Lecture Notes in Electrical Engineering 478

Kanad Ray · S. N. Sharan
Sanyog Rawat · S. K. Jain
Sumit Srivastava
Anirban Bandyopadhyay
Editors

Engineering Vibration, Communication and Information Processing

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Editors

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Editors
Kanad Ray
Amity School of Applied Sciences
Amity University Rajasthan
Jaipur, Rajasthan, India

S. K. Jain
Department of Physics
Manipal University Jaipur
Jaipur, Rajasthan, India

S. N. Sharan
Department of Electrical Engineering
Manipal University Jaipur
Jaipur, Rajasthan, India

Sumit Srivastava
Department of Information Technology
Manipal University Jaipur
Jaipur, Rajasthan, India

Sanyog Rawat
Department of Electronics and Communication Engineering
Manipal University Jaipur
Jaipur, Rajasthan, India

Anirban Bandyopadhyay
ANCC
National Institute for Materials Science
Tsukuba, Ibaraki, Japan

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Preface

The first International Conference on "Engineering Vibration, Communication and Information Processing" (ICoEVCI 2018) was organized at Manipal University Jaipur, Rajasthan, India, during March 9–10, 2018. The papers included in this book were presented at ICoEVCI 2018.

The purpose of holding such conferences is to bring together, on a common platform, professors, scientists, engineers, medical practitioners, researchers, and students in the field of vibrational research, communication, and information processing, making the conference a perfect platform to share experience, foster collaborations across industry and academia, and evaluate emerging technologies across the globe. Vibrations, oscillations, and rhythms have enriched science, engineering, and medicine, being a very fundamental part of it. Vibration tends to have plenty of advantages and a lot more disadvantages, stirring up researchers worldwide to put a lot of effort to use its advantages and curtail its disadvantages.

This book discusses the revolution of cycles and rhythms that is expected to take place in different branches of science and engineering in the twenty-first century, with a focus on communication and information processing. It presents high-quality papers in vibration sciences, rhythms and oscillations, neurosciences, mathematical sciences, and communication. It includes major topics in engineering and structural mechanics, computer sciences, biophysics and biomathematics, as well as other related fields. Offering valuable insights, it also inspires researchers to work in these fields.

We are thankful to the authors of the research papers for their valuable contribution to the conference and for bringing forth significant research and literature across the field of vibration, communication, and information processing. The editors also express their sincere gratitude to ICoEVCI 2018 patron, plenary speakers, keynote speakers, reviewers, program committee members, international advisory committee, local organizing committee, sponsors, and student volunteers, without whose support the quality of the conference could not be maintained.

We would like to express our sincere gratitude to Dr. J. E. Lugo, University of Montreal; Dr. A. Alphones, NTU, Singapore; Dr. Subrata Ghosh, CSIR-NEIST, Jorhat; Dr. Phool Singh, NorthCap University; Haryana; Dr. Gaurav Saxena, Government Women Engineering College, Ajmer; Dr. Deepak Yaduvanshi, Manipal Hospital, Jaipur; Prof. P. K. Singhal, MITS, Gwalior; Mr. Aninda Bose, Springer; and Prof. N. N. Sharma, Manipal University Jaipur, for delivering keynotes. We are also thankful to Ms. Hitu Sharma of Mathworks Pvt. Ltd, for conducting an industry session. We accord our indebtedness to Dr. Anirban Bandyopadhyay, NIMS, Japan, for his enriching plenary session.

We express our special thanks to Chief Guest, Dr. Ashoke Gupta, J. K. Lone Hospital, Jaipur, and Guest of Honor, Prof. S.L. Kothari, Amity University Rajasthan, for their gracious presence during the conference and delivering invited talks taking out time from their very busy schedule.

Finally, we would like to express our sincere gratitude to Springer and its team for the valuable support in the publication of the proceedings.

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About the Editors

Dr. Kanad Ray is Professor and Head of Physics at the Amity School of Applied Sciences, Amity University Rajasthan (AUR), Jaipur, India. He has obtained M.Sc. and Ph.D. in physics from Calcutta University and Jadavpur University, West Bengal, India. In an academic career spanning over 22 years, he has published and presented research papers in several national and international journals and conferences in India and abroad. He has authored a book on the electromagnetic field theory. His current research areas of interest include cognition, communication, electromagnetic field theory, antenna and wave propagation, microwave, computational biology, and applied physics. He has served as Editor of a Springer Books Series. Presently, he is Associate Editor of the Journal of Integrative Neuroscience published by IOS Press, the Netherlands. He has established an MOU between his university and the University of Montreal, Canada, for various joint research activities. He has also established collaboration with the National Institute for Materials Science (NIMS), Japan, for joint research activities and visits NIMS as a visiting scientist. He organizes international conference series such as SoCTA and ICoEVCI as General Chair. He is Executive Committee Member of IEEE Rajasthan Chapter.

Dr. S. N. Sharan is responsible for academic and administrative monitoring of the Department of Electrical, Electronics and Communication Engineering at Manipal University, Jaipur, India. In addition to this, he is also involved in teaching and research in the field of electronics and communication engineering/energy. His areas of expertise are energy and digital communication. He has 2 books, 20 research papers, and 15 conference papers published to his credit. He has evaluated over ten Ph.D. theses pertaining to the areas of energy and signal processing.

Dr. Sanyog Rawat is presently associated with the Department of Electronics and Communication Engineering, SEEC, Manipal University, Jaipur, India. He holds a B.E. in electronics and communication, an M.Tech. in microwave engineering, and a Ph.D. in planar antennas. He has been involved in organizing various workshops on “LabVIEW” and antenna designs and simulations using FEKO. He has taught various subjects, including electrical science, circuits and system, communication system, microprocessor systems, microwave devices, antenna theory and design, advanced microwave engineering, and digital circuits.

Dr. S. K. Jain is Head of the Department of Physics, Manipal University, Jaipur, India. His areas of interests are condensed matter physics, materials development and their characterization, and development of magnetic materials. He completed his B.Sc., M.Sc., and Ph.D. (condensed matter physics) from the University of Rajasthan, India. He has qualified NET, SLET, and GATE examinations. He is Executive Committee Member of Indian Physics Association, Jaipur, India, and Life Member of Material Research Society of India. He is currently teaching subjects like engineering physics, nanoscience and nanotechnology-II, oscillation and wave optics, and classical mechanics. He holds several publications to his credit.

Dr. Sumit Srivastava is Professor and Head of the Department of Information Technology, Manipal University, Jaipur, India. He has expertise in the domain of data analytics and image processing. He is also Senior Member of IEEE with more than 14 years of teaching experience. He has organized many national and international conferences under IEEE and Springer banner in Rajasthan. He has also served as Publication Chair of two consecutive editions of IEEE International Conference on MOOC, Innovation and Technology in Education (MITE). He has coordinated and mentored the bilateral exchange between the HEIG-VD University, Switzerland, and Manipal University, Jaipur, India, for two consecutive years. He has published more than 50 research papers in peer-reviewed international journals, book series, and IEEE/Springer/Elsevier conference proceedings.

Dr. Anirban Bandyopadhyay is Senior Scientist at the National Institute for Materials Science (NIMS), Tsukuba, Japan. He completed his Ph.D. in supramolecular electronics from the Indian Association for the Cultivation of Science (IACS), Kolkata, 2005. From 2005 to 2008, he was Independent Researcher, called ICYS Research Fellow at the International Center for Young Scientists (ICYS), NIMS, Japan, where he worked on the brain-like bio-processor building. In 2008, he joined as Permanent Scientist at NIMS, working on the cavity resonator model of human brain and design synthesis of brain-like organic jelly. From 2013 to 2014, he was Visiting Scientist at the Massachusetts Institute of Technology (MIT), USA. He has received several honors, such as the Hitachi Science and Technology Award 2010, Inamori Foundation Award 2011–2012, Kurata Foundation Award, Inamori Foundation Fellow (2011–), and Sewa Society International Member, Japan. He has patented ten inventions: (i) a time crystal model for building an artificial human brain, (ii) geometric musical language to operate a Fractal tape to replace the Turing tape, (iii) fourth circuit element that is not memristor, (iv) drugs for cancer and Alzheimer's diseases, (v) nanosubmarine as a working factory and nanosurgeon, (vi) Fractal condensation-based synthesis, (vii) a thermal noise harvesting chip, (viii) a new generation of molecular rotor,

(ix) spontaneous self-programmable synthesis (programmable matter), and (x) Fractal grid scanner for dielectric imaging. He has also designed and built multiple machines and technologies—(i) THz-magnetic nanosensor, (ii) a new class of fusion resonator antenna, etc. Currently, he is building time crystal-based artificial brain using three ways—(i) knots of darkness made of fourth circuit element, (ii) integrated circuit design, and (iii) organic supramolecular structure.

Temporomandibular Joint Syndrome Prediction Using Neural Network

Navodit Sharma, Ishfaq Gaffar Dar, Jayesh Kumar, Azzan Khan and Anita Thakur

Abstract The temporomandibular joints (TMJs) consist of complex formation of bones, muscles and tendons. Pain in jaw area is a result of disorders and injury of these structures. This TMJ disorder causes tinnitus headaches, vertigo, migraines and several TMJ arthritides. Prediction of TMJ syndrome is complex because this joint is different from the load joint of knee or hip. For diagnosis and prediction of TMJ syndrome, artificial intelligent techniques are indeed worth exploring. In this paper, the proposed model is based on neural network theory which will be helpful to sense whether a patient is suffering from TMJ disorder or not. This model automatically predicts the TMJ on the basis of risk factors and symptoms given by the patients.

Keywords Temporomandibular joints · Training algorithm backpropagation Neural network

1 Introduction

Today, around 30–40% of adults have oral problems and the second most common cause of oral problems is TMJ disorder [1, 2]. TMJ disorder is a condition that causes pain and dysfunction of jaw joint and the muscles which help in jaw movement. The

N. Sharma (✉) · I. G. Dar · J. Kumar · A. Khan · A. Thakur
Department of Electronics and Communication Engineering, Amity University Noida, Noida 201303, Uttar Pradesh, India
e-mail: navoditd@gmail.com

I. G. Dar
e-mail: ishfaqgaffar6@gmail.com

J. Kumar
e-mail: jayeshkr11@gmail.com

A. Khan
e-mail: azzanali_khan@yahoo.com

A. Thakur
e-mail: athakur@amity.edu

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temporomandibular joint connects the lower jaw, also known as the mandible to the bone situated at the side of head called the temporal bone. Because the joint is flexible in nature, the jaw has the freedom to move freely up and down and from side to side, which allows us to perform various functions like talk, chew and yawn. Muscles which are attached to and around the joint control the position as well as movement of joint. When we are opening our mouth, the round end of the lower jaw, known as condyles, slide along the socket of the joint of temporal bone [3]. The condyles return to their initial position as the mouth is closed. To ensure that this motion remains smooth, a soft disc is present between condyles and the temporal bone. The function of this disc is to absorb shocks generated from chewing and other movements. The temporomandibular joint is slightly different from other joints in the body. This joint is not only a hinge but also provides sliding motions which make this joint very complicated. Also, this joint is made up of tissues unlike any other load bearing joint tissues in the body. Due to the complex motion and unique build, the muscles and jaw joint pose an enormous challenge to both healthcare provider and patient when any problem occurs.

Disorders related to the jaw joint and chewing muscles and how people respond to them vary widely. Researchers are generally in agreement that the condition mainly falls into three categories [4, 5]:

1. Myofascial pain involving distress or ache in the muscles which operates the jaw.
2. Internal derangement or improper fitting of the jaw which includes dislocated jaw, injury to the condyle or displaced disc.
3. Arthritis concerns the group of inflammatory/degenerative joint disorders which affects the temporomandibular joint.

A person can have any one or more of the above conditions at the same time. It is possible that someone has different health issues which coexist with TMJ disorders, such as sleep disturbance, chronic fatigue syndrome or fibromyalgia, a painful situation which has effects on muscles and some other soft tissues in the entire body. Rheumatic diseases like osteoarthritis or rheumatoid arthritis can also have an effect on the temporomandibular joint. Rheumatic diseases concerns with a group of disorders that result in ache, stiffness in the joints and inflammation in muscles and bone [6]. TMJ disorder has resembling symptoms. How disorders of muscles and jaw joint progress over time is not clear and varies from patient to patient. It has been observed that symptoms have eased and worsened with time, but the reason behind these changes cannot be predicted. Most patients have a comparatively mild form of disorder where significant improvement in symptoms is seen with time but there are cases where the pain is consistent and unbearable.

Artificial Neural Network (ANN) has become very popular recently in medical research and studies [7, 8]. Several studies have been proposed based on ANN models for prediction of different diseases like hypertension, cardiac arrhythmias and tuberculosis. It is more popular because it predicts the solution with fuzzy and incomplete data set. Neural network provides a flexible model for the prediction-based application. It does not require prior hypothesis for input and output data set, also not impose any functional form in data set. Neural network theory has much strength to handle the big data set and missing data relation between input and output data set. It has hidden property to handle the fuzziness in data set. That why it is used in many fields like biology, avionics, communication, medical and so many [9, 10].

This paper proposes a solution for TMJ syndromes prediction using neural network model which can be prediction based on risk factor and symptoms of TMJ. We have collected more than 2300 patient's data of TMJ syndrome. Following organization method is used in this paper. TMJ prediction method is described in Sect. 2. Model simulation and results are in Sect. 3. Section 4 shows the conclusion of the TMJ syndrome prediction.

2 TMJ Prediction Method

2.1 TMJ Disorder Risk and Symptoms

As we know, the jaw is working as a joint which regulates our actions like yawn, eat, talk, etc. Jaw joint known as temporomandibular joint is connected to skull, teeth and spine with various parts of the body. They are very delicate in nature. This joint controls the various musculoskeletal systems; in case of any type of misalignment or imbalance, it can lead to other bodily problems. Like in plethora occurred due to TMJ disorder which is due to incorrect bite habits. For many people, it starts with bad bite; for others, it starts with clicking or popping sound in movement, although only clicking sound is not sufficient factor to call the condition TMJ disorder and warrant treatment.

The different risk factors and symptoms that are associated with TMJ are locking of jaw or limited movement, painful clicking or grating sound, change in fitting of upper and lower teeth, radiating pain in face, jaw or neck, aching pain in and around ear, jaw muscle stiffness, etc. [11]. There are some other factors which have a significant effect on TMJ, such as diabetes, deficiency of vitamin D, parathyroid and genetic.

2.2 TMJ Prediction Using Neural Network Model

Neural network is a robust method to predict the solution of problem with fuzzy data or missing data [12]. According to neural network theory, every system is defined in layer model. In this paper, TMJ neural network model consists of three layers which have hidden layer in between input and output layers. As first input layer is consisting of the information on risk factors and symptoms of TMJ syndromes, 2300 patient's information is obtained in terms of their symptoms of TMJ and other risks which increase the TMJ syndromes. On the basis of input data correlation, output data is formed in three levels decision. So, the input–output matrix of neural network model

Table 1 Performance comparison matrix

Algorithm for training	Epochs	Correlation coefficient (R)	Mean square error (MSE)
BFGS Quasi-Newton	36	0.98899	0.0048621
Gradient descent backpropagation	1000	0.98429	0.0060292
Resilient backpropagation	27	0.98888	0.0047029
Scaled conjugate gradient	33	0.90792	0.070927
Levenberg–Marquardt	17	0.98919	0.003533

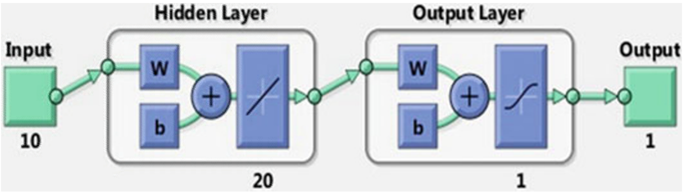

Fig. 1 The TMJ prediction neural network model

is 2300 × 10 and 2300 × 3 for the proposed model. In between the input and output layers, one hidden layer is in the model. For interaction of the layer, the activation function is used. Pure line transfer function is used in hidden to output layers, and log sigmoid function is used between hidden and input layers in the proposed TMJ model. To learn and train the supervised error, backpropagation (BP) algorithm is used in the proposed neural model. For the rapid convergence of the system, different training algorithms are implemented. Their comparison performance is shown in Table 1 (Fig. 1).

Input Layer

In neural network model, input layer is the layer which consists of the characteristics data of application. In TMJ syndrome prediction, we used 10 data as input, which include risk factors and symptoms. This symptoms and risk factor included in sample data are prepared by medical experts and dentists [4, 5]. Following risk factors and symptoms are used as input to the neural network model.

S1 Locking of Jaw or limited movement.
S2 Painful clicking, popping or grating sound.
S3 Change in fitting of upper and lower teeth.
S4 Radiating pain in face, jaw or neck.
S5 Aching pain in and around ear.
S6 Jaw muscle stiffness.
R7 Genetic.
R8 Diabetes.
R9 Parathyroid.
R10 Deficiency of vitamin D.

Hidden Layer
In between the input and output hidden layers lies in neural network which extracts the features of the input automatically to minimize the dimensionality. The number of hidden layers in the model that was chosen according to the mean square error is to be reduced. In the proposed model, one hidden layer is used which gives less error in actual output to targeted output.

Output Layer
The last layer is the output layer of the network; it is designed according to the nature of the problem which needs to be predicted. In the proposed TMJ prediction, three stages are needed to predict. They are severe chances, mild chance and no chance of TMJ disorders. Here if the output is 1, it is the case of severe TMJ disorder and the patient needs immediate treatment. If the output is 0.5, then it is the case of moderate disorder and patient should consult a doctor, and if the output is 0, it means no need to concern the doctor.

3 Results and Discussion

The proposed model of TMJ disorder prediction is simulated in neural network MATLAB tool. In which, nftool fitting tool is used to develop the neural network architecture. Where first decide the input, output layer with changeable hidden layer, then, the activation function has to be decided between the layer to get the desired output. Then, network has to be trained with supervised training algorithm by changing the number of neuron in the hidden layer. The best performance of the network

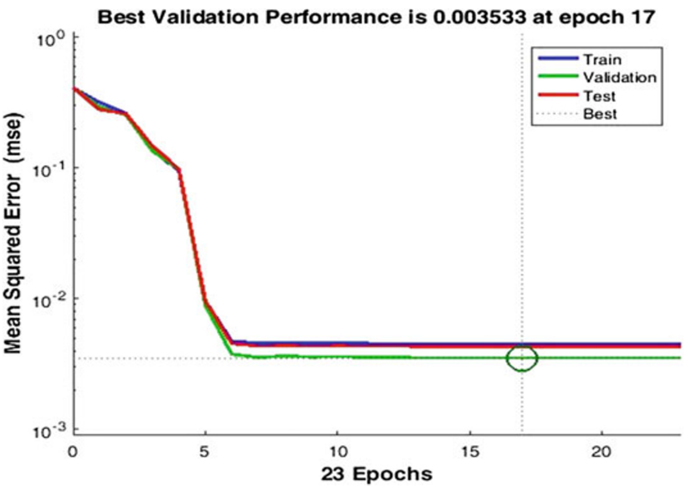

Fig. 2 Performance curve of TMJ neural network model

interest (e.g., ERPs, ERSPs, power spectra, etc.) in *R*, and finally brings the results back into MATLAB in order to plot them using EEGLAB graphics.

The necessity for creating such a tool came from the limitations we encountered using EEGLAB and the MPT to create a longitudinal statistical study design with four factors (including two crossed condition-related factors).

The recent increase in computing power has made possible the use of more complex statistical designs like mixed-effect models, which are better at modeling within-subject variability and at dealing with missing values and unbalanced datasets than the classical ANOVA [17, 18]. Furthermore, contrary to the classical ANOVA, mixed-effect models do not violate underlying assumptions (e.g., linearity, sphericity, etc.) [19]. Else, mixed-effect models are well-suited for the analysis of longitudinal data containing missing values [20–22], and were thus particularly relevant in our case.

StaR was developed to be flexible and to easily support different statistical tests in *R* with minimum changes in the code while keeping all other steps untouched (e.g., exporting the data, plotting results with EEGLAB, etc.).

Finally, by making StaR freely accessible, we hope to encourage the research community to explore their EEG data beyond traditional ERP curves (peak amplitude and latency) obtained from the electrodes, especially by using the MPT as IC clustering tool.

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