The 5th IEEE International Conference on Video and Audio Signal Processing in the Context of Neurotechnologies, and The 9th Brain Data Bank Challenge

(IEEE SPCN 2020 Taiwan)

Taoyuan, Taiwan

September 21-24, 2020
Facilitated by

IEEE Brain Initiative

IEEE Consumer Technology Society

National Central University, Taiwan

Pervasive Artificial Intelligence Research Labs, Taiwan

I. P. Pavlov Institute of Physiology, Saint Petersburg, Russian Academy of Sciences

Taiwan Photonics Society
Welcome

Video & Audio Signal Processing in the Context of Neurotechnologies - SPCN 2020, is the first joint conference on topics of Neuroscience and Signal Processing Technology, founded by Prof. Yuri Shelepin of the I. P. Pavlov Institute of Physiology, Russian Academy of Sciences in 2015, later collaborated with IEEE Brain Initiative, to investigate the storage and processing of brain signal and image data, coined the Brain Data Bank.

The first Brain Data Bank Challenge (BDBC) took place at SPCN2017 in Saint Petersburg, Russia, thanks to the host, Prof. Konstantin Glasman, Saint Petersburg State University on Film and Television. At SPCN 2018, led by the National Central University’s MINE Laboratory Director, Prof. Po-Lei Lee, leveraged on my Representative’s status within IEEE Brain, pursued exchange research program to infiltrate neuroscience theory with biomedical electronics. Unexpectedly COVID-19 pandemic happened, the original grand idea to celebrate in 2020, the 5th anniversary of SPCN on both Saint Petersburg and Taiwan could not carried out in a conventional conference setting.

Nevertheless, it is sincerely my privilege to welcome you to participate in this virtual conference connecting midnights in the United States, mornings over Neva River in Saint Petersburg, and afternoons on a Taiwan campus with COVID-19 well under control. As we adapt to this new norm for international scientific and industry knowledge exchange, our belief and ability stay strong in exploring neurotechnologies for consumer benefits, owing to the growing support from multiple dedicated channels, namely: the IEEE Brain Initiative and Consumer Technology Society, the Pavlov Institute of Physiology, Saint Petersburg, Russian Academy of Sciences, and the National Central University, MINE Laboratory in Taiwan. The future of neurotechnology depends on brilliant, daring, and persistent minds experimenting with known and unknown neuroscience, electronics, computer vision and artificial intelligence, those resources we find plenty from participants at SPCN 2020.
I believe you can benefit from SPCN-2020 to the fullest extent even in the form of virtual interaction. You will decide the success of SPCN-2020 based on your curiosity and dedication to subjects that are brought out in terms of tutorials, challenges in brain data bank analytics, brain stimulus experiments, and signal processing with EEG, and MRI, applying convolutional neural network models with deep learning.

Thank you for your participation and contribution. Let me know your comments and suggestions for future SPCN conferences.

N. Nan Chu, Ph.D.
Co General Chair, SPCN 2020
Global Chair, IEEE Brain Data Bank Challenge
CWLab International], Los Angeles, California, USA
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Venue

National Central University, College of Engineering #5
No. 300, Zhongda Rd., Zhongli Dist., Taoyuan City 320, Taiwan
Organizers

IEEE Brain Initiative
IEEE Consumer Technology Society
National Central University, Taiwan
Pervasive Artificial Intelligence Research Labs, Taiwan
Pavlov Institute of Physiology, Russian Academy of Sciences
Taiwan Photonics Society

Sponsors

五洲國際控股股份有限公司
The Getz Healthcare Cooperation
Sambest Cooperation
Honorary General Chairs

- President Jing-Yang Jou, National Central University, Taiwan.
- Dean Kuo-Chin, Fan, College of Electrical Engineering & Computer Science, National Central University
- Dr. Winston Chen, CEO of Mighty Micro Systems, Inc.
- Dr. Konstantin Glasman, Head of the Foreign Affairs Office, Saint Petersburg State University, Chair of IEEE TV-Committee

General Chairs

- Dr. N. Nan Chu, CWLab International., Los Angeles, USA.
- Prof. Kuo-Kai Shyu, Department of Electrical Engineering, National Central University.
- Prof. Yuri Shelepin, Pavlov Institute, Saint Petersburg, Russia.
- Prof. Po-Lei Lee, Department of Electrical Engineering, National Central University.

Technical Program Committee

Taiwan:

- Prof. Men-Tzung Lo, National Central University.
- Prof. Ting Kuang Yeh, Taiwan Normal University.
- Prof. I-Hui Lee, Taipei Veterans General Hospital.
- Prof. Yu-Te Wu, National Yang-Ming University.
• Prof. Cihun-Siyong Gong, Chang-Gung University.
• Prof. Lung-Hao Lee, National Central University.
• Dr. Hao-Teng Hsu, National Central University.

**USA:**

• Prof. Saraju Moharty, University of Northern Texas
• Dr. Frank Chang, Source Photonics Co., California
• Prof. Shaikh M Arifuzzaman, University of New Orleans
• Dr. Haymanot Helen Gebre-Amlak, T-Mobile and University of Missouri – Kansas City

**Russia:**

• Prof. Yuri Shelepin, I.P. Pavlov Institute of Physiology, Russian Academy of Sciences, St. Petersburg, Russia.
Conference Agenda

Brain Data Bank Tutorial
Venue: National Central University, College of Electrical Engineering and Computer Science, Taiwan.

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Brain Data Bank Challenge
Venue: National Central University, College of Electrical Engineering and Computer Science, Taiwan.

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### SPCN 2020 (Day 1)

**Venue:** National Central University, College of Electrical Engineering and Computer Science, Taiwan.

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### SPCN 2020 (Day 2)

**Venue:** National Central University, College of Electrical Engineering and Computer Science, Taiwan.

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Keynote Speaker

Date: September 22\textsuperscript{nd}, 2020

Time: 13:30-14:30 (UTC+8)

Dr. N. Nan Chu, USA

https://reurl.cc/A8yOXd
Challenges in Exploration of Neuroscience for Consumer Neurotechnology

Abstract:
The last 4 years of IEEE Brain exploratory events in the form of hackathon, challenge or competition, regarding brain signal datasets have covered brain computer interface and brain data bank processing incorporating neural network/Artificial Intelligence modeling. These exploratory efforts span from investigation of individual ElectroEncephaloGraphy (EEG) profiles, to multi-user and multi-modal physiological signal interactions and some advancements are destined for Internet of Things (IoT,) to benefit consumers. One missing perspective regarding brain dataset input to CNN modeling is particularly discussed for its criticality to any reliable performance assessment.

Biography:
Dr. N. Nan Chu, 朱南玉, retired from the Telecom and Consumer Electronics industry in 2009 as an Executive Program Manager, responsible for a $500M product line in Digital Set Top Box manufacturing and deployment. Her technical contributions had grown along the transformation from digital voice, Internet data, to digital video distribution and processing, where she engineered the first digital STB standards.

Dr. Chu has forged collaboration with the academia by corporate grant management and adjunct teaching in Universities from the East Coast to the West Coast in the USA and in Taiwan through her career in the industry and continuing into retirement stage. Most notably, she was the Director of Research & Services at California State University – Northridge. Along the way, she has started 2 companies and currently running CWLab International, among other entrepreneurial activities in Chicago, Southern California, and overseas.
She has published more than 80 papers in areas related to digital communication/networking technologies, and edited 2 books. She has been credited as the co-author of Digital Set-top Box Standards in the national SCTE and international CCITT Study Group 9, receiving Corporate awards for the early digital cable conversion standardization. Her interests in research and product development continue to evolve along social networking, cloud computing, data security, Internet connectivity to e-Healthcare, with the latest global involvement in brain communication.

Dr. Chu has volunteered in IEEE professional services since the 1980’s, and she is a Life Senior Member, having served on Board of Governors in Consumer Electronics Society, RFID, and Sensors Council, and General/Industry Chair for many high-tech international conferences. For the last 4 years, she has been the Founding Chair of the IEEE Brain Initiative Brain Data Bank Challenges, an extension from her earlier role in Brain Computer Interface Hackathons.

She received her B.S. from National Tsing Hua University, Taiwan; M.S. from Iowa State University, and Ph.D. from Northwestern University, USA; with major in Nuclear Engineering in 1972, 1973, and 1977, respectively.
Keynote Speaker

Date: September 22\textsuperscript{nd}, 2020

Time: 17:30-18:10 (UTC+8)

Prof. 羅定和 James Ting-Ho Lo,
Univ. of Maryland Baltimore County, USA

Deep Learning and a New Approach for
Machine Learning

Abstract:

The essence of modern AI is machine learning, whose state of the art is mainly the highly publicized deep learning at present. Due to its unique capabilities, deep learning is indispensable for many applications. However, its development for a wide range of other applications especially those related to cognitive signal processing has been stagnant. In this talk, some fundamental shortcomings of deep learning will be discussed in connection with big or streaming data. A new approach to machine learning will be proposed, and some results, which actually explain how the biological neural networks encode, learn, memorize, recall and generalize as a "learning machine" will briefly be summarized.

Biography:

James Ting Ho Lo is a Professor in the Department of Mathematics and Statistics of the University of Maryland Baltimore County. He received the BS degree from the National Taiwan University and the Ph.D. degree from the University of Southern California and was a Postdoctoral Research Associate at Stanford and Harvard University. His research interests have included optimal filtering, system control and identification, active noise and vibration control, and machine learning. In 1992, he solved the long standing notorious problem of optimal nonlinear filtering in its most general setting and obtained a best paper award. Subsequently, he conceived and developed adaptive neural networks with long and short term memories, accommodative neural network for adaptive processing without online processor adjustment, and robust/adaptive neural networks with a continuous spectrum of robustness; which constitute an effective systematic general approach to robust or/and adaptive processing for system control/identification/estimation and signal processing.

He has been developing a convexification method for avoiding nonglobal minima in data fitting (e.g., training deep neural networks and estimating regression models), which is ready for application and is nearing a
complete solution of the long standing notorious "local minimum problem", a main obstacle in data fitting. In recent years, Dr. Lo has also been developing a low order model of biological neural networks. The model comprises biologically plausible models of axonal/dendritic trees, synapses, spiking/nonspiking somas, unsupervised/supervised learning mechanisms, a maximal generalization scheme, and feedbacks with different delay duration; which integrate into a biologically plausible learning/retrieving algorithm and answer numerous fundamental questions in neuroscience.
Keynote Speaker

Date: September 23rd, 2020

Time: 13:30-14:30 (UTC+8)

Prof. Yuri Shelepin,
I.P. Pavlov Institute of Physiology,
Russian Academy of Sciences,
Saint Petersburg, Russia

https://reurl.cc/e8WOn7
Conscious and Unconscious Vision

Abstract:

The channels for unconscious signal processing were investigated. The signal was hidden by masking on the periphery of the visual field and presented for a short period of time. The hidden signal on peripheral vision channels was activated by loading the central vision channel with a "pseudo goal". We assumed that at these conditions it is easy to activate the channels of unconscious vision. We argue that if descriptions of unconscious signals are stored in memory, obtaining this stored information for its analysis in an experiment is possible only indirectly, by controlling the subject's unconscious reactions. The hidden information can be revealed by measuring involuntary movements under conditions of uncertainty.

Biography:

Prof. Yuri Shelepin received his M.D. in 1969, and went on to receive his Ph.D. in Technology. He has carried forward, vehemently, the Nobel Laureate, I. P. Pavlov's experimental psychology and physiology methodology over the last half a century, forging high-tech adaptation in medical science. He has published more than 800 technical papers and written many books in neuroscience and photonics; the latest one on Neuroiconics has been quoted by the IEEE Consumer Electronic Society in 2018, and it was fully translated in English the following year. He is a well-respected academic master, truly instrumental in training the next generation Russian physiologists to be equipped with skills blending emerging signal processing techniques for the advancement in
neuroscience, particularly human brain’s interaction with vision, hearing, speech, facial expressions, etc., consciously or unconsciously.

Prof. Shelepin has worked with international prestigious scholars from the United Kingdom, China, Korea, among other European countries adjacent to Russia. He is keen in recognizing cultural differences and he is well entrenched in exploring the reactions between Asians and Europeans, regarding neural perceptions. His leadership in the latest linkage with the National Central University in Taiwan brings yet another dimension in comprehending human behaviors and brain reaction, which presents unique influences due to culture differences. This joint effort would undoubtedly leverage upon the fast-paced electronics development in Taiwan.
Keynote Speaker

Date: September 23rd, 2020

Time: 14:30-15:30 (UTC+8)

Prof. 羅孟宗 Men-Tzung Lo,
National Central University, Taiwan

https://reurl.cc/GrXee3
A Real-World Implementation of Cloud-Based AI System for Large-Scale AFib Screening

Abstract:
Atrial fibrillation (AFib) is the most common arrhythmia, and the patients with AFib have five times higher risk for stroke. The prevalence is around 10% for the population over 65 years old. However, the occurrence of AFib can be episodic and sometimes asymptomatic which leads to underdiagnoses of AFib. New miniaturized intermittent ECG devices were adopted in several studies, and both population screening and home-based monitoring can significantly increase the detection rate. To develop an efficient and sustainable strategy for detecting undiagnosed AFib, we propose a cloud-based AI system for arrhythmia screening, especially for AFib. This system can be ubiquitously connected by incorporating with mobile devices in different scenarios such as health examination with real-time feedback or home-based monitor for the patients with 7-14 days screening. The system has been applied for Arrhythmia screening from Oct 2018 and over 14,000 people had been screened with 13.4% arrhythmia detection rate.

Biography:
Men-Tzung Lo, Ph.D., is Distinguished Professor of Department of Biomedical Sciences and Engineering, National Central University. The joint Lab directed by him and Dr. Chen Lin, Associated Professor of Department of Biomedical Sciences and Engineering, devote to two main research interests which are time varying interactions between multiple biological signals of human subjects and the changes of nonlinear properties in different physiological and pathological statuses. The Lab has been developing time saving nonlinear dynamic methods and revealing
basic physiological principles and applying them to medicine for over 10 years. The Lab has published over 100 original peer-reviewed articles and has been invited to present their research at international conferences (e.g., The 4th and the 5th Asia Pacific Heart Rhythm Society Scientific Sessions; The 3rd Asian Epilepsy Surgery Congress). The Lab holds 16 US patents demonstrating the innovative nature of their work. One of their prowess accomplishments was the development on the methodology of cardiac fibrillation and catheter ablation, their work has been published on several target journals. Recently, the Lab is known for the live demo of mapping system for real time identification of the source of atrial fibrillation maintenance on the Asia Pacific Heart Rhythm Society 2013 at Hong Kong, this work has been recognized at the 11th National Innovational Award, Taiwan.
Keynote Speaker

Date: September 24th, 2020
Time: 16:00-17:00 (UTC+8)

Prof. 吳育德 Yu-Te Wu,
National Yang-Ming University
Taipei, Taiwan

Combining Analysis of Multi-parametric MR Images into a Convolutional Neural
Network: Precise Target Delineation for Vestibular Schwannoma Treatment Planning

Abstract:
Manual delineation of vestibular schwannoma (VS) by magnetic resonance (MR) imaging is required for diagnosis, radiosurgery dose planning, and follow-up tumor volume measurement. A rapid and objective automatic segmentation method is required, but problems have been encountered due to the low through-plane resolution of standard VS MR scan protocols and because some patients have non-homogeneous cystic areas within their tumors. In this talk, a two-pathway U-Net model using multiparametric MR images (T1-weighted, T2-weighted (T2W), and T1-weighted with contrast images.) with different image contrasts as input for effectively segmenting tumors will be discussed.

Biography:
Yu-Te Wu received a B.S. degree in electrical engineering from National Cheng-Kung University, Tainan, Taiwan, R.O.C., in 1988, and M.S. and Ph.D. degrees in electrical engineering from the University of Pittsburgh, Pittsburgh, PA, in 1992 and 1997, respectively. He was a Research Associate at the Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, during 1997–1998. Currently, he is the Dean, Office of Research and Development, and Distinguished Professor, Institute of Biophotonics, at National Yang-Ming University, Taipei, Taiwan, R.O.C. He has published more than 100 articles in the areas of neuroimaging, machine learning, and brain-computer interface.

Prof. Wu has long been dedicated in brain magnetic resonance (MR) imaging analysis and applications using machine learning. The image-biomarkers, such as fractal dimension (FD), gyrification index (GI), curvedness (CVD), shape index (SI), and brain network connectivity have been applied to quantify the change of cortical morphology and network
properties on structural and functional MR images, respectively. He has investigated the modulation of structural and functional brain network and association between structural/functional alteration and clinical syndromes of neuropsychiatric and neurodegenerative disorders, such as major depressive disorder, bipolar disorder, spinocerebellar ataxia (SCA), and multiple system atrophy type C (MSA-C). In addition, these structural and functional image biomarkers subserve as important features for differentiating some neuropsychiatric and neurodegenerative disorders where the structural changes of the cerebrum and cerebellum are difficult to identify via visual inspection.

In recent years, Prof. Wu has collaborated with the Gamma Knife team at Taipei Veterans General Hospital (VGHTPE), Taipei, Taiwan, to develop a gamma knife treatment decision assisting system for vestibular schwannoma. Goals of this study include the development of deep-learning based method for automate tumor segmentation and application of deep-learning model to predict the VS treatment response. In addition, he also collaborated with the Department of Radiology, VGHTPE, in the application of machine learning for quantitative digital subtraction angiography for improvement of hemorrhagic risk stratification of brain arteriovenous venous malformations.
Keynote Speaker

Date: September 24\textsuperscript{nd}, 2020

Time: 17:00-18:00 (UTC+8)

Prof. Kirill Krinkin, Saint Petersburg State

Electrotechnical University "LETI", Russia

Integration AI to a Society: Threats, Benefits, and Challenges
Abstract:
Modern AI applications give us many benefits in an immense amount of domains. In many cases the performance of AI systems significantly overtakes human abilities. Technologies grow much faster than society is able to seamlessly adapt them. There are many problems and contradictions which are hindering wide applications of new kind of systems. A few examples: personal data privacy conflicts to data availability for machine learning algorithms; absence of fully interpretable AI systems based on machine learning; the lack of standards allowing delivery of reliable AI products; uncertainty with responsibility transferring from human to autonomous systems like self driving cars; rapid division of labour system transformation diminishes some professions and creates new ones. The main threats, benefits and challenges of AI systems will be summarized and modern approaches to solving existing problems will be discussed.

Biography:
Kirill Krinkin is an Adjunct Professor, Head Software Engineering and Computer Applications Department in Saint Petersburg State Electrotechnical University “LETI”, Director of International Innovation Institute on Artificial Intelligence, Cybersecurity, and Communications (Popov Institute). He is a professional member of IEEE, ACM, Robotics, and Automation Society. For the last more than twenty years, Krinkin has been doing research and development with international companies and Universities in Software Engineering, Autonomous Mobile Robots, and related domains.

Kirill Krinkin is an Author and co-author of more than 100 technical papers. He is actively giving lectures in universities on Mobile Robotics and operating systems development. He is an organizer of many hands-on STEM schools in Russia and Europe. He is a supervisor of the student team in Artificial Intelligence Driving Olympics Challenge – a benchmark the state of the art of artificial intelligence in autonomous driving technologies in standardized simulation and hardware environments for tasks related to multi-
sensory perception and embodied AI. His team took the 1st place twice in this challenge in 2019 at ICRA and NeuroIPS conferences.
Brain Data Bank Tutorials
Chair: Dr. N. Nan Chu, CWLab International and IEEE Brain
Date: September 21st, 2020.
Time: 14:00-15:30 (UTC+8)

ADNI Tutorial
A Tutorial on Neural Imaging Datasets from ADNI: Current Practices and Recommended Enhancements

Haymanot Gebre-Amlak, and Narisa Nan Chu
Department of Computer Science and Electrical Engineering
University of Missouri-Kansas City, Kansas City, MO, USA
CW Lab International, Thousand Oaks, CA, USA
Email: fhhgc77g@umkc.edu
nchu@cwlab.com

Abstract:
Using the image data from the Alzheimer’s Disease Neuroimaging Initiative (ADNI) website can be overwhelming for many researchers. The sheer volume and size of image data (3 terabytes) can be intimidating in addition to the methods and techniques involved which are inherently complicated and are rapidly evolving. Alternatives approaches are not available and many researchers have depended on ADNI data to perform evaluations for their fields of interest. The learning curve required to use ADNI is not trivial. This tutorial will provide supplement for the complexity of the subject matter and non-trivial user interface in times of insufficient software extensions/technological support. Moreover, research involving the sought-after AI models, has shown performance un-reproducible, with a shortage of interdisciplinary subject experts. This tutorial aims to bridge the gap between the researchers and the data collection. It also recommends areas of enhancements to make ADNI datasets more user-friendly.

https://reurl.cc/R1OXex
Brain Data Bank Tutorials
Chair: Dr. Nan Chu, CWLab International and IEEE Brain
Date: September 21st, 2020.
Time: 16:00-17:30 (UTC+8)

CNN Tutorial
A Tutorial on Deep Learning Research in Alzheimer’s Disease

Hoang (Mark) Nguyen
Department of Computer Science and Electrical Engineering
University of Missouri at Kansas City
hdnf39@mail.umkc.edu

N. N. Chu
CWLab International
nchu@cwlab.com

Abstract:
This tutorial explains the evolving approaches on Deep Learning (DL) modeling and their dependence on statistically comprehensive datasets as input in various forms of brain scan neuroimages. Powerful visual modalities, e.g., Magnetic Resonance Images (MRI) and Positron Emission Tomography (PET), can show neural changes during Alzheimer’s Diseases (AD) development. The recent success in computer vision has lent impetus to numerous deep learning modeling publications reporting accuracy above 90%, using AD Neurolmage (ADNI) datasets. However, several limitations exist when using DL for AD image interpretation. Due to lack of a comprehensive dataset and the complexity of medical images, there is little to no clinical value in such DL approaches. Furthermore, without well-accepted evaluation criteria, many of the published research results in the field are not comparable in experimenting with the ADNI datasets. This tutorial describes the fundamentals and gaps in applying DL methodology over ADNI datasets.

https://reurl.cc/m9Z3kA
SPCN 2020 Session I

CNN Applied to Neuro Images

Session I Chair : Prof. Jinchang Ren
University of Strathclyde, Scotland, United Kingdom
Date: September 23rd, 2020.
Time: 16:30-18:00 (UTC+8)

Paper 1

Opponent processes in representation of visual information by neurons in convolutional neural networks

Katerina Malakhova, Pavlov Institute of Physiology, Russian Academy of Sciences, Saint Petersburg, Russia

Abstract:

With remarkable similarities in the responses of neurons in the visual cortex and units of higher layers of convolutional neural networks (CNNs), CNNs are commonly considered as models of the primate visual system. However, when studied carefully, the response characteristics of artificial units diverge from what is observed in neuroscientific data. Most of the units of intermediate hidden layers of a CNN, in addition to emerging class-selectivity properties, exhibit strong negative selectivity towards some group of images from the same category. The response properties, therefore, differ from the neurons in the high-level visual cortex, where inhibition is mostly caused by images of non-relevant categories, thus pointing to differences in representation of visual information.

https://reurl.cc/GrXgeW
Paper 2

Transfer Learning to Predict Early Stages of Alzheimer’s Disease Using DenseNet

Hoang (Mark) Nguyen
Department of Computer Science and Electrical Engineering
University of Missouri at Kansas City
hdnf39@mail.umkc.edu

N. N. Chu
CWLab International
nchu@cwlab.com

Abstract:

In recent years, Deep Learning (DL) in Convolutional Neural Network (CNN) has caught significant attention from research in Alzheimer’s Disease (AD) detection, especially in processing brain image data administered by the AD NeuroImage Initiative (ADNI.) The increasing number of publications using DL/CNN models has reported accuracy above 93%, with little practical means for validation due to mostly inadequate model description. However, AD remains a challenging topic for DL experiments with the high hope to increase their clinical value. DL is particularly questionable when the quantity of dataset is below statistical significance. In this paper, we propose using transfer learning, a popular technique in DL, to predict transitional stages of AD in terms of Mild Cognitive Impairment (MCI). Our modeling process makes use of 1,854 MRI images of Early stage of MCI (EMCI) and Late MCI (LMCI,) transfer learning from 2,233 MRI images based of Cognitive Normal (CN) and AD states. Our DL/CNN modeling results in performance metrics showing 90.58% in accuracy, 0.947 in Area Under Characteristic Curve (AUC,) and 10.6% Equal Error Rate (EER) in CN-AD classification. The model with transfer learning outperformed the one without pre-trained network with 0.932% in accuracy, 0.932 in AUC, and 14.2% EER.

https://reurl.cc/7ojpWk
Abstract:

There is special interest in pattern-recognition tasks in recognizing a person’s facial expression. Under threshold conditions, the interpretation becomes ambiguous when the facial expression changes, a classical example of which is the indeterminacy of La Gioconda’s smile. Leonardo da Vinci brought the variation of the curve of her lips, imitating a smile, to the threshold value. With threshold values of a signal (a smile) under the influence of external noise of the visual system, her facial expression produces indeterminacy in the observer (is she smiling or isn’t she?). Thus, the research problem consisted of using the following methods of neuroiconics: digital image processing, functional magnetic-resonance tomography (fMRT) of brain activity, psychophysical and neurotechnology methods to determine under conditions of indeterminacy the minimum information needed to recognize faces with different intensities of the facial expression.

https://reurl.cc/j5RGO2
SPCN2020 Session II
BCI & EEG Signal Processing
Chair: Prof. Po-Lei Lee
National Central University, Taiwan
Date: September 24th, 2020.
Time: 13:00-14:30 (UTC+8)

Paper I
Classification of Four-class Motor Imagery Movements using Long Short-term Memory Network
Hung-Chang Lee, Hong-Guai Chen, Hao-Teng Hsu, Kuo-Kai Shyu, and Po-Lei Lee,
Department of Electrical Engineering, National Central University, Jhong Li, Taiwan.

Abstract:
In this study, we have developed a multi-channel dry-electrode EEG system to implement a Brain Computer Interface (BCI) for discriminating four-class motor imagery signals. The EEG channels recorded from Fz, F3, F4, C3, Cz, C4, P3, and P4 positions, according to international 10-20 EEG system, were acquired and wirelessly transmitted to a personal computer. Five subjects were recruited in our experiment. All subjects were asked to perform right hand, left hand, right foot, and left foot imagery movements, 60 trials in each movement type. EEG data were segmented into epochs from 0sec to 8sec, anchored to time points of imagery movement cues. The segmented EEG epochs were pre-processed by means of morlet wavelet. A long short-term memory (LSTM) neural network with 64 LSTM cells were constructed to discriminate EEG signals recorded from different imagery movements. Among total EEG epochs, 80% were randomly chosen as training data and the rest of 20% were used as validation data. The detection accuracy has achieved 89% in our study.
Paper 2

Electrophysiological Study of the Monkeys’ Brain Rhythms

Alexey Harauzov, et al, I. P Pavlov Institute, Russian Academy of Sciences, Saint Petersburg, Russia.

Abstract:

Investigation the neurophysiological basis of human brain functioning is difficult without the use of animal models. The closest animals to humans according to the anatomical and physiological characteristics are monkeys. So, information about electrical processes in the monkeys’ brain can be extrapolated to some extent to humans for understanding the principles of human brain functioning. Of special interest is investigation of the brain rhythms as a fundamental feature of neuronal activity in animals and humans. Particularly, we were interested in the phenomenon of ‘neuronal entrainment’ – temporal synchronization of neural responses to external rhythms. In electrophysiological experiments on humans (Regan, 1989; Herrmann et al., 2001), monkeys (Nakayama and Mackeben, 1982) and cats (Rager and Singer, 1998) has been shown that the brain responsiveness to rhythmic stimulation does not change uniformly with changing stimulation frequencies. The dependence of the response magnitude on the input frequency is characterized by local maxima, the so-called “resonance-like frequencies” which neuronal origin is still poorly understood. In the present study we asked a question, whether resonance-like frequencies depend on intrinsic dominant brain rhythms observed in resting-state EEG?
Paper 3
Implementation of a High frequency SSVEP based BCI Using Iterative Filtering - Empirical Mode Decomposition (IF-EMD)

Kuo-Kai Shyu, Kuan-Hsiang Yu, Jason Kao, Jun-Kai Hung, and Po-Lei Lee, Department of Electrical Engineering, National Central University, Jhong Li, Taiwan.

Abstract:
Steady-State Visual Evoked Potential (SSVEP) has been regarded as an efficient way to design a Brain Computer Interface (BCI). However, most SSVEP-based BCIs utilize visual stimuli with flashing frequencies lower than 30Hz, owing to their higher Signal-to-Noise Ratio (SNR). BCIs using SSVEP higher than 30Hz are rarely seen. In order to achieve the control of SSVEP-based BCIs at high stimulation frequency (>30Hz), we have implemented iterative filtering – empirical mode decomposition (IF-EMD) to classify the SSVEPs from viewing distinct high-frequency stimulators. EEG signals were recorded from dry EEG electrodes with impedance matching circuits. The EEG signals were pre-filtered within 35~55Hz as preprocessing (6th-order Butterworth IIR filter) to remove low-frequency drifts and 60Hz electricity noise. Three stimulation frequencies, designed at 47, 50, and 53 Hz were chosen to induce high-frequency SSVEPs, in order to control the leftward, upward, and rightward movements of the BCI cursor. Ten subjects were recruited, and each subject was requested to complete a control experiment of moving a cursor to reach three targets on a PC screen. The mean accuracy (Acc), command transfer interval (CTI), and information transfer rate (ITR) in the control experiment were 90.7±2.9%, 1.14±0.07 sec, and 54.94±5.41 bits/min, respectively. In the application experiment, the mean execution time and CTI were 30.0±4.69 sec and 1.50±0.31 sec, respectively.

https://reurl.cc/bRGEg6
Session III Brain Processing and Movements

Chair: Kuo-Kai Shyu,
National Central University, Taiwan
Date: September 24th, 2020.
Time: 14:30-15:30 (UTC+8)

Paper I

Using Holo-Hilbert Spectral Analysis (HHSA) to analyze EEG Oscillatory during Repetitive Movements

Hao-Teng Hsu, Kuo-Kai Shyu, and Po-Lei Lee
Department of Electrical Engineering, National Central University, Jhong Li, Taiwan.

Abstract:

Neural oscillatory activities existing in multiple frequency bands usually represent different levels of neurophysiological meanings, from micro-scale to macro-scale organizations. In this study, we adopted Holo-Hilbert Spectral Analysis (HHSA) to study the Amplitude-Modulated (AM) and Frequency-Modulated (FM) components in sensorimotor Mu rhythm, induced by slow- and fast-rate repetitive movements. We observed that the instantaneous power induced by slow-rate movements was significantly higher than that induced by fast-rate movements (p < 0.01, Wilcoxon signed rank test). The alpha-band AM frequencies induced by slow-rate movements were higher than those induced by fast-rate movements, while no statistical difference was found in beta-band AM frequencies. The discrepancy between slow- and fast-rate movements might be owing to the change of motor functional modes from default mode network (DMN) to automatic timing with the increase of movement rates. The use of HHSA for oscillatory activity analysis can be an efficient tool to provide informative interaction among different
frequency bands.

https://reurl.cc/bRGEg6

Paper 2
Development of a Method for Differential Diagnosis of Schizophrenia and Depression Using the Method of Cognitive Visual Evoked Potentials
S.V. Murav’eva (Muraveva), muravsvetlana@mail.ru, Pavlov Institute of Physiology, Russian Academy of Sciences, Saint-Petersburg, Russia

Abstract:
In recent years, increasing attention is paid to study of the neurophysiological mechanisms underlying cognitive impairment in patients with schizophrenia and depression. For these patients, characteristic features are disturbances in the processing of visual information, which plays a key role for human adaptation in the environment. In the basis of the violations lies primarily a dysfunction of the system of “object vision”: the contours of objects, letters and colors are perceived blurry, characterized by rapid color fatigue. The basis of the violations lies primarily in the dysfunction of the system of "object vision", later joined by violations of "spatial vision": complaints of spatial violations and impaired perception of black and white images.

To assess cognitive impairment in patients with neuropsychiatric pathology, the method of cognitive visual evoked potentials has long been
used. On the basis of this method, a more subtle research method was
developed and tested in the clinic - with the perception of images of
objects processed by the wavelet method, for the selective assessment of
the system of "object" (parvocellular system) or "spatial" (magnocellular
system) vision. The parvo system provides detailed analysis of the
fragments found with high resolution and is sensitive to high spatial
frequencies and high contrasts. Its function is to analyze color (mainly red,
yellow and green colors), texture, and recognition of small objects and
their details (“object vision”). The magnocellular system is sensitive to low
spatial frequencies and low contrasts and is able to respond quickly to
temporal changes in the image. Its function is to analyze black and white
images, dynamic changes in the image, localization of objects of interest
and processing of information necessary for orientation in space (“spatial
vision”).

https://reurl.cc/MdXNVX
SPCN Best Paper Award

1. Classification of Four-class Motor Imagery Movements Using Long Short-term Memory Network

Hung-Chang Lee, Hong-Guai Chen, Hao-Teng Hsu, Kuo-Kai Shyu, and Po-Lei Lee,
Department of Electrical Engineering, National Central University, Jhong Li, Taiwan.
(Receiving the First Place Award Certificate and $500)

2. Implementation of a High frequency SSVEP based BCI Using Iterative Filtering - Empirical Mode Decomposition (IF-EMD)

Kuo-Kai Shyu, Kuan-Hsiang Yu, Jason Kao, Jun-Kai Hung, and Po-Lei Lee,
Department of Electrical Engineering, National Central University, Jhong Li, Taiwan.
(Receiving the Second Place Award Certificate and $300)

3. Facial Expression Processing in Neuronal Nets: Architecture and Large-Scale Neural Networks Reconstruction of the Human Brain under Conditions of Indeterminacy

Olga V. Zhukova & Katerina Malakhova, I.P. Pavlov Institute of Physiology, Russian Academy of Sciences, Saint Petersburg, Russia
(Receiving the Third Place Award Certificate and $200)

4. Opponent Processes in Representation of
Visual Information by Neurons in Convolutional Neural Networks
Katerina Malakhova, Pavlov Institute of Physiology, Russian Academy of Sciences
(Receiving Honorary Mention Certificate)

Brain Data Bank Challenge Awards

• Deep learning in ADNI - A Reality Check
Team Deep Learning Rules - Hoang (Mark) Nguyen and Helen Gebre-Amlak,
University of Missouri- Kansas City, USA
(Receiving BDBC-2020 Taiwan Best Award Certificate and $300)

• Utilizing Deep Learning Model to Predict Brain Aging for Alzheimer's Disease and Mild Cognitive Impairment Patients
Team MINE Professor Brain - Hao-Teng Hsu, Hung-Chang Lee, and Hong-Guai Chen,
Department of Electrical Engineering, National Central University, Jhong Li, Taiwan
(Receiving BDBC-2020 Taiwan Best Award Certificate and $300)
**Acronym**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABE</td>
<td>Attention-Based Ensemble</td>
</tr>
<tr>
<td>ACC</td>
<td>Accuracy</td>
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<tr>
<td>ACP</td>
<td>Actual Coverage Probability</td>
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<tr>
<td>AC-PC</td>
<td>Anterior Commissure – Posterior Commissure</td>
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<tr>
<td>AD</td>
<td>Alzheimer's Disease</td>
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<tr>
<td>Adagrad</td>
<td>Adaptive gradient descent</td>
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<tr>
<td>ADAS-Cog13</td>
<td>AD Assessment Scale – Cognitive Subdomain 13</td>
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<tr>
<td>ADNI</td>
<td>Alzheimer's Disease Neuromaging Initiative</td>
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<tr>
<td>AE</td>
<td>AutoEncoder</td>
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<tr>
<td>AFib</td>
<td>Atrial Fibrillation</td>
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<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
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<tr>
<td>AIBL</td>
<td>Australian Imaging Biomarkers &amp; Lifestyles</td>
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<tr>
<td>Alpha</td>
<td>Weighted coefficient for each pattern commonly used in CNN</td>
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<tr>
<td>AM</td>
<td>Amplitude-Modulated</td>
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<tr>
<td>ASL</td>
<td>ARTERIAL Spin Labeling</td>
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<tr>
<td>AUC</td>
<td>Area Under ROC curve</td>
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<tr>
<td>BCI</td>
<td>Brain Computer Interface</td>
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<tr>
<td>BDBC</td>
<td>Brain Data Bank Challenge</td>
</tr>
<tr>
<td>Beta</td>
<td>Dynamic combination of weight coefficient commonly used in CNN</td>
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<tr>
<td>BIDS</td>
<td>Brain Imaging Data Structure</td>
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<tr>
<td>BN</td>
<td>Batch Normalization</td>
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<td>CN</td>
<td>Cognitive Normal</td>
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<tr>
<td>CNN</td>
<td>Convolutional Neural Network</td>
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<td>CSF</td>
<td>Cerebro-spinal Fluid</td>
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<tr>
<td>CTI</td>
<td>Command Transfer Interval</td>
</tr>
<tr>
<td>CVD</td>
<td>CurVeDness</td>
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<tr>
<td>DenseNet</td>
<td>Dense convolutional Network</td>
</tr>
<tr>
<td>DL</td>
<td>Deep Learning</td>
</tr>
<tr>
<td>DMN</td>
<td>Default Mode Network</td>
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<tr>
<td>DTI</td>
<td>Diffusion Tensor Imaging</td>
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<tr>
<td>ECG</td>
<td>Electrocardiogram</td>
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<tr>
<td>EEG</td>
<td>Electroencephalography</td>
</tr>
<tr>
<td>EER</td>
<td>Equal Error Rate</td>
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<tr>
<td>ELTI</td>
<td>Electrotechnical University, Saint Petersburg, Russia</td>
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<tr>
<td>EMCI</td>
<td>Early stage of MCI</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
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<tr>
<td>FD</td>
<td>Fractal Dimension</td>
</tr>
<tr>
<td>FM</td>
<td>Frequency-Modulated</td>
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<tr>
<td>fMRI</td>
<td>functional Magnetic Resonance Imaging</td>
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<tr>
<td>fMRIB</td>
<td>Functional Magnetic Resonance Imaging of the Brain</td>
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<tr>
<td>FSL</td>
<td>FMRIB Software Library</td>
</tr>
<tr>
<td>GAN</td>
<td>Generative Adversarial Network</td>
</tr>
<tr>
<td>GI</td>
<td>Gyrification Index</td>
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<tr>
<td>GWAS</td>
<td>Genome-Wide Association Analysis</td>
</tr>
<tr>
<td>HHSA</td>
<td>Holo-Hilbert spectral analysis</td>
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<tr>
<td>IDA</td>
<td>Image &amp; Data Archive</td>
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<tr>
<td>IF-EMD</td>
<td>Iterative Filtering - Empirical Mode Decomposition</td>
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<tr>
<td>IMCI</td>
<td>late stage of MCI</td>
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<tr>
<td>IoT</td>
<td>Internet of Things</td>
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<tr>
<td>ITR</td>
<td>Information Transfer Rate</td>
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<tr>
<td>LMCI</td>
<td>Late Mild Cognitive Impairment</td>
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<tr>
<td>LONI</td>
<td>Laboratory of Neuro Imaging at Univ. of Southern California</td>
</tr>
<tr>
<td>MCI</td>
<td>Mild Cognitive Impairment</td>
</tr>
<tr>
<td>MINC</td>
<td>Medical Imaging NetCDF (Network Common Data Form)</td>
</tr>
<tr>
<td>MMSE</td>
<td>Mini-Mental State Exam</td>
</tr>
<tr>
<td>MNI</td>
<td>Montreal Neurological Institute</td>
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<tr>
<td>MoCA</td>
<td>Montreal Cognitive Assessment</td>
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<tr>
<td>MPRAGE</td>
<td>Magnetization-Prepared Rapid Acquisition with Gradient Echo</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>MSA-C</td>
<td>Multiple System Atrophy - type C</td>
</tr>
<tr>
<td>NCU</td>
<td>National Central University</td>
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<tr>
<td>NIHITI</td>
<td>Neuroimaging Informatics Technology Initiative</td>
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<tr>
<td>PET</td>
<td>Positron Emission Tomography</td>
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<tr>
<td>RFID</td>
<td>Radio Frequency IDentification</td>
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<tr>
<td>ROC</td>
<td>Receiver Operating Characteristic</td>
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<tr>
<td>RNN</td>
<td>Recurrent Neural Network</td>
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<tr>
<td>SCA</td>
<td>SpinoCerebellar Ataxia</td>
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<tr>
<td>SI</td>
<td>Shape Index</td>
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<tr>
<td>SNR</td>
<td>Signal to Noise Ratio</td>
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<tr>
<td>SPCN</td>
<td>Signal Processing in the Context of Neurotechnologies</td>
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<tr>
<td>SSVEP</td>
<td>Steady-State Visual Evoked Potential</td>
</tr>
<tr>
<td>T2W</td>
<td>T2-Weighted</td>
</tr>
<tr>
<td>UMKC</td>
<td>University of Missouri – Kansas City</td>
</tr>
<tr>
<td>UMBC</td>
<td>University of Maryland – Baltimore County</td>
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</tbody>
</table>
VGHTPE  Taipei Veterans General Hospital
VS   Vestibular Schwannoma