram-negative bacteria*	Budi Satoto
BIO-09	1570673331	*An Evaluation Performance of Kernel on Support Vector Machine to Classify The Skin Tumors in Dermoscopy Image*	Andhryn Celica Dewi Rahajeng; Mohammad Nuh; Nada Fitrieyatul Hikmah
BIO-10	1570674199	*Gait Data Compression using Linear Prediction Modeling and Data Decomposition based on Discrete Wavelet Transform*	Khoirun Nahdliyah; Achmad Arifin; Muhammad Hilman Fatoni; Fauzan Arrofiqi
BIO-11	1570674607	*Estimation of Finger Joint Angle based on Surface Electromyography Signal using Long Short-Term Memory*	Khairul Anam; Cries Avian; Aris Zainul Muttaqin; Dwiretno Istiyadi Swasono; Harun Ismail
BIO-12	1570667343	*Identification of Epilepsy Phase Based on Time Domain Feature Using ECG Signal*	Wardah Rahmatul Islamiyah; Nadhira Neesa Sarasati; Diah Wulandari; Yoyon Suprapto; Santi Wulan Purnami; Anda Juniani
BIO-13	1570675259	*Image Segmentation Metrics in Skin Lesion: Accuracy, Sensitivity, Specificity, Dice Coefficient, Jaccard Index, and Matthews Correlation Coefficient*	Agung Setiawan

Estimation of Finger Joint Movement based on Electromyography Signal using Long Short-Term Memory

Publisher: IEEE

Khairul Anam ; Cries Avian ; Dwiretno Istiyadi Swasono ; Aris Zainul Muttaqin ; Harun Ismail **All Authors**

Abstract

Abstract: The presence of hand plays a vital role. Without a hand, humans experience difficulties in their activities. As a result, several solutions have emerged to overcome this ... **View more**

Metadata

Abstract:
The presence of hand plays a vital role. Without a hand, humans experience difficulties in their activities. As a result, several solutions have emerged to overcome this problem, especially finger movement regression using electromyography (EMG) signals for specific movements such as extension/flexion. Therefore, this study proposes a regression task on surface EMG (sEMG) collected from double Myo-Armband on finger movements. This experiment uses feature extraction of Mean Absolute Value (MAV) and Root Mean Square (RMS). Dimensionality reduction is then conducted to speed up the regression process using Principle Component Analysis (PCA), Independent Component Analysis (ICA), Non-Matrix Factorization (NMF), and Linear Discriminant Analysis (LDA). The last is estimating angle finger joint using Long Short-Term Memory (LSTM). The results show that the best performance is in the RMS and PCA features with an R-Square value of 0.874, and ICA and RMS perform the fastest time with an R-Square value of 0.871.

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Contents

I. Introduction (Heading 1)

The hand is one of the human motor tools, which is very vital for its role. With the disruption of hand function, human activities will be hampered. Especially if the hand has suffered a partial stroke, a therapeutic device is needed to rehabilitate the hand. One way to do this treatment is by utilizing the natural signals that humans have in the hands [1], namely hand signals or what is known as Electromyograph (EMG) [2].

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Metrics

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Estimation of Finger Joint Movement based on Electromyography Signal using Long Short-Term Memory

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***Abstract*— The presence of hand plays a vital role. Without a hand, humans experience difficulties in their activities. As a result, several solutions have emerged to overcome this problem, especially finger movement regression using electromyography (EMG) signals for specific movements such as extension/flexion. Therefore, this study proposes a regression task on surface EMG (sEMG) collected from double Myo-Armband on finger movements. This experiment uses feature extraction of Mean Absolute Value (MAV) and Root Mean Square (RMS). Dimensionality reduction is then conducted to speed up the regression process using Principle Component Analysis (PCA), Independent Component Analysis (ICA), Non-Matrix Factorization (NMF), and Linear Discriminant Analysis (LDA). The last is estimating angle finger joint using Long Short-Term Memory (LSTM). The results show that the best performance is in the RMS and PCA features with an R-Square value of 0.874, and ICA and RMS perform the fastest time with an R-Square value of 0.871.**

Keywords—finger movement, long-short term memory, mean absolute value, regression, root mean square, surface electromyography

I. Introduction (*Heading 1*)

The hand is one of the human motor tools, which is very vital for its role. With the disruption of hand function, human activities will be hampered. Especially if the hand has suffered a partial stroke, a therapeutic device is needed to rehabilitate the hand. One way to do this treatment is by utilizing the natural signals that humans have in the hands [1], namely hand signals or what is known as Electromyograph (EMG) [2].

EMG is an electrical signal generated by the body due to muscle activity in the human hand. An electrode sensor needs to be attached to particular hand skin to acquire this signal. Changes in the amplitude of the voltage signal obtained by the sensor indicate a shift in hand movement or gesture. Therefore, this signal is widely implemented for various types of use. Some of its functions are to move the therapeutic robot used for a subject suffering from a stroke [3]. This function is also applied to control the prosthetic robot hand [4], virtual keyboards [5], and wheelchairs [6]–[8].

The classification process is needed to use the EMG signal in the various applications above. Subjects were asked to move their hands with specific hand movements. These movements then generate an EMG signal. The EMG signal is then extracted by the feature extraction and then trained to classify the hand movements [9]. Then this classified signal can be used as a remote control for any device [10]–[13].

The successful study related to hand movement classification cannot be separated from finger movement since it is part of hand movement. As a result, many studies focused on finger movement [12], [14]–[16]. This study is in demand because it has more flexibility in hand movements [17]. This work popularity gains its moment because the function of the fingers on the hand has a crucial role, and almost all hand activities rely on finger movements [18]. Therefore, many studies concern about this field.

On the other hand, some studies, rather than focus on finger movements classification, they also focus on the regression of finger movement because it is more challenging to solve. The challenge happens since finger movement at a certain angle or position can be precisely estimated when using the regression task. When the regression task is applied to any device that needs precise movement like hand prostheses, the robot can move smoothly and reach a certain extension/flexion. It is different from the classification task, where the hand movements become stiff and only have digital properties (move or not move) on individual fingers. As a result, the specific movement cannot be addressed with this task because of the classification method's limitations. Therefore, some studies focused on the regression task using various methods. A study [19] used Artificial Neural Network (ANN) and a nonparametric Gaussian Process (GP) regressor, and it achieved R-Square of 0.85 for predicting 15 finger joints with eight surface-EMG (S-EMG) channels. Gijsberts et al. [20] employed Ridge Regression (RR) to regress ten S-EMG channels and reached an Root Mean Square (RMS) error of 16%. Ravindra et al. [21] used Ridge Regression (RR) to estimate the angles of six finger joints using ten S-EMG signals and yielded an RMS error of 10-20%.

The methods used to solve this problem are varied [22], such as Mean Absolute Value (MAV), envelope (ENV), autoregressive (AR) features, and some machine learning like Support Vector Machine (SVM), k-Nearest Neighbor (k-NN), Random Forest (RF), Ridge Regression (RR), and

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Linear Regression (LR). Previous studies aim to estimate finger joints using S-EMG as best as possible with various implementation objectives, such as therapeutic robot control. It triggers us to conduct and develop the same research. The development is to create a regression model that is not only to provide excellent R-Square performance and to improve existing research but also to get the regression model with a reasonably short time.

For achieving the above objectives, this study proposes the model by combining feature extraction, dimensionality reduction, and regressors. From existing studies, the use of Long-Short Term Memory (LSTM) proved to be a pretty good performance in regressing signals or other time series-tasks [23], [24]. Therefore, this study proposes a regression process on the extension/flexion of fingers using LSTM with a combination of some dimensionality reductions. It aims to reduce the time needed by the system to get the best model in a short time [25], [26]. There are four methods of dimensionality reduction, including Principle Component Analysis (PCA), Independent Component Analysis (ICA), Non-Matrix Factorization (NMF), and Linear Discriminant Analysis (LDA). The purpose of using these four methods is to explore the ability of each method combination against the two factors that are the target of this study. The two factors are predictive precision and fast timing. These dimentionality reductions must be observed is because dimensionality reduction also affects data, allowing a signal to lose its information and cause a decrease in performance [27], [28]. The EMG Double Myo is used, which has 16 channels to regress eight hand channels on CyberGlove. Testing is carried out using statistical parameters, namely R-Square (R2), representing the correlation of the real data and the prediction data. Besides, the consumption time has also been taken to determine the shortest time of the method used. Hence, the system performance can be evaluated.

II. Methods

A. Dataset

The dataset used in this study comes from Non-Invasive Adaptive Hand Prosthetics (NinaPro) with several datasets of EMG upper hand signals [29]. In this dataset, there are 9 databases available (DB1-DB9). However, this study used database 5 (DB5) to perform regression. In DB5, data has been provided with ten different subjects, in which there are three experiments marked with a vowel E in each dataset. The DB 5 data is a double Myo-Armband dataset, which is a product derived from Thalmic. Because of double Myo-Armband used, it means that the total available channels are 16 channels (8 x 2) and a frequency of 200Hz. For the acquisition data or output data, DB5 provides data from CyberGlove II, which measures extension/flexion and abduction/adduction in the metacarpophalangeal (MCP) joint. The number of channels provided for this data is 22 channels. However, this study only used eight channels, the specific channels of each finger to be regressed. These channels include: 1, 2, 3, 4, 5, 6, 7, and 11. The specific channel was chosen because it adapts to the functional movements often used by humans. These movements include pinch, grasp, rest, and many more. The channel was chosen because, in that channel, the hand movements tend to be independent movement compared to the other fingers [5], [30]. In detail, the sensor's position on CyberGlove II can be seen in Figure 1.

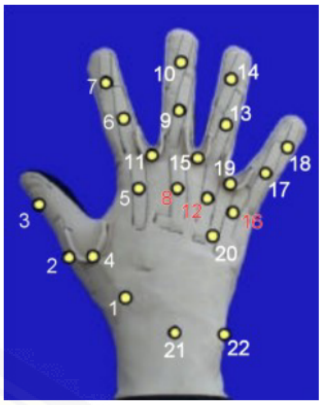

Figure 1. Cyberglove II channel [29]

This proposed study used 5 data from DB5 with experimental data 1 (E1), a finger movement dataset. These five datasets are from subjects 1 - 5 with the gender of three men and two women. The output used is eight channels on CyberGlove II, as mentioned above.

B. Model System

The built model system can be shown in Figure 2, in which the system architecture has three stages. The first is feature extraction. At this stage, the EMG signal is first extracted using the feature extraction of Mean Absolute Value (MAV) and Root Mean Square (RMS). The reason for choosing these two features is that hand movements are very suitable when represented by this feature.

Furthermore, the second block is dimensionality reduction. The function of this dimensionality reduction is to reduce the number of signals that enter the LSTM. The methods used at this stage are Principal Component Analysis (PCA), Independent Component Analysis (ICA), Non-Matrix Factorization (NMF), and Linear Discriminant Analysis (LDA). The signal originating from one of the feature extractors enters into one of these dimensional reductions. As a result, one subject's total data have six combinations of feature extraction and dimensionality reduction. For the dimensionality reduction used, there are eight components in each parameter of the method. The next stage is the regression stage. At this third stage, LSTM is employed as the regressor. The input on the LSTM consists of 8 components originating from dimensionality reduction and an output of 8 channels (1, 2, 3, 4, 5, 6, 7, and 11) representing the output of CyberGlove II. The architecture of LSTM uses one deep, with a total of 100 networks.

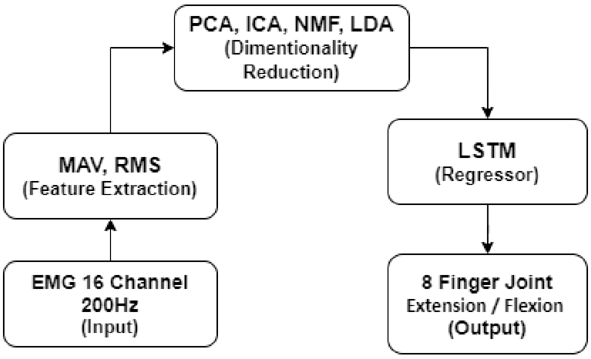

Figure 2. Block of the model system

For data splitting, the parameter given is 80:20. It means that 80% of the total data is for training data, and 20% is for testing data. The number of epochs is 10000, with the addition of an early stop. It aims to stop the system for training when overfitting or underfitting occurs. Meanwhile, the evaluation performance used statistical parameters, namely R-Square (R2) and time Elapsed. The detailed steps and test objectives using these two parameters are discussed in the result and discussion section.

III. Result and Discussion

The first testing is the time spent on the system to get the best model. This time is based on the calculation when the system begins to be compressed using the reductional dimension technique until the LSTM process runs with the best Mean Squared Error (MSE) indicator in the iteration or epoch used. The result of this test is shown in Figure 3, which has two axes. The X-axis is representing the dimensionality reduction used, and the Y-axis is representing the time-consuming needed for training and getting the best model.

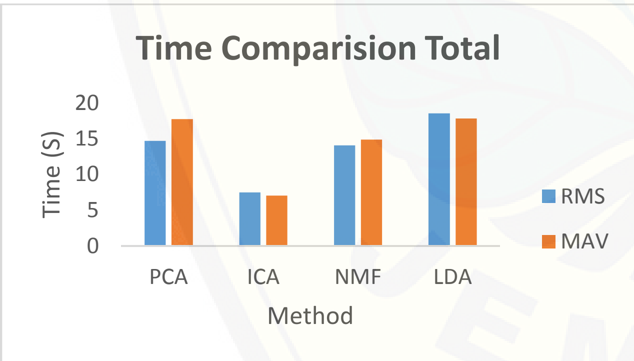

Figure 3. Time comparison of each method

The results obtained indicate that ICA has the fastest time consumption compared to other reductional techniques, as shown in Figure 3. The time consumption required by the average ICA for the five tested subjects was 7.04 on the RMS feature and 7.44 for the MAV feature. Then the next sequence is NMF, PCA, and LDA.

The next test is based on the results of R2 for each method used. In this test, this study used four different types of data usage. The difference lies in the data's length, a combination of frequency sampling (fs) and sliding windows (sw). Some of these combinations are 100 (fs) + 100 (sw), 100 (fs) + 50 (sw), 100 (fs), 50 (fs). The purpose of using the data's length is to test the system's performance based on its length with the assessment parameter of the R-Square value. The reason for using R-Square as the parameter is the correlation between the real data and the prediction data. The better value in R-Square is when it is close to 1. The result of this regression task is given in the two comparison forms of feature extraction. The first, shown in Figure 4, is the comparison method for RMS, and the second is the comparison method for MAV, as shown in Figure 5. The X-axis represents the combination of frequency sampling and sliding windows, while Y-axis represents the R-Square value. The R-Square value, displayed on the graph, is the average value of each system used. This system reflects the combination of feature extraction and dimensionality reduction.

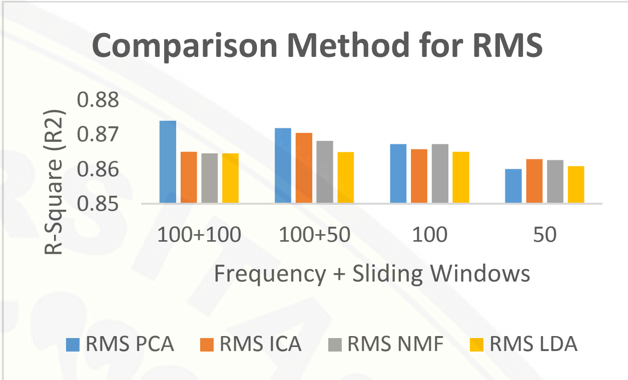

Figure 4. R-Square comparison for RMS as feature extraction

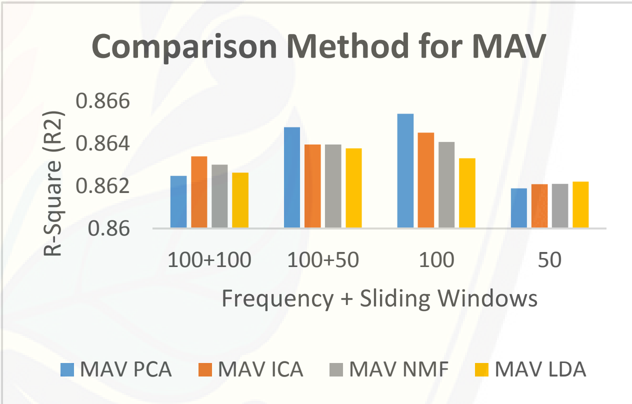

Figure 5. R-Square comparison for MAV as feature extraction

The results from Figures 4 and 5 show that the combination of RMS and PCA has optimal results if the data length is 100 (fs) + 100 (sw) with R-Square of 0.874 (close to 1). Meanwhile, for other data lengths, PCA also tends to dominate compared to other dimensional reduction techniques. It is just that, at a data length of 50, PCA has a lower R2 (R-Square) performance compared to other reduction techniques. However, in MAV as feature extraction, the best performance is shown by combining MAV with PCA in frequency sampling 100 with an R-Square value of 0.8654.

From the previous result, it can be known that all combination method has different performance for a combination of frequency sampling and sliding windows. The average R-Square comparison for all methods is shown in Figure 6. Therefore, the best performance can be known.

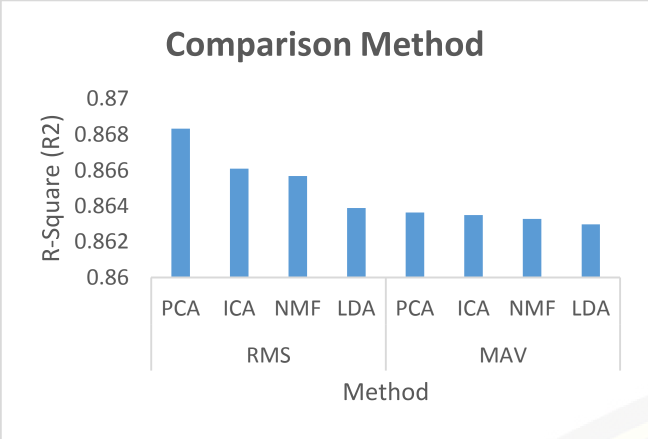

Figure 6. Average R-Square comparison for all methods

Figure 6 shows that PCA has high performance compared to other methods using all types of extraction features. Meanwhile, the second place is occupied by ICA, which, as time assessment, has a faster time susceptibility than PCA and other methods. PCA, specifically in this study, only contributed to its right performance level. However, in terms of consumption time, PCA takes the third position compared to other methods. Also, when seen in Figure 6, the RMS method has good performance compared to the MAV. It is proved by the value of the RMS method, which is higher than that of the MAV method. However, this difference is not very significant and only at 0.009 vulnerable compared to the RMS feature results.

IV. Conclusion

This study conducted finger angle prediction using Surface EMG (S-EMG) derived from double Myo-Armband. The technique used is to perform a feature reduction on data that has been extracted with MAV or RMS and then regressed using LSTM. The total channel used is 16 S-EMG channels as input. These 16 channels are then reduced using PCA, ICA, NMF, and LDA so that eight channels are used for the regression process and produce extension/flexion on the channels of 1, 2, 3, 4, 5, 6, 7, and 11. Several tests conducted show that PCA has better R2 (R-Square) performance with a value of 0.874 (RMS and PCA). Besides, PCA also dominates the level of performance in the two types of features used. However, when viewed in terms of time consumption, PCA is in the third position compared to other reduction techniques. ICA has the first position in its time performance and has a pretty good performance proved by the second position when assessed in R-Square with a value of 0.871 (RMS and ICA). Meanwhile, on the feature extraction side, RMS has a better performance compared to MAV. Therefore, if a system wants a small difference from the real data, a combination of RMS and PCA can be used, and if a system is to be built with priority of speed, a combination of RMS and ICA can be the best choice. The two combinations mentioned are the best combinations for the R-Square and time-consuming indicators.

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