

**MAKALAH ILMIAH  
PROSIDING SEMINAR INTERNASIONAL  
TERINDEKS SCOPUS**

**The 2019 International Conference on Computer Science,  
Information Technology, and Electrical Engineering  
(ICOMITEE 2019)**



Judul:

Finger Movement Regression with Myoelectric Signal and Deep  
Neural Network

disusun oleh:

Khairul Anam, Dwiretno Istiyadi Swasono, Aris Zainul Muttaqin, Faruq Sandi  
Hanggara

**JURUSAN TEKNIK ELEKTRO  
FAKULTAS TEKNIK  
UNIVERSITAS JEMBER  
2019**

---

Diseminarkan di Hotel Meotel Jember, Indonesia  
16 - 17 Oktober 2019

Organized by :



**ICOM**  
**ITEE**

**October**  
**16<sup>th</sup> - 17<sup>th</sup>, 2019**

 **Hotel Meotel**

 **Jember, Indonesia**

# PROCEEDING

The 2019 International Conference  
on Computer Science, Information  
Technology and Electrical  
Engineering (ICOMITEE)



Financial Sponsorship :



Technical Sponsorship :





**PROCEEDINGS**

**2019 International Conference on Computer Science, Information  
Technology, and Electrical Engineering (ICOMITEE 2019)**

**October 16<sup>th</sup> - 17<sup>th</sup> 2019, Jember, Indonesia**

**Editors:**

Slamin, University of Jember, Jember, Indonesia

Antonius Cahya Prihandoko, University of Jember, Jember, Indonesia

Fahrobby Adnan, University of Jember, Jember, Indonesia

Beny Prasetyo, University of Jember, Jember, Indonesia

Paramitha Nerisafitra, Universitas Nahdlatul Ulama Surabaya, Surabaya, Indonesia

Hendra Yufit Riskiawan, Politeknik Negeri Jember, Jember, Indonesia

Endang Sulistiyani, Universitas Nahdlatul Ulama Surabaya, Surabaya, Indonesia

Prawidya Destarianto, Politeknik Negeri Jember, Jember, Indonesia

## PROCEEDINGS

### **2019 International Conference on Computer Science, Information Technology, and Electrical Engineering (ICOMITEE 2019)**

Copyright and Reprint Permission: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. For reprint or republication permission, email to IEEE Copyrights Manager at [pubs-permissions@ieee.org](mailto:pubs-permissions@ieee.org).

All rights reserved.

Copyright ©2019 by IEEE.

ISBN : 978-1-7281-3435-2 (USB, Part Number: CFP19U07-USB)

ISBN : 978-1-7281-3436-9 (XPLORE COMPLIANT, Part Number: CFP19U07-ART)

Additional copies may be ordered to:

Faculty of Computer Science

University of Jember

Jl. Kalimantan no.37, Kampus Bumi Tegalboto, Sumbersari, Jember, 68121

+62331 - 326935

## TABLE OF CONTENTS

Welcome Message from The Dean of Faculty of Computer Science Universitas Brawijaya .....	iv
Welcome Message from The General Chair of 3 <sup>rd</sup> SIET 2018 .....	v
Committees .....	vi
Technical Program .....	ix
Parallel Session .....	xi
Table of Contents .....	xviii
 <b>Invited Speakers</b>	
Automatic Cattle Identification Based on Multi-Channel LBP on Muzzle Images <i>Worapan Kusakunniran; Thanatchon Chaiviroonjaroen</i>	1-5
EMG Based Control of Individual Fingers of Robotic Hand <i>Noman Naseer; Faizan Ali; Sameer Ahmed; Saad Iftikhar; Rayyan Azam Khan; Hammad Nazeer</i>	6-9
 <b>Data Mining and Artificial Intelligence</b>	
Customer Segmentation Using Two-Step Mining Method Based on RFM Model <i>Fitra A. Bachtiar</i>	10-15
Knowledge-Based System for Malaria Prevention and Control: A Conceptual Model <i>Dinda Lestarini; Sarifah Putri Raflesia; Indah Puspita; Phey Liana; Andra Kurnianto</i>	16-20
Continuous Top-k Dominating Query of Incomplete Data over Data Streams <i>Vynska Amalia Permadi; Bagus Santoso; Tohari Ahmad; Bayu Sektiaji; Royyana Muslim Ijtihadie</i>	21-26
Feature Selection Using Variable Length Chromosome Genetic Algorithm for Sentiment Analysis <i>Tirana Noor Fatyanosa; Fitra A. Bachtiar; Mahendra Data</i>	27-32
Improved Simulated Annealing for Poultry Feed Formulation <i>Vivi Nur Wijyaningrum; Wayan Firdaus Mahmudy; Muhammad Halim Natsir</i>	33-37
 <b>Image Processing</b>	
An Analysis of RGB, Hue and Grayscale Under Various Illuminations <i>Hurriyatul Fitriyah; Randy Wihandika</i>	38-41
	42-47

Design and Implementation of Human Detection Feature on Surveillance Embedded IP Camera <i>Widodo Setyo Yuwono; Dodi Wisaksono Sudiharto; Catur Wijutomo</i>	48-53
Comparison of Support Vector Machine Classifier and Naïve Bayes Classifier on Road Surface Type Classification <i>Susi Marianingsih; Fitri Utaminingrum</i>	54-59
Mammogram Breast Cancer Classification Using Gray-Level Co-Occurrence Matrix and Support Vector Machine <i>Syam Sarosa; Fitri Utaminingrum; Fitra A. Bachtiar</i>	60-65
<b>Artificial Intelligence</b>	
Optimization of Fuzzy Time Series Interval Length Using Modified Genetic Algorithm <i>Tomi Yahya Christyawan; M Syauqi Haris; Rafiuddin Rody; Wayan Firdaus Mahmudy</i>	66-70
Classification of Toddler Nutrition Status with Anthropometry Calculation Using Naïve Bayes Algorithm <i>Riris Aulya Putri; Siti Sendari; Triyanna Widiyaningtyas</i>	71-76
Hierarchical Algorithm for the Identification of Parameter Estimation of Linear System <i>Mohammad Abu Jami'in; Khairul Anam; Riries Rulaningtyas; Mohammaderik Echsony</i>	77-81
New Method for Obtaining Peak Value R and the Duration of Each Cycle of Electrocardiogram <i>Sabar Setia Widayat; Aviv Yuniar Rahman</i>	82-87
<b>Data Mining and Data Analysis</b>	
Adaptive SOMMI (Self Organizing Map Multiple Imputation) Base on Variation Weight for Incomplete Data <i>Bain Khusnul Khotimah</i>	88-91
Sentiment Analysis on Movie Reviews Using Ensemble Features and Pearson Correlation Based Feature Selection <i>Fachrul Rangkuti; M Ali Fauzi; Yuita Arum Sari; Eka Sari</i>	92-95
Twitter Sentiment Analysis of Movie Reviews Using Ensemble Features Based Naïve Bayes <i>Rosy Permatasari; M Ali Fauzi; Putra Pandu Adikara; Eka Sari</i>	96-100
<b>Data Mining and Data Analysis</b>	
The Implementation of Open Data Program in the Special Capital Region (DKI) of Jakarta Province <i>Givo Aulia; Teguh Kurniawan</i>	

Extract, Transform, Load Module in SOLAP for Indonesia Agricultural Commodity <i>Imas Sukaesih Sitanggang; Rina Trisminingsih; Fauzan Fuady; Husnul Khotimah</i>	101-105
Implementation of Naïve Bayes Classifier Algorithm to Categorize Indonesian Song Lyrics Based on Age <i>Faisal Rahutomo; Moch Fadli Shadiqin Thirafi</i>	106-109
Adaptive Genetic Algorithm Based on Crossover and Mutation Method for Optimization of Poultry Feed Composition <i>Nindynar Rikatsih; Wayan Firdaus Mahmudy</i>	110-114
<b>Decision Support System</b>	
Comparative Study Based on Error Calculation in Multiple Linear Regression Coefficient for Forest Fires Prediction <i>Mukhammad Alauddin</i>	115-120
Prediction Result of Dota 2 Games Using Improved SVM Classifier Based on Particle Swarm Optimization <i>Farhanna Mar'i; Mochammad Anshori; Mukhammad Alauddin; Fitra A. Bachtiar</i>	121-126
Automatic Scheduling Using Intelligent Water Drops Algorithm <i>Indra Maryati</i>	127-131
WA k-NN for Analyzing Decision of Prospective Students Admission <i>Aida Indriani; Mussallimah Mussallimah; Muhammad Muhammad</i>	132-136
Time Series Forecast for Rainfall Intensity in Malang City with Naïve Bayes Methodology <i>Mahmuda Muthmainnah; Muhammad Ashar; I Made Wirawan; Triyanna Widiyaningtyas</i>	137-141
The Relation of Fit Tables and Textual Requirements to Understand Requirements <i>Rizky Pamuji; Fatwa Ramdani; Yudistira Adi Saputra</i>	142-146
Comparison of Gaussian and ANOVA Kernel in Support Vector Regression for Predicting Coal Price <i>Olivia Bonita; Lailil Muflikhah</i>	147-150
Technology Acceptance Model on Internship Placement Recommendation System Based on Naïve Bayes <i>Nur Lailiyah Cintya Dewi; Aji P Wibawa; Utomo Pujiyanto</i>	151-155
<b>Mobile Application and Multimedia</b>	
Food Recipe Finder Mobile Applications Based on Similarity of Materials <i>Gusti Pangestu; Ahmad Afif Supianto; Fitri Utaminigrum</i>	156-161
Mobile Application Sales of Handicraft Products of Papua <i>Susi Marianingsih; Ahmad Afif Supianto</i>	162-167

Development of Mobile Applications for Posyandu Administration Services Using Google Maps Api Geolocation Tagging <i>Heru Nurwarsito; Nadia Savitri</i>	168-173
Educational Game for Training Spatial Ability Using Tangram Puzzle <i>Ivenulut Rizki Diaz Renavitasari; Ahmad Afif Supianto</i>	174-179
Design and Development Educational Media Diction of Madurese Language Level <i>Khairur Rosyidi; Dio Kudori; Ahmad Afif Supianto</i>	180-185
An Idea of Interactive Japanese Language M-Learning Application to Support Listening and Speaking Exercise <i>Komang Candra Brata; Adam Brata</i>	186-191
Design of Immersive Virtual Tour Application Based on Geospatial Analysis <i>Didik Dwi Prasetya; Triyanna Widiyaningtyas; Aji P Wibawa</i>	192-196
CoMiG: a Color Mix Game as a Learning Media for Color Mixing Theory <i>Ahmad Fairuzabadi; Ahmad Afif Supianto</i>	197-201
<b>Network and IoT System</b>	
Feasibility Analysis of RFID in the Management of Supply Chain for Consumer Goods Industries <i>Iqra Aitbar, Ms.; Tehseen Nisa</i>	202-205
The Defense Against ARP Spoofing Attack Using Semi-Static ARP Cache Table <i>Mahendra Data</i>	206-210
Optimization Deep Intelligence Investment Framework: A New Economic Design for Enhancing and Diversifying Investment Activities in the Kingdom of Saudi Arabia <i>Imam Cholissodin; Yenny Kornitasari</i>	211-215
Outdoor Air Quality Monitor Using MQTT Protocol on Smart Campus Network <i>Muladi Muladi; Siti Sendari; Triyanna Widiyaningtyas</i>	216-219
Web Server Load Balancing Based on Memory Utilization Using Docker Swarm <i>Mohamad Rexa Mei Bella; Mahendra Data; Widhi Yahya</i>	220-223
Information Security Awareness: Study on a Government Agency Arie Kusumawati	224-229
Performance Evaluation of Semantic IoT Middleware <i>Eko Sakti Pramukantoro; Ari Kusyanti; Yazid Samanhudi</i>	230-233
DDoS Detection on Network Protocol Using Cosine Similarity and N-Gram+ Method <i>Andi Maslan; Kamaruddin Malik Mohamad; Sasa Arnomo</i>	234-239



Implementation of Wireless Sensor Nodes for Monitoring Farmland Based 802.15.4 Protocol <i>Muhammad Misbahul Munir</i>	240-246
A Cluster Message Broker in IoT Middleware Using Ioredis <i>Eko Sakti Pramukantoro; Jessy Wulandari; Widhi Yahya; Heru Nurwarsito</i>	247-251
A LPWAN Based Wireless Sensor Node for Aquaculture Water Quality Monitoring System <i>Adhitya Bhawiyuga; Widhi Yahya</i>	252-256
Correction of Wind Effect on Quadcopter <i>Endrowednes Kuantama</i>	257-261
 <b>Information System management</b>	
Usability Evaluation of User Interface in Badan Narkotika Nasional East Java Province Website <i>Hanifah Az-zahra; Mochamad Chandra Saputra; Windha Parwaningsuci</i>	262-265
Bag Production Management of Joint Business Group in Getas Pejaten in Kudus District <i>Ag. Handoyo; Supriyono Supriyono; Ponny Harsanti</i>	
Audit of Information Technology Governance Using COBIT 5 Case Study in PT. PLN, Kediri, Indonesia <i>Mayang Anglingsari Putri; Ismiarta Aknuranda; Dwi Cahya Astriya Nugraha</i>	266-271
Criteria-Based Evaluation of Academic Information System Usage at Brawijaya University Based on Modified Technology Acceptance Model (TAM) <i>Admaja Dwi Herlambang; Yusi Mursityo; Mochamad Chandra Saputra; Larizza Novianti</i>	272-277
 <b>Information System management</b>	
Driver Information System for Sustainable Public Transportation <i>Daniel Vierling; Benedikt Schmuelling</i>	278-282
Development and Validation of Instruments Adoption FinTech Services in Indonesia (Perspective of Trust and Risk) <i>Erick Fernando; Surjandy Surjandy; Meyliana Meyliana; Derist Touriano</i>	283-287
Refused Bequest Code Smells Detection on Software Design <i>Faishal Firdaus; Bayu Priyambadha; Fajar Pradana</i>	288-291

**Good Educational Governance**

Multi-Objective Optimization for Proportional Tuition Fees Pricing Using Non-Dominated Sorting Genetic Algorithm II (NSGA II) <i>Farid Jauhari; Wayan Firdaus Mahmudy</i>	292-297
Stakeholder Act as an IT and General Compliance Auditor <i>Surjandy Surjandy; Meyliana Meyliana; Raymond Kosala; Suhono Harso; Erick Fernando; Angelica Angelica; Renita Amalia; Merry Marshela; Diani Dwiningrum</i>	298-301
Edmodo-Based Makerspace as E-Learning Technology to Improve the Management Project of Vocational Students in the Disruptive Technology Era <i>Andika Bagus</i>	302-307
Decision Tree Usage for Student Graduation Classification: A Comparative Case Study in Faculty of Computer Science Brawijaya University <i>Ahmad Afif Supianto; Alfi Julisar Dwitama; Muhammad Hafis</i>	308-311
LMS Technology by Using Makerspace Approach on Unique Experiments-Based Through MOOCs in Improving the Professional Competence of Vocational Students <i>Andika Bagus</i>	312-316

**Classification**

News Classification on Twitter Using Naive Bayes and Hypernym-Hyponym Based Feature Expansion <i>M Ali Fauzi; Fakhrudin Irfani; Yuita Arum Sari</i>	317-321
Classification of Posture Reconstruction with Univariate Time Series Data Type <i>Nindynar Rikatsih; Ahmad Afif Supianto</i>	322-325
Classification of Protein Structure with a Variety of Code Features on the Same Index <i>Dian Eka Ratnawati; Edy Santoso; Marji Marji</i>	326-331
Text Classification and Visualization on News Title Using Self Organizing Map <i>Tomi Yahya Christyawan; Wayan Firdaus Mahmudy</i>	332-344

## Foreword from General Chair ICOMITEE 2019

In the name of Allah, the Most Beneficent and the Most Merciful.

On behalf of the organizing committees, I would like to welcome all of you to Jember, Indonesia for the 2019 International Conference on Computer Science, Information Technology and Electrical Engineering (ICOMITEE)

ICOMITEE 2019 is the international conference hosted by University of Jember (UNEJ), co-hosted by State Polytechnic of Jember (POLIJE) and Nahdlatul Ulama University of Surabaya (UNUSA). ICOMITEE 2019 is officially approved by IEEE Indonesia Section and IEEE Indonesia Section Computer Society Chapter for technical co-sponsored. ICOMITEE 2019 is also officially sponsored by IEEE Signal Processing Society Indonesia Chapter.

This event is intended to provide technical forum and research discussion related to advance engineering on electrical & electronics, computer science and informatics. The Conference is aimed to bring researchers, academicians, scientists, students, engineers and practitioners together to participate and present their latest research finding, developments and applications related to the various aspects of Information System Management, Data Analytics & Big Data, IT Infrastructure and Security, Electrical and Telecommunication

Allow me to express my deepest gratitude to those who have made this conference possible. My thanks go to the Rector of University of Jember. I would also like to thank the invited speakers: Prof ASM Sajeev from Melbourne Institute of Technology, Australia, Prof. Richardus Eko Indrajit, chairman of ID-SIRTII and Associate Professor Kamal Kant Sharma from Chandigarh University, India for accepting our invitation in the conference.

At this conference, the committee received total 82 full manuscript from various cities in Indonesia and abroad such as Australia, Algeria, Iran and Sri Lanka. But, after the review process, 49 full manuscripts were accepted.

We also want to thanks and appreciation for your dedication for ICOMITEE 2019 to all committee, all TPC Sponsorship and Financial Sponsorship, TPC member, and 301 high reputation reviewer from various country.

We look forward to having a successful conference, and we hope that all the attendees enjoy and benefit from this conference.

**Prof. Saiful Bukhori ST., M.Kom.**  
**General Chair of ICOMITEE 2019**



## Foreword from IEEE Indonesia Section

Dear distinguished guests, keynote speakers, colleagues, researchers, professionals, ladies and gentlemen, good morning, a prosperous, warm, and spirited greeting.

On behalf of IEEE Indonesia Section, we would like to extend our warmest welcome to all keynote speakers, presenters, and participants to the 2019 International Conference on Computer Science, Information Technology and Electrical Engineering (ICOMITEE). The conference is organized by Universitas Jember (UNEJ) and technically co-sponsored by IEEE Indonesia Section. The conference aims to bring together researchers and experts in information systems to share their ideas, experiences and insights.

IEEE Indonesia Section has conducted many activities over 32 years in Indonesia. In terms of collaboration, IEEE Indonesia section has a good and mutual relationship with ICT organizations, Industries, Government, Universities as well as the Community in Indonesia. IEEE Indonesia Section has contributed in about 58 different International conferences annually. This conference shows its sustainability due to the hard work of the conference organizers, well organized conference and high quality papers. We do hope in the near future some high quality conferences will be continued and strengthened, so the result will give more benefit and positive impact to the human being, especially to Indonesian people.

In this occasion, I would also like to say welcome to Jember, which serves beautiful heritages, culture, with warm, polite and friendly people, a vibrant culture and lifestyle.

Finally, we do hope all of you will have enjoyable and valuable experience during this event. You may share your best knowledge in your area of research and professional activities.

Thank you.

**Prof. Dr.Eng. Wisnu Jatmiko**  
**Chairman, IEEE Indonesia Section**



## Foreword from IEEE Computer Society Indonesia Section

Dear colleagues, Professors, researchers, ICT professionals, ladies and gentlemen,

Representing IEEE Computer Society Indonesia Section of The 2019 International Conference on Computer Science, Information Technology, and Electrical Engineering (ICOMITEE) 2019, we would like to express our deep gratitude, to the researchers, paper authors, and all the participant of ICOMITEE 2019. Welcome to Jember in Indonesia!

The conference is an annual event, organized by University of Jember, Jember, Indonesia.

This ICOMITEE 2019 was has been approved and technically co-sponsored by IEEE Computer Society Indonesia Section, with the conference No. #47614

With nearly 100,000 members, the IEEE Computer Society is the world's leading organization of computer professionals. Founded in 1946, it is the largest of the 37 societies of Institute of Electrical and Electronics Engineers (IEEE). The Computer Society's vision is to be the leading provider of technical information and services to the world's computing professionals.

The IEEE Computer Society Indonesia promotes and facilitates the computer-related activities of the IEEE Indonesia. It is one of the IEEE Indonesia technical chapters.

Through this opportunity, I would also like to highlight that Indonesia is an emerging country, one of the fastest growing countries in South East Asia and Pacific. Based on International Data Corporation, Indonesia has become the largest spender on ICT in South East Asia and is ranked 19th by spending globally.

The ICOMITEE 2019 provides a good platform for researchers, scientists and the entire engineering community to meet each other and exchange ideas on electronic and computer related fields, and their applications including research stimulation, the applications of electronic and information technologies, and the discussion to advance for region-wide cooperation in related disciplines. It also offers opportunity, exhibition, and business meetings.

I do hope in the near future the event will be continuing continued and strengthened, so the result will be give more benefit and give more positive impact to the Indonesian people. Technology drives innovation, people can do more, do better. Technology drives higher quality of life, people can live better.

In this occasion, I would also like to say welcome to Jember, one of the famous destinations in Indonesia. , where Jember serves beautiful heritages and scenery with warm and friendly people, a vibrant culture and lifestyle.

# Digital Repository Universitas Jember

Finally, we do hope all of you will obtain an enjoyable and valuable experience. During this 2 days conference, , and also you may share your best knowledge in your area of research and professional activities., during this 2 days conference.

Thank you.



Dr. Tanty Oktavia

Treasury and Vice Chair of IEEE Computer Society Indonesia Section



## Foreword from Rector of University of Jember

In the name of Allah, the Most Beneficent and the Most Merciful.

First of all, I would like to welcome you all to the University of Jember, Indonesia. I am delighted to have you here to participate and attend the 2019 International Conference on Computer Science, Information Technology, and Electrical Engineering (ICOMITEE 2019). Thank you for coming, many of you travel long distances serves to remind us to conduct a highly fruitful conference.

This great event facilitates interaction among academics, researchers, and policymakers in this region through plenary sessions and parallel paper presentations. I am glad to know that this conference takes up some subjects like telecommunication, electrical, data analytics & big data, IT infrastructure & security, also management information system. I expected that every paper would inspire us to make more contributions to the related field. Hopefully, everyone will benefit from this event by sharing paper and experiences. Also learned new ideas from each other, which we could adopt to improve our work in this era further.

I would like to appreciate the Organizing Committee that has been working hard for the preparation of this international academic event. Also, I thank our sponsors (IEEE Indonesian Section, IEEE Computer Society Indonesian Section, IEEE Signal Processing Society), for providing support and assist us for the conference. Let me also thank the scientific conference committee.

Finally, let me reiterate my warm welcome to all of you to the university, and I wish you all a very successful conference.

**Assoc. Prof. Moh. Hasan**  
**Rector of University of Jember, Jember, Indonesia**



## Organizing Committee of ICOMITEE 2019

### Steering Committee

- Fitri Yuli Zulkifli, Universitas Indonesia, Jakarta, Indonesia
- Suryadiputra Liawatimena, IEEE Indonesia Section Computer Society Chapter
- Ford Lumban Gaol, IEEE Indonesia Section Computer Society Chapter
- Fiky Y. Suratman, IEEE SPS Indonesia Chapter
- Wisnu Jatmiko, IEEE Indonesia Section
- Moh. Hasan, University of Jember, Jember, Indonesia
- Khairul Anam, University of Jember, Jember, Indonesia
- Achmad Jazidie, Universitas Nahdlatul Ulama Surabaya, Surabaya, Indonesia
- Saiful Anwar, Politeknik Negeri Jember, Jember, Indonesia

### General Chair

- Saiful Bukhori, University of Jember, Jember, Indonesia

### General Co-Chair

- Slamini, University of Jember, Jember, Indonesia

### Finance Chairs and Treasurer

- Windi Eka Yulia Retnani, University of Jember, Jember, Indonesia
- Siti Maemona, University of Jember, Jember, Indonesia
- Elok Zakia, University of Jember, Jember, Indonesia
- Suhaima, University of Jember, Jember, Indonesia

### Technical Program Committee Chairs

- Antonius Cahya Prihandoko, University of Jember, Jember, Indonesia
- Beny Prasetyo, University of Jember, Jember, Indonesia
- Tio Dharmawan, University of Jember, Jember, Indonesia
- Yudha Alif Auliya, University of Jember, Jember, Indonesia
- Hendra Yufit Riskiawan, Politeknik Negeri Jember, Jember, Indonesia
- Dwi Putro Sarwo Setyohadi, Politeknik Negeri Jember, Jember, Indonesia
- Paramitha Nerisafitra, Universitas Nahdlatul Ulama Surabaya, Surabaya, Indonesia

### Publication Chairs

- Fahrobby Adnan, University of Jember, Jember, Indonesia
- Prawidya Destarianto, Politeknik Negeri Jember, Jember, Indonesia
- Didit Rahmat Hartadi, Politeknik Negeri Jember, Jember, Indonesia
- Endang Sulistiyani, Universitas Nahdlatul Ulama Surabaya, Surabaya, Indonesia
- Ima Kurniastuti, Universitas Nahdlatul Ulama Surabaya, Surabaya, Indonesia



## **Publicity and Sponsorship Chairs**

- Januar Adi Putra, University of Jember, Jember, Indonesia
- Hariyono Rakhmad, Politeknik Negeri Jember, Jember, Indonesia
- Rizqi Putri Nourma Budiarti, Universitas Nahdlatul Ulama Surabaya, Surabaya, Indonesia

## **Secretary and Information Chair**

- Fitriyana Dewi, University of Jember, Jember, Indonesia

## **Local Arrangement and Registration Chairs**

- Oktalia Juwita, University of Jember, Jember, Indonesia
- Qilbaaini Effendi, University of Jember, Jember, Indonesia
- Beni Widiawan, Politeknik Negeri Jember, Jember, Indonesia
- Yogiswara, Politeknik Negeri Jember, Jember, Indonesia
- Syamsul Arifin, Politeknik Negeri Jember, Jember, Indonesia

## **Technical Program Members**

- Hasan Aksoy, Turk Hava Kurumu Universitesi, Turkey
- Humaira Anwer, National University of Sciences & Technology, Pakistan
- Mahdi Baradarannia, University of Tabriz, Iran
- Deniz Dal, Ataturk University, Turkey
- Evgeny Markin, Russia & Richemar LLC, USA
- Agus Minarno, Universitas Muhammadiyah Malang, Indonesia
- Naveed Sabir, Mehran University Of Engineering & Technology, Pakistan
- Robert Szabolcsi, Obuda University, Hungary
- Syed Zafaruddin, BITS Pilani, India

## **Reviewers**

- Mahmoud Rokaya, Taif University, Saudi Arabia
- Rodrigo Campos Bortoletto, Instituto Federal de São Paulo, Brazil
- Hussain Saleem, University of Karachi, Pakistan
- Pooya Taheri, SFU, Canada
- Eduard Babulak, Liberty University, USA
- Tresna Dewi, Politeknik Negeri Sriwijaya, Indonesia
- Ezra Morris A. Gnanamuthu, Universiti Tunku Abdul Rahman, Malaysia
- Sutrisno Sutrisno, Diponegoro University, Indonesia
- Julian L. Webber, Osaka University, Japan
- Sandeep Kakde, Y C College of Engineering, India
- Manojkumar Somabhai Parmar, Robert Bosch Engineering and Business Solutions Private Limited, India
- Qi Zhao, University of California, Los Angeles, USA
- Haitham Abu Ghazaleh, Tarleton State University, USA

# Digital Repository Universitas Jember

- Raveendranathan Kalathil Chellappan, College of Engineering Thiruvananthapuram, India
- Kashif Sharif, Beijing Institute of Technology, P.R. China
- Ali Al Janaby, Ninevah University, Iraq
- Hamid Alasadi, IRAQ- BASRA, Iraq
- Parameshachari Bidare Divakarachari, GSSSIETW, Mysuru, Visvesvaraya Technological University, India
- Narumol Chumuang, Muban Chombueng Rajabhat University, Thailand
- Hossein Jafari, Intelligent Fusion Technology, Inc., USA
- Haijun Pan, New Jersey Institute of Technology, USA
- Andrews Samraj, Mahendra Engineering College, India
- Jiachyi Wu, National Taiwan Ocean University, Taiwan
- Mohd Khairul Ikhwan Bin Ahmad, Universiti Tun Hussein Onn Malaysia, Malaysia
- Emad Hasan Al-Hemiary, Al-Nahrain University, Iraq
- Konstantinos Giannakis, Ionian University, Greece
- Seng Hansun, Universitas Multimedia Nusantara, Indonesia
- Ramoshweu Solomon Lebelo, Vaal University of Technology, South Africa
- Amrit Mukherjee, Jiangsu University, P.R. China
- Indra Riyanto, Universitas Budi Luhur, Indonesia
- Nadheer A. Shalash, Al-Mamon University College, Iraq
- Rostyslav Sklyar, Independent Professional, Ukraine
- Srinivasulu Tadisetty, Kakatiya University College of Engineering and Technology, India
- Kesavaraja D, Dr Sivanthi Aditanar College of Engineering, India
- Akhil Gupta, Lovely Professional University, India
- Gen Motoyoshi, NEC Corporation, Japan
- Cong Pu, Marshall University, USA
- Grienggrai Rajchakit, Maejo University, Thailand
- YunWu Zhang, Southeast University, P.R. China
- Karim Hashim Al-Saedi, Mustansiriyah University, Iraq
- Amirah 'Aisha Badrul Hisham, University of Nottingham Malaysia, Malaysia
- Liang-Bi Chen, Southern Taiwan University of Science and Technology, Taiwan
- Saad Elmansori, Concordia University, Canada
- Muhamad Fadli Ghani, Universiti Kuala Lumpur Malaysian Institute of Marine Engineering Technology, Malaysia
- Yuchun Guo, Beijing Jiaotong University, P.R. China
- Roberto Carlos Herrera Lara, National Polytechnic School, Ecuador
- Oktalia Juwita, University of Jember, Indonesia
- Cheruku Sandesh Kumar, Amity University Rajasthan, India
- Punith Kumar M b, University of Mysore, India
- Michael McGuire, University of Victoria, Canada
- Zahéra Mekkioui, University of tlemcen, Algeria

- Khalil Azha Mohd Annuar, Universiti Teknikal Malaysia Melaka, Malaysia
- Marwan Nafea, University of Nottingham Malaysia, Malaysia
- Henry Novianus Palit, Petra Christian University, Indonesia
- Shashikant Shantilal Patil, SVKM NMIMS Mumbai India, India
- Ema Rachmawati, Telkom University, Indonesia
- Akbar Sheikh-Akbari, Leeds Beckett University, United Kingdom (Great Britain)
- Heni Sulistiani, Universitas Teknokrat Indonesia, Indonesia
- Ryan Randy Suryono, Universitas Teknokrat Indonesia, Indonesia
- Adrian Tam, Clarity Solutions Group, USA
- Nidhal Abass, University of Kufa, Iraq
- Louazani Ahmed, Ahmed ZABANA University Center of Relizane, Algeria
- Lateef Adesola Akinyemi, Lagos State University, Lagos, Nigeria
- Mohammad Al-Shabi, University of Sharjah, United Arab Emirates
- Eraclito De Souza Argolo, Universidade Federal do Maranhão, Brazil
- Muhammad Sohaib Ayub, Lahore University of Management Sciences, Pakistan
- Omar R. Daoud, Philadelphia University, Jordan
- Muftah Fraifer, IDC-CSIS-UL, Ireland
- Zaher Haddad, Alaqsa University, Palestine
- Saifullah Khalid, Civil Aviation Research Organisation, India
- Vahid Khalilzad-Sharghi, Medical Imaging Solutions USA, USA
- Agus Eko Minarno, Universitas Muhammadiyah Malang, Indonesia
- Arshad Muhammad, Sohar University, Oman
- Nasser Najibi, Cornell University, USA
- Rajesh M. Pindoriya, Indian Institute of Technology Mandi, India
- Harikumar Rajaguru, Bannari Amman Institute of Technology, India
- Karthikeyan Ramasamy, Anna University, Chennai, India
- Mehrdad Rostami, (Formerly) Shahed University, Canada
- Nafiul Siddique, New Mexico State University, USA
- Rana Pratap Sircar, Ericsson, India
- Thitinan Tantidham, Mahidol University, Thailand
- Deepti Prakash Theng, G. H. Rasoni College of Engineering, India
- Shibiao Wan, The Hong Kong Polytechnic University, Hong Kong
- Wei Wei, University of Washington, USA
- Tarun Yadav, Scientific Analysis Group, Defence Research & Development Organisation, Ministry of Defence, GOI, India
- Mohamad Fauzi Zakaria, Universiti Tun Hussein Onn Malaysia, Malaysia
- Areej M. Abduldaim Al-Alwash, University of Technology, Iraq
- Mehran Alidoost Nia, University of Tehran, Iran
- Intan Sari Areni, Hasanuddin University, Indonesia
- Rahadian Bisma, Universitas Negeri Surabaya, Indonesia
- Anjali Avinash Chandavale, University of Pune, India

- Ying-Ren Chien, National I-Lan University, Taiwan
- Paolo Crippa, Università Politecnica delle Marche, Italy
- Bogdan Eugen Cristea, Microchip, Romania
- Deniz Dal, Ataturk University, Turkey
- Raul de Lacerda, Laboratoire de Signaux et Systèmes (L2S, CNRS), CentraleSupélec, France
- Rohit Gupta, Thapar University, India
- Abdelfatteh Haidine, ENSA El Jadida - University Chouaib Doukkali, Morocco
- Suneeta Harlapur, Vemana Institute of Technology, India
- Ching-Ting Hsu, University of Taipei, Taiwan
- Md. Moidul Islam, Friedrich-Schiller-Universität Jena, Germany
- Sunil Kumar Kopparapu, Tata Consultancy Services, India
- E Hari Krishna, Kakatiya University, India
- Sunil Kumar, Manipal University Jaipur, India
- Otavio P. Lavor, UFERSA, Brazil
- Xia Li, Apple, USA
- Ali Mahdoum, Centre de Développement des Technologies Avancées, Algeria
- Dina Fitria Murad, Bina Nusantara University, Indonesia
- Mas Rina Mustaffa, Universiti Putra Malaysia, Malaysia
- Tripura Pidikiti, R V R and J C College of Engineering, India
- Pramod K B Rangaiah, Uppsala University, India
- Wael A. Salah, Palestine Technical University - Kadoorie, Palestine
- Riko Arlando Saragih, Maranatha Christian University, Indonesia
- Alexander B. Sergienko, St.-Petersburg Electrotechnical University, Russia
- Aditi Sharma, Quantum University, Roorkee, Uttarakhand, India
- Joni W. Simatupang, President University, Indonesia
- Dhananjay Singh, Hankuk University of Foreign Studies, Korea
- Miguel Antonio Sovierzoski, Federal University of Technology - Parana', Brazil
- Suryakanthi Tangirala, Faculty of Business, Botswana
- Ashish Tanwer, Stony Brook University, USA
- Rahmat Trialih, Brawijaya University, Indonesia
- Evi Wahyuni, University of Muhammadiyah Malang, Indonesia
- Mohammed Ali Al-Qodah, Prince Sattam bin Abdulaziz University, Saudi Arabia
- Humaira Anwer, National University of Sciences & Technology, Islamabad, Pakistan
- Srinivasa Rao Balasani, Visakha Institute of Engineering & Technology, India
- Renaldi Gondosubroto, GReS Studio, Indonesia
- Cataldo Guaragnella, Politecnico di Bari, Italy
- Patrick W.C. Ho, Monash University, Malaysia
- V Jyothsna, JNTUH, India
- Yogesh S. Kale, North Carolina A&T State University, USA
- Suraya Mohammad, University Kuala Lumpur - British Malaysian Institute, Malaysia

# Digital Repository Universitas Jember

- Fernando L. R. Mussoi, Federal Institute of Santa Catarina, Brazil
- Fajrin Nurman Arifin, Jember University, Indonesia
- Vanita Pawar, DIAT, Pune, India
- Uppu Ramachandraiah, Hindustan University, India
- Nuno Rodrigues, Instituto Politécnico de Bragança, Portugal
- Gnane Swarnadh Satapathi, AJ Institute of Engineering and Technology, India
- Dana I. Sensuse, Universitas Indonesia, Indonesia
- Seppo Sirkemaa, University of Turku, Finland
- Apol Pribadi Subriadi, Institut Teknologi Sepuluh Nopember, Indonesia
- Arif Tirtana, STIKI, Indonesia
- Gabriel Venegas-Mancilla, Universidad Católica de Temuco, Chile
- Gang Wang, PCTEL, Inc., USA
- Thaweesak Yingthawornsuk, King Mongkut's University of Technology Thonburi, Thailand
- Izham Z. Abidin, Universiti Tenaga Nasional, Malaysia
- Abrar Zahin, Utah State University, USA
- Shao Ying Zhu, University of Derby, United Kingdom (Great Britain)



# Finger Movement Regression with Myoelectric Signal and Deep Neural Network

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
60  
61  
62  
63  
64  
65

Khairul Anam  
Department of Electrical  
Engineering  
University of Jember  
Jember, Indonesia  
khairul@unej.ac.id

Dwiretno Istiyadi Swasono  
Department of Computer  
Engineering  
University of Jember  
Jember, Indonesia  
istiyadi.s@gmail.com

Aris Zainul Muttaqin  
Department of Mechanical  
Engineering  
University of Jember  
Jember, Indonesia  
arizm@gmail.com

Faruq Sandi Hanggara  
Intelligent System and  
Robotics Lab, CDAST  
University of Jember  
Jember, Indonesia  
faruqsandi@gmail.com

**Abstract**— Research on electromyographic (EMG) signals is intensively carried out to help disabled people to control prosthetic hands. Neural Networks have been widely used in research on the classification of finger movements using EMG. The study of a classification system generally still works on a limited number of movements, even though the human body, especially fingers, has a nearly unlimited combination of movements to help do daily activities. To overcome this, a proportional control system is needed. In its recent development, research on myoelectric control using EMG devices is still in a laboratory environment. Hence, the results obtained in a clinical setting are often different. However, along with technological developments, the emergence of affordable and wearable commercial EMG devices such as Myo Armband, has encouraged this study to develop control systems of prosthetic fingers using regression. One of many options available is neural networks that have been widely used in various fields. By estimating each joint with a different neural network, the result shows the predicted is fitted to the actual angle with  $R^2$  as high as 99%.

**Keywords**— *electromyographic (EMG) signals, neural network, regression.*

## I. INTRODUCTION

The interface of prosthetic robots or assistive devices for the disabled that use hands (joysticks or keyboards), sounds, or facial expressions, is inconvenient to use. Therefore, it is necessary to use a hand-free interface. A myoelectric signal should be able to provide an accurate, intuitive, and responsive interface. Thus, myoelectric control systems (MCS) have been widely used to interface prosthetic robots and assistive devices by using electromyographic (EMG) signal patterns[1].

Electromyographic (EMG) signals are signals generated from the process of evaluating and recording the electrical activity produced by muscles (Myoelectric). Electromyography can be done by inserting an electrode needle into the skin or attaching an electrode plate over the skin so that it can capture the electrical signal from the muscle. The Myoelectric signals produced vary depending on ongoing muscle activity. The myoelectric signal is formed by a sum of motor action potentials generated by muscle contraction [1].

The myoelectric control system has many potentials, including but not limited to, multi-functional prostheses, wheelchairs, grasping controls, virtual keyboards, and gait generations [1], even though the myoelectric control system is still far from widespread commercial applications due to obstacles to have good control. Myoelectric control system research centers on arm movements [2][3] and uses a classification system [1][4][5][6]. However, one of the most

common losses suffered by people with arm disabilities is the loss of functional hand positions whereas daily activities depend on this functional hand position [7], such as using a spoon, buttoning a shirt, holding a ball, and so on.

Research on finger movements also yields impressive classification results but with non-wearable surface EMG and more sensor channels that may bother the user and make replacement more difficult [8][9][10]. Research with fewer sensors is done and produces a good classification though it only works on very limited movement class [10][11][12]. The fact that previous research focused on the classification means that it is contrary to the number of body movements like fingers which are almost unlimited. This type of control is inadequate to exploit all functions offered by prosthetic robot as only one class of movement activated at a time in classification system [13]. Therefore, a proportional control system is needed [14]. Proportional control systems require predictions in each joint.

Although better results are obtained with invasive EMG electrodes [15], this technique needs special medical treatment and further observation of long-term effects. Myo Armband, a wearable surface EMG device, is a non-intrusive tool that allows users to slip the device on. However, the limitation comes as quality and quantity of signals of dry electrodes on Myo Armband are less accurate than gel-based one [16]. Some previous studies such as [17] and [18] also estimate finger joints, but we found that previous studies (although estimating one joint with a different estimator) used recording EMG signals on non-functional movements such as extensions on one finger while the other fingers were in flexion. Finger gesture such as thumb up, V-sign, and horn-sign is the result of different muscle synergies. Thus, this study proposes regression of the finger joint for functional movements using a deep neural network.

## II. METHOD

### A. Dataset

This study uses a database of NinaPro (Non-Invasive Adaptive Hand Prosthetics) [19], which is a surface EMG signal benchmark data resource from the upper arm. NinaPro has a dataset that was of concern in this study. The dataset (called NinaPro DB5) was obtained by recording using the Myo-Armband device, the surface EMG signal recording device with low prices issued by Thalmic startup (Ontario, Canada) in 2013. Myo-Armband has a much lower price than other devices used in NinaPro but provides competitive performance with Cometa miniWave and Dormo in the classification system [20].

As with the dataset available at NinaPro, DB5 provides hand kinematic data recordings obtained using 22-channel CyberGlove II and EMG data obtained with two Myo Armbands, each of which has 8-channel EMG sampled at 200Hz. Each of CyberGlove II finger has four sensors. Two are to record distal and proximal interphalangeal (DIP, PIP) joint angles. The remaining two are for measuring extension/flexion and abduction/adduction in the metacarpophalangeal (MCP) joint (Fig. 1) [21]. The acquisition setup is described in detail [20].

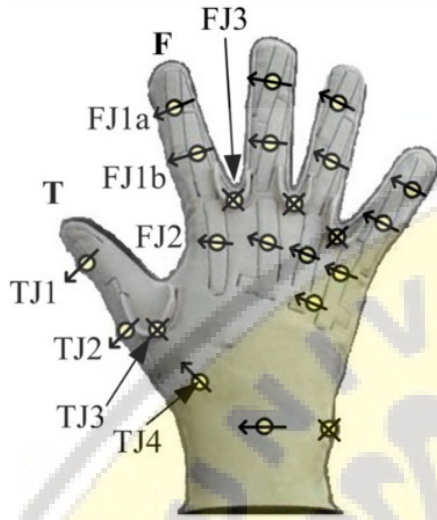


Fig. 1. Channel sensor placement depicting joint movement [21]

Fig. 2 shows the arrangement of devices during recording. This study uses exercise C from a paper [19], which consists of 23 grasping and functional movements that use everyday objects (Table 1).

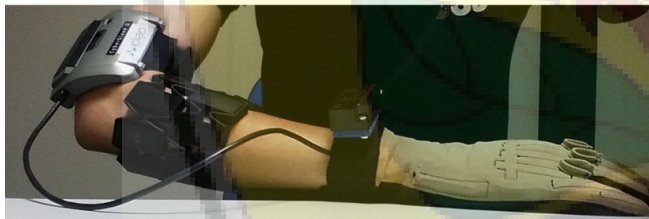


Fig. 2. NinaPro DB5 data acquisition setup [20]

NinaPro DB5 has ten subjects consisting of 8 male subjects and two female subjects. Nevertheless, this study used two male subjects and two female subjects. This study also only uses two fingers, the thumb, and index finger as [22] mentioned that previous studies [23][24] have shown digits such as the thumb and index finger. These are moved relatively independently, whereas the others are most often moved together. Thus, channel number 1, 2, 3, 4, 5, 6, 7, and 8 of CyberGlove have been used (Fig. 3).

TABLE I. TWENTY-THREE FUNCTIONAL MOVEMENT OF FINGERS AND REST [19]

Action	Figure	Action	Figure
Large diameter grasp		Tripod grasp	
Small diameter grasp (power grip)		Prismatic pinch grasp	
Fixed hook grasp		Tip-pinch grasp	
Index finger extension grasp		Quadpod grasp	
Medium wrap		Lateral grasp	
Ring grasp		Parallel extension grasp	
Prismatic four fingers grasp		Extension type grasp	
Stick grasp		Power disk grasp	
Writing tripod grasp		Open a bottle with a tripod grasp	
Power sphere grasp		Turn a screw (grasp the screwdriver with a stick grasp)	
Three fingers sphere grasp		Cut something (grasp the knife with an index finger extension grasp)	
Precision sphere grasp		Rest	

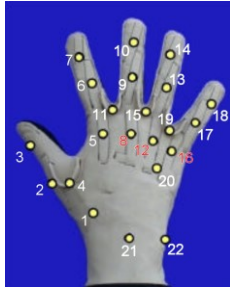


Fig. 3. The sensor channel position of 22-channel Cyberglove [25]

### B. Feature extraction

Successfully recorded EMG signal cannot be used directly because the nature of the EMG signal is complex and is a synergy of several muscles. The DB5 exercise C dataset contains 23 types of movements and is interrupted by rest time in a file. Pre-processing data before feature extraction was split into groups of 23 functional movements and one rest movement. This grouping is done to make windowing of the EMG signal easier to eliminate transition signal. The windowing itself produces a different number of windows, so down sampling is then done. This leads to the same number of samples for each movement. This grouping and down sampling are done because the NinaPro data acquisition protocol requires repeating each type of the movement six times interspersed with resting movements.

The features of this study are extracted from the time domain because it is simpler and only based on amplitude [1]. The features are obtained from the sliding window instead of using the disjoint window, to get redundant data. The feature obtained are mean absolute value (MAV), root means square (RMS), waveform length (WFL), integrated absolute value (IAV), zero crossings (ZC), dan slope sign change (SSC). A detailed definition of these features can be found in [26] and [3]. Thus, each channel will produce six different features. Some equations of the features are described in equation (1) to (3).

$$MAV = \frac{1}{N} \sum_{k=1}^N |x_k| \quad (1)$$

$$RMS = \sqrt{\frac{1}{N} \sum_{k=1}^N x_k^2} \quad (2)$$

$$WL = \sum_{k=1}^N |x_k - x_{k-1}| \quad (3)$$

Where  $x$  is a signal window,  $N$  is the length of window  $x$  and  $k$ -th element of window  $x$  correspond to  $x_k$ .

### C. Deep Neural Network

A neural network (NN) is a collection of algorithms arranged to mimic how relationships between neurons in the brain work [27]. Neural networks are almost used in every field, from self-driving cars to drug discovery [28]. A neural network works forward (feed-forward) from the input layer to the output layer [27]. Nevertheless, neural networks learn by doing repeated weighing, which is done after a neuron receives feedback from a neuron that is right in front of it (moves backward) [29]. Thus, it named backpropagation. For the regression process with a neural network, this study uses Keras [30], the deep learning framework in the Python programming language.

## III. RESULT

This study uses data from 2 men (M 1, M 2) and 2 women (F 1, F 2). After windowing with window length 200 frames and increment 25 frames, each produces 3552, 2904, 3120, and 3816 windows. Then, the features of windows have been extracted. The features are normalized before being inserted into the neural network. Neural network (NN) is used to study the relationship between EMG signals and finger positions. This paper uses a different NN for each joint. The neural network model created in this study uses four hidden layers (Fig. 4). The neuron number ratio between a former and latter was fixed to 2:1, so that the number of hidden neurons is (128, 64, 32, 16) with each having ReLU as the activation function. The model fitted dataset with batch size 32, shuffled (which are the default values of Keras), and compiled with Adadelta as optimizer [31] and mean square error (MSE) as loss function and metric model.

Data is separated for training and validation/test 0.8 and 0.2, respectively. NN with 4 hidden layers is chosen, because in general, training Deep NN will be more difficult as the network gets bigger [32]. The problems that can be effectively solved by a single layer feed-forward network (SLFN) turn out to be inefficient when applied at DNN [33]. This problem can be overcome by implementing dropout, batch normalization, and similar regularization, but these will add to the variation of the network architecture created. To keep the model simple, we used 4 hidden layers.

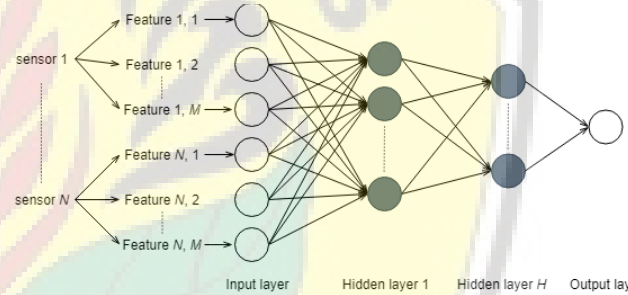


Fig. 4. Neural network regression model with multiple hidden layers and feature extractions before the input layer.

The neural network is first tested by doing five cross-validations (5-CV) with 100 epochs to see a general picture of the performance of the neural network on each channel and subject (Table 2). 5-CV was chosen because it can be assumed that 4/5 of the data as training data is enough to estimate how well each fold represents the whole without sacrificing computing time. Performance is measured with MSE.

TABLE II. NEURAL NETWORK 5-CV AVERAGE PERFORMANCE (MSE)

	Channel Number							
	1	2	3	4	5	6	7	11
M 1	26.5	3.9	4.9	2.0	8.5	7.3	1.8	510.5
M 2	30.7	3.8	10.2	2.9	13.1	11.3	1.2	739.2
F 1	45.6	9.7	5.1	2.3	9.1	10.4	1.5	885.7
F 2	31.9	1.8	2.6	1.4	6.9	5.0	0.2	495.7
Avg.	33.7	4.8	5.7	2.1	9.4	8.5	1.2	657.8

Moreover, using the same parameters and data with the help of Keras, a neural network is trained by limiting the number of epochs to avoid overfitting. The training will early stop if, for the last ten epochs, the validation loss does not decrease (Table 3). The  $R^2$  score (the percent variability in the actual angular values explained by the estimated values) is



shown in Table 4 to tell how close the data are to the fitted regression line. The results of prediction errors of subject male 1 can be seen in Fig. 5 and Fig. 6.

TABLE III. NEURAL NETWORK PERFORMANCE (MSE) WITH AN EARLY STOP

	Channel Number							
	1	2	3	4	5	6	7	11
M 1	24.3	11.7	5.8	4.2	9.8	14.3	3.1	627.1
M 2	60.6	3.1	11.8	2.2	8.8	12.1	1.7	727.6
F 1	33.9	9.7	3.3	1.6	7.0	9.7	1.7	725.5
F 2	13.9	1.7	1.9	1.1	4.5	6.2	0.2	269.1
Avg.	33.1	6.5	5.7	2.3	7.5	10.6	1.6	587.3

TABLE IV. NEURAL NETWORK COEFFICIENT OF DETERMINATION ( $R^2$ ) IN PERCENT

	Channel Number							
	1	2	3	4	5	6	7	11
M 1	93.9	67.6	98.7	97.0	97.0	96.5	97.0	99.1
M 2	85.8	95.8	97.8	97.4	96.7	94.5	98.4	98.2
F 1	89.2	92.3	95.8	97.6	98.0	95.7	94.3	98.8
F 2	93.7	97.6	98.4	98.7	98.5	97.6	98.9	98.8
Avg.	90.7	88.3	97.7	97.7	97.6	96.1	97.2	98.7

We also measure results of epsilon-support vector regression (SVR) and indicate, in Table 5, that SVR hardly reaches 80%.

TABLE V. SVM COEFFICIENT OF DETERMINATION ( $R^2$ ) IN PERCENT

	Channel Number							
	1	2	3	4	5	6	7	11
M 1	79.3	87.7	61.6	90.3	79.9	65.1	89.0	23.7
M 2	70.4	76.5	42.6	67.4	72.0	62.6	75.8	41.0
F 1	53.9	67.6	71.5	54.9	64.2	60.9	58.9	20.1
F 2	89.0	75.3	79.4	68.5	70.1	80.0	91.4	41.7
Avg.	73.1	76.8	63.8	70.3	71.6	67.1	78.8	31.6

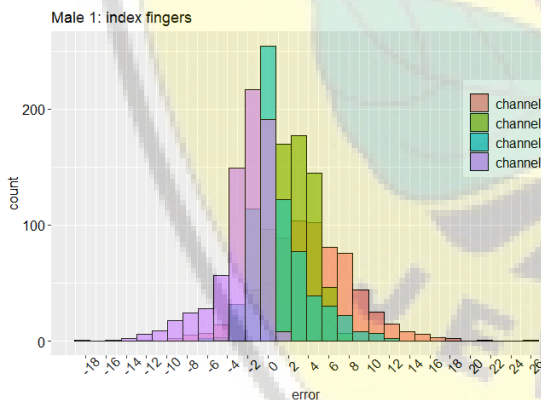


Fig. 5. Index finger movement prediction error histogram for male 1

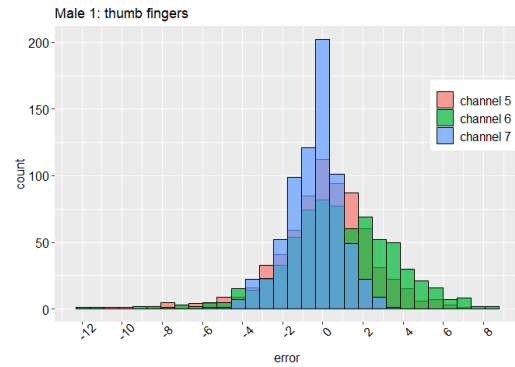


Fig. 6. Thumb movement prediction error histogram for male 1

#### IV. CONCLUSION

If we only look at MSE, we cannot know whether the prediction results are good enough, because there is no information regarding the real value of the joint angle (CyberGlove sensor's reading is proportionally declared to the angle with a resolution of less than one degree, depending on the size of the subject's hand). Table 4 shows how close the data are to the fitted regression line and the result is quite high. CyberGlove channels for number 1 and 11 show a very high MSE value, but the channel is on the MCP joint and measures abduction/adduction, while other channels measure flexion/extension.

#### REFERENCES

- [1] M. Asghari Oskoei and H. Hu, "Myoelectric control systems-A survey," *Biomed. Signal Process. Control*, vol. 2, no. 4, pp. 275–294, 2007.
- [2] Y. Huang, K. B. Englehart, B. Hudgins, and A. D. C. Chan, "A Gaussian mixture model based classification scheme for myoelectric control of powered upper limb prostheses," *IEEE Trans. Biomed. Eng.*, 2005.
- [3] S. Micera, J. Carpaneto, and S. Raspopovic, "Control of hand prostheses using peripheral information Review," vol. 3, pp. 48–68, 2010.
- [4] T. Gupta, J. Yadav, S. Chaudhary, and U. Agarwal, "EMG pattern classification using neural networks," *Adv. Intell. Syst. Comput.*, vol. 683, pp. 232–242, 2018.
- [5] M. A. Oskoei and H. Hu, "Support vector machine-based classification scheme for myoelectric control applied to upper limb," *IEEE Trans. Biomed. Eng.*, vol. 55, no. 8, pp. 1956–1965, 2008.
- [6] S. W. Lee, K. M. Wilson, B. A. Lock, and D. G. Kamper, "Subject-specific myoelectric pattern classification of functional hand movements for stroke survivors," *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 19, no. 5, pp. 558–566, 2011.
- [7] S. D. McPhee, "Functional hand evaluations: a review.," *Am. J. Occup. Ther.*, vol. 41 3, pp. 158–163, 1987.
- [8] F. V. G. Tenore, A. Ramos, A. Fahmy, S. Acharya, R. Etienne-Cummings, and N. V. Thakor, "Decoding of individuated finger movements using surface electromyography," *IEEE Trans. Biomed. Eng.*, vol. 56, no. 5, pp. 1427–1434, 2009.
- [9] A. Al-Timemy, G. Bugmann, N. Outram, J. Escudero, and H. Li, "Finger movements classification for the dexterous control of upper limb prosthesis using EMG signals," *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 7429 LNAI, pp. 434–435, 2012.
- [10] R. N. Khushaba, S. Kodagoda, M. Takturi, and G. Dissanayake, "Toward improved control of prosthetic fingers using surface electromyogram (EMG) signals," *Expert Syst. Appl.*, vol. 39, no. 12, pp. 10731–10738, 2012.
- [11] G. Tsenov, A. H. Zeghib, F. Palis, N. Shoylev, and V. Mladenov, "Neural Networks for Online Classification of Hand and Finger Movements Using Surface EMG signals," pp. nil20–nil20, 2011.
- [12] K. Anam, R. N. Khushaba, and A. Al-Jumaily, "Two-channel surface electromyography for individual and combined finger movements,"

- Proc. Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. EMBS*, pp. 4961–4964, 2013.
- [13] S. Muceli and D. Farina, “Simultaneous and proportional estimation of hand kinematics from EMG during mirrored movements at multiple degrees-of-freedom,” *IEEE Trans. Neural Syst. Rehabil. Eng.*, 2012.
- [14] M. Santello *et al.*, “Hand synergies: Integration of robotics and neuroscience for understanding the control of biological and artificial hands,” *Phys. Life Rev.*, vol. 17, no. February, pp. 1–23, 2016.
- [15] T. R. Farrell and R. F. Weir, “Pilot comparison of surface vs. implanted EMG for multifunctional prosthesis control,” in *Proceedings of the 2005 IEEE 9th International Conference on Rehabilitation Robotics*, 2005.
- [16] U. Côté-Allard *et al.*, “Deep Learning for Electromyographic Hand Gesture Signal Classification Using Transfer Learning,” *IEEE Trans. Neural Syst. Rehabil. Eng.*, 2019.
- [17] N. A. Shirao, N. P. Reddy, and D. R. Kosuri, “Neural network committees for finger joint angle estimation from surface EMG signals,” *Biomed. Eng. Online*, 2009.
- [18] J. G. Ngeo, T. Tamei, and T. Shibata, “Continuous and simultaneous estimation of finger kinematics using inputs from an EMG-to-muscle activation model,” *J. Neuroeng. Rehabil.*, 2014.
- [19] M. Atzori *et al.*, “Electromyography data for non-invasive naturally-controlled robotic hand prostheses,” *Sci. Data*, vol. 1, pp. 1–13, 2014.
- [20] S. Pizzolato, L. Tagliapietra, M. Cognolato, M. Reggiani, H. Müller, and M. Atzori, “Comparison of six electromyography acquisition setups on hand movement classification tasks,” *PLoS One*, vol. 12, no. 10, pp. 1–17, 2017.
- [21] B. A. Kent, N. Karnati, and E. D. Engeberg, “Electromyogram synergy control of a dexterous artificial hand to unscrew and screw objects,” *J. Neuroeng. Rehabil.*, vol. 11, no. 1, pp. 1–20, 2014.
- [22] J. N. Ingram, K. P. Körding, I. S. Howard, and D. M. Wolpert, “The statistics of natural hand movements,” *Exp. Brain Res.*, vol. 188, no. 2, pp. 223–236, 2008.
- [23] S. L. Kilbreath and S. C. Gandevia, “Limited independent flexion of the thumb and fingers in human subjects,” *J. Physiol.*, vol. 479, no. 3, pp. 487–497, 1994.
- [24] C. Hager-Ross and M. H. Schieber, “Quantifying the independence of human finger movements: Comparisons of digits, hands, and movement frequencies,” *J. Neurosci.*, vol. 20, no. 22, pp. 8542–8550, 2000.
- [25] N. J. Jarque-Bou, A. Scano, M. Atxori, and H. Müller, “Kinematic synergies of hand grasps: a comprehensive study on a large publicly available dataset,” *J. Neuroeng. Rehabil.*, vol. 6, pp. 1–14, 2019.
- [26] A. Phinyomark, P. Phukpattaranont, and C. Limsakul, “Feature reduction and selection for EMG signal classification,” *Expert Syst. Appl.*, 2012.
- [27] F. Rosenblatt, “The perceptron: A probabilistic model for information storage and organization in the brain,” *Psychol. Rev.*, vol. 65, no. 6, pp. 386–408, Nov. 1958.
- [28] N. Brown *et al.*, *Big Data in Drug Discovery*, 1st ed., vol. 57, no. 1. Elsevier B.V., 2018.
- [29] R. Hecht-nielsen, “Theory of the backpropagation neural network,” *Int. Jt. Conf. neural networks*, pp. 593–605, 1989.
- [30] F. Chollet, “Keras.” 2015.
- [31] M. D. Zeiler, “ADADELTA: An Adaptive Learning Rate Method,” 2012.
- [32] G. Tesauro, “Practical Issues in Temporal Difference Learning,” *Mach. Learn.*, vol. 8, no. 3, pp. 257–277, 1992.
- [33] L. Arnold, S. Rebecchi, S. Chevallier, H. Paugam-Moisy, L. Arnold, and S. Chevallier, “An Introduction to Deep Learning,” in *European Symposium on Artificial Neural Networks (ESANN)*, 2011.



 **ICOM**  
**ITEE** 2019  
[www.icomitee.org](http://www.icomitee.org)