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## TABLE OF CONTENTS

- A-01 **A Process Capability Assessment Model of IT Governance Based on ISO 38500**  
*Rahmi Eka Putri and Kridanto Surendro*
- A-02 **Automatic Sperm Motility Measurement**  
*Priyanto Hidayatullah, Iwan Awaludin, Reyhan Damar Kusumo and Muhammad Nuriyadi*
- A-03 **Comparative Study between Part-of-Speech and Statistical Methods of Text Extraction in the Tourism Domain**  
*Guson P. Kuntarto, Fahmi L. Moechtar, Berkah I. Santoso and Irwan P. Gunawan*
- A-04 **A Multi-Method Exploration: The Use of Mobile Spiritual Applications amongst Older Adults**  
*Azaliza Zainal, Nahdatul Akma Ahmad, Fariza Hanis Abdul Razak and Ariza Nordin*
- A-05 **Visual Object Tracking Using Improved Mean Shift Algorithm**  
*Sulfan Bagus Setyawan, Djoko Purwanto and Ronny Mardiyanto*
- A-06 **Experiment on a Phrase-Based Statistical Machine Translation Using PoS Tag Information for Sundanese into Indonesian**  
*Arie Ardiyanti Suryani, Dwi Hendratmo Widyantoro, Ayu Purwarianti and Yayat Sudaryat*
- A-07 **An Analysis of Software Project Management (Case Study: Government Agencies)**  
*Mas'ud Adhi Saputra and Arry Akhmad Arman*
- A-08 **A Speech Emotion Recognition Method in Cross-languages corpus Based on Feature Adaptation**  
*Xinran Zhang, Gang Xiao, Cheng Zha and Li Zhao*
- A-09 **Dynamic Student Assessment to Advocate Personalized Learning Plan**  
*Ahmad Sofian Shminan and Mohd Kamal Othman*
- A-10 **The Intensity of the Research Activities on E Learning for Care Givers of Autistic Children**  
*Ahmad Sofian Shminan, Norsiah Fauzan and Merikan Aren*
- A-11 **A Strategy to Create Daily Consumer Price Index by Using Big Data in Statistics Indonesia**  
*Doran Pandapotan Manik and Albarda*
- A-12 **An Ontology Tropical Weather Model For Sensor Network Interoperability**  
*Sandra Yuwana and Devi Munandar*
- A-13 **Software Complexity Metric-based Defect Classification Using FARM with Preprocessing Step CFS and SMOTE (A Preliminary Study)**  
*Mohammad Farid Naufal and Siti Rochimah*
- A-14 **Designing a Rice Logistics Distribution System In West Java**  
*Muhammad Rizkarmen, Rolan Mauludy Dahlan and Yudi Satria Gondokaryono*
- A-15 **Generating Cultural Heritage Metadata as Linked Open Data**  
*Nurul Fajrin Ariyani and Umi Laili Yuhana*
- A-16 **Implementation of Dendritic Cell Algorithm as an Anomaly Detection Method for Port Scanning Attack**  
*Silvia Anandita, Yusep Rosmansyah, Budiman Dabarsyah and Jong Uk Choi*
- A-17 **Design and Implementation Information Security Governance Using Analytic Network Process and COBIT 5 For Information Security A Case Study of Unit XYZ**  
*Haryo Laksono and Yose Supriyadi*
- A-18 **Modeling of the Pixel Based Segmentation to Detect Nerve Optic Head on the Retinal Image**

- Arif Muntasa, Indah Agustien Siradjuddin and Moch Kautsar Sophan*
- A-19 **Agent-Based Structural Health Monitoring System on Single Degree of Freedom Bridge: A Preliminary Study**  
*Seno Adi Putra, Bambang Riyanto Trilaksono, Agung Harsoyo and Achmad Imam*
- A-20 **Comparison on the Rule based Method and Statistical based Method on Emotion Classification for Indonesian Twitter Text**  
*Aldy Rialdy Atmadja and Ayu Purwarianti*
- A-21 **Assessment Of Information Technology Security Governance For Supervisory Control And Data Acquisition (Scada) On The Smart Grid Electricity**  
*Ahmad Budi Setiawan, Aries Syamsudin and Yusep Rosmansyah*
- A-22 **Study of Management Information System and Organizational Culture toward the Success of several Banks in Indonesia**  
*Trisna Febriana*
- A-23 **Genetic Algorithm for Capacitated Vehicle Routing Problem with Considering Traffic Density**  
*Rasyid Kurniawan, Mahmud Dwi Sulistiyo and Gia Septiana Wulandari*
- A-24 **Automatic Indonesia's Questions Classification Based On Bloom's Taxonomy Using Natural Language Processing (A Preliminary Study)**  
*Selvia Ferdiana Kusuma, Daniel Siahaan and Umi Laili Yuhana*
- A-25 **JavaScript-based Device Fingerprinting Mitigation Using Personal HTTP Proxy**  
*Tio Dwi Laksono, Yusep Rosmansyah, Budiman Dabarsyah and Jong Uk Choi*
- A-26 **Acoustic Emissions Waveform Analysis for the Recognition of Coal Rock Stability**  
*Jing Li, Li Zhao, Jianhua Yue and Yong Yang*
- A-27 **Design and Implementation of Digital Signage System based on Raspberry Pi 2 for e-Tourism in Indonesia**  
*Yoanes Bandung, Yonathan F. Hendra and Luki Bangun Subekti*
- A-28 **Modified Kleptodata for Spying Soft-Input Keystroke and Location Based on Android Mobile Device**  
*Surya Michrandi Nasution, Yudha Purwanto, Agus Virgono and M. Faris Ruriawan*
- A-29 **The Challenges of Delivering Multimedia-based Learning Services in Rural Areas**  
*Yoanes Bandung, Achmad Maulana Gani, Harry Chandra Tanuwidjaja and Jaka Sembiring*
- A-30 **Wavelet Based Feature Extraction for The Vowel Sound**  
*Risanuri Hidayat, Priyatmadi and Welly Ikawijaya*
- A-31 **Review and Classification of Electronic Cash Research**  
*Dany Eka Saputra, Suhono Harso Supangkat and Sarwono Sutikno*
- A-32 **Assessing Users' Acceptance toward a Closed Access Library Service System Using the UTAUT Model: A Case Study at the National Library of Indonesia**  
*Dewi Endah Wasitarini and Wiratna Tritawirasta*
- A-33 **TF-IDF Method in Ranking Keywords of Instagram Users' Image Captions**  
*Bernardus Ari Kuncoro and Bambang Heru Iswanto*
- A-34 **Gaussian Mixture Model and Spatial-Temporal Evaluation for Object Detection and Tracking in Video Surveillance System**  
*Luqman Abdul Mushawwir and Iping Supriana*
- A-35 **E-commerce Implementation to Support Ornamental Fish Breeders in Indonesia**  
*Meyliana and Henry Antonius Eka Widjaja*

- A-36 **A Design of Software Requirement Engineering Framework based on Knowledge Management and Service-Oriented Architecture Decision (SOAD) Modeling Framework**  
*Noor Afies Prasetyo and Yoanes Bandung*
- A-37 **The Design of Production Modules of ERP Systems based on Requirements Engineering for Electronic Manufacturing Services Company**  
*Kursehi Falgenti, Chandra Mai and Said Mirza Pahlevi*
- A-38 **Combining Ground-based Data and MODIS Data for Rice Crop Estimation in Indonesia**  
*Sani M. Isa, Suhadi Chandra, Dyah Erny Herwindiati and Sidik Mulyono*
- A-39 **Mobile-Agent's Self-Reliant Host Security Examination**  
*Irwan, Armein Z. R. Langi and Emir Husni*
- A-40 **Assembly of Tin Oxide Nanowires for Dielectrophoretic Response Modeling**  
*Ahmad Sabry Mohamad, Kai F. Hoettges and Michael Pycraft Hughes*
- A-41 **Design and Implementation Service Oriented Architecture for Data and Information Service in Bandung Health Office**  
*Fathonah Tri Hastuti and R. Andri Priyatna P*
- A-42 **CSF for implementation E-portfolio model: A Systematic Review**  
*Puji Rahayu and Dana Indra Sensuse*
- A-43 **The Estimation of Cartoons Effect on Children's Behavior Based on Exaggeration Action by Using Neural Network**  
*Riwinoto, Sandi Prasetyaningsih and Cahya Miranto*
- A-44 **Measuring Performance Level of Smart Transportation System in Big Cities of Indonesia Comparative Study: Jakarta, Bandung, Medan, Surabaya, and Makassar**  
*Atut Pindarwati and Arie Wahyu Wijayanto*
- A-45 **Defining Knowledge of Government Human Capital Management: A Qualitative Study**  
*Elin Cahyaningsih, Dana Indra Sensuse and Wina Permana Sari*
- A-46 **Critical Success Factor of Knowledge Management Implementation in Government Human Capital Management: A Mixed Method**  
*Elin Cahyaningsih, Dana Indra Sensuse and Wina Permana Sari*
- A-47 **Improving Infectious Diseases Prevention System: The Case Study of Departement of Health Sragen**  
*Rochim Wahyu Pramudyo, Rian Agustama Susilo, Dianti Eka Aprilia and Albarda*
- A-48 **A Study of TESCA an Indonesia' Higher Education E-Readiness Assessment Model**  
*Marcel*
- A-49 **Social CRM using Web Mining for Indonesian Academic Institution**  
*Nyoman Karna, Iping Supriana and Nur Maulidevi*
- A-50 **Risk Assessment Model of Application Development using Bayesian Network and Boehm's Software Risk Principles**  
*Josua Johan Pandapotan Sipayung and Jaka Sembiring*
- A-51 **Development of Real-Time Collaboration System for E-book Writing**  
*Muhammad Eko Budi Prasetyo and Yoanes Bandung*
- A-52 **Development of User Acceptance Model for Electronic Medical Record System**  
*Arry Akhmad Arman and Sri Hartati*
- A-53 **Design of FTTS Forecasting Model using Markov Chain and P2AMF Framework Case Study : Farmer's Terms of Trade of Smallholders Estate Crops Subsector in Riau**



- Zulyadi and Jaka Sembiring*
- A-54 **Improvement of Fuzzy Geographically Weighted Clustering-Ant Colony Optimization using Context-Based Clustering**  
*Nila Nurmala and Ayu Purwarianti*
- A-55 **Lip Reading Based on Background Subtraction and Image Projection**  
*Fatchul Arifin, Aris Nasuha and Hardika Dwi Hermawan*
- A-56 **A Comparative Study On Three Electronics Toll Collection Systems In Surabaya**  
*Rudy Hermawan Karsaman, Yudo Adi Nugraha, Sri Hendarto and Febri Zukhruf*
- A-57 **Analysis On The Implementation Of Digital Marketing Towards Motorbike Transport Service Case Study: GO-JEK (Online Taxi Motorbike) Jakarta, Indonesia**  
*F.A. Wisnu Wirawa and Elsie Oktivera*
- A-58 **A Preliminary Study of Modelling Interconnected Systems Initiatives for Preserving Indigenous Knowledge in Indonesia**  
*Handrie Noprisson, Erzi Hidayat and Nuralamsah Zulkarnaim*
- A-59 **WSN Infrastructure for Green Campus Development**  
*Eko D. Widiyanto, Adian F. Rochim, Oky D. Nurhayati and Sumardi*
- A-60 **Measurement of Learning Motivation in Electronic Learning**  
*Christina Juliane, Arry A. Arman, Husni S. Sastramihardja and Iping Supriana*
- A-61 **An Analysis of Information Technology Governance Case study: Statistics Indonesia**  
*Amalia Romadhona and Arry Akhmad Arman*
- A-62 **Identification of Causal Pattern using Opinion Analysis in Indonesian Medical Texts**  
*Susetyo Bagas Bhaskoro, Saiful Akbar and Suhono Harso Supangkat*
- A-63 **Intelligent Home Management System Prototype Design and Development**  
*Azka Ihsan Nurrahman and Kusprasapta Mutijarsa*
- A-64 **Relationship Between Features Volatility And Software Architecture Design Stability In Object-Oriented Software: Preliminary Analysis**  
*Felix Handani and Siti Rochimah*
- A-65 **Design and Development Prototype of Electronic Payment System for Angkot Case Study: City of Bandung, Indonesia**  
*Khairani Ummah and Kusprasapta Mutijarsa*
- A-66 **ERP Assimilation and Benefit Realization: Analyzing the Influence of Leader Characteristics**  
*Rajesri Govindaraju, Rizka Aisha Rahmi Hariadi and Ahmad Zamakhsyari Sidiq*
- A-67 **Critical Processes in Developing Client-Vendor Relationship in the Case of Offshore IT/IS Outsourcing**  
*Rajesri Govindaraju, Yogi Yusuf Wibisono and Ahmad Zamakhsyari Sidiq*
- A-68 **A Framework for Designing Survey Training based on 3D Virtual Learning Environment Using SLOODLE**  
*Rico Martenstyaro and Yusep Rosmansyah*
- A-69 **Survey on Research Paper's Relations**  
*Yuliant Sibaroni, Dwi Hendratmo Widyantoro and Masayu Leylia Khodra*
- A-70 **Methodology Development of Information Technology Value Engineering using Systems Engineering Approach**  
*Lukman Abdurrahman and Suhardi*
- A-71 **Consolidating Service Engineering Perspectives**  
*Purnomo Yustianto, Suhardi and Robin Doss*



**A-72 Appliances Identification Method of Non-Intrusive Load Monitoring based on Load Signature of V-I Trajectory**

*Nur Iksan, Jaka Sembiring, Nanang Haryanto and Suhono Harso Supangkat*

**A-73 Design of Organization Readiness Model for E-learning Implementation**

*Arry Akhmad Arman and Cindy M. N. S. Wiyono*

# Lip Reading Based on Background Subtraction and Image Projection

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**Abstract**— Someone who does not have vocal cords, has no ability to produce voice and speech. This problem is suffered by laryngectomy patients. Over half of all laryngectomy patients worldwide are using electrolarynx for the rehabilitation of their speech ability. Unfortunately, the electrolarynx is relatively expensive, especially for patient from the lower classes. In this research, portable speech aid tool for laryngectomy patient based on lip reading is studied, especially for who use Indonesian language. Two problems in a lip lip reading system, especially if it run in portable device, are lighting and limited resources. Background subtraction and image projection method are studied in this research to overcome these two problems.

**Keywords**— laryngectomy, lip reading, background subtraction, image projection

## I. INTRODUCTION

Someone who does not have vocal cords, has no ability to produce voice and speech. This problem is suffered by late-stage laryngeal cancer patients. They are usually treated with total laryngectomy, in which larynx, and tissues around it, including vocal cord, should be removed. By doing surgery, a hole in front of the patient's neck, known as stoma, is made. Then, the trachea is attached to this stoma which is used by the patients to breathe. As the vocal cord of the laryngectomy patients have been removed, they will not be able to speech anymore. They lost their ability to speak as they did [1].

Efforts to assist the laryngectomee, person who has no larynx, to speak has much been studied, for example research on silent speech interface [2]. However these research are still in laboratory stage. Other research on automatic lip reading system on cell phone has done, for example in [3], but the result is not encouraging. Moreover, research into this issue for patients using Indonesian language, has not been done or is very limited.

In addition, general research on automatic lip reading for embedded systems is still not produce satisfactory results, one of which is due to existing algorithms usually require large resources, which would be a heavy run on embedded systems.

Or need to be always connected to the internet, while in some areas it is not available, or is still relatively expensive.

Another problem on an automatic lip-reading system is lighting. Less light, causing the image obtained by the camera becomes more difficult to be processed, so it requires a more reliable system for minimum lighting conditions. In this research we propose method to use in lip reading using background subtraction as lip segmentation and image projection to extract the feature of lip.

## II. SEGMENTATION AND FEATURE EXTRACTION

### A. Background Subtraction

Background subtraction is a technique in the field of image processing, in which foreground image is extracted for further processing. Generally, region of interest of the image is objects in the foreground of image. After the stage of image preprocessing, the object localization is required, which can use this technique. Background subtraction is a widely used approach to detect moving objects in the video of a static camera. The rationale for this approach is that it detects a moving object from the difference between the frame and the frame of reference [4]. Background subtraction done if the image is a part of the video stream. Background subtraction gives important cues for a variety of applications in computer vision, for example, surveillance or tracking human pose estimation.

Principle of lip reading is observing lip pattern, assuming the lips represent the pronunciation of certain syllables or words. Meanwhile, lip detection is not always easy to do, especially if the lip color does not contrast compared to surrounding areas, or because of the weak illumination. The use of background subtraction method to observe the movement of the lips will be able to solve the above problem, assuming the image included in the frame is just around the lips, no movement other than the lip, and there was no lighting changes during the pronunciation.

The basic principle of background subtraction method is to calculate the difference between the value of the intensity of the pixels in the current frame and pixel values in the previous frame, or can be expressed by equation (1).

$$dI(x,y,t) = I(x,y,t) - I(x,y,t-1) \quad (1)$$

where  $I(x,y,t)$  is intensity value in pixel  $(x,y)$  at frame  $t$

### B. Image Projection

Image projections are one-dimensional representations of image contents. Horizontal and vertical projection of image is histogram over horizontal and vertical way of grayscale level. Horizontal and vertical projections of image  $I(u,v)$  is defined in equation (2) and (3).

$$F_{\text{hor}}(v_p) = \sum_{u=0}^{M-1} I(u, v_p) \quad \text{for } 0 < v_p < N \quad (2)$$

$$F_{\text{ver}}(u_p) = \sum_{v=0}^{N-1} I(u_p, v) \quad \text{for } 0 < u_p < M \quad (3)$$

Each row and each column of image become a bin in the histogram. The count that is stored in a bin is the number of 1-pixels that appear in that row or column.

This method can extract image features quickly and easily. This method has proven successful for Cursive character recognition [5], Amazigh Handwritten Character Recognition [6], and traffic sign recognition for intelligent vehicle [7]

### III. IMPLEMENTATION

In order to test our proposed method, we use video recorded from 10 volunteers, 5 men and 5 women. All video are color and focused around subject's mouth. In these video, all volunteers recorded in frontal face. Each of them pronounces 3 simple Indonesian word twice, i.e. "saya", "mau" and "makan", therefore there are 60 video data. Original video size is 640x480 pixels. Video recording time for each volunteer is 1 second for each word or each data consists of 25 frames. Examples of screen shots recording can be seen in Fig. 1.

Our proposed method consists 4 stages:

- 1). Grayscale, i.e. convert video from RGB color space to grayscale
- 2). resizing the image in each frame, from 640x480 pixels into 32x24 pixels
- 3). background subtraction to segment the lips from sequential image
- 4). vertical and horizontal projection, to extract the features of the lip image, that will be used as input of classifier. The results of feature extraction for each frame is  $(32 + 24)$  features, or  $(32 + 24) \times 25$  features for each data.
- 5). word recognition using artificial neural network as classifier, i.e. backpropagation with 3 layers. Input layer size depends on the number of features and output layer size is 3. Hidden layer size and number of iteration is varied



Fig. 1. Examples of screen shot recording

to produce the best result. As a comparison, another classifier is used, i.e. SVM (Support Vector Machine).

Other feature extraction methods used for comparison are:

- (1) background subtraction followed by a vertical projection, this feature extraction output is  $(32 \times 25)$  features
- (2) background subtraction followed by a horizontal projection, feature extraction output is  $(24 \times 25)$  features
- (3) vertical and horizontal projection (without background subtraction), this feature extraction output is  $(32 + 24) \times 25$  features.

### IV. EXPERIMENTAL RESULT

To determine whether the system can recognize words spoken by volunteers, we use 5-fold cross validation. This method of evaluation divide all data into 5 parts, one part, say the first part, is used as the test data, the rest as training data. Then the second part of the data as the test data, the rest for training data, and so on, until all the parts has been used as the test data.

Evaluation is done for each of the feature extraction method, and each uses two classifier, which are artificial neural network (ANN) and Support Vector Machine (SVM). Table I until Table IV show the results of accuracy for each of these methods, which is expressed in a confusion matrix. Rows on the confusion matrix shows the actual classes (true classes), while the columns show predictions. The shaded cells show the test results are correct.

TABLE I. CONFUSION MATRIX FOR PROPOSED METHOD

ANN	Makan	mau	saya	SVM	makan	mau	saya
makan	14	1	5	makan	11	3	6
mau	2	13	5	mau	1	15	4
saya	5	2	13	saya	5	2	13

TABLE II. CONFUSION MATRIX FOR BACKGROUND SUBTRACTION FOLLOWED BY VERTICAL PROJECTION

ANN	makan	mau	saya	SVM	makan	mau	saya
makan	13	2	5	makan	2	16	2
mau	3	16	1	mau	15	2	3
saya	4	2	14	saya	10	10	0

TABLE III. CONFUSION MATRIX FOR BACKGROUND SUBTRACTION FOLLOWED BY HORIZONTAL PROJECTION

ANN	makan	mau	saya	SVM	makan	mau	saya
makan	10	5	5	makan	8	5	7
mau	5	11	4	mau	5	11	4
saya	2	6	12	saya	3	5	12

TABLE IV. CONFUSION MATRIX FOR HORIZONTAL AND VERTICAL PROJECTION (WITHOUT BACKGROUND SUBTRACTION)

ANN	makan	mau	saya	SVM	makan	mau	saya
makan	8	6	6	makan	5	9	6
mau	4	15	1	mau	1	6	13
saya	7	2	11	saya	7	10	3

The test results of each these extraction methods can be measured by calculating the average accuracy from each confusion matrices. However, put attention only in accuracy, in many cases, has not been sufficient, so it is necessary to calculate F1 score, which is a combination of precision and recall. F1 score is expressed by Equation (4).

$$F1 = 2 \frac{\text{precision} \cdot \text{recall}}{\text{precision} + \text{recall}} \quad (4)$$

$$\text{precision} = \frac{\sum \text{true positive}}{\sum \text{true positive} + \sum \text{false positive}} \quad (5)$$

$$\text{recall} = \frac{\sum \text{true positive}}{\sum \text{true positive} + \sum \text{false negative}} \quad (6)$$

TABLE V. F1 AND AVERAGE F1 SCORE FOR EACH METHOD

	Proposed method		BS + vert.		BS + hor.		Vert + hor	
	ANN	SVM	ANN	SVM	ANN	SVM	ANN	SVM
saya	0.605	0.605	0.700	0.000	0.585	0.558	0.579	0.143
mau	0.722	0.750	0.800	0.083	0.524	0.537	0.698	0.267
makan	0.683	0.595	0.650	0.085	0.541	0.444	0.410	0.303
average F1	0.669	0.645	0.717	0.056	0.545	0.513	0.562	0.238

TABLE VI. ACCURACY OF EACH METHOD

Proposed method		BS + vert.		BS + hor.		Vert + hor	
ANN	SVM	ANN	SVM	ANN	SVM	ANN	SVM
0.67	0.65	0.71	0.07	0.55	0.52	0.57	0.23

By observing Fig. 2, Table V, and Table VI, it is known that the accuracy of the test is always offset by the value of F1, which means that the accuracy of the test is not in doubt. As of the classifier used, ANN showed better accuracy than SVM, for all the feature extraction methods. In terms of feature extraction methods, the best assay results obtained from the Background subtraction method followed by the vertical projection, which uses ANN classifier, i.e. 71.7% accuracy. However, this method with SVM classifier, produces poor accuracy, which is only 6.7%. SVM parameters had been varied, but the results were not much different.

The second best feature extraction methods are the proposed method, the method of background subtraction

followed by vertical and horizontal projection, which generates 67% accuracy. This method using SVM classifier also results remain fairly good accuracy, namely 65%.

In terms of the number of features produced, method of background subtraction followed by the vertical projection, produce fewer features than the proposed method. Fewer number of features will make this method lighter when run on portable devices. However, this method still need to be evaluated, considering its accuracy is so low for SVM classifier.

## V. CONCLUSION

This paper presented a method for lip reading based on background subtraction and image projection. The result shows that our proposed method using ANN classifier achieves 67% accuracy. A comparison method, i.e. using background subtraction followed by vertical projection and ANN classifier, yields better accuracy, namely 71%. However the last method need further evaluation, because it produces so low accuracy for SVM classifier.

## ACKNOWLEDGMENT

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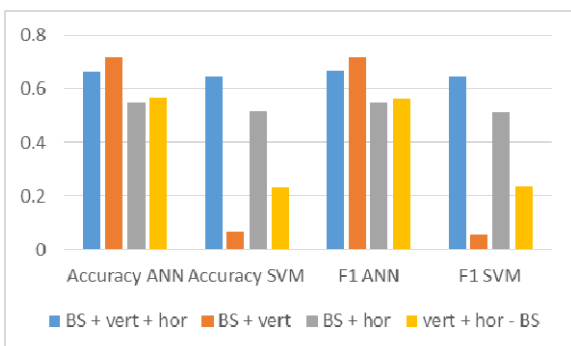


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The Relationship between Electromyography Signal of Neck Muscle and Human Voice Signal for Controlling Loudness of Electrolarynx	Arifin, F., Sardjono, T.A., Purnomo, M.H.	2014	Biomedical Engineering - Applications, Basis and Communications	0

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